State of South Carolina

Governor Henry McMaster

Thomas S. Mullikin, Chairman

South Carolina Floodwater Commission

South Carolina Floodwater Commission Report

November 8, 2019

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ACKNOWLEDGEMENTS

I. OVERVIEW

A. INTRODUCTION

Governor Henry D. McMaster set our beautiful state on course to address challenges associated with flooding and extreme weather systems through the creation of the South Carolina Floodwater Commission by Executive Order 2018-50 on October 15, 2018. In the last four years, South Carolina has experienced very serious episodes of flooding along the coast, rivers, and low-lying interior areas as a result of rains, storms, and hurricanes that highlight the need for a statewide plan to accommodate and mitigate flooding impacts in the state. Coastal communities are experiencing increasing numbers of disruptive "sunny day flooding," or "nuisance flooding," during normal tidal cycles, due to higher sea level and health risks resulting from both coastal and freshwater flooding are posing a threat to South Carolina citizens. Problems with excess *Vibrio* bacteria and toxins from cyanobacteria in freshwater systems are being exacerbated by natural disasters, such as nuisance flooding along the coast and inland (University of South Carolina, n.d.).

It is vital to mitigate flooding to lessen the negative impacts to our state's economy in order to facilitate growth, promote tourism and assist communities and businesses struggling from repeated flooding events, and protect the health and wellbeing of our citizens. A coordinated national, state, local and community effort is necessary and appropriate to facilitate the interaction between all levels of government and private and academic sectors to address these issues. The South Carolina Floodwater Commission is constituted to serve as a vehicle to research, evaluate, share and coordinate measures and ideas being considered.

The commission is charged with developing short-term and long-term recommendations to alleviate and mitigate flood impacts to the state, with special emphasis on cities, communities and enterprises located on or near the coast and rivers across South Carolina. Relevant studies, data, reports and expert and lay opinions on storm water management and use, urbanization impact, coastal shoreline fluctuation, project and operational financing, affordability, available grants, appropriate partnerships, and the impacts on neighboring cities, counties and states are being considered to ensure that a comprehensive, executable strategy is adopted.

B. RECENT HISTORY OF FLOOD EVENTS, AND FLOOD VULNERABILITY IN SOUTH CAROLINA

Four major flooding disasters affected South Carolina in the period between 2012 to 2018: Hurricane Joaquin and the Historic Flood (2015), Hurricane Matthew (2016), Hurricane/Tropical Storm Irma (2017), and Hurricane Florence (2018). The South Carolina Emergency Operations Division (SCEMD) has compiled the following statistics on the impact of each event on our state.

1. HURRICANE JOAQUIN AND THE HISTORIC FLOOD (2015)

Hurricane Joaquin and the Historic Flood in 2015, one of the most destructive events since Hurricane Hugo in 1989, impacted over 100,000 citizens across South Carolina. Approximately 20,000 citizens were evacuated from their homes by flooding as South Carolina received 26 inches of accumulated rainfall, causing nine rivers to flood, and resulting in a devastating 19 fatalities. The National Flood Insurance Program (NFIP) paid out over $140 million, Small Business Administration loans were over $166 million, and upwards of $283 million in commercial insurance payments
(South Carolina Emergency Management Division, 2018). FEMA granted 23 of South Carolina's 46 counties individual and household assistance upwards of $90 million, with approximately $116 million obligated public assistance grants to 35 counties (Federal Emergency Management Agency, 2015).

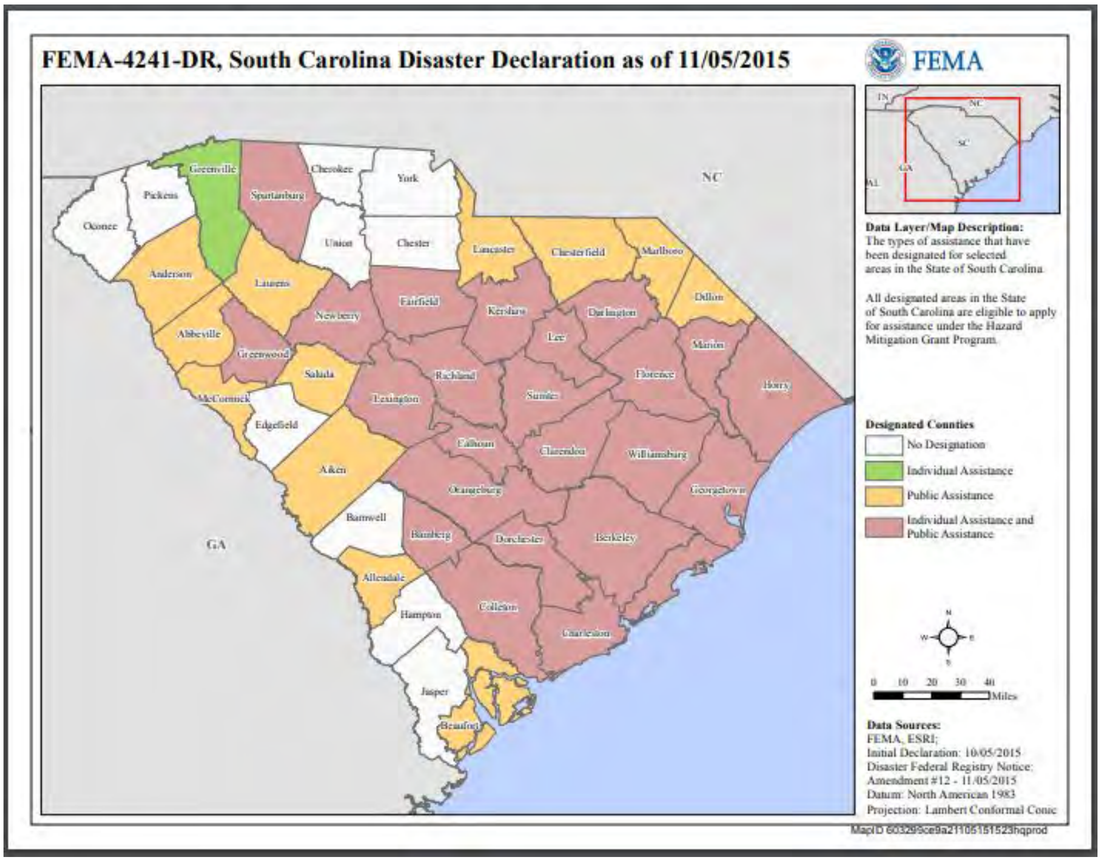

FIGURE 1: SC Disaster Declaration – Historic Flood (Federal Emergency Management Agency, 2015).

2. HURRICANE MATTHEW (2016)

In 2016, Hurricane Matthew became the first Category 1 storm to demand an evacuation of the coast, since Hurricane Floyd in 1999. South Carolina experienced 15 inches of rain causing flooding in five rivers. 350,000 citizens were forced to evacuate the coast with 5 fatalities. The most devastating storm event in recent years, infrastructure repair throughout South Carolina cost nearly $320 million, while Small Business Administration loans were over $60 million. Additionally, the NFIP paid over $166 million and commercial insurance payments totaled over $878 million (South Carolina Emergency Management Division, 2018). FEMA paid approximately $40 million to over 11,000 individuals and families in 25 counties and obligated over $239 million to public assistance in 26 different counties throughout the state (Federal Emergency Management Agency, 2016).

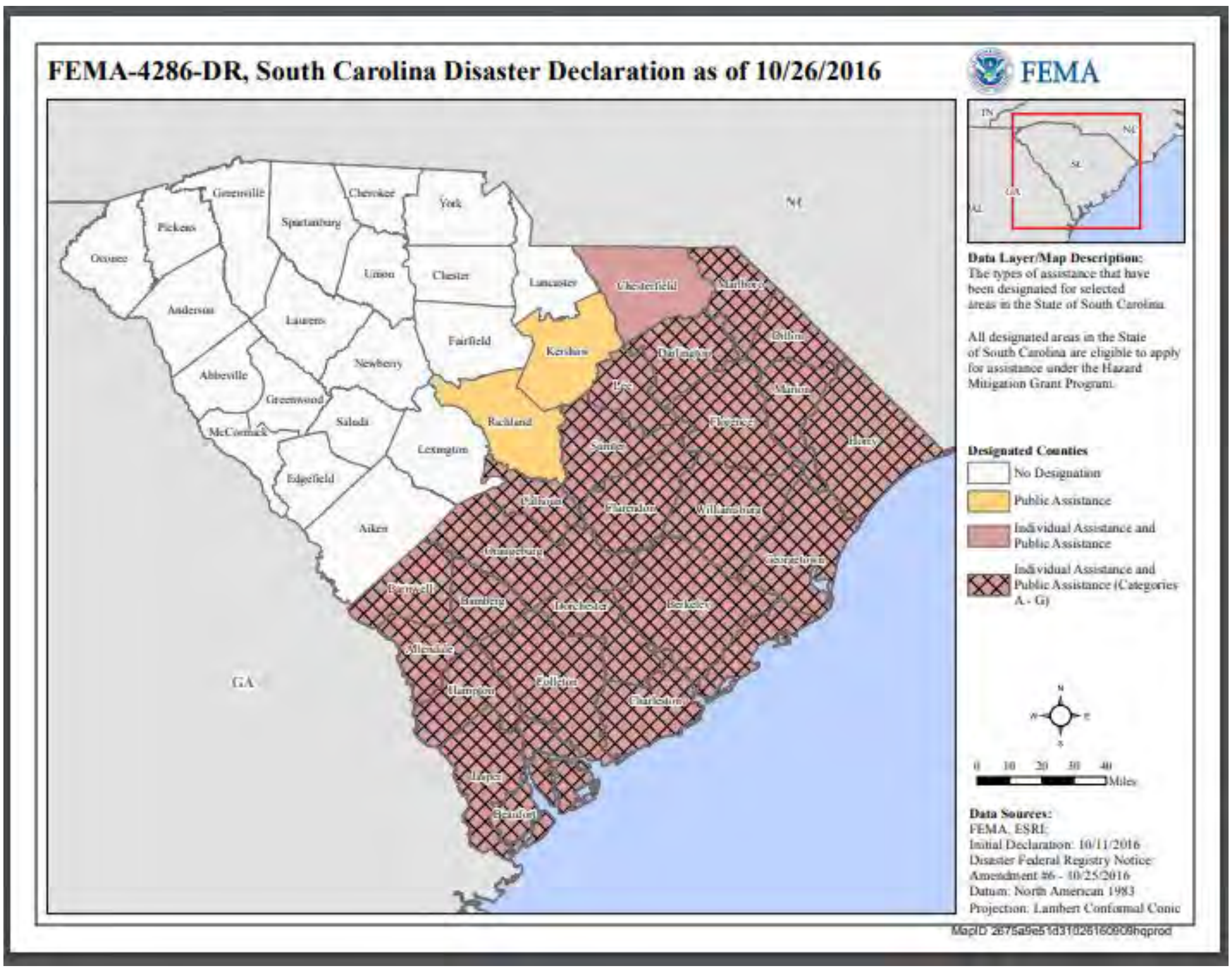

FIGURE 2: SC Disaster Declaration – Hurricane Matthew (Federal Emergency Management Agency, 2016).

3. HURRICANE/TROPICAL STORM IRMA (2017)

While only causing an evacuation of the barrier islands along South Carolina's coast, Hurricane/Tropical Storm Irma affected 47,000 citizens throughout the state. About nine inches of rainfall led to flooding conditions in four rivers. Four deaths are attributed to the storm. Hurricane/Tropical Storm Irma led to an estimated $43 million in repairs to infrastructure, with $120 million paid in commercial insurance, and another $55 million in NFIP payments (South Carolina Emergency Management Division, 2018). No FEMA payments were made to individuals or families, but approximately $29 million was obligated to be made available throughout all counties in the state (Federal Emergency Management Agency, 2017).

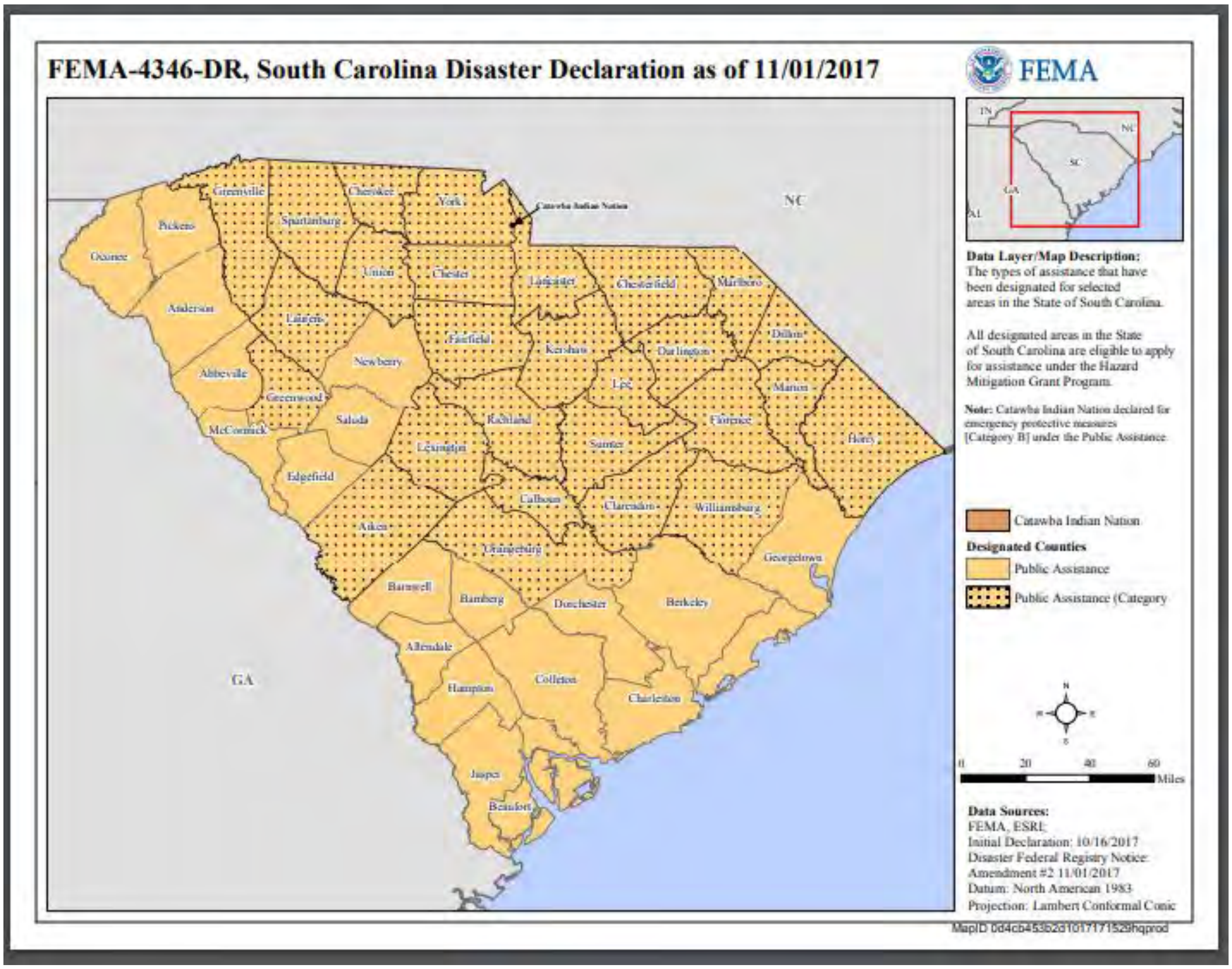

FIGURE 3: SC Disaster Declaration – Hurricane/Tropical Storm Irma (Federal Emergency Management Agency, 2017).

4. HURRICANE FLORENCE (2018)

Two-thirds of the coast was evacuated for Hurricane Florence, a Category 1 hurricane, which caused severe damage to the Eastern portion of South Carolina. Almost 190,000 citizens were left without power, while another 8,000 were displaced to shelters, with a total of nine fatalities. While Hurricane Florence caused only a limited coastal surge, significant inland flooding affected 15,000 residents. Six rivers rose to flood levels after the storm dropped 23 inches of rain in some areas. Ten stream and river gauge locations in South Carolina and 18 in North Carolina experienced the highest water levels ever recorded (US Geological Survey, 2018). The cost to repair infrastructure is estimated at $135 million, with Small Business Administration loans of over $50 million. Commercial insurance payment to assist with recovery were about $200 million, while NFIP paid over $100 million (South Carolina Emergency Management Division, 2018a). FEMA granted over $24 million to more than 5,000 individuals and families through 8 counties in South Carolina, and obligated upwards of $38 million in public assistance grants in 19 counties (Federal Emergency Management Agency, 2018).

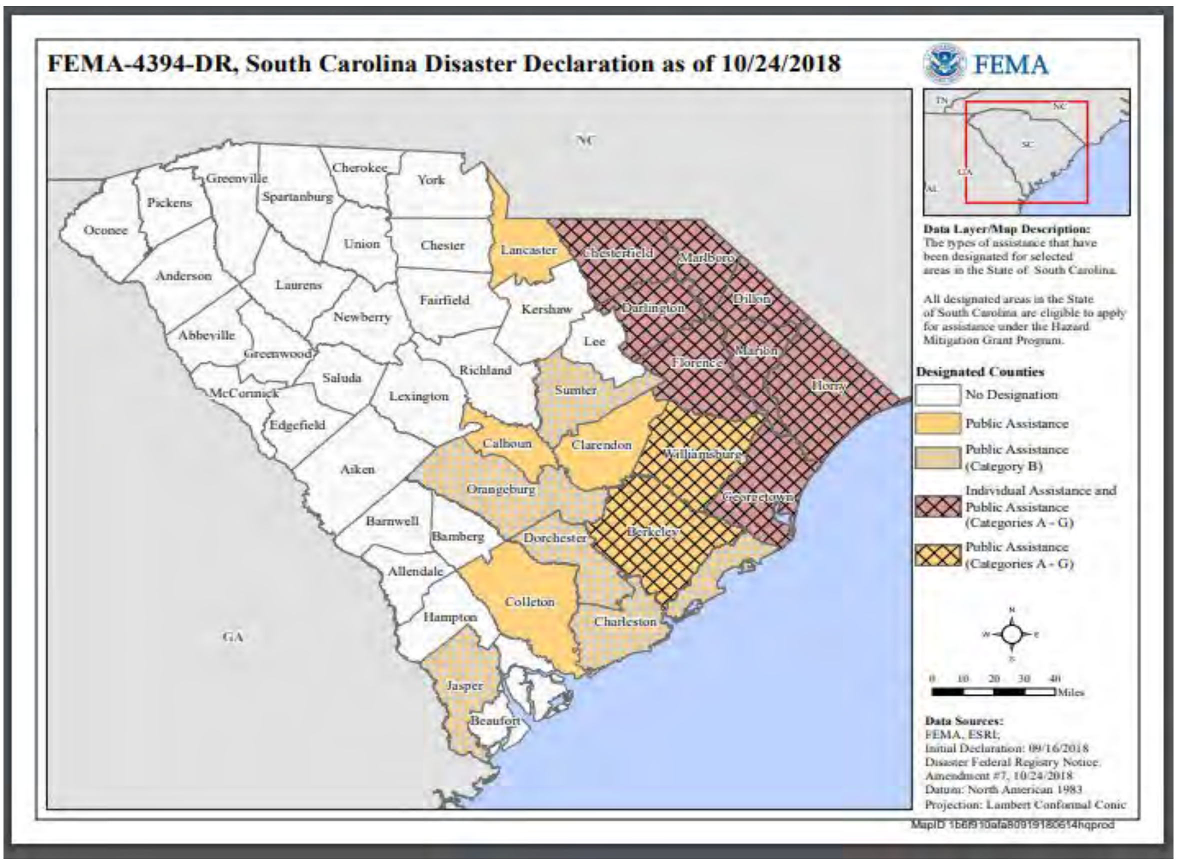

FIGURE 4: SC Disaster Declaration – Hurricane Florence (Federal Emergency Management Agency, 2018).

5. SUMMARY OF EVENTS

These four events have collectively resulted in 37 deaths and 1,634 homes destroyed or experiencing major damage, some repeatedly in more than one storm. An additional 146,017 homes received moderate to minor damage. Flooding resulted in the breach or failure of 81 regulated dams throughout South Carolina. Combined FEMA payments to individuals exceeded $150 million and the total cost of infrastructure repairs is estimated at $680 million, with an estimated total loss of $320 million in tourism dollars.

6. VULNERABILITY TO FLOODING

a. *Geography*

South Carolina ranks 40th in size among the states, with an area of 32,020 square miles, including 1,008 square miles of inland water and 72 square miles of coastal waters over which it has jurisdiction. The coastline of South Carolina is approximately 187 miles in length, and is characterized by 2,876 miles of tidal shoreline, and over 500,000 acres of coastal marshes, which is the most salt marsh acreage of any US Atlantic Coast state (South Carolina Coastal Council, 1979). There are 6 major estuaries along the S.C. coast, and 40 barrier islands running parallel to it (Hayes et al., 2008). The state's mean elevation is 350 feet.

Three geographic land areas define South Carolina; the Atlantic Coastal Plain, the Piedmont, and the Blue Ridge. Two thirds of South Carolina is covered by the Atlantic Coastal Plain, from the Atlantic Ocean extending to the west, approximately to a line followed by US Highway 1 from Cheraw to Aiken. The land rises gradually from the southeast to the northwest. To the northwest of the Atlantic Coastal Plain is the Piedmont. The Piedmont is marked by higher elevations, from 400 to 1,200 feet above sea level and reaching 1,400 above sea level on its western edge. The border between the Piedmont region and the Atlantic Coastal Plain is called the Fall Line to mark the line where the upland rivers "fall" to the lower Atlantic Coastal Plain. The Blue Ridge covers the northwestern corner of South Carolina. This region is part of the larger Blue Ridge Mountain Range that extends from southern Pennsylvania south to Georgia (South Carolina Emergency Management Division, 2018b).

South Carolina's climate is humid and subtropical, with long, hot summers and short, mild winters. The subtropical climate of South Carolina arises from the combination of the state's relatively low latitude, its generally low elevation, the proximity of the warm Gulf Stream in the Atlantic, and the Appalachian Mountains, which in winter, help to block cold air from the interior of the United States.

Rainfall is abundant and well distributed throughout South Carolina. Most of the state receives, on average, 49 inches of precipitation per year (South Carolina – SCIWAY, 2019). The Pee Dee, Santee, Edisto, and Savannah River systems drain the state, flowing from the highlands to the sea.

b. *Flooding*

Flooding is the most frequent and costly natural hazard in the United States, causing almost 4,000 deaths since 1950. About 75% of presidential disaster declarations are related to flooding. Most fatalities are due to people driving into flooded areas.

Floods are generally the result of excessive precipitation over a span of days, intense rain in a short period of time, river overflow, or failure of water structures (dams, levees). Floods may be broadly classified into two categories, as either general floods or flash floods. General floods are usually long-term events that may last for several days. Riverine and coastal flooding fall under general flood types. Flash floods are caused by locally heavy rains in areas where water runs off quickly, moving at very high speeds. Flash floods can cause severe damage as the floodwater is able to pick up debris, uproot trees, destroy buildings, and damage bridges and roads. Urban flooding and dam/levee failure fall under the flash flooding type. Flash floods are killer floods, often catching people unaware in their vehicles when bridges and roads are washed out.

There are five distinctive types of flooding in South Carolina (South Carolina Emergency Management Division, 2018b):

1. **Flash flooding**: rapid onset events which occur from short, heavy rainfall, accumulating in areas faster than the ground is able to absorb it. Urban flooding can occur because of impervious surfaces (streets, roads, parking lots, residential and business areas that inhibit ground water absorption causing runoff).
2. **Riverine flooding**: this occurs when an increase in water volume within a river channel causes an overflow onto the surrounding floodplain.
3. **Coastal flooding**: water pushed inland as a result of higher tides associated with storm surge, wind-driven waves, and heavy rainfall produced by hurricanes, tropical storms, and other coastal storms.
4. **Local drainage problems**: can occur anywhere in the State where the ground is flat, where the drainage pattern has been disrupted, or where channels or stormwater drains have not been maintained or have been overwhelmed by factors such as changes in land use (e.g., impervious surfaces).
5. **Dam/levee failure**: each dam in the State has the potential to fail and suddenly release its impounded water, flooding the land downstream. The threat from dam failure increases from aging dams, and when additional dams are built for retention basins and amenity ponds in new developments.

c. *Location*

Floodplains are "flat areas adjacent to streams and rivers that are prone to flooding." Though flooding could occur anywhere in the state, given the correct atmospheric circumstances or an inappropriate level of upkeep to drainage systems or other methods of flood control, it is the floodplains that are most likely to experience flood events. Floodplains are classified by the frequency that flooding could inundate the area. A 10-year floodplain will have a 10% chance flooding within a year's time, while a 100-year floodplain will have a 1% percent probability within that same year, and a 500-year floodplain will have a 0.2% chance. Though it is not likely to experience two or more floods in these various floodplains, it is not an impossibility (South Carolina Emergency Management Division, 2018b).

d. *Impacts*

Based on data from the National Oceanic and Atmospheric Administration (NOAA), South Carolina is ranked seventh among all states in coastal flooding vulnerability, even though our state ranks 23rd in total population. 400,000 people throughout the state are at risk of inland and coastal flooding throughout the state, especially in communities situated in hazardous low-lying areas (PurocClean, 2017).

A permanently installed tide gauge in Charleston Harbor has measured sea level rise at a rate of 1.07 feet/century since 1901 (NOAA, 2018). Recent studies by NOAA indicate different sea level rise scenarios in the future based on varying rates of land-based ice melt, and project an accelerating rate of sea level rise over time. The low, intermediate, and high projections for Charleston in 2050 are 0.67, 1.36, and 2.54 feet above current water levels, respectively. The southern US Atlantic coast, including South Carolina, is experiencing faster sea level rise than the global average, due to weather cycles and regional oceanic changes (Yale, 2018).

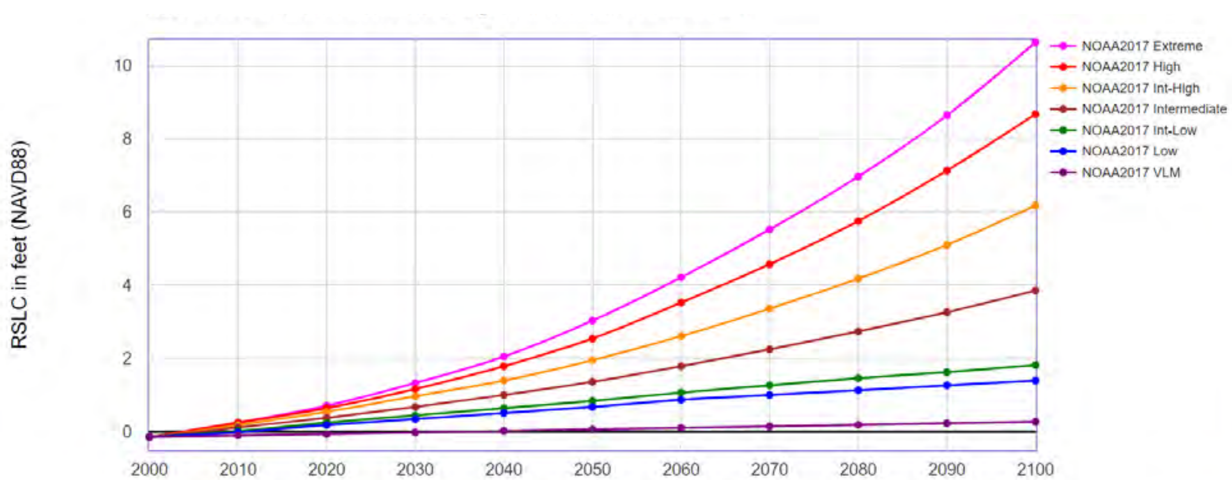

FIGURE 5: NOAA et al. 2017 Relative Sea Level Change Scenarios for Charleston, SC (US Army Corp, 2017).

South Carolinians are already experiencing impacts from sea level rise, resulting in more days of flooding in our coastal communities. These impacts can include both "sunny day" floods during normal tidal cycles, as well as higher storm surges which are on top of higher sea levels. During the 1970's, exceptionally high tides and storm surges caused an average of two flood days per year in Charleston. In the 2010-2015 period, flood days in Charleston have risen to an average of 25 times per year. Projections show that the number of flooding days could rise to as many as 180 times a year by 2045 (NOAA, 2016). This high tide flooding results in flooded roads and properties, regularly disrupting commuting and other daily activities. The Medical University of South Carolina located on the Charleston peninsula, the region's only Level One Trauma Center, has stated that it's operations may soon be compromised by flooding, and in 2017 they had to acquire a "high water" military vehicle to transport staff between buildings during flooding incidents (Wildeman and Johnson, 2019).

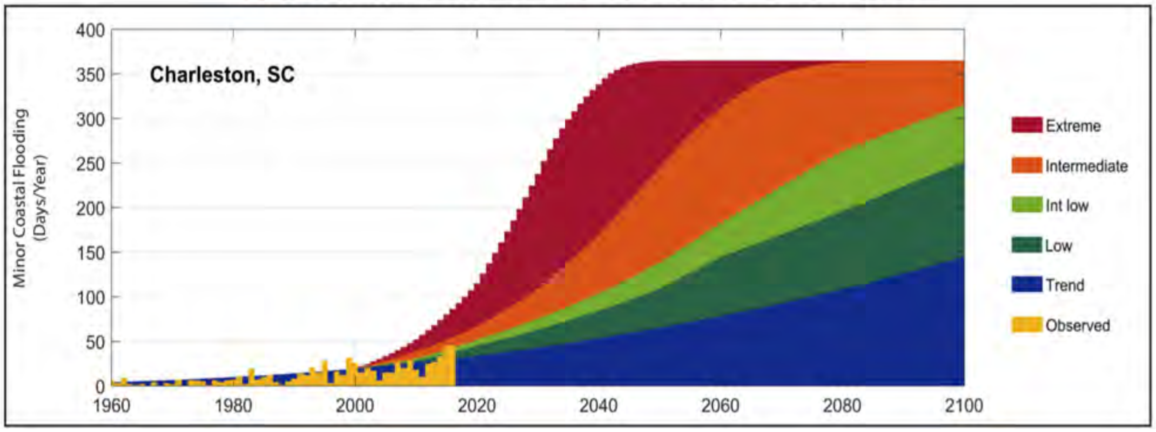

FIGURE 6: Observed and Predicted "Minor Coastal Flooding" in Charleston (City of Charleston, 2015).

In October 2015, instruments at the Charleston International Airport showed a record-breaking rainfall of 20 inches over the course of three days, more than had ever been recorded during the site's 77-year history (City of Charleston, 2015).

South Carolina's 2,876 miles of tidal shoreline experience an annual average of 50-52 inches of rain per year (South Carolina State Climatology Office, n.d.). With threats from natural wave energy, storm surges, longshore currents, and impact of hurricanes and tropical storms, coastal erosion is a mounting problem along our shores. Rates vary drastically across the state (Hayes et al., 1979). While recent years have shown the beaches in Georgetown to have an average erosion rate of 2-3 feet per year, Morris Island off the shore of Folly Beach has experience 30-50 feet of erosion per year (Erosion Data, 2015).

Moving away from oceanfront beaches, approximately 57% of our extensive salt marsh shorelines are eroding, at an average rate of 0.55 meter/year (1.8 ft/year), due to a variety of causes (Jackson, 2017). Our state's extensive salt marshes provide significant protection for coastal communities. Salt marshes act as "horizontal seawalls" reducing wave height and absorbing storm tides (Narayn et al., 2017). As salt marshes erode, coastal communities are more vulnerable to flooding and storm damage.

A 26% chance exists that an unelevated house in a floodplain will be damaged in the course of a 30-year mortgage. Though all waterways do not have explicit floodplains, any waterway has the potential to flood (Erosion Data, 2015).

A significant percentage of all South Carolina lands fall within floodplains designated as "Special Flood Hazard Areas" by the Federal Emergency Management Agency (FEMA) – over 40% along the coast and 20% statewide (Federal Emergency Management Division, 2019):

TABLE 1: DHEC/OCRM: Horry, Georgetown, Charleston, Berkeley, Dorchester, Colleton, Beaufort, Jasper.

Region	Acres in 100-Year Floodplain	% of Region in 100-Year Floodplain	Acres in 500-Year Floodplain	% of Region in 500-Year Floodplain	Total Acres in Special Flood Hazard Areas	Total % of Region in Special Flood Hazard Areas
Coastal Counties*	1,850,128	39%	141,641	3%	2,004,769	42%
Statewide	3,827,509	19%	181,238	0.9%	4,008,747	20%

7. EPIDEMIOLOGICAL AFFECTS OF FLOODING

The health risks resulting from both coastal and freshwater flooding pose a significant threat to South Carolina citizens, that many might be wholly unaware. Much of the problem lies with the threat posed by *Vibrio* bacteria and in toxins from cyanobacteria in freshwater systems. The problems caused by climate related natural disasters, such as nuisance flooding along the coastal and inland flooding, only further exacerbate the adverse effects to human health posed by such threats (University of South Carolina, n.d.).

Vibrio bacteria, found along the coast of South Carolina, can cause serious infections, leading to hemorrhage and edematous skin on extremities. The CDC has estimated approximately 8,000 *Vibrio* related infections resulting in 57 deaths on an annual basis in the United States. The foremost cause of death associated with eating raw shellfish is a strain of *Vibrio* bacteria, totaling 50% of all United States death related to eating seafood. Other strains of *Vibrio* bacteria can infect open wounds, often during recreational activities along the coast. *Vibrio* infections have only shown a persistent increase in the last decade (Deeb, 2011). Likewise, cyanobacteria form harmful algal blooms (HABs) pose threats to ecological and human health, including a risk to crops watered with surface waters and inland aquaculture. HABs may even impact the commercial and recreational fishing throughout inland waterways. (Brooks et al., 2018).

The Southeastern US is the most rapidly urbanizing region in the United States with population growth exceeding 50% for most states in the region over the last 30 years (Cleven et al. 2005; Scott et al., 2006, 2012). Indeed, the fastest growing cities on the east coast are allocated in South Carolina- Myrtle Beach, Charleston and Hilton Head. Urbanization results in changes in landscape ecology that increases imperviousness and resulting alterations in the hydrological cycle, increasing runoff of nonpoint source runoff pollution including increased levels of nutrients, microbes and chemical contaminants (Scott et al., 2006). This may result in increased levels of nutrients within aquatic ecosystems which then may result in overgrowth and changes in the speciation of the algae, moving from beneficial algal species such as diatoms and dinoflagellates to more cyanobacteria, many of which cause Harmful Algal Blooms (HABs) which produce toxins which then may impact swimmers and result in foul/tainted drinking water.

Increased extreme weather associated with climate change such as increased temperatures and drought may further exacerbate this condition. Sandifer and Walker (2019) reported that the U.S. has experienced 230 weather- or climate-related ("natural") disasters that each exceeded $1

Billion in damages since 1980, with a total economic cost of $1.5 Trillion (10). These include hurricanes and other severe storms, tornados, droughts, freezes, wildfires, etc. (Figure 7).

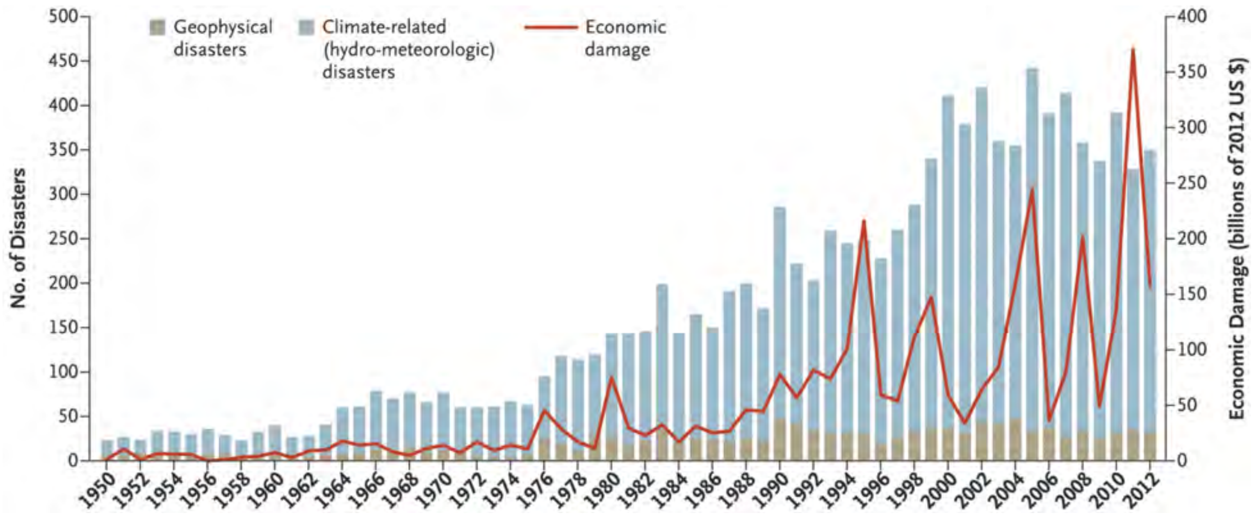

FIGURE 7: Numbers and types of natural disasters, 1950–2012, not including biological disasters [From Learning and Guha-Sapir cited in Sandifer and Walker, 2018). Massachusetts Medical Society. Reprinted with permission from Massachusetts Medical Society].

HAB events may occur as a result of natural disasters. Recently the state of Florida had an extended marine and freshwater HAB (FW HAB) event which lasted for > 17 months and closed beaches from Sarasota, Florida on the west coast all the way around south Florida and up the east coast to Cape Kennedy, greatly impacting coastal tourism and marine fisheries. Backer et al. (2015) reported on HAB related illnesses in the US from 2007-2011 as 4,534 events were reported in Harmful Algal Bloom-related Illness Surveillance System (HABISS). Most reported HAB events were detected during routine monitoring (93.6%), as bloom reports (2.6%), health events (2.5%) and fish kills (1.3%) were less common in occurrence. Also, most HAB events (n = 3499 or 77% of the reports) occurred in freshwater (e.g. lakes, rivers, streams, and ponds) habitats with the remaining reports occurring in brackish (n = 973 or 21%); marine (n = 82 or 2%) or unknown water body types (n = 172 or 4%). Cyanobacteria were the most common type of organism reported (73%) in samples analyzed for organism taxonomy. States most commonly reported Anabaena spp. (20% of samples), Aphanizomenon spp. (7% of samples), and Microcystis spp. (7% of samples). More recent data from 2015, indicated 252 FW HAB events were observed in the US with approximately 70% occurring in July and August (Ravencroft, 2016).

Key forcing factors for the development of FW HABs may include (1) climate change and often associated droughts; (2) Anthropogenic activities including nutrient enrichment, hydrological modifications resulting in increased discharges of contaminants from effluent and stormwater discharges associated with urban and agricultural runoff; (3) natural resource extraction; and (4) salinization and de-salinization changes in water quality (Anderson et al., 2002; Moor et al., 2008; O'Neal et al. 2012; Paerl and Paul, 2012). Many HAB forming species are invasive and/or opportunistic and take advantage of altered habitat conditions in developed regions (Brooks et

al.2011). HAB pollution impacts are not as predictable as are those from conventional chemical contaminants; interactions among multiple factors, both natural and anthropogenic, determine the severity to which a HAB will occur in a specific waterbody and can affect the magnitude of toxin production [regions (Brooks et al.2011) Brooks et al (2016) provided evidence that freshwater HABs may be the greatest public health threat in freshwater ecosystems in the US.
The EPA found in their Lake Study that most HAB events occur in freshwater lakes throughout the US and that 33% of 123,000 lakes had cyanobacterial HAB species and blooms. Many of these freshwater species produce toxins that affect the liver, kidney and central nervous system when ingested from either drinking water or contact recreation.

In 2018 the South Carolina Department of Health and Environmental Control tested for microcystin in lakes throughout the state and found detectable levels in several lakes including Lake Wateree but all below levels of concern for public health. Researchers at the University of South Carolina have also found levels of Lyngbya in Lake Wateree which produces a neurotoxin. This toxin is held internally within the algae and is not released unless the plant is stressed, or the cell wall is lysed. Bloom conditions within Lake Wateree have shown this HAB species is increasing in growth throughout much of the lake and has changed the pH of the lake as a result.

Lake Wateree is at the end of a chain of several lakes managed by Duke Energy. Often, during impending hurricanes or flood events, large volumes of water are released prior to the event to prevent flooding, which may lower the pH in the lake. There is a concern that these more acidic conditions may stress or damage the Lyngbya and allow the toxins to be released. Further ongoing research is being conducted by researchers at the University of South Carolina to investigate this situation. The neurotoxins produced by Lyngya are highly toxic and a potential health concern if released from the algae.

The University of South Carolina has begun a research partnership with Baylor, The College of Charleston, The Citadel, and the University of Maryland’s Environmental Science Center, to form the NIEHS Center for Oceans and Human Health and Climate Change Interactions (OHHC2I). The center is examining how climate and natural disasters, like flooding, affect the Vibrio bacteria and cyanobacteria and their adverse impact on human health. Collectively the OHHC2I has begun detailed projects to further investigate the impact or Vibrio bacteria and HBAs, and to study other long-term impacts and educate the public (University of South Carolina, n.d.).

C. POPULATION GROWTH; BUILT AND NATURAL INFRASTRUCTURE

1. POPULATION GROWTH AND URBAN EXPANSION

South Carolina has had steady population growth since the 1700’s. Currently, our state’s population is growing 1.06% per year, which ranks 18th in the US (South Carolina Population, 2019). Demographic projections show continued growth in our state. This growth has unquestionably increased prosperity and opportunities. At the same time, it has significant consequences for flood management and resilience.

TABLE 2: South Carolina's Population Growth Projections (United States Census, 2018; University of Virginia, 2018).

YEAR	POPULATION	INCREASE OVER 2018	PERCENT INCREASE OVER 2018
2018	5,084,127	---	---
2025	5,457,700	373,573	7.34%
2030	5,730,490	646,363	12.7%
2040	6,352,502	1,268,375	24.9%

Because most of our state's growth will be in urban and suburban areas, we will experience a large expansion of these land uses, as illustrated in the table and figures below. This has significant consequences for flood management and community resilience. As in most of the US, the size of urban areas in our state grows faster than the population growth rate. Studies project that from 2018 to 2100 we will add 5.8 Million acres of urban/suburban land uses, covering 39% of the state (Terando et al, 2014).

GROWTH OF URBAN & SUBURBAN LAND USES IN SOUTH CAROLINA:

TABLE 3: Growth of Urban & Suburban Land Uses in South Carolina (SOURCE: Terando et al., 2014).

YEAR	AREA OF URBAN & SUBURBAN LAND USES (ACRES)	PERCENT OF STATE IN URBAN & SUBURBAN LAND USES	INCREASE OVER 2010 (ACRES)	PERCENT INCREASE OF URBAN & SUBURBAN LANDS OVER 2010
2010	1,900,000	9%	---	---
2050	4,400,000	22%	2,500,000	132%
2100	7,700,000	39%	5,800,000	305%

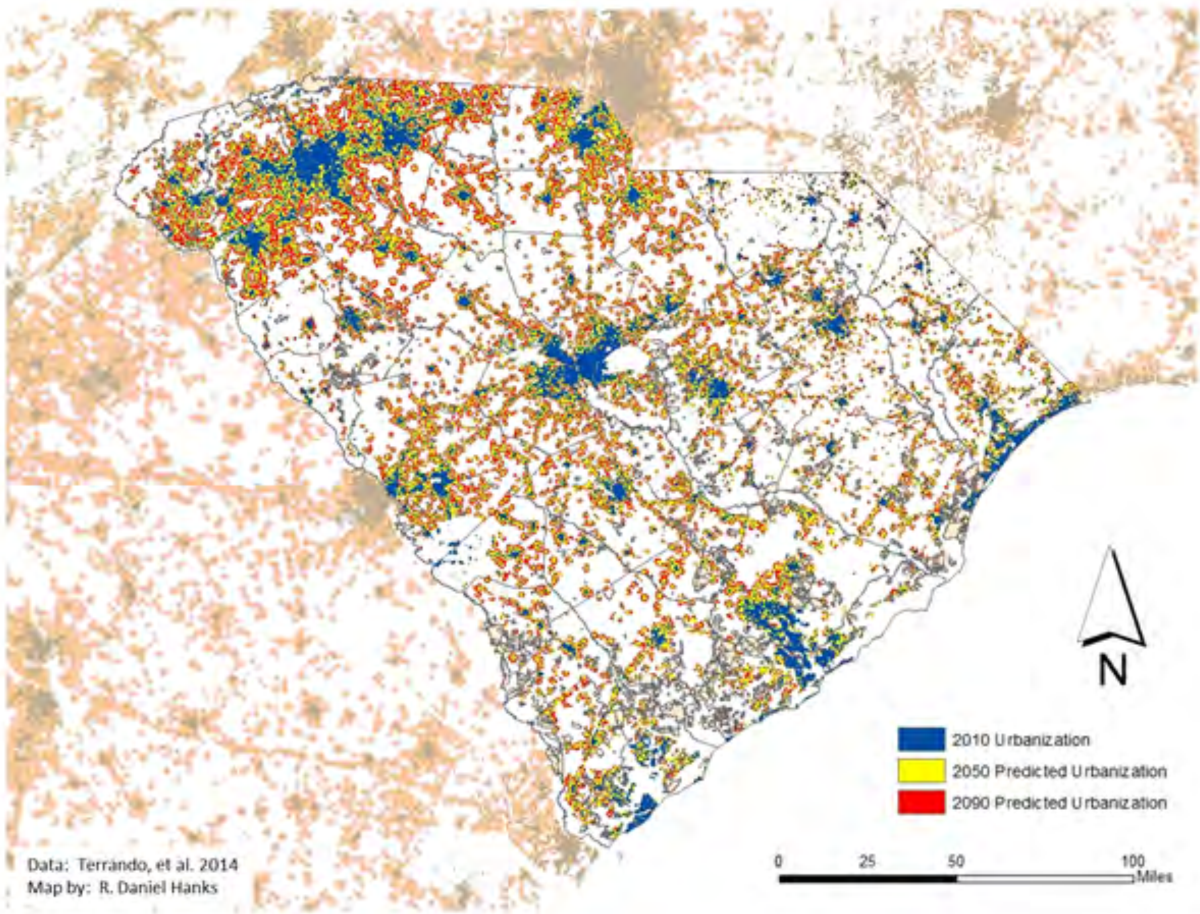

FIGURE 8: Urbanization Across SC Showing Urbanized Lands in 2010 and Projected Urbanization in 2050 and 2090 (Terando et al., 2014).

The South Carolina coast is experiencing especially rapid population growth. In the 2012-2017 period, three coastal regions were in the Top 25 US metropolitan areas with the fastest population growth:

#23: Hilton Head Island – Bluffton – Beaufort: 14.7% growth

#12: Charleston – North Charleston: 16.2% growth

#2: Myrtle Beach – Conway – North Myrtle Beach: 22.6% growth

(United States Census Bureau, 2018)

The urban/suburban land uses in these three coastal regions will expand especially fast, as illustrated for the Tri-County Charleston region in the following figure. These areas are going to present special challenges for flood management and resilience, because our coastal region has the greatest amount of land in floodplains and is most likely to be impacted by tropical storms and hurricanes.

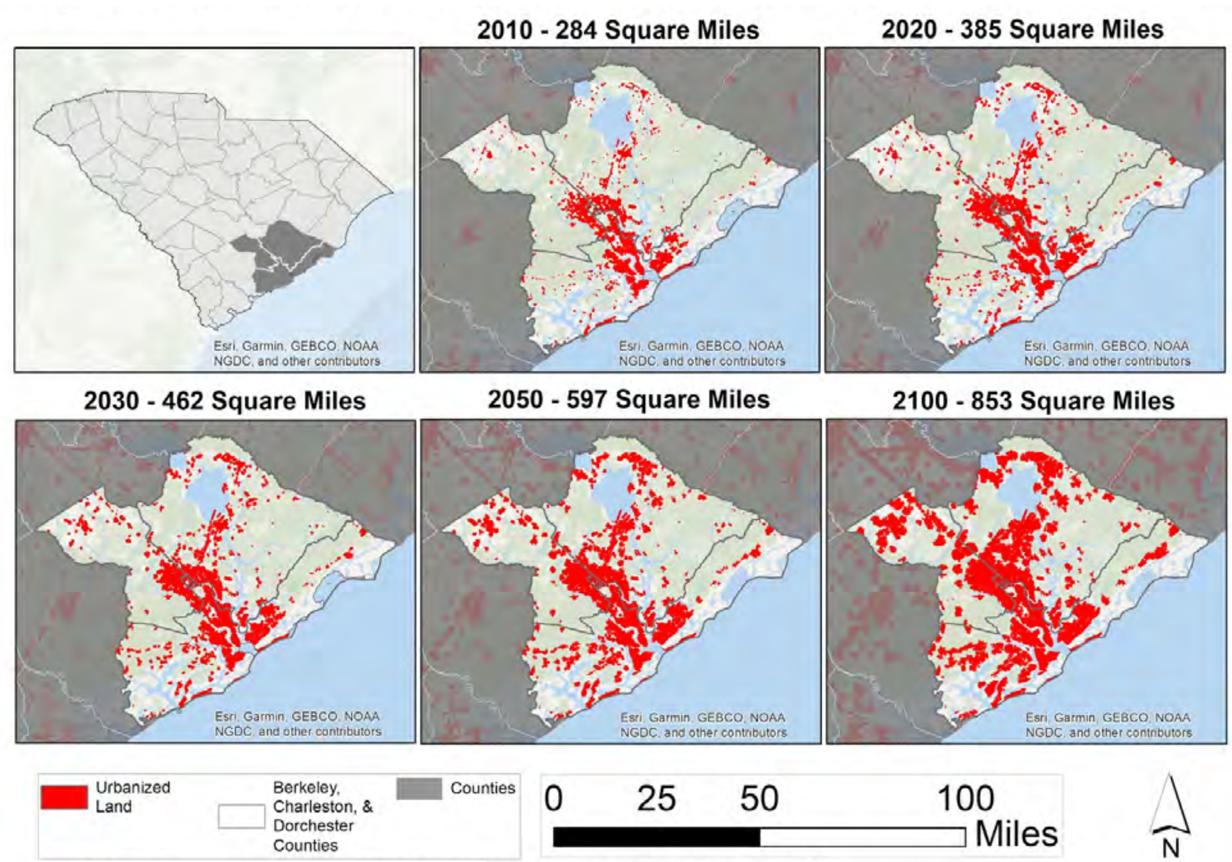

FIGURE 9: Projected Urbanization for Berkley, Charleston, and Dorchester Counties, SC (Terando et al., 2014).

Expanding urban areas create a number of challenges to flood management and community resilience. Larger urban areas expand the acreage of impervious surfaces (road, roofs, etc.). Expanded impervious surfaces significantly increase both the amount and the speed of stormwater runoff during rain events. This increases flooding risk, especially where older stormwater drainage systems or dams may have been designed and built for a less urbanized environment. In addition, expanding urban areas increase the pressure to develop in floodplains and wetlands, which eliminates the natural sponges that absorb and slow down floodwaters. Floodplain development puts people and investments directly in the path of floodwaters.

At the same time, there is an opportunity presented by the investments that state and local governments will be making in infrastructure to support our state's growing population, as well as the investments that will be made by the private sector in development. Flood resilience and flood-risk reduction should be considered as these new roads, public facilities, homes and businesses are located, designed and built. Older infrastructure and buildings will also have to be rebuilt or upgraded in many places. This also presents an opportunity to advance resilience and reduce flood risk if they are rebuilt with resilience and flood risk reduction in mind.

Incorporating "nature-based solutions" into the location, design and construction of new or rebuilt development, as discussed in the following section, may also increase resilience and reduce flood risk.

2. NATURAL INFRASTRUCTURE OPPORTUNITIES

Natural resources such as salt marshes, beach dunes, oyster reefs, forests, wetlands, river floodplains, and protected open space have widely documented values to increase the resilience of adjacent and downstream human communities by reducing flood risk. For example, just 15 feet of salt marsh can absorb 50% of wave energy from storm surge (Shepard et al., 2011). One acre of intact floodplains can prevent up to $1,800 in flood damage from rising rivers (Opperman, 2014). Over a year, a single mature tree is capable of absorbing thousands of gallons of rainwater. Nature and nature-based solutions are often underappreciated and underutilized tools for flood mitigation. Nature-based solutions use nature, often in concert with engineered systems, to mimic or restore natural processes such as water flow and water storage. By using nature, damages and impacts are minimized and communities can recover more quickly from disasters and impacts.

South Carolina is blessed with an abundance of natural resources, which should be utilized to our benefit for flood mitigation. These natural resources have been well documented for their economic benefit to the state in terms of tourism and recreation. Coastal tourism is responsible for about 27% ($9 billion) of the $33.4 billion of economic activity produced by all of South Carolina's natural resource-based sectors (Willis and Straka, 2017). South Carolina would benefit from recognizing their flood mitigation value as well and working towards preserving and restoring natural areas to protect human communities and create healthier environments.

a. *Salt Marsh*

Coastal South Carolina contains 20% of all the salt marsh on the U.S. East Coast, around 500,000 acres (South Carolina Depart of Natural Resources, 2014). Salt marshes act as "horizontal seawalls" by reducing wave energy and wave height and have added benefits of acting like sponges to absorb floodwaters (Shepard et al., 2011). These expansive salt marshes are a major natural asset that can help buffer coastal communities from flood and storm damage. However, recent studies have shown that our state's salt marshes are eroding and shrinking in many areas due to a variety of causes, including coastal development, sea level rise, and erosion induced by increased storm activity and human activity such as boat traffic. More than half of the state's shoreline (>4,600 miles) is eroding, at an average rate of 1.8 ft every year (Jackson, 2017). This loss increases the risk of storm damage and the costs of flooding to coastal communities as this highly valuable natural resource dwindles. Protection and restoration of our marshes will provide upland land protection for future marsh migration pathways as sea level rises.

b. *Forests*

South Carolina is approximately 67% forested as of 2017 (Lambert et al., 2019). The state's forest cover was stable from 1968-2006 (South Carolina's Forest, 2019), though recent inventories document losses of 16,320 acres in 2016 (Brandeis et al., 2017) and 56,800 acres in

2017 (Lambert et al., 2017). Forest land is a critical form of natural infrastructure, as it regulates infiltration and runoff. For example, 1 inch of rainfall on an acre of forest will produce 750 gallons of runoff, while a 1-acre parking lot will produce 27,000 gallons (Penn Station, 2015). Forests also maximize water infiltration into soil compared to other land covers. For example, a Florida study found soil infiltration rates reduced from 15-26 inches of rainfall/hour to 0-7 inches of rainfall/hour when forest soil was compacted, but not paved, for urban uses (Gregory et al., 2006). Forests also prevent rainfall from reaching streams and rivers by intercepting rainfall and evaporating it back into the atmosphere. Loblolly pine plantations, for example, intercept an average of 15% of annual rainfall when various states of growth and thinning are accounted for over time (Gavazzi et al., 2016). Retention of South Carolina's forest lands to the extent possible and retain or re-establish tree canopies in developed areas will aid in flood resiliency.

c. *Wetlands and Floodplains*

Wetlands and floodplains are natural sponges that absorb floodwaters and reduce floodwater velocity, leading to reduced impacts. However, expanding populations and urban areas are increasing pressure to build in floodplains and wetlands, only putting more people and structures at risk. Current FEMA data indicates that over 3.8 million acres of the state are in a 100-year Special Hazard Flood Area (SHFA). An additional 181,238 acres lie in the 500-year SHFA. In the eight coastal plain counties designated by the Office of Ocean and Coastal Resource Management, 1.85 million acres are in the 100-year SHFA and 181,238 acres are in the 500-year SHFA. This indicates that 42% of these coastal counties are at a high risk for flooding.

As of 1989, South Carolina had retained 73% of its historic wetland acreage which is significantly above the average of 47% in the lower 48 states. Nevertheless, South Carolina was still losing 2,920 acres of wetland per year (Dahl, 1999). Comparison of 2001 vs. 2016 National Land Cover Data (NLCD) for South Carolina shows that South Carolina continues to lose wetlands at a slightly reduced rate of 2,574 acres per year, primarily to urban development (Multi-Resolution Land, 2016).

One cost-effective flood management and resilience strategy is to retain existing wetlands and floodplains and incentivize development in less risky areas to maintain the natural function of floodplains and wetlands. Recent events also clarify the need to more completely map 100- and 500-year floodplains. Current FEMA maps in many rural areas only define Special Hazard Flood Areas as 100-year or 500-year, but do not provide base flood elevation zones upon which to base community planning or response.

d. *Beaches and Dunes*

South Carolina beaches and barrier islands are dynamic environments that despite accumulation of sand, naturally or otherwise, can face significant erosion. South Carolina beaches function as critical habitat for wildlife and are vital to the state's coastal tourism industry. For example, visitors to Folly Beach, SC, generate $17 million in state and local taxes and $5 million in federal taxes (Rhodes and Pan, 2015). Healthy beach and dune systems also provide a natural buffer and storm surge protection for beachfront communities. The beachfront at Folly Beach protects $500 million in property, beach access, and infrastructure, which generates $11.6 million in property taxes for state and local governments (Rhodes and Pan, 2015).

e. *Nature-Based Solutions*

Nature-based solutions are tools we can utilize to enhance natural functions of water flow and storage in our environment. These tools range from the strategic preservation and restoration of natural areas such as those listed above, but also include more engineered solutions such as constructed wetlands, living shorelines, and using dredged sediment in beneficial ways such as thin-layer placement in marshes.

TABLE 4: Natural Based Solutions.

Floodplain preservation – Maintain functions and values of floodplains, such as allowing for the storage and conveyance of water through existing and natural flood conveyance systems.	**Stream restoration –** Restore the natural state and functioning of the river system in support of biodiversity, recreation, flood management and landscape development.	**Living shorelines –** An erosion control strategy that incorporates native wetland vegetation alone, or in combination with structural elements like natural fiber logs, bagged oyster shell, or rock.
Pipe and culvert retrofits – Retrofitting roads and the water conveyance structures, such as culverts, ditches, and drains, that are undersized to adequately convey water in developed areas.	**Wetland restoration** – Restore a former or degraded wetland's physical, chemical, or biological characteristics to return its natural structure and function.	**Constructed wetlands** – An artificial wetland to treat wastewater or stormwater runoff or may also be designed as a mitigation step for natural areas lost to land development.
Beneficial use of sediment – Using sediment (i.e. sand or mud) dredged from waterways in an environmentally beneficial way, such as increasing marsh elevation, rather than confining in a disposal site.	**Property buyout and restoration** – The acquisition of flood-prone properties. Once the property has been purchased, buildings are removed, and the land can be restored to a natural state with the potential for habitat restoration.	**Low impact development –** An integrated, comprehensive approach to land development or redevelopment that works with nature to manage stormwater as close to its source as possible.

Nature-based solutions are often highly cost-effective. South Carolina should incorporate these options into planning and projects to reduce flood risk and increase resilience.

D. <u>DEVELOPING A HOLISTIC & INTEGRATED FRAMEWORK TO REDUCE FLOOD RISK</u>

Flooding is one of the most dangerous and threatening hazards to South Carolina's citizens, communities, and economy. Distributions of flood losses and fatalities across South Carolina are driven by structural failure and physical vulnerabilities. Flooding is not solely a result of rainfall levels and storms. Regions can be impacted due to variations in topography, regional land-use (including the extent of impervious surfaces), watershed soil composition, blockage to water flow from road crossings or other developments, operation and condition of upstream dams, the condition and operation of ditches and stormwater infrastructure, and humidity conditions. A necessity exists for flood control design and structural modification to mitigate damage along South Carolina's floodplains in an effort to prevent extensive damage and devastation throughout the state to "erodible, low-lying land" and low-income communities (Ashley et al., 2008).

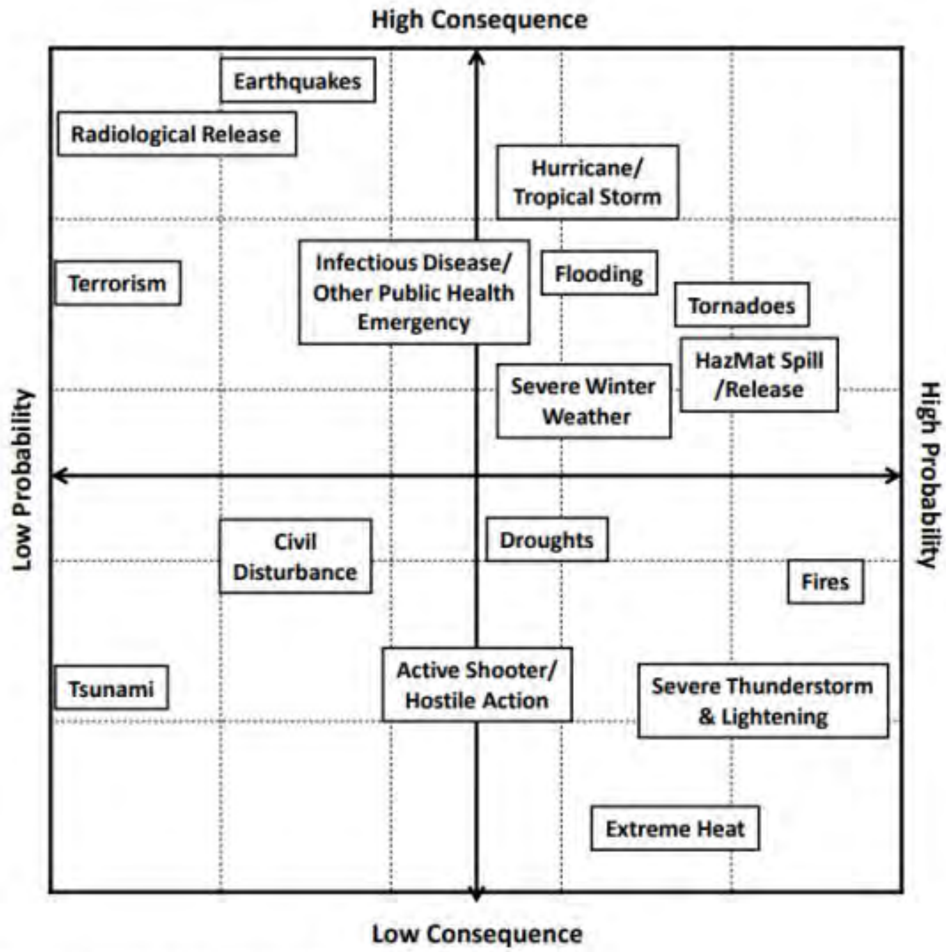

FIGURE 10: Probability vs. Consequence (South Carolina Emergency Management Division, 2018).

For South Carolina, the risks are heightened by the fact that 42% of the coastal counties and 20% of the state are in "Special Flood Hazard Areas" designated by FEMA. Looking forward, the projections for expansion of urban and suburban land uses across the state could put more people and economic assets at risk in flood-prone areas.

Flooding in South Carolina often has a great impact on the state's most vulnerable citizens. The Center for Disease Control's Social Vulnerability Index (SVI) denotes the resilience of communities when challenged with external pressures on human health, including the impact of natural disasters like flooding. Areas that rank higher under the SVI require more support in preparing themselves for natural disaster and greater efforts in recovering in their aftermath (CDC, 2018). A National Environmental Public Health Tracking Network analysis measuring the SVI by overall percentile of vulnerability in 2016, shows that 16 counties ranking the ninetieth percentile, as seen below (Center for Disease Control, 2016).

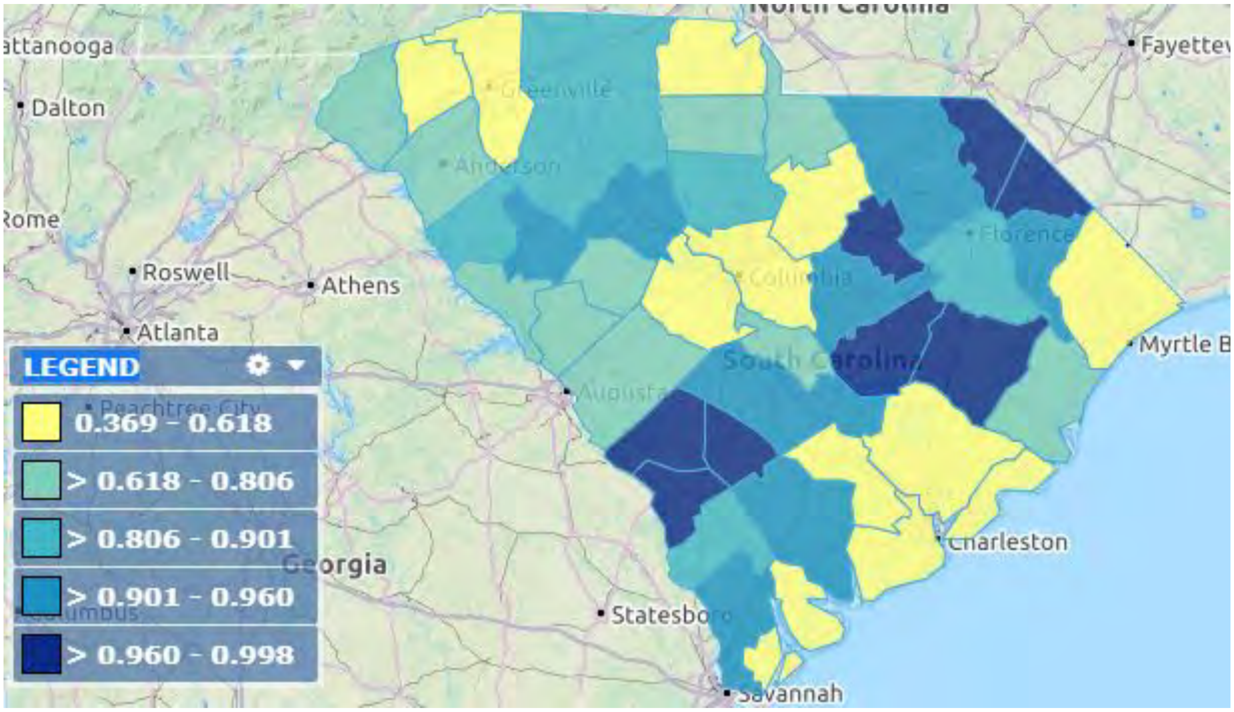

FIGURE 11: Social Vulnerability by Overall Percentage Rank, 2016 (Center for Disease Control, 2016).

Reducing flood-risk and increasing resilience requires a very wide range of programs and actions, that must be deployed over a great range of time scales and geographic scales (urgent to long-term; local to watershed to statewide). The number of factors that influence flooding, and their interactions, requires a highly integrated approach to reduce flood risk and build resilience, based on high-quality science and data that is widely shared and available. Flood risk management is best addressed as a complex network of issues spanning from flood hazard prediction, societal consequences, measures for regional strategies, and proven techniques for risk reduction.

Due to this multi-faceted problem, management of flood risks in South Carolina needs systematization and integration. In order for South Carolina's state and local governments to provide the best possible flood protection, we will need to develop a holistic plan.
An accurate recognition of flood risk and its drivers are crucial for effective flood preparedness and management. A new holistic integrated framework for flood strategies and resilience across South Carolina, along floodplains and spanning our coast is crucial for the capacity to resist, absorb, and recover from flood disaster and high economic damage.

1. SIMILAR APPROACHES

South Carolina is not alone in facing these challenges, and we can learn from the experience and initiatives of other states. In response to severe storms and coastal flooding, a number of states and regions have initiated new approaches to reduce flood risk and increase resilience. There are important lessons and principles that can be learned from these initiatives. In these examples, state and local governments have found that the most successful approaches are integrated and holistic, and bridge traditional boundaries.

Louisiana Watershed Initiative (Council on Watershed, 2018)

After years of historic rain events and damage from hurricanes, this initiative was developed by Louisiana to take steps to better understand the risks that flooding poses to the state, as well as create obtainable solutions at both state and community levels. Five state agencies comprise the "Council on Watershed Management Agencies." A key principle of this initiative is that it is organized around river basin (watershed) boundaries, recognizing that water flows and flooding do not follow political boundaries. The governor of Louisiana has allocated $1.2 Billion in post-disaster funding from US Dept. of Housing and Urban Development to the Louisiana Watershed Initiative, to be spent under a comprehensive plan. The funding will be distributed and spent based on plans and actions designed around watershed boundaries, encouraging cross-boundary collaboration. The initiative includes the following programs:

- *Watershed Monitoring, Mapping, and Modeling*
  Developing and exploring topographic, bathymetric, and surveys of river crossings data, along with discerning critical areas in waterways that remain unmonitored by the U.S Geological Survey, to gain more data on current flood problems so that stakeholders and decision makers can better develop effective solutions. Using this data, as well as any other information that could address flooding risks to the state, hydraulic and hydrologic watershed models can be created to pinpoint solutions for reducing risk. The goal is to develop high-quality hydrologic data and models that are accurate, shared across agencies, transparent and accessible.

- *Cost Share Assistance and Coordination*
  Developing cost-share programs to mitigate hazard damages, potentially through grants to fund projects dedicated to reduction and resilience projects. Recognizing that many under-resourced local governments do not have the capacity to develop high-quality, actionable hazard mitigation and flood-risk plans, the Watershed Initiative will make capacity-building grants.

- *Building Collaboration and Trust*
  Taking steps to build trust, cooperation, and collective action; and bridging boundaries that have traditionally separated agencies and units of government.

- *Watershed- Based Programs and Projects*
  Using watersheds as the geographic units for action, supporting resiliency and recovery by developing programs to help alleviate that risk and cost to the state and help citizens return from the damage sustained by them. This spans economic development, to improving watersheds and restoring waterways, to assisting in building capacity across state agencies and groups to support in the assistance of mitigation wherever possible.

- *Recognition of the Role of Natural Resources*

Including floodplain conservation and restoration in resilience plans, recognizing that the natural beneficial functions of floodplains go hand in hand with flood risk management.

- *Large Scale Projects and Programs*
  Creating clear and obtainable objectives for recognizing, selecting, and funding major projects that will further the goals of the state to see major flooding reduction impacts at a regional level.

<u>High Water Mark Initiative (High Water, 2017)</u>

This program was developed in Monmouth County, New Jersey to help mitigate further damage to communities in the wake of Superstorm Sandy.

- *Increase Public Awareness Through Signage*
  By designing and placing signage that will appropriately inform communities of the risk and dangers present to areas during events that have exacerbated flooding conditions, there can begin a visible outreach into areas around the state.

- *Community Rating System Program*
  Developing a rating system that will work to rank communities based on their susceptibility to flooding. Through identification and assessment of risks, communities will hopefully begin to develop better means of reduction and resilience through creditable means within the rating systems itself, like low density zoning, better stormwater management techniques, or open space preservation.

<u>State of Texas Plans for Resilience and Disaster Recovery</u>

- *Local Infrastructure Program (Hurricane Harvey recovery) (Texas General, 2018)*
  Creating an effective plan for the use of funds, such as HUD Community Development Block Grant Disaster Recovery (CDBG-DR) funding, to plan for flood control and drainage repair and improvements, restore damages infrastructure, demolition and rehabilitation of public or private commercial and industrial buildings, stricter code enforcement, and increasing public services (job training, healthcare, child care, etc.), elevating and floodproofing nonresidential structures where possible, or any other economic development.

- *Texas Coastal Resiliency Master Plan (Texas Coastal, 2019)*
  The Texas General Land Office (GLO) was authorized to "restore, enhance and protect the state's coastal natural resources." The GLO developed the Texas Coastal Resiliency Master Plan in 2017 and updated it in 2019. The "scope of the Plan is focused on nature-based projects to enhance coastal resiliency." The Plan recognizes the critical role and integration of both natural and build infrastructure to sustain the multiple values that the coast provides. In developing the Plan, the GLO conducted a comprehensive analysis of existing data and information to

identify gaps; and use a comprehensive scientific foundation to set priorities and guide funding decisions.
Texas has used more than $1 Million of federal HUD-CDBG-DR funding in developing its Coastal Resiliency Master Plan.

Southeast Florida Regional Compact to Advance Resilience Solutions Through Regional Action (Southeast Florida, 2019)

- Four counties in southeastern Florida formed the regional compact in 2010. The combined population of the region is 6.3 Million people.

- The four counties have worked together to develop a regional action plan. The plan is a "framework for concerted regional action rather than a set of directives," and it "identifies vulnerabilities, prioritized actions, and integrated policy initiatives."

City of Charleston Sea Level Rise Strategy (City of Charleston, 2015)

- *Reinvest*
  By strategically investing in infrastructure and necessary physical resources, including levees, better drainage systems, and participating In the National Flood Insurance Program's Community Rating System, there could be major improvements to public health, safety, and quality of life.

- *Respond*
  Addressing the issues of flooding and the danger posed to citizens through various initiatives. These projects could be both internal, such as strengthening communication between government entities, installing flood gauges in high risk flooding areas, or purchasing more effective rescue equipment, or external, by working with groups like the U.S. Army Corp of Engineers to create flood protection studies or with individual areas to address specific flooding needs.

- *Ready*
  Creating a better system of coordination and collaboration between state agencies and developing working groups of public and private stakeholders to prepare for future flooding events.

2. RECOMMENDED PRINCIPLES FOR AN INTEGRATED FRAMEWORK ON FLOOD MANAGEMENT IN SOUTH CAROLINA

The SC Floodwater Commission recommends that the state adopt a comprehensive and integrated structure and plan to reduce flood risk and increase resilience, in order to deliver effective programs to our state's citizens. An integrated and holistic approach is recommended in order to be cost-effective. The state is receiving hundreds of millions of dollars from congressional post-disaster appropriations. This federal funding presents a unique opportunity for our state to maximize the funding's effectiveness.

Currently, responsibility for flood risk management is divided among numerous state and local agencies including: SC-EMD, SC Disaster Relief Office, DOT, DHEC, DNR, SC National Guard; plus local agencies for law enforcement, emergency response, floodplain management, flood insurance compliance, land use and zoning, stormwater management. The staff in these organizations all have a sincere desire to deliver effective flood management and resilience. In the absence of an integrated plan and structure, intentionally designed, our state may not deliver what is the optimum results that are both needed and possible.

Based on the work of the Floodwater Commission and its ten Task Forces, we recommend the following principles as the foundation to design and implement a comprehensive and integrated approach to reduce flood risk and increase resilience.

RECOMMENDED PRINCIPLES:

- Flood management plans and actions should be based on watershed boundaries, recognizing that water flows and floods do not follow jurisdictional or political lines.

- Decisions and actions should be based on high-quality, shared and integrated hydrologic and hydrographic models that are derived from increased data collection; the data and models should be transparent and freely accessible to all stakeholders.

- Building the capacity of local governments to develop science-based and actionable flood management plans and hazard mitigation plans should be a priority, especially for under-resourced communities. It does little good for one local jurisdiction to have high-quality plans if the upstream jurisdiction does not.

- Success will depend on collaboration. Collaboration must take place between state agencies to bridge boundaries, as well as between the state and local governments. Collaboration is essential to build trust among all stakeholders, which leads to partnerships, coordination and more effective programs. Collaboration should also be explicitly encouraged with key federal agencies (i.e. US Army Corps of Engineers, US Geological Survey, NOAA).

- Ongoing opportunities for public participation and education should be developed to encourage collaboration and build trust.

- Flood management programs should recognize the beneficial functions of natural floodplains, salt marshes, beach dunes, forests, living shorelines and other natural features to reduce flood risk, as well as the co-benefits they deliver for recreation, forestry, tourism, fisheries, and wildlife. “Nature-based solutions” should be considered included in the design of flood control projects whenever possible in order to increase resilience and be cost-effectiveness.

- Post-disaster funding coming to South Carolina from congressional appropriations should be managed in a unified state plan as much as federal rules and guidelines will permit, and coordinated across the multiple sources (i.e. FEMA, HUD).

The Floodwater Commission recommends that an effort begin to design a comprehensive and integrated structure and plan needed for flood risk reduction and resilience. The principles outlined above are the foundation that can guide this process. The comprehensive structure will provide the necessary framework to integrate and implement the recommendations from the Commission's Task Forces.

E. <u>FUNDING</u>

The US Congress has passed special appropriations that direct "post-disaster" funding to South Carolina as a result of the storms in 2015-2018. These funds far exceed any other source that is available to the state to address flood risk and build resilience.

In the past four years, FEMA has obligated approximately $483 million to be made available for total public assistance grants for potential relief for South Carolina residents affected by disaster like Hurricane Joaquin and the Historic Flood, Hurricane Matthew, Hurricane/Tropical Storm Irma, and Hurricane Florence. About $261 million of these funds is intended to go towards Emergency work, while over $113 million are intended for permanent work funds. In 2015 and 2016, HUD granted South Carolina approximately $157 million for CDBG-DR to support mitigation activities (HUD, 2018). Together, funds from FEMA and HUD could be used to improve infrastructure and strengthen coordination between knowledge holders and decision makers throughout South Carolina to mitigate the risk that future floods pose our beautiful state. By using these funds to protect persons, property, and enterprises, we can make major impacts to the threats posed to South Carolina citizens by coastal erosion, nuisance flooding, and inland/river flooding.

TABLE 5: FEMA Disaster Declaration chart, 2015-2018.

Event	Total Individual & Households Program (IHP) - Dollars Approved*	Total Housing Assistance (HA) - Dollars Approved*	Total Other Needs Assistance (ONA) - Dollars Approved*	Total Individual Assistance (IA) - Applications Approved*	Total Public Assistance Grants (PA) - Dollars Obligated**	Emergency Work (Categories A-B) - Dollars Obligated**	Permanent Work (Categories C-G) - Dollars Obligated**
Historic Flood (FEMA, 2015)	$90,173,586.11	$78,309,657.45	$11.863,928.66	28,184	$116,370,286.11	$50,586,170.52	$50,780,707.15
Hurricane Matthew (FEMA, 2016)	$39,826,354.31	$32,764,562.39	$7,061,791.92	11,662	$239,387,542.72	$164,784,698.63	$60,174,104.11
Hurricane/Tropical Storm Irma (FEMA, 2017)	n/a	n/a	n/a	n/a	$29,522,859.61	$17,757,810.74	$2,540,975.99
Hurricane Florence (FEMA, 2018)	$24,093,039.03	$21,126,398.95	$2,966,640.08	5,166	$38,675,259.83	$28,520,929.12	n/a
Total	$154,092,979.45	$132,200,618.79	$21,892,360.66	45,012	$483,955,948.27	$261,649,609.01	$113,495,787.25

* Dollars Approved: Assistance dollars approved but not necessarily disbursed.

** Dollars Obligated: Funds made available to the State via electronic transfer follow FEMA's final review and approval of Public Assistance projects; all may not be included here.

Some homeowners who have experienced significant and sometimes repeated damage to their homes are committed to moving to higher ground but are often unable to do so due to limited sources of funding. Many are forced to repair or rebuild in the same vulnerable locations and become trapped in a cycle of repeated flooding and rebuilding.

The South Carolina Floodwater Commission is supportive of the type of legislation as contained in a Bill pending in the SC Legislature regarding creation of a Resilience Revolving Fund Act. The Bill, S.259 (by South Carolina Senators Goldfinch, Campsen, Kimpson, Senn and Campbell) would establish a low interest revolving loan fund to help communities finance the purchase of repetitive loss properties from homeowners volunteering to relocate (South Carolina Resilience, 2019). The properties would be returned to open space in perpetuity and provides the opportunity for the functions of the natural floodplain to be restored. This proposed program provides a new mechanism for ensuring the health of floodplains and helping people who want to move out of harm's way, especially low- and moderate-income families and provide a source of match funding for FEMA grants to local governments and leverages FEMA applications from South Carolina to be more competitive in the federal process.

To incentivize successful flood buyout planning, loan forgiveness or a grant for up to 25% of a loan could be offered if the community undertakes certain best practices— such as aiding residents in relocating outside of the floodplain, relocating within the tax base, and completing floodplain restoration. There is currently no other program like this in operation in the United States. This program could provide a model for the rest of the nation.

To date, this bill has received bipartisan support from the Governor and key members of the South Carolina General Assembly. The bill favorably passed the Senate after a 44-1 vote and will be considered by the General Government Subcommittee of the House Ways and Means Committee in January 2020. If passed there is an opportunity to capitalize the Fund using federal disaster recovery money, including the HUD Community Development Block Grant Disaster Recovery (CDBG-DR) funding.

The comprehensive plan for flood risk reduction that the Floodwater Commission is recommending should include a unified plan to utilize these funds as effectively as possible. These funds will go further and accomplish more flood risk reduction if they are managed as part of a unified plan.

Post-disaster funds come to South Carolina through more than one federal agency, including FEMA and HUD. At the state level, they are also managed by multiple state agencies, or in some instances go to specific local governments. The allowable uses of these funds, matching requirements, and other regulations are different, depending on which "channel" they come through. And, the geography where they can be spent is different, depending on which natural disaster they are tied to. This creates a complex operating environment. Nevertheless, our state will maximize the benefits to flood risk reduction and resiliency if we can coordinate the use of these funds and manage them as part of a unified plan.

F. <u>FLOOD INSURANCE</u>

Promoting the Purchase of Private Flood Insurance

Over the last four years, flood waters have risen again and again in South Carolina, yet the National Flood Insurance Program (NFIP) has not seen a significant rise in flood insurance policies from the Palmetto State. It is time that South Carolinians take flooding seriously and consider purchasing flood insurance.

A typical homeowners' insurance policy or renter's policy does not provide coverage for losses due to rising waters. At present, most citizens do not consider the purchase of this important coverage unless they are required to procure flood insurance by their mortgage company.

Through the October 2015 1,000-year flood as well as hurricanes Matthew, Irma, and Florence, we've learned that rising waters don't stay in high-risk areas. Too often, serious damage has been experienced in areas never considered to be high risk on flood maps.

In order to protect personal assets and possessions from this serious risk, all South Carolina citizens are encouraged to consider purchasing flood insurance. This coverage is most typically purchased through the NFIP but is also available from some private insurance companies.

The South Carolina Floodwater Commission recommends that all insurance agents and real estate agents talk to their clients about this important coverage. Further, the Commission encourages all citizens to understand their risk and to make the best-informed decision for their home and personal property.

G. SUMMARY

A full report of each task force follows. The top takeaways of the task force report recommendations include:

Key Recommendations

1. Continue and enhance development of operational models for addressing deferred maintenance of the state's drainage system. Various stakeholder groups are being engaged for feedback on other flood and drainage projects. To date, the initial draft contains 244 projects from 31 counties and will be ongoing.

2. Incentivize the use of green infrastructure as a cost-effective approach for managing and reducing stormwater at its source, through such methods as tree canopies, stormwater tree trenching, stormwater basins and stormwater wetlands. Planting of native vegetation along the coast in conjunction with beach renourishment projects. Identify high-priority floodplains, wetlands and open spaces through existing maps and analyses on a county by county basis and maintain the flood storage capacity of floodplains, wetlands and critical open space.

3. Construct 1-2 demonstration artificial reefs seaward of coastal areas experiencing shoreline erosion in order to evaluate the impact of the engineered reef system and the protection potential for similar reefs covering significant segments of the coast. Additionally, continuation and investment in artificial oyster reefs to provide both erosion resilience and protection for wetlands and an economic boost.

4. Stabilization of marsh edges by identifying locations coast-wide where living shorelines and other emerging methods may be used to allow marshes to regrow where they have been eroded, and replenish marshes not keeping up with sea-level rise. Identifying and conserving transition areas for future marsh movement inland.

5. Consolidation of state resources to create greater efficiencies and cost effectiveness. Coordination among multiple state agencies to develop a comprehensive, science-based regulatory process to address the design of living shorelines and streamline permitting processes where possible.

6. Grid protection through undergrounding of some distribution circuits and hardening the overall transmission systems to increase the stability of the grid in areas along with streamlining stricter vegetation management to protect the power lines. Additional Grid protection through continued development of Distributed Energy Resources (DERs), Microgrids and integrated planning.

7. Developing and coordinating of the sharing of available river modeling data, optimizing the modeling and then utilizing these results for development planning, emergency planning, and emergency operations. Shared modeling will allow South Carolina to develop in an ecologically friendly manner that reduces the potential for damage from

flooding. Build in control structures in the development and operate as part of the Smart River Operations with the goal of preparing real time smart river topography for the coordination of actions by states, counties, local authorities and private companies and individuals based on modeling before during and after emergencies.

8. Ensuring that military facilities better withstand flooding and severe weather issues by coordination with the Department of Defense (DoD) to make appropriate changes to installation master planning, design, and construction standards including efforts to better understand rates of coastal erosion, natural and built flood protection infrastructure, and inland and littoral flood planning and mitigation.

9. Development of flood water channelization and the construction of reservoirs to assist with flooding while providing regions with lakefront property, business and recreational opportunities and energy.

10. Development of a capacity building program to assist under-resourced local governments in identifying solutions and developing a plan and applying for federal funding. Timeliness of the release of federal disaster funds allocated to the state from the recent disaster relief bills is important to South Carolina's recovery from the devastation of storms. It is essential that efforts on initiatives to help recovery and preparation for the future be coordinated and data collection be shared at all levels.

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LIVING SHORELINE TASK FORCE

INFRASTRUCTURE & SHORELINE ARMORING TASK FORCE

SMART RIVERS & DAM SECURITY TASK FORCE

GRID SECURITY TASK FORCE

LANDSCAPE BEAUTIFICATION TASK FORCE

NATIONAL SECURITY TASK FORCE

STAKEHOLDER ENGAGEMENT TASK FORCE

FEDERAL FUNDING TASK FORCE

ECONOMIC DEVELOPMENT TASK FORCE

State of South Carolina

GOVERNOR HENRY MCMASTER

THOMAS S. MULLIKIN, CHAIRMAN

South Carolina Floodwater Commission

Artificial Reef Systems Task Force Report

November 8, 2019

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I. INTRODUCTION

A. Coastal Erosion Overview

Most coastal areas in the United States are eroding (Thieler and Hammar-Klose, 2000) and the geomorphology of the southeast United States makes it especially susceptible to erosion from storms and sea level rise. The beaches along the Southeast states are largely composed of unconsolidated sediment and the coastal plain is flat and only meters above sea level (Brandt 2009). Furthermore, most of the inner shelf of North and South Carolina is sediment starved with a thin veneer of sediment overlying hardbottoms (Riggs et al. 1998, Barnardt 2009). This means that small changes in the annual balance in the sediment budget can cause significant changes to the nearshore and recreational beaches (Barnardt 2009).

Historically, the response to coastal erosion has been shoreline hardening or armoring (Dugan et al. 2011). Shoreline hardening is the placement or construction of vertical hard structures, such as seawalls or bulkheads, jetties (groins), and breakwaters, or slopped riprap along a shore to prevent erosion and/or to mitigate flooding (Gittman et al. 2016). Roughly, 14% of the United States shoreline and 50% of urban areas worldwide are hardened (Gittman et al. 2015).
While shoreline hardening can be locally effective at reducing erosion and limiting flooding, this approach has negative impacts on the recreational beach and surrounding areas, beach access, and wildlife (Table 1; Doody 2004, Seitz et al. 2006, Gittman et al. 2016, Williams et al. 2018). Jetties modify the delivery and deposition of sediment, resulting in sediment accreting in some areas and eroding in others. Seawalls and slopped riprap are very effective in preventing erosion but modify wave reflection, often destabilizing the adjoining beach and eliminating the recreational beach and eventually they will be overtopped by the sea. These solutions to erosion are also expensive and often require additional maintenance. Furthermore, shoreline hardening has negative impacts on the biodiversity and abundance of coastal organisms thereby reducing the ecosystem services that coastal residents rely on (Gittman et al. 2016).

Many coastal communities have adopted soft stabilization of beaches (e.g. beach nourishment, sand dune construction) as a better alternative to hard stabilization for arresting erosion and protecting coastal infrastructure. Beach nourishment seeks to replace sand lost to erosion with beach material, usually sand, and recreate lost beaches, while dune construction builds defensive dunes. Large scale beach nourishment projects began about 50 years ago, though the first recorded projects in the United States were in California in 1919 and on east coast barrier islands in 1935 (Spreybroek et al. 2006 and references therein). Beach nourishment is often seen as the only practical alternative, with minimal long-term environmental impact (Dean 2005, Speybroeck et al. 2006), but it is expensive, requires periodic maintenance, and the environmental impacts are not fully understood (Peterson and Bishop 2005).

Today, beach nourishment is the method of choice to protect coastal property and peoples, but the long-term viability of this approach is open to question (Parkinson and Ogurcak 2018). In addition to the construction costs that are steadily rising, there are other challenges to sustained beach nourishment. These include unsuitable or inadequate sources of sand; coastal geomorphology, which dictates the suitability of beaches for nourishment; the need to expand nourishment to other shorelines, such as back barrier, embayments, etc.; and a full assessment of environmental impacts. In the face of sea level rise and increasing intensity and frequency of coastal storms, it is reasonable to question if beach nourishment is the long-term, cost-effective solution to protecting coastal communities (Parkinson and Ogurcak 2018).

TABLE 1: Pros and cons of different types of coastal erosion and flooding mitigation structures (after Williams et al. 2018).

TYPES	PROS	CONS
Jetty/Groin Intercept long-shore sand movement	1. Effective in beach building 2. Valuable amenity 3. Easy, quick construction	1. Local scour, increased erosion down-drift 2. Requires sediment supply 3. Less effective at controlling cross-shore sand movement 4. High potential maintenance cost 5. Negative impact on biota 6. Rip current generation
Seawalls Vertical/near vertical stone or concrete wall	1. Effective in preventing erosion and overtopping 2. Resists wave exposure 3. Serve as a promenade, safe for public use 4. Variety of designs	1. Poor energy absorption/high wave reflection 2. May destabilize beach 3. May require additional energy absorbing apron 4. Negative impact on biota 5. Expensive 6. Limited sea access
Riprap Sloped solid or open construction	1. Good energy dissipation & hydraulic performance 2. Cheaper construction cost than solid structures 3. Can reduce toe scour in conjunction with seawalls 4. Little maintenance	1. Poor energy absorption & high wave reflection 2. Expensive 3. Negative impact on biota 4. May need additional input 5. Limited sea access
Sand Dunes Artificial or natural	1. Aids energy dissipation 2. Amenity/wildlife value	1. Highly susceptible to erosion
Beach Nourishment/ Replenishment Addition of sand to replace material lost to erosion	1. Resembles natural beach	1. Periodic maintenance required 2. Expensive 3. Uncertainty surrounding impacts on biota
Offshore Structure/ Artificial reef Sinking of natural or artificial material offshore	1. Promotes beach build up/reduces erosion 2. Little beach maintenance required 3. Enhances biodiversity and organism abundance	1. Costly 2. Navigation hazard/public safety risk 3. Construction limited to shallow water 4. Down-drift erosion possible 5. Possible water-quality reduction

B. Beach Preservation

South Carolina has 300 km (187 miles) of coastline and because of its numerous bays, rivers, and islands an effective shoreline of 4,628 km (2,876 miles) (coast.noaa.gov). This shoreline, coupled with the rapid population growth that has occurred in South Carolina's coastal counties during the last few decades, places a large number of people and high-value infrastructure at risk to coastal hazards. Shoreline counties account for approximately 25% of the state's population and support an annual $15 billion tourism industry and commercial and recreational fisheries (Barnhardt 2009). The fall 2018 hurricanes and associated rainfall reinforced the region's susceptibility to storms and prompted an evaluation of measures to mitigate flood and storm damage to coastal infrastructure and peoples.

Healthy beaches are vital to the South Carolina's economy. These beaches, however, simultaneously provide billions of dollars of flood risk reduction by protecting the tourism infrastructure behind the beach and dune system. The beach and dune system is the first line of defense when hurricanes threaten the South Carolina coast. The hotels, rental properties, tourist attractions, and restaurants that allow for our state's thriving beach tourism industry are protected from storm flooding by the very beaches that attract their guests. As an added benefit, the protective beach/dune system is a natural, living feature that provides critical habitat for coastal species, such as sea turtles and shorebirds. Beaches are a water infrastructure project that serves to diminish the effects of coastal flooding while enhancing opportunities for tourism and critical habitat restoration.

Many metrics of beach health exist, but perhaps the most commonly used is the long-term shoreline erosion rate. South Carolina has the highest average rate of shoreline erosion amongst all the states in the Southeast Atlantic based on a long-term (>80 years) survey (Himmelstoss et al. 2017). That survey revealed that 54% of the South Carolina beaches measured were eroding at an average rate of 0.6 m/yr. (+0.4) which is the greatest average erosional shoreline change among the southeast and Gulf of Mexico states. South Carolina also has the highest maximum erosion rate among these states at 27.4 m/yr. (+0.4) at the north end of Cape Island based on a short-term (20-50 years) survey (Himmelstoss et al. 2017). Figure 1 illustrates a map created by the Hazard Vulnerability Assessment (HVA) tool, which includes statewide shoreline change data that were provided by South Carolina's Department of Health and Environmental Control (DHEC) Ocean and Coastal Resource Management (OCRM) division. The maps were created using an open-source geospatial tool called AMBUR (Analyzing Moving Boundaries Using R). The shoreline change analysis used three-time steps: 1800s, 1930s, and 2000s. The change rate utilized with the HVA tool was the End Point Rate (EPR). [Rates would be higher if calculated from immediate post-nourishment to immediate pre-nourishment. With EPR, surveys may have been conducted at any point in the beach nourishment cycle].

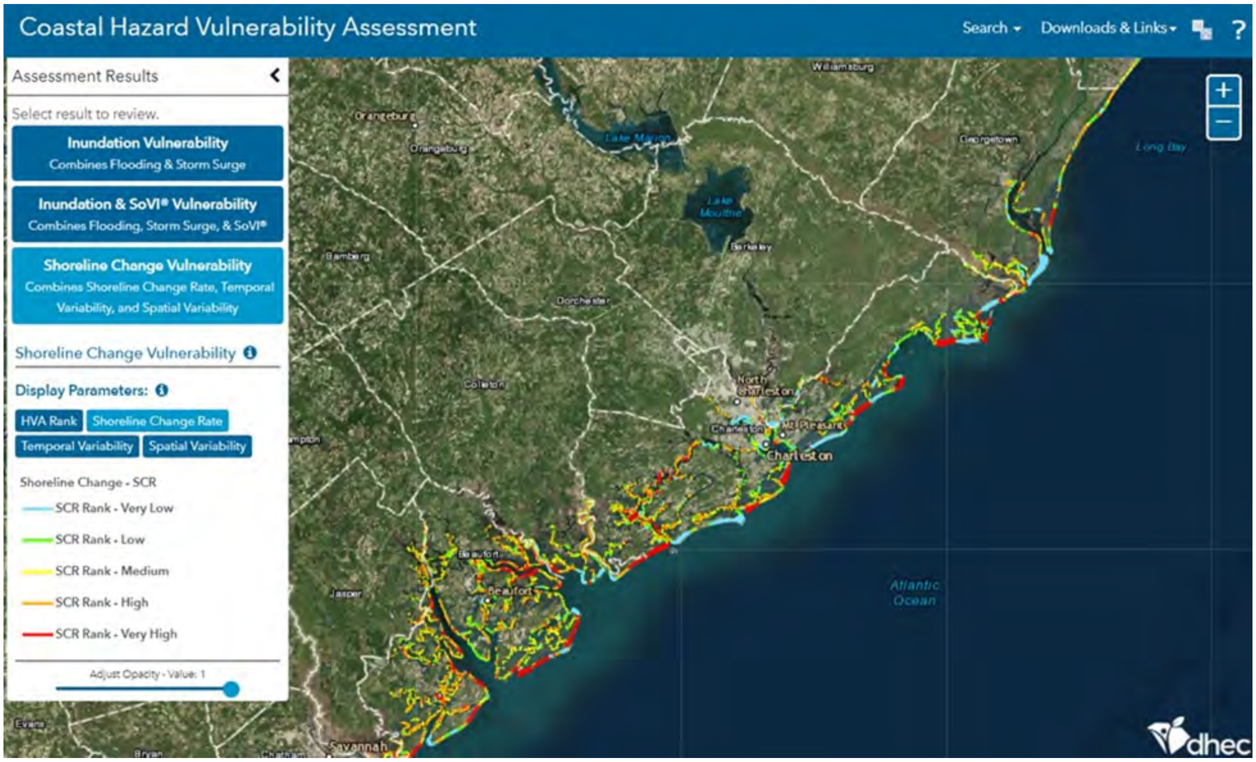

FIGURE 1: Map of shoreline change rates. Shoreline Change Rate (SCR Rank) is defined as follows: Very High: < -1 m/yr.; High: -0.2 to -1 m/yr.; Medium: -0.2 to 0.2 m/yr.; Low: 0.2 to 1 m/yr.; Very Low: 1 m/yr.

South Carolina's DHEC-OCRM, has convened Blue Ribbon Panels focused on the state's ocean beaches over the last 30 years to address chronic beach erosion, gradual sea level rise, increased shoreline development and population growth, and a lack of comprehensive beachfront planning and management. Historically, erosion prevention in South Carolina was no different from other areas and relied on shoreline hardening. Prior to 1988, there was limited regulation of coastal development in South Carolina and seawalls and other means of shoreline hardening to arrest erosion were permitted. Most hard stabilization of beaches occurred in the 1970s and 1980s under the auspices of the South Carolina Coastal Zone Management Act (Barnardt 2009). The lack of regulation of hard stabilization destroyed the integrity of the beaches. As a result, the Beachfront Management Act (SCBMA; S.C. Code Ann. § 48-39-250 et seq.) was passed in 1988. The SCBMA prohibited hard stabilization and promoted the use of soft alternatives such as beach nourishment and sand dune construction. The SCBMA established a baseline (usually at the crest of the primary dune) and called for development no closer than where the line is estimated to be in 40 years (i.e. 40 times the annual rate of erosion). Uneven rates of erosion mean that beaches have different set back lines. The SCBMA also prohibits new construction of hardened structures though older structures can be maintained. Amendments to the SCBMA in 1990 and 2002 permit exceptions to the building restrictions on a case-by-case basis and with a limitation on the size of the structure to be constructed. South Carolina continues to prohibit hard stabilization and in May 2019, the Governor of South Carolina successfully vetoed a bill that would have allowed seawall construction to protect seventeen high-end houses at the DeBordieu Colony, a wealthy development in Georgetown County (Johnson 2019).

As described above, beach preservation is the common alternative to hard stabilization and serves to restore the beach and dune system and its storm-surge-barrier, tourism, and ecosystem functions. Beach preservation efforts have reduced coastal flood risk to the natural and built environments along South Carolina's beachfront since their widespread use beginning in the 1980's. Beach preservation involves the implementation of coastal management techniques such as beach nourishment, sand dune restoration (see below) using sand fencing and native vegetation, beachfront construction control using setback lines and rebuilding rules, the landward movement and/or removal of habitable structures whenever necessary and feasible, and the conservation of undeveloped shorelines. The elements of beach preservation can inform the state's application of other flood reduction projects, like living shorelines and artificial reefs, in the future.

1. <u>Beach Nourishment</u>

The predominant strategy to reduce oceanfront flooding and mitigate beach erosion in South Carolina has been beach nourishment. Beach nourishment is the periodic pumping of sand onto a beach to replace sediment lost from routine and storm-related waves and currents. One goal is to add volume and width to the beach system in front of the dunes to help dissipate wave and current energy front directly affecting coastal dunes and infrastructure. A second goal is to support sand dunes, which provide a higher barrier to water driven waves, wind and pressure in the form of storm surges. The first beach nourishment project in South Carolina was completed in 1954 at Edisto Beach (Kana 2012). Since 1982, the state of South Carolina has spent just over 457 million dollars (in 2018 dollars) on beach nourishment (Beach Nourishment Viewer). This expenditure placed nearly 60 million cubic yards of sand on approximately 950,000 ft. (180 miles) of shorefront in 76 separate projects. This represents 96% of the ocean coast because many beaches have received nourishment more than once. Success has varied; some beaches are significantly wider than they were in the 1980s while some are not significantly improved (Kana 2012). During the most destructive hurricanes of the 2000's like Ivan, Katrina, Sandy, Matthew, Irma, and Florence the communities that did not have a beach maintenance plan (for example, regular renourishment) fared worse than their neighboring beach communities with beach nourishment projects in place (with a wide beach and high dunes). Beach nourishment is currently expensive and the cost of sand suitable for nourishment is increasing (Gopalakrishnan et al. 2017). Additionally, beach nourishment is not a permanent fix, nationally beaches need to be nourished about every 5 years.

2. <u>Sand Dune Restoration</u>

Sand dune restoration is another approach to mitigate the impact of erosion and flooding on coastal infrastructure. Sand dunes form in areas with low long-term erosion rates and sufficiently wide back beach areas over which the wind may blow and suspend sediment in the air (known as aeolian sediment transport). Native vegetation and/or installed sand fencing then traps the wind-blown sand causing the dunes to build over time in a cycle of vegetation burial and emergence. Dune vegetation also helps bind the sediment within extensive root structures. Sand dunes provide the additional elevation needed to prevent overtopping during major storm events. The surge from recent hurricanes has breached South Carolina dune systems at weak points, such as pedestrian walkways, which amount to a break in an otherwise continuous barrier (Figure 2).

It has become common practice to include a sand dune restoration component in conjunction with beach nourishment projects. The combination of these two elements yields a more comprehensive beach preservation project.

FIGURE 2: Photograph taken from a high-rise hotel in North Myrtle Beach looking down on the beach/dune system during the passage of Hurricane Matthew in October 2016. Note the storm surge pouring into the public infrastructure by way of the low areas between the dunes.

3. <u>Beachfront Construction Control</u>

The SCBMA established a jurisdictional "setback area" (bound by the baseline and setback line) along the beach in which any construction would require a permit. The lines are used to regulate new beachfront construction and are updated every 8 to 10 years. The policies and regulations within the beachfront setback area are designed to protect the beach/dune system by discouraging new construction in close proximity to the beach/dune system and by encouraging those who have erected structures too close to the system to retreat from it.

State and local efforts to control beachfront development are directly applicable along South Carolina’s estuarine shorelines. Some examples already underway include local planning efforts to identify critical infrastructure at risk to nuisance flooding, coastal storms, and marsh degradation. Some communities are considering modifying development regulations to increase freeboard, require setbacks and buffers, and reduce impermeable surfaces.

C. South Carolina's Present Approach to Beach Preservation

Oceanfront flooding in South Carolina is not as prevalent as during the Hugo era thanks to the implementation of beach preservation projects. Beach preservation efforts increased dramatically following the passage of Hurricane Hugo. Over 20 million cubic yards of sand were placed on South Carolina beaches in the 1990s, as compared to a total of about 10 million cubic yards placed in the 50s, 60s, 70s, and 80s combined (Kana, 2012). Since the 1990's, most South Carolina beaches have been restored on regular intervals.
South Carolina has had a lot of experience with state beach project permitting, local community funding strategies, and Federal/local coordination to implement beach preservation projects. Only since 2015, however, South Carolina has shown a genuine commitment to funding beach preservation projects at the state level. Of all the moving parts of these effective flood reduction projects, local communities agree that state funding is today's most critical challenge in South Carolina beach preservation. A coalition of beach communities was formed in 2015 to advocate for a dedicated state funding plan for beach preservation (South Carolina Beach Advocates or SCBA, 2019). Three main beach preservation models exist today in South Carolina: The Federal project, the state/local project, and the community association project (Table 2).

1. The Federal Project

The Grand Strand communities of North Myrtle Beach, Myrtle Beach, and Surfside Beach, as well as the City of Folly Beach have 50-year agreements with the U.S. Army Corps of Engineers (USACE). USACE manages and administers Coastal Storm Damage Reduction (CSDR) projects that are cost shared with the communities and the state. For example, a Local Cooperation Agreement between the USACE and the City of Folly Beach was justified in a 1991 report (USACE 1991) and executed on September 14, 1992. It allowed for the initial construction of a 5.34 mile long Federal CSDR project in 1993.

In South Carolina, Federal projects require a non-Federal cost share of 15 to 35% depending on location. In recent years, the state has split the non-Federal cost with the local communities (Table 2). This is a common practice in other coastal states with a commitment to beach preservation such as North Carolina, New Jersey, and Florida.

2. The State/Local Project

Beach communities with public beach access like Edisto Beach, Pawley's Island, and parts of the Isle of Palms collaborate with the state to cost share the public portions of their beach preservation projects 50/50. Also included in this group are the South Carolina State Park beaches, such as Edisto Beach State Park and Hunting Island State Park. Table 1 illustrates that the state has played a significant role in state beach preservation in recent years.

3. The Community Association Project

Finally, several of South Carolina's beachfront communities are private, and not eligible for public funds such as DeBordieu Colony Community Association, Seabrook Island Homeowners Association, and the Wild Dunes Community Association. These communities hire private consultants and raise funding within their communities through fees and property assessments.

D. Objective

Beach preservation is not limited to beach nourishment and sand dune restoration; other methods exist for mitigating the effects of coastal erosion and flooding on coastal communities. These include living shorelines, a form of soft or natural stabilization, and artificial reefs or submerged breakwaters which is a hard engineering solution but one that is off the beach and does not have many of the negative impacts incurred by armoring shores (Table 1; Harris 2009). The purpose of our report is: to assess the suitability of artificial reefs for erosion and flood protection in South Carolina by reviewing the current knowledge of artificial reefs and their potential to protect beaches; to lay out a plan to deploy and evaluate the effectiveness of a test reef, and to consider the issues involved in using artificial reefs on a large scale.

TABLE 2: South Carolina's Commitment to Beach Preservation Funding with Federal Projects in blue, State/Local projects in pink, and Community Association projects in gray.

Project Name	Local Sponsor	Type of Project	Year	Total Cost*	State Cost Share
Arcadian Shores	Horry County	Nourishment	2019	$ 8,582,500	$ 4,291,250
Myrtle Beach Reach 1 USACE	City of North Myrtle Beach	Nourishment	2018	$ 6,500,000	$ 890,848
Myrtle Beach Reach 2 USACE	City of Myrtle Beach	Nourishment	2018	$ 23,000,000	$ 450,000
Myrtle Beach Reach 3 USACE	Horry & Georgetown Counties	Nourishment	2018	$ 36,500,000	$ 2,400,000
Garden City + Huntington Beach State Park	Georgetown County	BU dredged material	2017	$ 6,350,000	$ -
Pawleys Island Groin Repair	Town of Pawleys Island	Groin Rehab	2019		
Pawleys Island USACE Nourishment	Town of Pawleys Island	Nourishment	2020	$ 35,428,571	$ 6,200,000
DeBordieu Beach & Dune Restoration	DeBordieu Colony Comm Assn	Nourishment	2015	$ 10,050,000	
DeBordieu Groin Construction	DeBordieu Colony Comm Assn	Groin construction	2020		
Isle of Palms Beach and Dune Restoration*	City, Community Assn, FEMA	Nourishment	2018	$ 13,575,568	$ 2,982,603
Folly Beach USACE Nourishment	City of Folly Beach	Nourishment	2018	$ 15,000,000	
Folly Beach Groin Rehab	City of Folly Beach	Groin Rehab	2018	$ 2,639,479	$ 1,319,739
Edisto Beach	Town of Edisto Island, SCPRT	Nourishment	2017	$ 12,141,685	$ 6,070,843
Edisto Beach State Park	SCPRT	Nourishment	2017	$ 3,126,038	$ 3,126,038
Edisto Beach Groin Extensions	Town of Edisto Island	Groin Rehab	2017	$ 5,424,642	$ 2,712,321
Hunting Island State Park	SCPRT	Nourishment	2019	$ 10,900,000	$ 10,900,000
Hilton Head	Town of Hilton Head	Nourishment	2017	$ 31,900,000	
Total Since 2017*				**$ 200,168,483**	**$ 41,343,642**

*Total cost includes the Federal, state, local, and private share of projects.

**Isle of Palms project contains a Community Association component at Wild Dunes.

II. ARTIFICIAL REEF REVIEW

An artificial reef is a fabricated man-made underwater structure, typically built to promote marine life in areas with a generally featureless bottom, to control erosion (Seaman, 2000), block ship passage, block the use of trawling nets, or to improve recreational amenities such as surfing or swimming. Centuries ago, sailors and seafarers recognized that sunken vessels and all sorts of other objects that found their way to the sea floor would soon colonize with life. As early as the 1830s, curious individuals began purposefully building artificial reef structures off the coast of South Carolina using log huts. Over 100 years later, in the 1950s, fishermen began sinking man-made materials of opportunity or secondary use materials such as railcars, buses, tires, porcelain toilets and a myriad of other objects to enrich marine life in local fishing areas (Jackson, 2012). In the ensuing decades, marine resource managers, scientists and fishermen gradually became more purposeful in artificial reef design, siting, construction and monitoring (Rosemond et al. 2018).

Many natural reefs function as submerged breakwaters and protect beaches in their lee (Harris 2009) and there is no reason *a priori* to suspect that artificial reefs would not function the same. The use of artificial reefs for coastal erosion protection and ecosystem restoration has the added potential to increase aquaculture and create new opportunities for recreational amenities. Artificial reefs enhance the survival of marine life, providing food and shelter. Such habitats for fish, flora, and invertebrates also attract larger marine life such as sea turtles, dolphins, sharks, and rays, as well as fisherman and divers. Additionally, artificial reefs allow for an increase in tourism and research opportunities, which stimulate local economies by creating jobs.

A. <u>Purpose & Policy for Artificial Reef Protection</u>

The National Artificial Reef Plan (33 USCS § 2103) was developed under direction of the National Fishing Enhancement Act of 1984 by the Secretary of Commerce to promote and facilitate responsible and effective artificial reef use based on the best scientific information available to enhance fisheries. (United States Department of Commerce, National Artificial Reef Plan) The continuous health of state and national fisheries to enhance economic growth are the purpose of artificial reefs in areas that lack natural resources that promote concentrated populations of marine life. Under the National Artificial Reef Plan parties must include geographic, hydrographic, geologic, biological, ecological, social, economic, and other criteria for sitting artificial reefs. In addition, mechanisms and methodologies for monitoring and managing the use of artificial reefs are to be within requirements of permits issued under the Construction and Management of Artificial Reefs Act (33 USCS § 2104), including, but not limited to, credits for environmental mitigation and modified tax obligations. Design and construction must ensure title to artificial reef construction material is unambiguous, and that responsibility for maintenance and the financial ability to assume liability for future damages are clearly established. The program is administered by the National Oceanic and Atmospheric Administration (NOAA), which is part of the Department of Commerce.

Florida, for example, has an established a program through the Florida Fish and Wildlife Conservation Commission that put in place policies to enhance saltwater opportunities and to promote proper management of fisheries resources (Fla Stat. § 379.249). This was done to encourage the development of artificial reefs as well as for monitoring and evaluating such reefs and their effectiveness. These policies are adaptable to incorporate artificial reefs used to mitigate onshore erosion and flooding. The national government and state legislatures have found that artificial reefs are a valuable resource that contributes ecologically, aesthetically, and economically (Fla Stat. § 403.93345). This gives the legislature powers and authority to construct and protect artificial reefs.

These policies provide authority with means to support comprehensive and coordinated conservation and management of marine areas, and activities affecting them in a manner which complements existing regulatory authorities. They also promote scientific research and long-term monitoring of resources within these marine areas (National Marine Sanctuaries Act 16 USCS §1431(b) also administered by NOAA). This is to ensure that viable habitats are maintained, restored, and enhanced as living resources by providing places for species that depend upon these marine areas to survive and propagate. Federal agencies taking actions pursuant to this must act in accordance with international law and with Presidential Proclamation (Ronald Reagan)(Presidential Proclamation 5928), on the Territorial Sea of the United States of America (43 USCS § 1331 et seq) Presidential Proclamation (Ronald Reagan)(Presidential Proclamation 5030), on the Exclusive Economic Zone of the United States of America (43 USCS § 1453), and Presidential Proclamation (Bill Clinton) (Presidential Proclamation 7219), on the Contiguous Zone of the United States of America (43 USCS § 1331 et seq).

B. History

1. Conference on Artificial Reefs and Related Aquatic Habitats (CARAH)

In the spring of 1974, a cohort of 250 international scientists gathered together in Houston, Texas to discuss and deliberate the potential value of artificial reefs (NOAA, 2016). This gathering represented the first international conference of its kind, focused exclusively on artificial reefs, and was designed to bring colleagues of mutual interest together to improve the exchange of information among persons interested in artificial reefs and focus international attention on the potential use of artificial reefs in fishery management.

2. National Artificial Reef Plan (NARP)

National oversight of artificial reefs in U.S. waters did not exist until the early 1980s, even though several states had programs in place. In recognizing the increased use of artificial reefs, and the need for good practices, the National Fishing Enhancement Act of 1984 (H.R.5447) directed the Department of Commerce, and by extension the National Oceanic and Atmospheric Administration (NOAA), to develop a long-term, national plan to guide artificial reef development in U.S. waters.

The purpose of the national plan is to promote and facilitate responsible efforts to establish artificial reefs in the navigable waters of the United States and waters superjacent to the outer continental shelf as defined in 43 USC, Section 1331 (NOAA, 2016). The Act establishes national standards for artificial reef development under the National Fishing Enhancement Act for siting and construction, and subsequent monitoring and management in a way that will:

1. Enhance fishery resources to the maximum extent practical;
2. Minimize conflicts among competing uses of waters covered under this title and the resources in such waters;
3. Minimize environmental risks and risks to health and property; and
4. Be consistent with generally accepted principles of international law and shall not create any unreasonable obstruction to navigation.

A group of NOAA scientists in the National Marine Fisheries Service drafted the first ever National Artificial Reef Plan in 1985, the latest revision to the National Artificial Reef Plan was published in 2007 and emphasizes the use of the most recent and best information available. The NARP provides state and local artificial reef program managers, policy makers and interested parties with guidelines and resources on siting, construction, development and assessment of artificial reefs. In addition, the Plan outlines the respective roles of Federal, state and local governments in the permitting, oversight and ongoing management of artificial reefs. Today approximately half of U.S. coastal states have artificial reef programs or strategic plans based on guidance from the NARP (NOAA 2016). Despite the Federal government's broad role, there is currently no Federally coordinated program regulating artificial reef activities in U.S. waters. Responsibility for artificial reef permitting and oversight is divided among five Federal entities:

- **U.S. Department of the Interior (DOI)** through the U.S. Fish and Wildlife Service provides funding for state artificial projects that enhance recreational fisheries resources.

- **Department of Commerce (DOC)** through NOAA provides a long-term National AR Plan for responsible and effective artificial reef use.

- **Department of Defense (DOD)** through the U.S. Army Corps of Engineers is the lead Federal agency for permitting artificial reefs.

- **Department of Transportation (DOT)** through the Maritime Administration has provided surplus ships for artificial reef construction material.

- **Environmental Protection Agency (EPA)** oversees the placement of fill material or structures used to create artificial reefs.

C. <u>Benefits and Challenges</u>

The National Marine Sanctuaries Act (16 USCS § 1431) gives Congressional credence to the tenet that historically this Nation has recognized the importance of protecting special areas of public domain, but these areas have been almost exclusively above the highwater mark. Certain areas of the marine environment possess these same important attributes that require Federal programs where legislative protection is established to promote public awareness, understanding and appreciation of these fragile marine environments for future generations. Protection of this kind was realized in part using the Federal compliance with pollution control standards (42 U.S.C.S. § 4321). The Presidential Executive Order (William J. Clinton) (Executive Order Number 13158), provided for additional protection for the purposes of the National Marine Sanctuaries Act, and by utilizing the National Wildlife Refuge System Administration Act of 1966 (16 USCS § 668dd), National Park Service Organic Act (16 USCS § 1), National Historic Preservation Act (16 USCS § 470), Coastal Zone Management Act (16 USCS § 1451), Construction and Management of Artificial Reefs Act (33 USCS § 2104), and Endangered Species Act of 1973 (16 USCS § 1531), to establish Marine Protected Areas (MPA) (to the extent permitted by law and subject to the availability of appropriations through Department of Commerce and the Department of the Interior and other pertinent Federal agencies (16 U.S.C.S. § 1431). Florida has codified these federal statutes for state waters under the Florida Coral Reef Protection Act (Fla. Stat. § 403.93345), and enforced standards of liability under the Marine Protection, Research and Sanctuaries Act (33 USCS § 1401) to protect the Nation's only natural coral reef system and Florida's expensive artificial reefs.

Florida Fish and Wildlife Conservation Commission (FWC) codified a state artificial reef program that is supported by grants, and financial and technical assistance to local governments (Fla. Stat. Ann. § 379.249). Florida has one of the most active artificial reef programs among the 15 Gulf and Atlantic coastal states involved in artificial reef development. Because of its extensive coastline and statewide involvement in reef activities, the Florida artificial reef program is the only state program that is not exclusively run at a state agency level. FWC depends on partnerships with local counties to hold reef permits and manage new reef construction.

Since the 1940s, Florida has placed more than 3,330 planned public artificial reefs in state and Federal waters and maintains a statewide database accessible to the public of all reef deployment locations (FWC). Artificial reef construction objectives include:

1. <u>Erosion Prevention</u>

Artificial reef structures can be constructed and utilized in a variety of ways to prevent and mitigate coastal erosion. Some are designed to force waves to deposit their energy offshore rather than directly on the coastline. Other reefs are designed to hold sediment on beaches by limiting the transfer of sediments within the reef. These reefs are custom designed for each unique zone (Morang, A., et al., 2014).

2. Recreational Dive Sites

Thousands of popular wreck diving sites throughout the world are built around shipwrecks sunk as artificial reefs. Some of these wrecks were sunk deliberately to attract divers. The USS Spiegel Grove and USS Oriskany in Florida, USS Indra and USS Aeolus in North Carolina, and Bianca C in Grenada draw thousands of divers annually (Gerken, M. 2013). Other focused areas considered as advantages of artificial reefs include:

1. Mitigation reefs to replace hard bottom habitat lost through activities such as beach re-nourishment and damage caused by vessel groundings
2. Oyster reef regeneration
3. Enhancing recreational and charter fishing and diving opportunities
4. Increasing reef fish habitat
5. Facilitating reef related research

D. Surveys and Ecosystems Analysis

The bottom composition and character at an artificial reef site affect reef stability and longevity and should be carefully evaluated in the site selection process. In most cases, soft sediments such as clays, silts, and loosely packed sands should be avoided. Over time, reef materials may sink into these sediments or become partially covered. Areas lacking in numbers or variety of species may already have insufficient habitat to support an aquatic community, therefore reef developers may avoid the need for lengthy environmental assessments (Fikes, R., 2013).

Marine Protected Areas

Federal inclusion in state waters to the extent permitted by law and subject to the availability of appropriations, the Department of Commerce and the Department of the Interior, in consultation with the Department of Defense, the Department of State, the United States Agency for International Development, the Department of Transportation, the Environmental Protection Agency, the National Science Foundation, and other pertinent Federal agencies were directed under Executive Order 13158 to establish a national system of Marine Protected Areas (MPAs). They were further directed to coordinate and share information, tools, and strategies, and provide guidance to enable and encourage the use of the following in the exercise of each agency's respective authorities to further enhance and expand protection of existing areas and to establish or recommend new protected areas, as appropriate:

1. science-based identification and prioritization of natural and cultural resources for additional protection;
2. integrated assessments of ecological linkages among MPAs, including ecological reserves in which consumptive uses of resources are prohibited, to provide synergistic benefits;
3. a biological assessment of the minimum area where consumptive uses would be prohibited that is necessary to preserve representative habitats in different geographic areas of the marine environment;

4. an assessment of threats and gaps in levels of protection currently afforded to natural and cultural resources, as appropriate;
5. practical, science-based criteria and protocols for monitoring and evaluating the effectiveness of MPAs;
6. identification of emerging threats and user conflicts affecting MPAs and appropriate, practical, and equitable management solutions, including effective enforcement strategies, to eliminate or reduce such threats and conflicts;
7. assessment of the economic effects of the preferred management solutions; and
8. identification of opportunities to improve linkages with, and technical assistance to, international marine protected area programs.

To better protect beaches, coasts, and the marine environment from pollution, the Executive Order also directed the Environmental Protection Agency (EPA), relying upon existing Clean Water Act (33 USCS §§ 1251 et seq.) authorities, to propose new science-based regulations to ensure appropriate levels of protection for the marine environment. Such regulations may include the identification of areas that warrant additional pollution protections and the enhancement of marine water quality standards.

NOAA created and maintains a Marine Protection Area Center under the terms of the Executive Order, and also maintains a website in conjunction with the Department of Interior on the subject.

1. Biological Effects

Administered by NOAA, the purposes and policies of title 16 USCS §§ 1431 are to identify and designate as national marine sanctuaries areas of the marine environment which are of special national significance and to manage these areas as part of the National Marine Sanctuary System. Under this law NOAA has the authority for comprehensive and coordinated conservation and management for established marine areas, and the activities that directly affect them, in a manner which complements existing regulatory authorities to maintain the natural biological communities within the marine sanctuaries, as well as to protect and as appropriate, restore and enhance natural habitats, populations, and ecological processes. These policies are for natural habitats, not man-made marine sanctuaries that, once in place become rooted into the biological community where the structures are deployed; to enhance public awareness and understanding for the appreciation and use of the marine environment, as well as the historical, cultural, and archeological resources artificial reefs require protection within the National Marine Sanctuary System.

The United Nations Convention on the Law of the Sea ("UNCLOS") is the most comprehensive international legal agreement for marine conservation to date. Most importantly, UNCLOS shifted the legal assumption that the ocean is an inexhaustible commodity and adopted a precautionary approach that treated the seas as a vulnerable resource worthy of human stewardship (Sylvan, 2006). To fully protect and conserve reefs, management practices need to be updated, enhanced, or better put into action. To start, communication and exchanging of information needs to be implemented and improved at all levels of reef management (Seaman, 2004; Gombos et al, 2010).

2. Impacts on Physical Environment

An environmental assessment that justifies the project site based upon minimum environmental impact must be performed. The environmental assessment should include a description of potential onsite, offsite, and cumulative impacts of the proposed artificial reef construction project on vegetation, threatened or endangered species, fisheries, wildlife, water quality, and cultural resources. Specifically, Project Site Selection and Environmental Assessment requires a general location map using the most recent NOAA nautical chart showing:

1. The chart name, chart number, and date of chart;
2. The coastline adjacent to the proposed deployment location;
3. The bearing and distance (in nautical miles) from a described navigational marker or distinctive topographical feature (e.g. mouth of inlet) to the proposed deployment location.
4. Area of the permitted site in acres and/or square nautical miles;
5. Center and corner coordinates in latitude/longitude format as described in the Army Corps of Engineers permit;
6. Minimum and maximum water depths (feet, MLW) for the permitted site; and
7. The location of the closest natural habitats (e.g., hardbottom) to the deployment site.

In addition, include a discussion of the availability of other relevant prior biological, or environmental data associated with the proposed reef site or general reef vicinity, with determinable factors of the range of wave height, current velocity, temperature, salinity, visibility, tidal range, and other physical oceanography conditions and how those factors may affect the project including:

1. A detailed description and discussion of the reef design and configuration, habitat complexity, interstitial spaces, surface area, material placement and positioning.
2. A demonstration of the durability and stability of the reef material at the depth proposed for placement based on prior field evaluations or stability analyses.
3. A written artificial reef monitoring and assessment plan.
4. The presence of at least one navigable inlet access point of the project site.
5. A demonstration of public support for the proposed artificial reef project, based upon written letters or resolutions.

III. SHORELINE STABILIZATION UTILIZING ARTIFICIAL REEFS

The purpose of reef breakwaters is to reduce the hydraulic loading to a required level that maintains the dynamic equilibrium of the shoreline (Penchev 2004). Reefs promote wave breaking, reducing action on the shore, providing shoreline stability, restricting coastal erosion, and preserving existing or artificially nourished beaches. Reef breakwaters are frequently used when erosion control is needed. Water transfers its dynamic forces to the surrounding shoreline whenever currents or wave movements occur. Particles within water beds and shorelines are carried away and deposited elsewhere, resulting in sedimentation and erosion.
Reef breakwaters are often constructed as rubble mound structures that include using special shaped blocks, reef balls, geo-tubes to create artificial reefs and submerged sills. The distinction between breakwaters and submerged sills can be made by noting their effects on waves and sediment transport (Penchev 2004). Breakwaters reduce waves; submerged sills act as barriers to shore-normal sediment motion. Artificial reefs are always submerged.

A submerged breakwater using artificial reefs can be designed so that waves break on the structure, reducing the wave energy that reaches the shore (Harris 2009). This wave attenuation is quantified by the wave transmission coefficient, which is the ratio of the transmitted wave height to the incident wave height. During periods of smaller wave action little or no wave attenuation occurs as waves pass over the structure, allowing for the normal coastal processes to occur with little disruption and minimizing any adverse effects to the coastlines. During periods of larger waves, the submerged breakwater forces the waves to break, reducing the wave energy reaching the shore, and reducing the erosion of the coastlines.
Artificial reefs allow shoreline stabilization by mimicking the functionality of natural reefs. Recent breakwater projects constructed using artificial reefs in shallow water reduce wave energy reaching the shore. This provides possible recreational benefits associated with artificial reefs, such as swimming, snorkeling, diving, fishing and surfing.

When waves break at an angle to the shoreline it can produce a longshore current that can transport sand down the coast. The greater the angle of the waves to the shoreline the greater the magnitudes of the longshore current and littoral transport of sand. As waves enter shallower water, they bend to become parallel to the shoreline. For waves that travel across wide and shallow breakwaters the wave refraction can reduce the magnitude of the longshore current and sand transport, reducing sand losses from an area (Mead and Black, 2002) and assist with shoreline stabilization due to the wave refraction effects.

Artificial submerged reefs need to respond to the growing demand for environmentally friendly solutions to coastal protection (Penchev 2004). Submerged breakwaters must be designed and constructed such that the structure is high enough to significantly reduce wave action and reduce offshore losses; reduce longshore currents instead of increasing them; avoid creating zones with high velocities with properly engineered placement of reefs; and consideration is given to any potential hazards to coastal navigation.

A. Engineering and Science of Artificial Reefs for Erosion Mitigation

The effect of artificial reefs varies with wave amplitude, wavelength, wave exposure, suspended sediment concentration, and complexity of the substrate. The offshore submerged reef has the capacity to be a very sophisticated with many adjustment factors. Offshore reefs can be permanently submerged or located inter-tidal where the breakwater is periodically exposed. In each case, the depth of the reef, its size and its position relative to the shoreline determine the coastal protection level provided by the reef.

Due to the complexities in wave breaking, models are used to determine the wave transmission coefficients for various materials. Reef break waters provide a sensitive engineering solution targeted to maintain the dynamic equilibrium of the shoreline. A competent economical and functional design method requires the knowledge of relationships linking wave transmission and set-up behind the structure with freeboard, crest width, structure permeability, and other reef parameters. The roles played by these parameters are still being studied.

Regarding wave transmission, several empirical formulae have been proposed. These formulae derive from data collected from different laboratories. Design formulae have indicated a variety of important variables associated with wave transmission over submerged breakwaters. The most important physical variables that affect the transmission coefficient $K_t = H_t / H_i$ have been identified as:

b - crest width of breakwater
d - freeboard
h - water depth (in front of the structure)
m - front slope (or other parameter for the shape) of the breakwater
n - permeability (or other parameter for permeability)
D_{50} - nominal material diameter of the cover layer
H_i - incident wave height
H_t - transmitted wave height
L - wavelength at local depth

Ahrens (1987) presented an empirical wave transmission design formula for submerged breakwaters, where most of these parameters are included.
Van der Meer (1990) analyzed hydraulic model tests by Seelig (1980), Powell and Allsop (1985), Daemrich and Kahle (1985), Ahrens (1987), Van Der Meer (1988).] (Penchev 2004).

Modern numerical models provide a good possibility to simulate the processes and to compute hydrodynamic behavior in detail. Physical model studies are still a powerful tool to improve the knowledge on the processes of interaction of waves with engineering structures. An essential part of testing is to provide results of measurement of the transmitted wave height, and the wave energy dissipation rate. Tests under irregular waves have proven that, for the given reef construction, and a relative submergence of d / h = 0.15 the most part of the wave energy dissipates during the wave-structures interaction process, mainly due to the wave breaking. Testing parameters (wave height, distance of breaking, as well as wave envelopes) have been conducted estimating characteristics of waves breaking over reefs to measure the dissipation of wave energy when breaking.

General design guidelines developed for offshore breakwaters by the U.S. Army Corps of Engineers refer to the design wavelength and breakwater layout (length, offshore distance and gap width), (ROSATI, 1990; CIRIA, 1991). Equations 1 and 2 below list those guidelines suggested by ROSATI (King, D.M., et al., 2000).

(1) $L \geq 2 \times \lambda_d$ and $L \approx X$

(2) $G \leq \lambda_i$

where L = breakwater length, G = gap between adjacent breakwaters, X = breakwater distance offshore, and λ is wavelength, (subscript *d* for design wavelength and *i* for the wavelength of incident waves).

The natural character of the shoreline must also be considered. When developing breakwaters or deploying artificial reefs, all options to provide a complete solution need to be explored using a sophisticated view of an interrelated protective system to achieve the desired outcome (Black, 2001).

B. Artificial Reefs in Practice

There are several reasons to consider the use of erosion control structures. The primary reason is to reduce beach erosion on a case-by-case basis along the open coast. There are many examples worldwide of erosion control structures that have been used to successfully retain sand and control erosion (ASBPA 2011). In countries with limited resources beach sand and coral are used for construction. Many times, sand or the lack of sand can be a problem and rock wall structures are built that unnecessarily change the character of the beach permanently. In places such as Bali and Indonesia where there is a split over the need for rock walls or groins, it is generally cost determinative to what defense against erosion prevails; whereas in England, the government has regulations in place to minimize changes to the natural character of the shoreline to one of human control (Black, 2001). Japan’s coastline has been barricaded for wave protection and tsunami protection.

The methods and types of shoreline protection depends on that country’s ecological views, such as in Australia, New Zealand and the United States and the need to prevent erosion. One design of artificial reef / groins that have been used to construct a breakwater is the Reef Ball. It can be easily manufactured in various sizes, weights and features (Harris 2007). This is economical because of their ease of fabrication using molds, ease of deployment and secondary use as habitat for selected benthic and pelagic species.

In Australia and New Zealand, the development of a coastal industry has been induced for the protection of the natural character of the shoreline. The government put in place strong management legislation through the Resource Management Act (1991). The unification of an international group of coastal scientists, planners and legal advisers, plus strong cultural support for protection of natural resources, has led to the establishment of the "Artificial Reefs Program" in New Zealand (BLACK et al., 1997a). Submerged reefs off Australia's coast have been constructed using a cost-benefit analysis that shows the shoreline re-nourishment has been projected to increased tourist revenue (Black, 2001). Recreational and public amenity can be incorporated through surfing, diving, sheltered swimming, water games, fishing and marine habitat. Additionally, the benefits of offshore reefs are relevant to coastal research by using a series of natural examples, case studies and model simulations (FWC).

Holly Beach, Louisiana, is an example of a breakwater field combined with a beach nourishment project in 2001 that is performing well. The sub-aerial beach was constructed using sands buried in an offshore channel located about 3.5 miles offshore. Prominent salient sediment deposition*??(There was no relevant word here……please check with the author)* has formed in the lee of the emergent segmented breakwaters (Mann and Thomson, 2003). Within nourishment projects, hot spot erosion areas are often good candidates for structures as they typically lose sand and storm protection well before the scheduled renourishment of the beach. This usually results in renourishing early and more frequently than planned and an increase in cost (Elko et al., 2005). Structures can be introduced to slow the erosion or stop it from eroding altogether. Long breakwater fields (10 or more breakwaters) will reduce both littoral transport and littoral transport gradients but may not eliminate erosion within the field (Mann and Thomson, 2003). At Holly Beach, monitoring showed that the littoral transport was reduced uniformly by the breakwaters, but the littoral transport gradient was not eliminated. Therefore, erosion continued within the breakwater field, albeit at a reduced rate, and thus required nourishment.

IV. SOUTH CAROLINA'S ARTIFICIAL REEFS

Coral reefs are among the most biologically diverse and valuable ecosystems on Earth. An estimated 25 percent of all marine life, including over 4,000 species of fish, are dependent on coral reefs at some point in their life cycle. Approximately half a billion people globally depend on coral reef ecosystems for food, coastal protection, and income from tourism and fisheries. The coral reef structure buffers shorelines against waves, storms, and floods, helping to prevent loss of life, property damage, and erosion. When reefs are damaged or destroyed, the absence of this natural barrier can increase the damage to coastal communities from normal wave action and violent storms (NOAA, https://oceanservice.noaa.gov/facts/coral_protect.html).

Healthy coral reefs provide: habitat, feeding, spawning, and nursery grounds for over 1 million aquatic species, including commercially harvested fish species; food for people living near coral reefs, especially on small islands; recreation and tourism opportunities, such as fishing, scuba diving, and snorkeling, which contribute billions of dollars to local economies; protection of coastal infrastructure and prevention of loss of life from storms, tsunamis, floods, and erosion. All of the services provided by coral reefs translate into tremendous economic worth. By one estimate, the total net benefit per year of the world's coral reefs is $29.8 billion. In the U.S., the National Marine Fisheries Service estimates the annual commercial value of U.S. fisheries from coral reefs alone to be over $100 million annually (2001). Reef-based recreational fisheries generate another $100 million annually in the U.S (EPA, https://www.epa.gov/coral-reefs/basic-information-about-coral-reefs).

Naturally occurring coral reefs exist in seven U.S. states and territories, including: Florida, Puerto Rico, U.S. Virgin Islands, Hawaii, Guam, American Samoa, and the Commonwealth of the Northern Mariana Islands. There are also coral reefs 100 miles offshore of Texas and Louisiana in the Gulf of Mexico, living on the tops of geologic 'mesas'.

An artificial reef is a manmade structure that may mimic some of the characteristics of a natural reef. Marine resource managers also create artificial reefs in underwater areas that require a structure to enhance the habitat for reef organisms, including soft and stony corals and the fishes and invertebrates that live among them. There are now companies that specialize in the design, manufacture, and deployment of long-lasting artificial reefs that are typically constructed of limestone, steel, and concrete (NOAA, https://oceanservice.noaa.gov/facts/artificial-reef.html).

A. <u>History of Artificial Reefs in South Carolina</u>

The South Carolina Marine Artificial Reef Program was created in 1973 for the purpose of enhancing recreational fishing and diving opportunities in the state's coastal waters and to enhance marine and estuarine fishery stocks by increasing the amount of productive hard bottom habitat on the ocean bottom. Only about 5-10 percent of the continental shelf off the southeastern coast is comprised of naturally occurring live- bottom reef areas. These areas are heavily exploited and often over-fished by recreational and commercial anglers. Creation of artificial reefs provide a readily accessible habitat to relieve fishing pressure on these areas by placing suitable, environmentally safe materials (usually concrete or steel) on permitted areas of the ocean bottom. These materials then provide the hard substrate necessary for the formation of a live-bottom reef community (Martore, 2007).

The South Carolina Marine Artificial Reef Program has received Saltwater Recreational Fisheries License revenues since inception of the Recreational Fisheries Stamp Program in 1991. Prior to that time, the program was minimally staffed with state-supported personnel but had no annually dedicated funds to support reef construction activities. Artificial reefs were constructed solely through donated materials and services or through funds specifically appropriated for individual projects. Since the addition of Fisheries revenues, reef materials became more evenly distributed among coastal counties, more suitable reef materials could be manufactured or purchased and the overall development of South Carolina's artificial reefs more effectively managed (Martore, 2007).

There are 45 active public permitted fishing reef sites. Each reef site receives multiple material deployments over time. Program development is measured by the total number of deployments made each year. A single deployment is made up of any material placed on a reef site at any one time, for example, the sinking of a vessel or placement of an individual barge load of material such as culvert pipe or bridge rubble. From 1973 through 1991, the Marine Artificial Reef Program averaged 5.7 material deployments per year. Since FY2008 there have been 111 deployments which include over 3000 concrete culvert pipes, over 100 concrete junction boxes, 352 designed concrete modules, over 1000 tons of concrete rubble, 48 miscellaneous steel structures, 44 subway cars, 18 barges (40’ – 260’), 7 boats/ships (24’-175’) and 276 armored personnel carriers (Martore, 2015).

New offshore reef sites have been permitted in areas of heaviest artificial reef usage or to function in alternative capacities (i.e. Charleston Deep Reef – an Artificial Reef Marine Protected Area), however, the total number of permitted artificial reef sites has deliberately been kept at current levels. Several previous reef sites are no longer maintained while new sites are permitted. The primary reason for discontinuing reef sites is a lack of production for several inshore reefs (Martore, 2015).

Offshore reef areas range in size from 1200-foot circles for nearshore sites (26 acres) up to 1.5 nautical mile squares for those sites farthest offshore. The majority of offshore sites are half nautical mile squares (206 acres). These dimensions encompass areas vast enough to accommodate a tremendous amount of usable reef material. While some reef sites may appear to contain large numbers of structures the actual footprint of those materials, even on the most heavily constructed reef sites, is actually only 2-3% of the available permitted bottom, leaving a great deal of room for further expansion on those sites. Underwater observations have shown that the greater concentrations and complexity of materials hold greater densities of fish than lesser developed areas. Therefore, from a biological standpoint, continued development and enhancement of current reef sites will provide a greater return (Martore, 2015).

In addition to monitoring the physical characteristics of artificial reefs, information concerning user populations is collected. Growth along South Carolina's coast results in an increasing strain on our available natural resources. Artificial reefs help alleviate fishing pressure and user conflicts on existing productive areas by providing saltwater recreational anglers and divers with productive habitats located at numerous and readily accessible locations. By maintaining this information on artificial reef users, construction activities are able to better accommodate the increase in participants.

Material deployments on all currently active, permitted artificial reefs since 2008 have averaged nearly 15 reef deployments per year with the material distributed to almost every reef site off every coastal county. The availability of different types of reef building materials has varied widely through the years. While outdated and surplus steel-hulled vessels of various designs were once fairly numerous, the rise in scrap metal prices has significantly limited their availability. In contrast, an increase in roadway and construction projects around the state has resulted in an abundance of surplus concrete structures like culvert pipe and junction boxes. A wide variety of materials continue to be utilized on the state' s reef sites. A complete list of all reef deployments including location and material type can be found online at http://www.dnr.sc.gov/artificialreefs/docs/ReefGuide2015.pdf - Guide to South Carolina Marine Artificial Reefs (South Carolina Department of Natural Resources, September 2015).

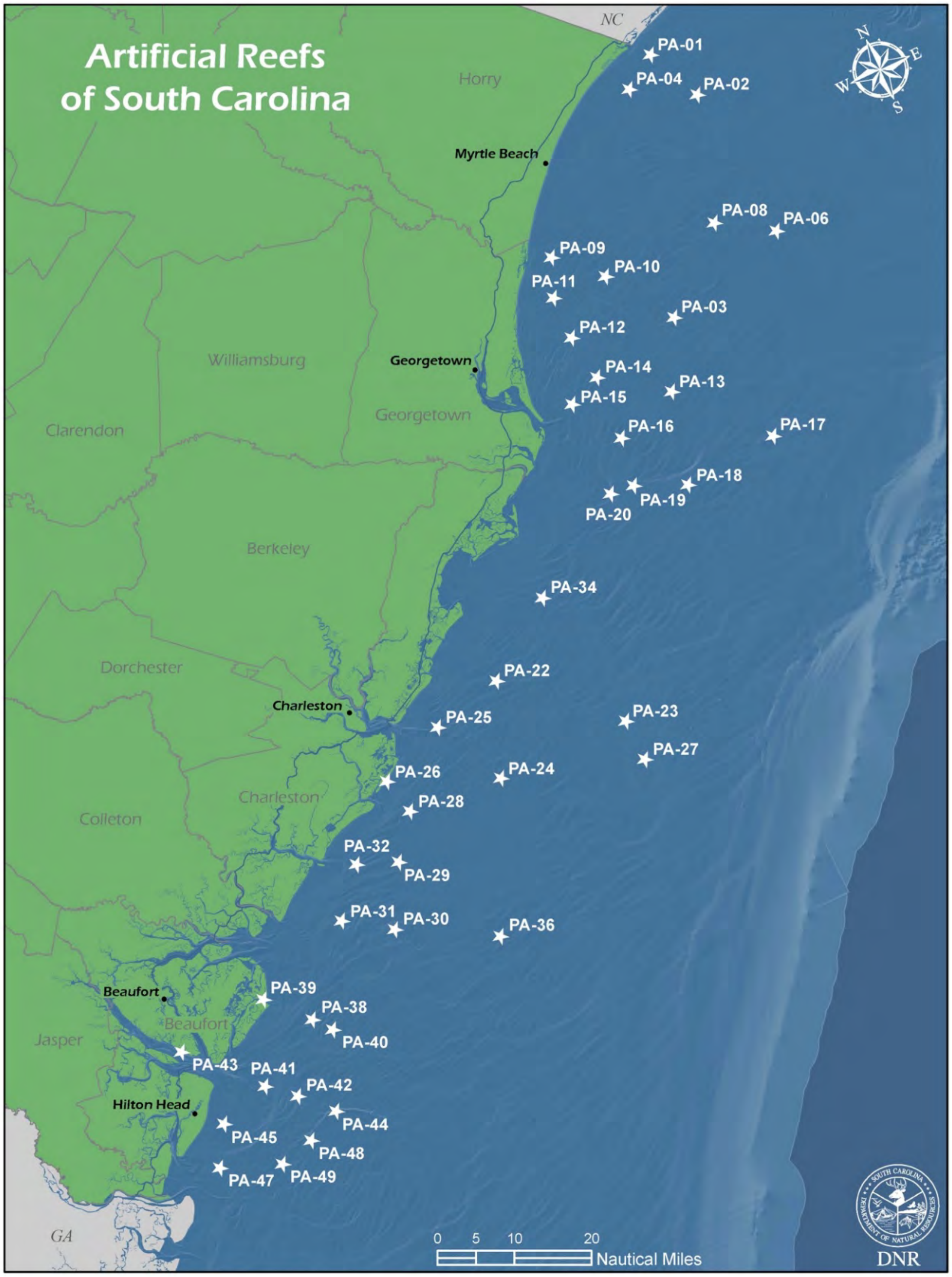

FIGURE 3: Illustration from "Guide to South Carolina Marine Artificial Reefs" (SCDNR – September 2015).

1. Examples of SC Marine Artificial Reef Materials (Martore, 2015)

a) *Steel-hulled Vessels*

Since 2008, a total of 25 steel-hulled vessels have been sunk on the state's reef sites with each coastal county receiving multiple vessels. These include deck barges ranging from 40 feet to 260 feet in length, recreational vessels such as a pontoon boat, shrimp trawlers, tugboats, and even a 175-foot coastal freighter. These vessels require differing amounts of cleanup and preparation and, therefore, have different associated costs. In some instances, even a vessel that requires little in the way of cleanup, like a deck barge, may incur greater towing costs depending on the distance to an appropriate reef site. Significant funding is required to ensure relative equity in vessel placement among the state's reef sites.

95-foot tugboat sunk on the Little River Offshore Reef.

80-foot trawler sunk on the Comanche Reef.

FIGURE 4: Photographs of vessels used for marine artificial reefs in South Carolina (Martore, 2015).

b) *Concrete Material* (Martore, 2015)

Concrete structures, both surplus and designed, are the most utilized material for artificial reef construction in South Carolina, primarily because of their abundant availability across the state. In most instances surplus materials like culvert pipe and concrete boxes are donated to the reef program at no cost but must be trucked to dockside staging and loading areas. Marine towing and deployment costs are the greatest expenses incurred with this type of material. In some cases, such as with memorial reefs, individuals or organizations prefer to use designed materials like reef cones or the patented Reef Balls and are willing to donate funds to the program in order to do so. The reef program has utilized over 3000 surplus concrete structures, more than 350 designed concrete modules, and over 1000 tons of concrete rubble.
The wide range of shapes and sizes of concrete material has afforded the reef program the ability to observe the effects of these parameters on fish assemblages.

All concrete material has proven to be effective in rapidly creating reef communities. The similarity to natural limestone rock enables these structures to become quickly colonized by marine invertebrates and to rapidly and effectively produce and hold a variety of important fish species. Surplus concrete structures are available in a variety of shapes and sizes.

FIGURE 5: Photographs of concrete being dropped in the Gulf of Mexico off of Marco Island, Florida for the creation of artificial reef habitats (Naples Daily News, Jan. 2015).

Most designed concrete structures are equally effective in creating productive reef communities.

FIGURE 6: Photographs of designed concrete structures (The Reef Ball Foundation - http://www.reefball.org).

c) *New York City Subway Cars* (Martore, 2015)

The New York City Transit Authority periodically retires older subway cars and, on some occasions, offers them to states as artificial reef material. The initial deployment of 200 subway cars off South Carolina in 2002-2003 was highly successful in creating a stable, productive habitat that proved to be extremely popular with anglers and divers. In 2008 the city of New

York once again offered states additional subway cars for reef material. The South Carolina Marine Artificial Reef Program received 44 of these newer, slightly larger, stainless steel subway cars that were deployed on the Bill Perry Jr. Reef which is located equidistant between Murrells Inlet and Little River Inlet off Georgetown and Horry counties. This deployment received a great deal of fanfare and publicity. Since this deployment the New York City Transit Authority has not offered any additional subway cars to state reef programs, although they have not ruled out doing so again in the future.

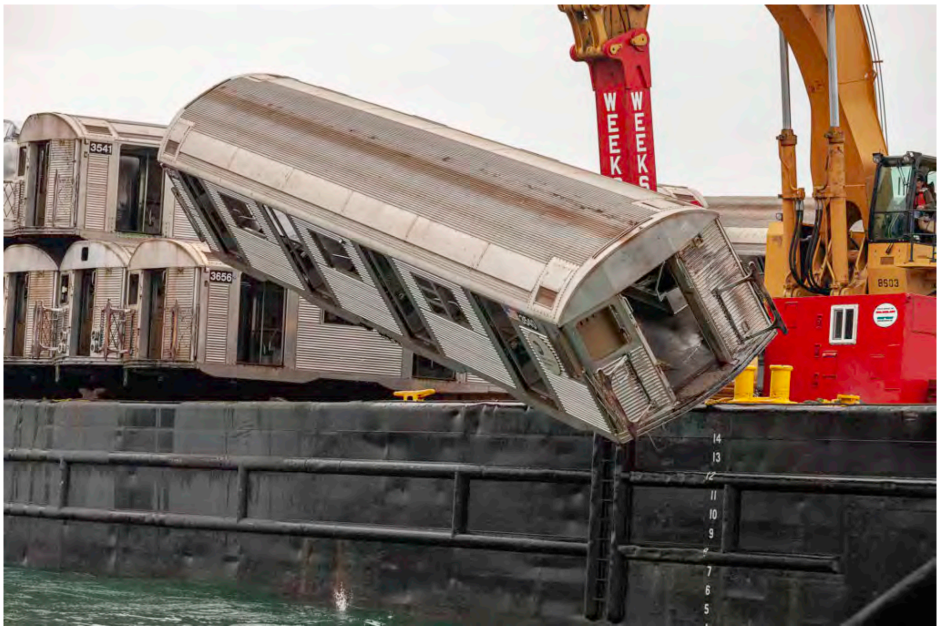

FIGURE 7: Photograph of New York City Subway car dropped in the Atlantic to become an artificial reef (*Air Break, 2008. Photo by Stephen Mallon - https://www.6sqft.com/photo-exhibit-shows-10-years-of-subway-cars-dropped-in-the-atlantic-ocean-to-become-artificial-reefs/*).

d) *Armored Military Vehicles* (Martore, 2015)

Since 1997 DNR' s artificial reef program has conducted joint reef building projects with the South Carolina Army National Guard (SCARNG). These projects, termed 'Reef-Ex' by the military, are funded primarily by the Department of Defense; however , they require that SCDNR contribute a percentage of the project, in the form of buoys, personnel time and underwater surveys, all of which are paid for by Saltwater License funds. Since 2008, 276 armored personnel carriers, as well as numerous 20-foot long steel container boxes and concrete culvert pipe, have been contributed, cleaned, prepared by SCARNG and deployed on reef sites all along the coast. Because of the design and construction of these military vehicles they have proven to be highly stable and productive structures on the reef site.

B. Permitting a Near Shore Artificial Reef Along the South Carolina Coast

1. Guidance from SCDHEC OCRM

In 1977, The South Carolina Coastal Zone Management Act was passed by the General Assembly of South Carolina to provide for the protection and enhancement of South Carolina's coastal resources. Under the Act, the South Carolina Department of Health and Environmental Control (DHEC) has direct statutory authority within the eight coastal counties (Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, Horry and Jasper) for all structures and alterations within the critical area, including coastal waters, tidelands, beaches and the beach/dune system. DHEC is also empowered to review all state and federal permit applications and activities to determine their consistency with the South Carolina Coastal Zone Management Program.

DHEC's Office of Ocean and Coastal Resource Management (OCRM) is the designated state coastal management agency and is responsible for the implementation of the state's Coastal Management Program. Implementation includes the direct regulation of impacts to coastal resources within the critical areas of the state including coastal waters, tidelands, beaches and beach dune systems; and indirect certification authority over Federal actions and state permit decisions with the eight coastal counties (SCDHEC Laws and Regulations: Coastal Zone).

To date, artificial reefs in SC have been constructed either offshore for habitat benefits or along estuarine shorelines for the dual purpose of improving habitat and reducing erosion.

SC DHEC OCRM has provided the following guidance for the steps involved for permitting a nearshore artificial reef along a South Carolina ocean beach.

The Department would review the proposal through our Major Special Critical Area Permit process (see **S.C. Code Ann. Section 48-39-290(D)** and **S.C. Code Ann. Regs. 30-15(F)** (See Appendix A).

In addition, the Department would evaluate the project based on the General Guidelines for Beaches and the Beach/Dune System in **S.C. Code Ann. Regs. 30-11(D),** the Further Guidelines, which apply to all projects in **S.C. Code Ann. Regs. 30-11(C),** and the regulations applicable to jetties and offshore breakwaters found in **S.C. Code Ann. Regs. 30-13(N)** (See Appendix A).

Reg. 30-13(N) specifically states:
(1) Jetties and offshore breakwaters interfere with the natural transport of sediment and therefore require special permits. They shall only be permitted after thorough analysis of the project demonstrates that there will be no negative effect on adjacent areas.
And,
A monitoring plan to assess post-project impact on adjacent areas must be approved by the Department prior to the issuance of a permit.

To comply with guidance from OCRM, a nearshore artificial reef would need to be designed by a coastal engineer and be analyzed for potential local and downdrift impacts, would be evaluated by other state and federal agencies, and would be subject to extensive monitoring requirements (similar to current monitoring requirements for groins). The Department would likely apply similar requirements as those for groins, found in **R.30-15(G)** (see Appendix A). To protect against the potential for significant impacts from this type of structure along ocean shorelines, any proposal would need to be extensively analyzed during the design process before being submitted to the Department.

In the design phase of an artificial reef for wave attenuation, in addition to the coastal engineer's analysis of local and downdrift impacts, beach nourishment and longshore transport, an analysis should be completed to address the following concerns:

a. Impacts to rare, threatened, endangered species
b. Impacts on commercial and recreational fisheries
c. Impacts to essential fish habitat
d. Effects on storm runoff and submarine discharge
e. Impacts on navigation
f. Impacts on Atlantic Training and Testing Area and minefield impact

Additional state permits may be required including:

a. 401 Water Quality Certification
b. State Navigable Waters Permit
c. Coastal Zone Consistency Certification

2. Coordination and Certification with Other Agencies

In addition to state requirements, coordination with the following federal and other agencies and entities must be considered:

a. National Marine Fisheries Service
b. U.S. Fish and Wildlife Service
c. U.S. Army Corps of Engineers
d. U.S. Coast Guard
e. Bureau of Ocean Energy Management
f. U.S. Navy's Atlantic Fleet Training and Testing Area
g. South Atlantic Fishery Management Council
h. South Carolina Ports Authority
i. Atlantic States Marine Fisheries Council (Habitat Areas of Particular Concern)

3. Coordination with Local Authorities

As with the construction of groins, coordination with, and written approval from, the local government which has jurisdiction in the area where the proposed artificial reef is to be located is required. In addition, a financially binding commitment, such as a performance bond or letter of credit may be required that is reasonably estimated to cover the cost of reconstructing or removing the artificial reef and/or restoring the adversely affected beach through renourishment may be required.

V. THE ARMY CORPS OF ENGINEERS – ASSISTANCE

In 2013, the US Army Corps of Engineers (USACE) reported (US Army Corps of Engineers 2013), "Recent hurricane events have emphasized the increasing vulnerability of coastal areas to natural disasters through the combination of changing climate, geological processes, and continued urbanization and economic investment. Improving resilience—the ability to anticipate, prepare for, respond to, and adapt to changing conditions and to withstand and recover rapidly from disruptions with minimal damage—is a key objective of reducing risk….

Coastal risk reduction can be achieved through a variety of approaches, including natural or nature-based features (e.g., wetlands and dunes), and structural interventions (e.g., seawalls and breakwaters). Natural and nature-based features can attenuate waves and provide other ecosystem services (e.g., habitat, nesting grounds for fisheries). However, they also respond dynamically to processes such as storms, both negatively and positively, with temporary or permanent consequences. Perhaps more well-known are the structural measures that reduce coastal risks by decreasing shoreline erosion, wave damage, and flooding (US Army Corps of Engineers 2013).

The Federal, state, local, NGO, and private sector interests connected to our coastal communities possess a complementary set of authorities and capabilities for developing more integrated coastal systems. The effective implementation of an integrated approach to flood and coastal flood hazard mitigation relies on a collaborative, shared responsibility framework between Federal, state, and local agencies and the public." (US Army Corps of Engineers 2013).

Several authorities and missions of the USACE support U.S. coastal risk reduction through measures that increase the resilience of coastal systems.

A. Army Corp of Engineers Authorities for Assistance

1. Section 22 - Planning Assistance to States

Section 22 of the Water Resources Development Act, commonly known as Planning Assistance to States (PAS), is an authority granted to the U.S. Army Corps of Engineers to cooperate with states, political subdivisions of states, and Federally recognized Native American tribes to provide planning assistance in any matters related to water resources. No design or construction is authorized under this program. Examples of services that can be performed under this authority include water supply studies, stormwater management studies, watershed studies, water resources and recreation planning, data collection, master drainage planning, surveying floodplain inventories, and pipe network analyses (USACE – Section 22).

The program does not give the Corps the authority to complete detailed final designs or construction activities.

Any non-Federal government entity can serve as the Sponsor for a PAS study. Project initiation requires a letter to the District office requesting Corps assistance.

All study costs are shared at a rate of 50% Federal, 50% Sponsor. The Sponsor may contribute their share as in-kind services.

There is a spending cap of $5,000,000 Federal expenditure per state or tribe per fiscal year. (Individual studies are typically funded for less than the maximum allowed.)

Annual Federal program limit is $45 million.

All studies are subject to availability of Federal appropriations.

PAS studies vary greatly in size and scope. Some can be completed in a few months from receipt of funds, while others may take a full 12-18 months to complete. In some cases, multi- phased studies can be completed over the course of 2 years, subject to availability of Federal funds.

2. <u>Section 103 - Hurricane and Storm Damage Reduction</u>

Section 103 of the 1962 River and Harbor Act gives the U.S. Army Corps of Engineers the authority to plan, design and construct measures to provide protection to properties against damages caused by storm driven waves and ocean currents. Section 103 projects cannot be undertaken on private beaches or where no public access to the beach exists (USACE – Section 103).

Any non-Federal government entity can serve as the Sponsor for a Section 103 project. Project initiation requires letter to the District office requesting Corps assistance.

The initial $100,000 of any Section 103 Feasibility Study is paid 100% by the Federal government. All additional feasibility expenditures are cost shared at a rate of 50% Federal, 50% Sponsor. The Sponsor may contribute work in kind for their share.

The Sponsor shall provide all necessary lands, easements, rights-of-way, and any relocation of utilities necessary for project construction and subsequent operation and maintenance of the project. Costs associated with these items may be creditable towards the non-Federal cash contribution for the project.

The Design and Implementation Phase is cost shared 65% Federal and 35% Non-Federal.
There is a spending cap of $10 million of Federal expenditure per Section 103 project.
Annual Federal program limit is $30 million.

Section 103 feasibility studies can take approximately 24 to 30 months and include two major milestones. The first milestone is a Federal Interest Determination document to be accomplished with the first $100,000. The second milestone is a Major Subordinate Command Decision Milestone (MDM) to discuss the selected alternatives for a potential construction project. The outcome of the MDM and the feasibility study will be a Detailed Project Report. The feasibility study includes all alternatives analysis, design work, NEPA compliance, and benefit-cost analysis. Construction time varies depending on the project being implemented.

3. Section 204 - Beneficial Use of Dredged Material

Section 204 of the Water Resources Development Act of 1992 gives the U.S. Army Corps of Engineers the authority to implement projects for the protection, restoration and creation of aquatic and ecologically related habitats in connection with the construction or maintenance dredging of an authorized navigation project. (USACE – Section 204).

Any non-Federal government entity can serve as the Sponsor for a Section 204 project. In some cases, non-government agencies may serve as Sponsors. Project initiation requires a letter to the District office requesting Corps assistance.

The Feasibility Phase is 100% Federally Funded.

The Design and Implementation Phase is cost shared 65% Federal and 35% Non- Federal.

There is a spending limit of $10 million of Federal expenditure per Section 204 project.

Annual Federal spending limit is $50 million.

Section 204 feasibility studies can take approximately 12 to 24 months and include two major milestones. The first milestone is a Federal Interest Determination document to be accomplished with the first $100,000. The second milestone is a Major Subordinate Command Decision Milestone (MOM) to discuss the selected alternatives for a potential construction project. The outcome of the MOM and the feasibility study will be a Detailed Project Report. The feasibility study includes all alternatives analysis, design work, NEPA compliance, and benefit-cost analysis. Construct ion time varies depending on the project being implemented.

4. Section 205 - Flood Damage Reduction

Section 205 of the 1948 Flood Control Act gives the U.S. Army Corps of Engineers the authority to plan, design and construct flood risk management projects. These projects can be structural projects, such as modified channels, small reservoirs or small levees, or can be non-structural measures such as raising structures in place or removing them from the floodplain (USACE – Section 205).

Any non-Federal government entity can serve as the Sponsor for a Section 205 study. Project initiation requires a letter to the District office requesting Corps assistance. All Section 205 Sponsors must comply with the Federal flood insurance plan and prepare floodplain management plans within 1 year of project completion.

First $100,000 of the Feasibility Phase is 100% Federally Funded.

The remainder of the Feasibility Phase is cost-shared 50%/50%.

The Design and Implementation Phase is cost shared 65% Federal and 35% Non-Federal.

The sponsor must contribute in cash a minimum of 5 percent of the total project cost. The sponsor must also pay for and obtain all lands, easements, rights of way and relocations (LERR) for the project.

There is a spending cap of $10 million of Federal expenditure per Section 205 project.

Annual Federal program limit is $55 million.

All studies are subject to availability of Federal appropriations.

Section 205 feasibility studies can take up to 2 years to complete and include two major milestones. The first milestone is a Federal Interest Determination document to be accomplished with the first $100,000. The second milestone is the Major Subordinate Command Decision Milestone (MOM) to discuss the selected alternatives for a potential construction project. The outcome of the MOM and the feasibility study will be a Detailed Project Report. The feasibility study includes all alternatives analysis, design work, NEPA compliance, and benefit-cost analysis. Construction time varies depending on the project being implemented.

5. <u>Section 206 - Aquatic Ecosystem Restoration</u>

Section 206 of the Water Resources Development Act of 1996, as amended, gives the U.S. Army Corps of Engineers the authority to carry out aquatic ecosystem restoration projects if the project will improve environmental quality, is in the public interest, and is cost effective. Most of Section 206 projects include a combination of hydrologic manipulation, structural restoration, and biological restoration. Section 206 project cannot be undertaken for the sole purpose of improvement of water quality. There must be an aquatic ecosystem benefit other than improved water quality (USACE – Section 206).

Any non-Federal government entity can serve as the Sponsor for a Section 206 project. In some cases, non-government agencies may serve as Sponsors. Project initiation requires a letter to the District office requesting the Corps' assistance.

First $100,000 of the Feasibility Phase is 100% Federally Funded.
The remainder of the Feasibility Phase is cost-shared 50/50%.
The Design and Implementation Phase is cost shared 65% Federal and 35% Non-Federal.
The Non-Federal sponsor cost share can be a combination of cash, Lands, Easements, Rights-of-way, Relocations, and Disposal areas (LERROs) or work-in-kind. Work-in-kind may be provided subsequent to the execution of a Project Partnership Agreement (PPA).
Project costs are limited to $10 million Federal investment per project.
Annual Federal program limit is $50 million per year.
All studies are subject to availability of Federal appropriations.

Section 206 feasibility studies can take up to 2 years to complete and include two major milestones. The first milestone is a Federal Interest Determination document to be accomplished with the first $100,000. The second milestone is a Major Subordinate Command Decision

Milestone (MOM) to discuss the selected alternatives for a potential construction project. The outcome of the MOM and the feasibility study will be a Detailed Project Report. The feasibility study includes all alternatives analysis, design work, NEPA compliance, and benefit-cost analysis. Construction time varies depending on the project being implemented.

B. Flood Plain Management Services

Under the authority provided by Section 206 of the 1960 Flood Control Act (PL 86-645), as amended, the Corps of Engineers can provide the full range of technical services and planning guidance that is needed to support effective flood plain management. General technical assistance efforts under this program includes determining: site-specific data on obstructions to flood flows, flood formation, and timing; flood depths, stages or floodwater velocities; the extent, duration, and frequency of flooding; information on natural and cultural flood plain resources; and flood loss potentials before and after the use of flood plain management measures. Types of studies have been conducted under the FPMS program include flood plain delineation/hazard, dam failure analyses, hurricane evacuation, flood warning, floodway, flood damage reduction, stormwater management, flood proofing, and inventories of flood prone structures (USACE – Flood Plain Management Services).

The program does not give the Corps the authority to complete detailed final designs or construction activities.

Any non-Federal government entity can serve as the Sponsor for PAS. In some cases, non-government agencies may serve as Sponsors. All it takes is a simple request to the District office and a representative will discuss your problem with you and let you know if you qualify for the program.

FPMS is 100% Federally Funded.
Other Federal agencies and private parties must pay 100 percent of the costs of all FPMS efforts. All studies are subject to availability of Federal appropriations.

The process for FPMS assistance begins after a state, regional, local government, or Native American Indian tribe requests Corps of Engineers assistance under the program. When funding is available, the Corps of Engineers will work with the requesting organization to develop a scope of work and assemble the appropriate study team for the effort being requested. At their option, the requesting organization may provide voluntary contributions toward the requested services to expand the scope or accelerate the provision of those services. All requestors are requested to furnish available field survey data, maps, historical flood information, etc., to help reduce the cost of services. The timeline depends on the complexity of the services required.

VI. IMPLEMENTATION AND DELIVERABLES

Establishment of an artificial reef is not a rapid process. As detailed above (Permitting a Near Shore Artificial Reef along the South Carolina Coast), numerous permits are necessary before a reef is authorized. Additional considerations will be necessary for an artificial reef which is designed to impact beach stabilization (see Appendix A: South Carolina Statute and Regulations Pertinent to Major Special Critical Area Permit Process for regulations regarding modification of critical areas and placement of structures shoreward of the DHEC-established baseline). Once a permit is issued, it may take an additional 12-18 months before a reef is in place. While artificial reefs for shoreline protection have been implemented in other parts of the world, no artificial reef to protect a large section of a coastline has been constructed and no reef to protect even a limited section of shoreline has been deployed in South Carolina.

A number of challenges exist in order to construct an artificial reef in South Carolina for shoreline protection:

Financial Analysis: Is an artificial reef for shoreline protection financially feasible? A detailed economic analysis of the cost of a site-specific artificial reef(s) will need to be completed which compares the cost of the proposed reef to current methods of protecting coastal populations and infrastructure (e.g. beach nourishment, adaptation, and relocation), costs of maintaining the reef and if necessary replacement, and the potential impacts on coastal economics (e.g. oil/gas/wind development, commercial fisheries, tourism and recreation). As artificial reefs may only slow the rate of beach erosion, the analysis should also include a combination of shoreline protection, ongoing renourishment programs, and Living Shoreline solutions where appropriate.

Engineering Analysis: Is it possible to engineer a site-specific artificial reef that will effectively reduce coastal erosion and flooding and protect coastal assets? The study will require an analysis of the optimal location offshore, water depth, and depth below the sea surface [note this might be different at different locations along the coast]; the most effective material and design for construction; an analysis of the impacts of the reef(s) on hydrodynamics and negative down-drift impacts on coastal geomorphology; a comparison of the reef's expected effectiveness to other options to mitigate or adapt to coastal changes; and the response of the reef to sea level rise.

Environmental Impact Analysis: What are the environmental impacts of a near-shore artificial reef? Environmental concerns to be addressed include: impacts to rare, threatened, and endangered species; modification of essential fish habitat; interference with fish, turtle, and marine mammal migration; influences on submarine groundwater, piped discharge, and storm water runoff; and any potential the proposed reef may have to concentrate pollutants (oil, trash, fuel) near shore.

Navigation/Safety and National Security Analysis: What effects would a proposed near-shore artificial reef have on navigation and national security? Navigation and issues relating to National Security will need to be considered and addressed prior to installation of any proposed artificial reef.

Proposed Course of Action: Considering these questions for constructing an artificial reef along the South Carolina Coast, we propose the following steps:

1. Consolidate state assets that are devoted to studying and establishing artificial reefs along the coast to mitigate erosion and flooding. Both OCRM and SCDNR Marine Resources Division currently have extensive knowledge of artificial reefs in South Carolina for marine/fishery purposes.

2. Determine to what extent the U.S. Army Corps of Engineers (USACE) can assist the effort by helping to evaluate and assess the feasibility and effectiveness of an artificial reef extending along significant portions of the South Carolina coast and to what extent the USACE Authorities may be utilized to access federal funding for engineering studies.

3. Charge the South Carolina institutes of higher learning and other institutions of higher learning across the United States to develop curricula to study the effects of submerged breakwaters on wave energy dissipation for the purpose of utilizing the findings in engineered artificial reefs in South Carolina.

4. Construct 1-2 demonstration reefs seaward of coastal areas experiencing erosion. This would require:
    a. Identifying suitable areas.
    b. Conducting a study of the coastal morphology and hydrodynamics of the areas if they do not exist.
    c. Engineering an artificial reef(s).
    d. Obtaining local, state, and Federal permits.

5. Construct and deploy the reef(s) and evaluate the impact of the reef for its desired effect and for additional impacts as outlined above. Reefs should be studied for long enough to include seasonal changes in coastal conditions and episodic events such as storms and hurricanes.

6. In conjunction with 1, 2 and 3, coordinate with local municipalities and NGOs to address their needs and concerns regarding the initial demonstration reef(s) and the potential for reefs covering significant segments of the coast.

7. In conjunction with steps 1, 2, and 3, conduct the necessary studies to assess the environmental impacts of an extensive, nearshore artificial reef.

8. Design additional reef(s) covering significant portions of the South Carolina coast based on the results from the demonstration reefs.

The models for combining local, state, and federal funding for beach nourishment might be adapted to construct artificial reefs. Legislation and regulatory amendments may be needed to accommodate artificial reefs designed primarily for shoreline protection which are close enough to shore and the sea surface to be effective in stabilizing beaches.

As an alternative to designating DHEC/DNR the task of designing and deploying artificial reefs, an institute could be established within the South Carolina University system devoted to studying the ramifications of and working towards the establishment of an extensive artificial reef system. This approach has the advantages of including an educational component in the process and engaging geologists, biologists, engineers, attorneys, and policy experts in an interdisciplinary effort. The charge of such a 'center of excellence' should also be broadened to include the work of other Floodwater Commission task forces (e.g. Living Shorelines) and could greatly enhance our general understanding of South Carolina's coastal ecosystem beyond the study of methods for floodwater control and mitigation.

A. Deliverables – Timeline

Short Term

- Determine the South Carolina State agency or entities responsible for the initial phases of the study.
- Plan the demonstration reef(s).
- Initiate necessary state legislation/regulation changes.
- Acquire all necessary permits for the demonstration reef(s).
- Acquire funding for construction.

Mid Term

- Deploy demonstration reef(s) and study their effectiveness and impacts.
- Initiate studies to address the economic, environmental, and social impacts of an extensive artificial reef system.

Long Term

- Continue impact studies.
- Conclusions of Impact Studies of demonstration reef(s) – Economic, Environmental, and Social.
- Recommendations for expansion of reef systems.

B. Conclusion

Sea level rise and the projected increase in the frequency and severity of storms threaten South Carolina's coastal infrastructure and its billion-dollar recreation and tourist industry. South Carolina is spending millions of dollars annually to protect its beaches and coastal systems and these costs are only expected to increase. Artificial reef(s) and/or barrier breakwaters are known to be effective at stabilizing beaches and mitigating coastal flooding. Artificial reefs have not been used extensively in the United States and never in South Carolina, but they have the potential to protect the coast with low environmental impact if designed and constructed properly. South Carolina should take the necessary steps outlined in this report towards developing an artificial reef system designed to stabilize its beaches and the infrastructure they protect and the tourist industry they support.

APPENDIX A

SOUTH CAROLINA STATUTE AND REGULATIONS PERTINENT TO MAJOR SPECIAL CRITICAL AREA PERMIT PROCESS

S.C. Code Ann. Section 48-39-290(D) and **S.C. Code Ann. Regs. 30-15**

S.C. Code Ann. Section 48-39-290(D)

(D) Special permits:
(1) If an applicant requests a permit to build or rebuild a structure other than an erosion control structure or device seaward of the baseline that is not allowed otherwise pursuant to Sections 48-39-250 through 48-39-360, the department may issue a special permit to the applicant authorizing the construction or reconstruction if the structure is not constructed or reconstructed on a primary oceanfront sand dune or on the active beach and, if the beach erodes to the extent the permitted structure becomes situated on the active beach, the permittee agrees to remove the structure from the active beach if the department orders the removal. However, the use of the property authorized under this provision, in the determination of the department, must not be detrimental to the public health, safety, or welfare.
(2) The department's Permitting Committee Coastal Division shall consider applications for special permits.
(3) In granting a special permit, the committee may impose reasonable additional conditions and safeguards as, in its judgment, will fulfill the purposes of Sections 48-39-250 through 48-39-360.
(4) A party aggrieved by the decision to grant or deny a special permit application may appeal pursuant to Section 48-39-150(D).

S.C. Code Ann. Section 48-39-250 (Referenced in Section 48-39-290(D))

SECTION 48-39-250. Legislative findings regarding the coastal beach/dune system.

The General Assembly finds that:
(1) The beach/dune system along the coast of South Carolina is extremely important to the people of this State and serves the following functions:
(a) protects life and property by serving as a storm barrier which dissipates wave energy and contributes to shoreline stability in an economical and effective manner;
(b) provides the basis for a tourism industry that generates approximately two-thirds of South Carolina's annual tourism industry revenue which constitutes a significant portion of the state's economy. The tourists who come to the South Carolina coast to enjoy the ocean and dry sand beach contribute significantly to state and local tax revenues;
(c) provides habitat for numerous species of plants and animals, several of which are threatened or endangered. Waters adjacent to the beach/dune system also provide habitat for many other marine species;
(d) provides a natural healthy environment for the citizens of South Carolina to spend leisure time which serves their physical and mental well-being.

(2) Beach/dune system vegetation is unique and extremely important to the vitality and

preservation of the system.

(3) Many miles of South Carolina's beaches have been identified as critically eroding.

(4) Chapter 39 of Title 48, Coastal Tidelands and Wetlands, prior to 1988, did not provide adequate jurisdiction to the South Carolina Coastal Council to enable it to effectively protect the integrity of the beach/dune system. Consequently, without adequate controls, development unwisely has been sited too close to the system. This type of development has jeopardized the stability of the beach/dune system, accelerated erosion, and endangered adjacent property. It is in both the public and private interests to protect the system from this unwise development.

(5) The use of armoring in the form of hard erosion control devices such as seawalls, bulkheads, and rip-rap to protect erosion-threatened structures adjacent to the beach has not proven effective. These armoring devices have given a false sense of security to beachfront property owners. In reality, these hard structures, in many instances, have increased the vulnerability of beachfront property to damage from wind and waves while contributing to the deterioration and loss of the dry sand beach which is so important to the tourism industry.

(6) Erosion is a natural process which becomes a significant problem for man only when structures are erected in close proximity to the beach/dune system. It is in both the public and private interests to afford the beach/dune system space to accrete and erode in its natural cycle. This space can be provided only by discouraging new construction in close proximity to the beach/dune system.

(7) Inlet and harbor management practices, including the construction of jetties which have not been designed to accommodate the longshore transport of sand, may deprive downdrift beach/dune systems of their natural sand supply. Dredging practices which include disposal of beach quality sand at sea also may deprive the beach/dune system of much-needed sand.

(8) It is in the state's best interest to protect and to promote increased public access to South Carolina's beaches for out-of-state tourists and South Carolina residents alike.

(9) Present funding for the protection, management, and enhancement of the beach/dune system is inadequate.

(10) There is no coordinated state policy for post-storm emergency management of the beach/dune system.

(11) A long-range comprehensive beach management plan is needed for the entire coast of South Carolina to protect and manage effectively the beach/dune system, thus preventing unwise development and minimizing man's adverse impact on the system.

S.C. Code Ann. Regs. 30-15(F)

30–15. Activities Allowed Seaward of Baseline.

F. Special Permits: The Department shall consider applications for special permits. Special permits are to be issued only in situations where without such a permit, the property owner would have no reasonable use of his property, or when an overriding public benefit can be demonstrated. When issuing special permits, the Department shall consider the legislative findings and policies as set forth in Sections 48–39–30, 48–39–250 and 48–39–260. Specifically, the following criteria shall serve as guidelines when issuing special permits:

(1) A structure cannot be constructed or reconstructed on a primary oceanfront dune or on the active beach, and in the event that the beach erodes so that in the future the permitted habitable structure is located on the active beach, the property owner agrees to remove the structure at his own expense.

(2) There shall be no adverse impact on the stated policies of the Beachfront Management Act, including the policies protecting the sand dunes and preservation of the dry sand beach.

(3) The granting of a special permit shall not create a situation contrary to the public health, safety or welfare.

(4) In determining whether or not a permit is contrary to the public health, safety or welfare, the Department shall consider:

(a) whether or not the proposed structure would be constructed on renourished beach;
(b) the erosion rate at the site;
(c) how soon the structure will be located on the active beach;
(d) whether or not the proposed structure meets American National Standards Institute building standards; and/or
(e) the potential cumulative effect that similar structures will have upon the beach/dune system.

S.C. Code Ann. Regs. 30–11. General Guidelines for All Critical Areas.

S.C. Code Ann. Regs. 30-11(C)

C. Further Guidelines: In the fulfilling of its responsibility under Section 48–39–150, the Department must in part base its decisions regarding permit applications on the policies specified in Sections 48–39–20 and 48–39–30, and thus, be guided by the following:

(1) The extent to which long-range, cumulative effects of the project may result within the context of other possible development and the general character of the area.

(2) Where applicable, the extent to which the overall plans and designs of a project can be submitted together and evaluated as a whole, rather than submitted piecemeal and in a fragmented fashion which limits comprehensive evaluation.

(3) The extent and significance of negative impacts on Geographic Areas of Particular Concern (GAPC). The determination of negative impacts will be made by the Department in each case with reference to the priorities of use for the particular GAPC. The priorities of use are found in Chapter IV of the Coastal Management Program.

S.C. Code Ann. Regs. 30-11(D)

D. General Guidelines for Beaches and the Beach/Dune System: In addition to the provisions of the South Carolina Coastal Management Act of 1977, the policies of the South Carolina Coastal Management Program, and applicable rules and regulations, the Department shall base its decisions on activities in the beach/dune system on the findings and policies specified in Section 48–39–250 and Section 48–39–260 of the 1977 Coastal Zone Management Act, as amended, and the following:

(1) The Department shall discourage new construction in the beach/dune system and encourage those who have erected structures within the system to retreat.

(2) The Department shall promote soft-solutions to erosion within the context of a policy of retreat of development from the shore and prevent the strengthening and enlargement of existing erosion control structures.

(3) The Department shall promote public access to the beaches of this state.

(4) The Department shall consider state and local comprehensive plans. No permit shall be issued which is inconsistent with the state plan, and all permits issued shall be consistent with local plans to the maximum extent practicable.

(5) The Department shall be guided by the prohibitions against construction contained in Section 48–39–290 and Section 48–39–300 which are based upon the conclusion that ill-planned development, whether habitable structures, recreational amenities, erosion control devices or other man- made structures, will now and in the future adversely impact the fragile beach/dune system. These structures interfere with the natural system and impact the highest and best uses of the system. In order to protect the highest and best uses of the beach/dune system, the Department, in its management capacity, shall encourage minimal development therein.

(6) The destruction of beach or dune vegetation seaward of the setback line is prohibited unless there is no feasible alternative. When there is destruction of vegetation permitted seaward of the setback line, mitigation, in the form of planting new vegetation to rectify the destruction is required as a permit condition. In no event shall any part of a building be constructed on a primary oceanfront sand dune.

S.C. Code Ann. Regs. 30–13. Specific Project Standards for Beaches and the Beach/Dune System.

S.C. Code Ann. Regs. 30-13(N)

N. Erosion Control.

(1) Jetties and offshore breakwaters interfere with the natural transport of sediment and therefore require special permits. They shall only be permitted after thorough analysis of the project demonstrates that there will be no negative effect on adjacent areas. The following standards shall apply:

(a) A bond may be required to ensure that necessary remedial steps are taken to alleviate any adverse effects on adjacent areas caused by the installation of these structures. These remedial steps may include redesign and reconfiguration of the structures or even complete removal.

(b) A monitoring plan to assess post-project impact on adjacent areas must be approved by the Department prior to the issuance of a permit.

(c) Construction activities shall be scheduled so as not to interfere with nesting and brood- rearing activities of sea birds, sea turtles, or other wildlife species.

(d) Where feasible, jetties shall be designed to provide public recreational fishing opportunities.

(e) The applicant must have written approval from the local government which has jurisdiction in the area where the project is proposed.

(2) Protection of Beaches and Artificial Beach Nourishment: The following requirements apply to the Department's consideration of projects for the renourishment of beaches:

(a) Careful study shall be given to the type (grain size and quality) of material most suitable for nourishment of a particular beach area;

(b) Borrow areas and sand for artificial nourishment shall be carefully selected to minimize adverse effects. Where possible, artificial beach nourishment shall be performed in concert with inlet stabilization or navigation projects;

(c) Dredging in the borrow areas shall not be in conflict with spawning seasons or migratory movements of significant estuarine or marine species. Nourishment of beach areas shall be scheduled so as not to interfere with nesting and brood-rearing activities of sea birds, sea turtles, or other wildlife species;

(d) All policies concerning dredging and filling cited at R.30–12(G) shall be applied to beach nourishment proposals;

(3) Erosion Control Structures or Devices

(a) No new erosion control structures or devices are allowed seaward of the setback line except to protect a public highway which existed as such on June 25, 1990.

(b) No erosion control structures, or devices may be incorporated as an integral part of a habitable structure.

(c) Erosion control structures or devices must not be enlarged, strengthened, or rebuilt but may be maintained in their present condition if not destroyed more than the percentage allowed in Section 48–39–290(B)(2)(b)(i), (ii) and (iii). Repairs must be made with materials similar to those of the structure or device being repaired.

(d) Erosion control structures or devices determined to be destroyed more than the percentage allowed in Section 48–39–290(B)(2)(b)(i), (ii) and (iii) must be removed at the owner's expense. Nothing in this section requires the removal of an erosion control structure or device which existed on July 1, 1988, that protected a public highway.

(e) Erosion control structures or devices which existed on June 25, 1990, must not be repaired or replaced if destroyed:

(i) more than eighty percent above grade through June 30, 1995;

(ii) more than sixty-six and two-thirds percent above grade from July 1, 1995, through June 30, 2005.

(iii) more than fifty percent above grade after June 30, 2005. [See R.30–14(D)(3)(c) and (d) for damage assessment.]

S.C. Code Ann. Regs. 30–15. Activities Allowed Seaward of Baseline.

G. Groins. Existing groins may be reconstructed, repaired, and maintained. New groins may only be allowed on beaches that have high erosion rates with erosion threatening existing development or public parks. In addition to these requirements, new groins may be constructed, and existing groins may be reconstructed only in furtherance of an on-going beach *renourishment effort which meets the criteria set forth in R.30–14.G, and in accordance with the following:*

(1) The applicant shall institute a monitoring program for the life of the project to measure beach profiles along the groin area and adjacent and downdrift beach areas sufficient to determine erosion/accretion rates. For the first five years of the project, the monitoring program must include, but is not necessarily limited to:

(a) establishment of new monuments;

(b) determination of the annual volume and transport of sand; and

(c) annual aerial photographs.

Subsequent monitoring requirements must be based on results from the first five-year report.

(2) Groins may only be permitted after thorough analysis demonstrates that the groin will not cause a detrimental effect on adjacent or downdrift areas. The applicant shall provide a financially binding commitment, such as a performance bond or letter of credit that is reasonably estimated to cover the cost of reconstructing or removing the groin and/or restoring the affected beach through renourishment pursuant to subsection 30–15.G(3).

(3) If the monitoring program established pursuant to subsection 30-15.G(1) shows an increased erosion rate along adjacent or downdrift beaches that is attributable to a groin, the department must require either that the groin be reconfigured so that the erosion rate on the affected beach does not exceed the pre-construction rate, that the groin be removed, and/or that the beach adversely affected by the groin be restored through renourishment.

(4) Adjacent and downdrift communities and municipalities must be notified by the department of all applications for a groin project.

(5) An adjacent or downdrift property owner that claims a groin has caused or is causing an adverse impact shall notify the department of such impact. The department shall render an initial determination within sixty (60) days of such notification. Final agency action shall be rendered within twelve months of notification. An aggrieved party may appeal the decision pursuant to the Administrative Procedures Act.

(6) In an area in which new groins have been permitted, or in an area in which existing groins have been reconstructed or repaired, access along the beach from one groin compartment to another must be maintained or improved. If access is impacted or eliminated, temporary access around or over the groin must be established immediately. Within thirty days of notification from the Department, a plan to provide permanent access around or over the groin must be submitted by the entity responsible for the groin construction. This permanent access plan must be implemented within ninety days of the Department approval.

(7) The applicant must have written approval from the local government which has jurisdiction in the area where the project is proposed.

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State of South Carolina

GOVERNOR HENRY MCMASTER

THOMAS S. MULLIKIN, CHAIRMAN

South Carolina Floodwater Commission

Living Shoreline Task Force Report

November 8, 2019

LIVING SHORELINE TASK FORCE

MEMBERS

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Coastal Carolina University

Sharon Richardson (Secretary)
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I. CHARGE FROM THE SC FLOODWATER COMMISSION TO THE LIVING SHORELINE TASK FORCE

The Living Shorelines (LSL) Taskforce was charged to identify the potential for Living Shoreline applications towards:

1. Helping reduce erosional pressures being experienced along various types of shorelines across the state;

2. Enhancing the resilience of properties and communities in the face of increasing vulnerability to flooding;

3. Contributing to restoration of important ecosystem services in areas impacted by land use change and erosional/storm pressures (e.g. habitat, water quality, sustainable natural resource utilization etc.); and

4. Being incorporated within other flood mitigation strategies and associated engineering and landscape modifications towards a more integrated systems-oriented approach to address flood and other evolving changes to the state's natural and human landscape.

The Task Force was to identify a series of resilience strategies to mitigate identified issues and concerns and recommend actions in the near- and long-term to improve the resilience of South Carolina in the face of increasing risk and vulnerability to flooding and other pressures in a dynamic and changing world.

II. INTRODUCTION

Living Shorelines seek to restore or enhance natural habitat functionality and resistance to erosional pressures. They have traditionally been focused on estuarine and salt marsh settings and designed to emulate coarser or partially cemented materials such as oyster bars that are considerably more resistant to reworking and erosion by waves and currents than the surrounding fine-grained materials found in mud-flats and adjacent habitats. Similarly, erosion resistant vegetation features, such as the dense mats of plant roots found under salt marshes, that are naturally resistant to erosion are also simulated. These living resources help bind sediment that otherwise could be eroded routinely by wave and current energy. Living Shoreline applications are an evolving and expanding option for managing estuarine shoreline erosion and associated loss of property and habitat. Standardized best practices and permitting guidance is not yet established for South Carolina.

Living Shorelines have also been created to restore and enhance habitats or ecosystem services (e.g. water quality) that have been reduced from a range of pressures on coastal intertidal and estuarine environments such as filling for development, dredging for navigation, storms, sea level rise, wakes from boats, channelization of flows, change in sediment availability or physical armoring of shorelines by bulkheading or rocky revetments.

With historical trends in population growth and urban expansion close to our state's coastal, estuarine and riverine environments, there is a high likelihood of building engineered "gray infrastructure" in response to pressures of sea level rise, flooding, aging infrastructure and proliferating development in sensitive or vulnerable areas. Various efforts to safeguard against one pressure, such as ditching and channelizing waterways, or bulkheading and armoring shorelines from erosion, may result in undesirable changes in other areas of concern for communities and the state. As urban and suburban areas have expanded, we have built a massive network of storm retention ponds across the state to manage local runoff, associated flooding and water pollution, in order to mimic natural processes and function. The interest in Living Shorelines is driven by a very similar conceptual approach to mimic natural features and functions, and it may be applicable more broadly in the anticipated infrastructural needs to address flooding and changing forces and landscapes in the future. It is possible that a more systems-oriented strategy which replicates the natural system may find efficiencies and overall reduction of costs by focusing on systemic challenges rather than on individual symptoms of a changing system.

The state and nation are experiencing a change in flood-causing rain events. A shift has occurred nationally from predominately ocean shoreline surge damage being the primary threat to, more recently, inland flooding becoming a much more expansive challenge as experienced in South Carolina over the last decade. This shift can largely be attributed to a change in the nature of storm events, tracking and especially water volume associated with increased ocean and atmospheric temperature. It should be stressed that the risks and threats to the immediate coast have not diminished and still remain a primary concern to coastal states and the nation. The increase of inland flooding events represents a considerable expansion of impact and cost challenging our communities, environment and economy. The event driven impacts are immersed within the long-term chronic flooding from sea level rise and "Sunny Day" coastal inundation. As a result, a range of actions and approaches are required to address the integrated pressures upon our coastal, wetland, riverine and adjacent areas.

In most general terms, flooding issues at a given site are essentially a rate problem: more water is delivered to a location than can be drained off further down the system. The range of potential responses to reduce flood impacts are: 1) to enhance the residence time of water across the larger watershed upland (reduce the rate of input), 2) increase the rate of removal of water out of the location, 3) encourage building and zoning regulations that discourage vulnerable development, or 4) adapt to the increasing probability a given area may flood periodically. The chronic rise of sea level, as the ultimate base-level for drainage, greatly enhances the challenge and, in some areas, may come to exceed realistic, cost acceptable strategies.

These are essentially the same issues that the state has been wrestling with along the ocean front shoreline for several decades. Shoreline erosion is a challenge for coastal communities on long-term and episodic time scales. There may be many parallels to consider with the environmental, economic, legal, and public/private policies of the state's experience managing its ocean shoreline, as similar pressures and experiences are also progressively challenging other estuarine, lake and river shorelines, and adjacent communities, economies and infrastructure across the state.

This report explores Living Shoreline techniques, the regulatory framework for Living Shorelines, as well as other diverse shoreline types to consider potential applications of Living Shoreline concepts beyond the traditional estuarine/marsh system. Each of these three topics is further sub-divided into three sections focused on identifying specific challenges, resilience or mitigation strategies and near-, mid- and long-term recommended actions to address the challenges and benefits defined by the overall charge of the Floodwater Commission. These action items include: 1) improving the efficacy and establishing best practices for traditional Living Shoreline applications in estuarine and marsh settings in South Carolina, 2) establishing an effective and efficient regulatory structure and pathways to manage and permit Living Shoreline applications in the state, and 3) identifying other areas or potential applications of Living Shoreline approaches to mitigate undesirable outcomes in the broader range of shoreline environments beyond marsh and estuarine settings.

As traditionally practiced, Living Shorelines have been established on very small and local/private scales, largely reducing erosion locally in front of a given property or very small stretch of marsh/creekfront. The scale of floods and changing forces threatening the state extend well beyond the immediate coast and are proving extremely costly. The Task Force is mindful of the scale of the challenge and worked to consider the upscale of the conceptual approach to optimize its benefit in working to address the diverse impacts and pressures on the state.

It is also stipulated that the primary focus of the report is on traditional applications of Living Shorelines in estuarine settings. Living Shorelines have been the focus of several multi-year studies that are presently releasing results and recommendations. As a result, the Task Force seeks to leverage the most recent work over the last few years that are best informed and tasked with releasing specific results, assessments and recommendations. The potential broader application of Living Shoreline concepts is intended to promote discussion across the various

Task Forces and consideration of an integrated systems approach to the overall change in flooding pressures and drivers across the state and nation.

III. TRADITIONAL LIVING SHORELINE APPLICATIONS
Reducing Loss and Enhancing Function of Salt Marshes

A. <u>Statement of the Issue and Associated Challenges</u>

Salt marshes are an integral part of coastal ecosystems. They provide habitat for aquatic species, filter nutrients from upland sources, and help reduce the impact of coastal storms by absorbing wave energy. The presence of large areas of salt marsh has been documented to significantly reduce the damage and costs caused by storms in nearby communities. Flood heights may be reduced by higher bottom friction from vegetation, relief and bio-structures modifying flood flows.

> "One-acre of wetland can typically store about three-acre feet of water, or one million gallons. For example, studies conducted after Superstorm Sandy concluded that salt marshes reduced the cost of storm damage by $625 million with 1,400 miles of roads and highways protected by wetlands. After reviewing 2000 storms in New Jersey, areas behind existing marshes have experienced an average of 20% less property losses than areas where marshes have been lost. And those benefits for damage reduction are much higher for properties at lower elevations."

The Atlantic coastline of the United States is an especially high-risk area for storm-induced flooding damage and this risk will continue to increase with climate change and increasing development. Storm surge & sea level rise exacerbate this situation. Population growth and urban development on these coastlines increase the risk by damaging ecosystems & impacting natural defenses.

South Carolina is fortunate to have the largest acreage of salt marsh on the US Atlantic Coast – about a half-million acres. Given that about 1.3 million people live on the coast in South Carolina and about 49% of South Carolina's population lives in the floodplain in Charleston County, this buffering capability of the large marsh is crucial to protecting important infrastructure. South Carolina has experienced 61 billion-dollar coastal hazards since 1980[4]. South Carolina's salt marshes are eroding and shrinking in many areas due to a variety of causes, including coastal development, sea level rise, and erosion induced by increased storm activity and human activity such as boat traffic. Coastal South Carolina experienced 3,773 square miles of land cover change (17%), including a 21% increase in developed areas from 1996 to 2010. More than half of the state's shoreline (>4,600 miles) is eroding, at an average rate of 1-1.5ft every year. Erosion was particularly severe in sounds, harbors and inlets that were exposed to the sea, such as those formed by the Beaufort, Coosaw, Broad and Combahee rivers south of Charleston. Nearly 80 percent of river banks had eroded over the long term. Some river banks lost on average about 3 feet a year. This loss will increase the risk of storm damage and the costs of flooding to coastal communities as this highly valuable natural resource dwindles.

Some South Carolina sheltered coastlines are stable and a few stretches gained ground. Coastal wetlands adapt to changes in sea level and land use by accreting or losing sediment. *Sporobolus alterniflorus*, the dominant plant in salt marshes, captures sediment as tides raise and lower, leaving sediments behind. Marshes equilibrate at a relative elevation that depends on the rate of sea level rise and local sediment supply, tidal amplitude, and biomass. For salt marshes to persist despite rising waters, they must grow upward at a rate equal to or greater than the rate of sea level rise plus erosion.

Structural defense measures like shoreline armoring can be very costly and often have adverse effects on coastal ecosystems. Hence, there is growing interest in cost effective risk reduction measures that include natural and nature-based defenses and that simultaneously address habitat conservation needs. In addition to the Army Corps NWP54 (the nationwide permit covering construction and maintenance of living shorelines to control erosion in coastal areas), the research and permitting standard that is currently under development by the Department of Health and Environmental Control (DHEC) and the Department of Natural Resources (DNR) will support a broader implementation of Living Shoreline projects adjacent to private parcels in the near future. But as we look to the future we also need to address those areas where marshes will be migrating or moving inland as seas rise. The Nature Conservancy has developed a method to identify resilient coastal areas for the southeast where marshes can move as sea level rises, and this mapped data was released in summer 2019. In most areas of the coast, we still have time to act to sustain our valuable salt marshes. By preserving and restoring our marshes, by stabilizing their edges, and ensuring inland movement paths we can maintain this natural flood buffer that is so critical for our coastal communities.

B. Proposed Resilience Strategy

1) Complete a coast-wide assessment and spatial analysis to map where critical infrastructure vulnerable to flood and storm impacts, shoreline erosion rates, and social vulnerability data align. This will identify the most vulnerable and important areas where salt marsh protection and restoration are most needed. Study oversight and participants could include: SC Emergency Management Division, SC Disaster Relief Office, Dept. of Transportation, Dept. of Health & Environmental Control, Dept. of Natural Resources, The Nature Conservancy, academic institutions;

2) Identify locations coast-wide where Living Shorelines and other emerging methods that restore natural habitats and natural processes will be most beneficial and cost-effective to stabilize marsh edges, allow marshes to re-grow where they have been eroded, and replenish marshes not keeping up with sea-level rise;

3) Assess the feasibility and benefits of additional methods to sustain vulnerable salt marshes, such as thin-layer sediment application;

4) Identify funding sources for Living Shoreline and salt marsh protection and restoration. For example, FEMA or HUD disaster mitigation funds, modifications to 404 wetland mitigation procedures to include living shorelines and salt marsh enhancement (e.g., thin-layer sediment application);

5) Keep current intact marshes undeveloped into the future; and

6) Identify and conserve transition areas for future marsh movement inland as sea level rises.

C. Deliverables

1. Short-Term Deliverables

Develop a coast-wide analysis of critical infrastructure, shoreline and marsh erosion data, and social vulnerability data to identify highest priority sites. Invite state agencies like EMD, DRO, DOT, DHEC to be on a steering committee. Summer 2019
The Nature Conservancy (TNC) is conducted Phase I in summer 2019.

Literature review to determine the value of the marshes to reduce flooding and storm damage, and the vulnerability of marshes to erosion and degradation.

Share The Nature Conservancy's coastal resilience mapping data with partners in SC.
TNC, Land Trust Alliance & Open Space Institute held an information release meeting in Charleston for the land trusts and government agencies in June 2019.

2. Mid-Term Deliverables

Incorporate TNC's Living Shoreline Explorer on-line analytical tool in the public website for South Carolina property owners to identify locations suitable for living shorelines. Fall/Winter 2020/2021.

Broaden discussion of *what* a Living Shoreline is in South Carolina. Include more materials (e.g., oyster castles) than those currently being considered in the DHEC regulation development, as well as salt marsh enhancement methods such as thin layer sediment placement.

Organize a funding task force to identify and advance funding and financial incentives for Living Shorelines, and salt marsh protection and restoration.

Use the coast-wide analysis to identify a vulnerable area suitable for a pilot large-scale Living Shoreline project (e.g. ½ - 1-acre oyster reef).

3. Long-Term Deliverables

Implementation and monitoring of Living Shoreline projects – both small and large scale.

Propose amendments to DHEC permitting process to include other materials (i.e. oyster castles).

Assess thin layer sediment placement as a method to build up eroding salt marshes; implement and evaluate pilot projects using thin-layer sediment placement and other methods to restore and sustain vulnerable salt marshes.

Utilize TNC’s coastal resilience mapping for the southeast in land planning and land conservation within the coastal counties.

Install a large-scale project to protect and restore a vulnerable area of the SC coast.

IV. LIVING SHORELINE REGULATORY FRAMEWORK AND BEST PRACTICES

A. Statement of the Issue and Associated Challenges

In low to moderate wave energy environments, such as South Carolina's salt marshes and tidal creeks and bays, nature-based Living Shorelines offer a more holistic solution to shoreline stabilization than traditional hardened erosion control structures. Living Shorelines provide numerous benefits including shoreline stabilization, protection of surrounding riparian and intertidal environments, water quality improvement through upland runoff filtration, and habitat for aquatic and terrestrial species. Protection benefits are also conferred to adjacent upland property owners and coastal communities. Living Shorelines show promise in coastal South Carolina as a tool to protect coastal areas from both short-term hazards (e.g., storms) and long-term threats (e.g., sea level rise). Living Shorelines can also be incorporated into "gray infrastructure" projects to improve effectiveness and provide natural habitat benefits. However, South Carolina currently does not have specific project standards or regulations to guide the permitting and construction of Living Shoreline projects within the estuarine environment.

The current regulations for shoreline stabilization in the estuarine environment only address hardened (gray) erosion control structures including bulkheads and rip-rap revetments. Per the existing regulations, erosion control structures are prohibited at sites that have an adequate marsh buffer which serves to protect the upland shoreline from tidally induced erosion (S.C. Code Regs. 30-12(C)(1)(c)). Where erosion control structures are permissible, they are required to conform to the upland boundary, with allowances for up to 18 inches of channelward extension when construction at the upland boundary is not feasible (S.C. Code Regs. 30-12(C)(1)(a)-(b)). Living Shorelines are often built on the seaward edge of a salt marsh to protect both the marsh and the adjacent uplands from the impacts of sea level rise and erosion. Erosion control structures within the estuarine environment, including Living Shorelines, are authorized through an individual Critical Area Permit issued by DHEC. Due to the complexities of Living Shorelines, these installations are subject to more rigorous review under the current regulatory framework.

B. Proposed Resilience Strategy

The lack of specific project standards or regulatory definition for Living Shorelines has resulted in longer permit review times, loose design requirements, and potentially ineffective projects. To address this gap, DNR, the ACE Basin National Estuarine Research Reserve (NERR), and DHEC's Office of Ocean and Coastal Resource Management (OCRM) are undertaking a multi-year strategy to develop a comprehensive, science-based regulatory process to address the design of Living Shorelines and streamline the permitting process where possible. This strategy includes an ongoing research project involving the installation, monitoring and evaluation of oyster-based Living Shoreline projects. The study will comprehensively analyze optional Living Shoreline designs specifically suited to South Carolina and evaluate performance under varying physical and environmental conditions.

Information gathered from this study will be used to determine regulatory options to streamline and simplify authorization of Living Shoreline installations. A streamlined permitting process may encourage property owners to use Living Shorelines as an alternative to hardened erosion control structures. This regulatory pathway will also address current requirements of placing erosion control devices at the upland boundary. Establishing a framework to allow Living Shorelines techniques to be installed at the seaward edge of the marsh provides a proactive approach with benefits of creating marsh and flood protection, while reducing the negative impacts that can result from hardening estuarine shorelines.

C. Deliverables

The following deliverables will be provided by the appropriate funding agency as part of the current multi-year strategy.

1. Short-Term Deliverables

- Develop a Living Shorelines Guidance Document to provide research findings and science-based guidance to inform related regulations, policy, and standards for the evaluation and permitting of Living Shorelines.
Deliverable to granting agency – Summer 2019

2. Mid-Term Deliverables

- Continue monitoring of existing Living Shoreline projects to determine success and performance of specific designs in various environments. Summer 2019 through 2020

3. Long-Term Deliverables

- Establish a regulatory definition of Living Shorelines and develop specific regulatory project standards for the permitting of Living Shoreline projects in South Carolina. 2021

- Promote available tools and develop additional educational materials as needed to inform property owners and marine contractors of benefits and installation techniques. 2021

V. BROADER APPLICATIONS
Diverse Shoreline Types and “Systematic Engineering and Infrastructure”
Potential Applications Beyond Estuaries/Marsh

A. Statement of the Issue and Associated Challenges

Application of the Living Shoreline concept of restoring or enhancing natural habitat functionality and resistance to erosional pressures has traditionally been focused on estuarine and salt marsh settings. There are, however, a wide range of other forms of shorelines more broadly distributed across the state that collectively span all regions under pressure from flooding. These include natural and constructed environments such as river flood plains, wetlands, storm-water retention ponds, and lakes as well as open ocean shorelines. In addition to potential for erosion and loss of land, restoration of enhanced shoreline habitats and associated ecosystem services may play important roles in water and overall environmental quality locally.

The flooding issues being faced by our state are complex and interact as a mosaic of challenges across South Carolina’s landscape operating on a range of time and spatial scales. Modifications to adjust the rate of water flow from one part of the state affects areas both up- and downstream. For large events, infusion of large volumes of runoff can also affect coastal ocean conditions such as turbidity, nutrients, salinity, temperature and dissolved oxygen levels. These changes can kill off valuable marine life such as oysters and finfish. Collectively, surface runoff and flood waters may import bacteria and contaminants into the coastal zone. This can influence bacteria levels along the immediate coast and trigger swimming restrictions and temporary beach closings which similarly may threaten local populations and economies.

It is likely there will be considerable modifications of societal infrastructure to address increased flooding and storminess. As a result, emphasis on the dual-benefit of Living Shorelines and other habitat restoration applications should increasingly be considered within infrastructure changes to address the systems-level challenges. Fully incorporating the broader costs and benefits of potential modifications should be undertaken. Isolating respective costs and benefits of flood mitigation and water quality, public and environmental health concerns may result in decisions that are apparently cost-effective in the near term but prove costly and design-limiting for subsequent approaches to address cascading effects in the long-term.

A fundamental challenge for addressing the flooding and associated issues charged to the Commission and the Living Shorelines Task Force in particular is to stress the need to reduce to a greater degree future development in areas which would significantly diminish the natural storage capacity for large volumes of water within the system, and where rates of input exceed the capacity of natural channels to move floodwaters effectively to the ocean as the ultimate destination for the drainage of the state.

In its simplest form, river floodplains and wetlands naturally serve the functions of water storage and filtration – they are nature’s sponges. Construction of Living Shorelines, or application of Living Shoreline principles, seeks to re-establish some of those functionalities where their effectiveness relative to natural capacities is reduced. For large areas of the state, especially along the I-95 corridor where flooding has been particularly hazardous there remain large areas of undeveloped land able to contribute to these water and management functions.

A key challenge to the state is to avoid the elimination of areas serving critical functions for natural storage and filtration of floodwaters – floodplains and wetlands. In its simplest form, this would conserve and restore natural river floodplains and wetlands as Living Shorelines and could proactively manage those natural assets as floodwater storage capacity required by the changing weather/rainfall experienced across the state.

Another large-scale environment with Living Shoreline applications is the ten thousands of storm water retention ponds and structures constructed across the state. These features are designed to hold the first inch or two of rainfall on a given property for the purpose of nutrient cycling from runoff and managing local drainage. A comprehensive review of storm water pond issues and efficacies has recently been completed by researchers at USC-Baruch Institute and the S.C. Sea Grant Consortium. This body of work should be leveraged in developing remedies for future flooding and water management in the state.

South Carolina's oceanfront shorelines are a vulnerable and dynamic environment. Many of these shorelines are chronically eroding while others accrete or gain sand. Changes to the shoreline occur over time due to ocean currents, rising sea levels and episodic storm events. The primary mitigation strategy adopted by most coastal communities to address oceanfront erosion has been beach nourishment. One of South Carolina's state policies is to "promote carefully planned nourishment as a means of beach preservation and restoration where economically feasible" (SC Code §48-39-260(5)). Beach nourishment is the physical re-construction and restoration of a volume of beach sand that is lost due to ocean currents or other coastal influences that would otherwise result in a retreat and landward relocation of the oceanfront shoreline/system.

Oceanfront sand dune systems play an important role as a source of mobile sand made available to the active beach system during the heightened energy of storm events. A large, healthy primary dune has also been shown to be one of the more effective defenses from modest scales of storm surge and impact to coastal properties. Dune restoration efforts are effectively a Living Shoreline application targeting reestablishing or enhancing oceanfront dunes. Typically, these efforts include installation of sand fencing or dune grass plantings to emulate the natural capture of wind driven sand within dune systems and the stabilization effect of vegetative root mass within the dune. One key issue is the dependence of dune systems on having sufficiently wide-open sandy surfaces landward of the highwater tide to allow effective wind-driven transport to sustain dune systems. (Wind-driven transport is the first process of coastal dune formation and involves the movement of and weathering of sand particles behind and parallel to the shoreline.)

In some areas, renourishment projects in South Carolina re-established sufficiently wide space on a beach above the high tide line, where wind-driven sand movement enabled largely functional dune systems to re-establish themselves and provide added protection of coastal property and infrastructure. Such areas (e.g. central North Myrtle Beach) are the sites of relatively low average rates of erosion and large-scale commitments to beach nourishment. Within these communities and nourishment projects there are, however, local hotspots for erosion and associated narrowing of open, sandy beach area and dunes, where there is not the same level of benefit against inundation during storms. Over the last decade, with the change in relative storminess, the previously better-established dunes are also experiencing erosion and loss of size and integrity in several areas. The track and character of the series of storms impacting the coast over the last decade did not result in particularly large storm surges, but they have modified the beach and dune systems morphology and stability, in some areas significantly so.

B. Proposed Resilience Strategies

1. Floodplains

There presently exist vast areas of the state composed of largely undeveloped flood plains and wetland areas. The state and local communities should incentivize reduction of future risk and cost by sustaining existing hydrologic storage and environmental quality functions of these vast areas. Development that is permitted should be designed to be minimally impacted when the site is flooded and isolated for extended periods.

a) *Short-Term Deliverables*

- Engage state, county and local agencies, private sector mitigation experts, planners and conservation organizations to expand annual public contributions and tax incentives, along with a percentage of future disaster funding, to conservation and mitigation banks targeting flood/erosion prone locations that have not yet been developed, as well as those that have been flooded and experienced recurring flooding. Fall 2019
- Generate alternative land use models for flood prone areas where property owners could derive a significant income stream for activities that would not be impacted by severe flooding~~.~~ Summer/Fall 2019

b) *Mid-Term Deliverables*

- Support a comprehensive economic analysis of the costs of flooding and various land use decisions for South Carolina. This study should critically review all assumptions historically considered in developing cost/benefit analyses. An update of assumptions and costs based on the frequency and actual costs of disaster scale events over the last decade should be included. A central question should be if, and at what point does, short-term economic production become overtaken by long-term public and private costs. (See https://www.ncdc.noaa.gov/billions/time-series)

2. Stormwater Retention Ponds and Other Short to Long Term Storage

A comprehensive inventory and assessment of storm water retention ponds was recently completed by researchers at USC, Sea Grant and others. Such retention ponds seek to emulate natural short- to mid-term storage capacity of modest rain events and water quality functions of wetlands and flood plains. At present, there are estimated to be 14,000 stormwater retention ponds in the SC coastal region. Recent research has called into question the efficacy of this significant modification of the state's hydrology (https://seagrant.noaa.gov/News/Article/ArtMID/1660/ArticleID/126/Stormwater-Ponds-in-South-Carolina—Challenges-and-Opportunities). There is an opportunity to build on the recent body of work related to both the water quality and ecological functionality of this primary tool to address local flooding associated with small to modest scale events. In addition, it would seem an opportune time to consider the integrated effect on community, county and state hydrology and prospects for modifications of this tool that is already heavily invested in and required as part of permitting for development. As with estuarine shorelines, this issue is focused on individual local structures and should consider the potential integrated effect across the broader landscape. It is likely other types of water management devices such as large-scale reservoirs may be considered in the future. In effect, that functionality already largely exists within the broader flood plains; there may be opportunities to consider larger but distributed storm-water retention capacities within uplands and developments.

a) *Short-Term Deliverables*

Engage South Carolina Sea Grant state researchers and environmental organizations to assemble a panel to consider the potential for improvement in functionality and scale in water and environmental quality management afforded by these systems. Fall 2019

That discussion should result in a prospectus for research/demonstration projects associated with upcoming development efforts somewhere in the state for upscaled storm runoff management.

b) *Mid-Term Deliverables*

Demonstration project of upscaled runoff retention strategies on a community scale.

3. <u>Ground Water</u>

Ground water is another significant reservoir that can modulate runoff and affect flooding across several spatial and temporal scales. Considerable concern and resources have gone into reducing the amount of impervious surfaces that accelerate the discharge of local runoff downstream in urbanized areas. In effect, increasing use of pervious surfaces whether through conservation or materials used in roads, parking lots and other developed surfaces seeks to restore or enhance natural infiltration of precipitation within a potentially large, but still finite, shallow groundwater system. Slow flow of water through the groundwater system helps reduce the rates of initial flows into the drainage network during events. The water eventually returns to the surfaced drainage over the long term also helping to moderate water levels within the system during dry periods.

One of the challenges of the change in rainfall events with the broader continued rise of the sea and the base level for drainage of the state is that these trends reduce the capacity of local runoff to be stored within groundwater and affects delivery to communities downstream. The net effect from increased frequency or intensity of rain events is less capacity to absorb runoff into the ground water system, especially in the coastal zone. At some point, local soils are saturated and their effectiveness as a short-term storage for flooding is severely diminished.

The effect of ditching and expediting surface water movement from one area to another has a local effect on increasing efficiency of local groundwater table draining down basin. Historically, such practice has had negative effects on adjacent wetlands. Nonetheless, ground water and other local reservoirs such as storm water retention ponds may have expanded capacity to help moderate rate of delivery of surface waters and reduce flooding downstream, at least up to some levels of discharge. Another influence on these reservoirs is the amount and nature of vegetative cover. Water uptake by plants and subsequent transpiration through plants to the atmosphere can also significantly influence the local hydrologic cycle.

In addition to challenges of past development practices which increase rate of water delivery into a given area or community run-through - ditching, placement of fill, impervious surface cover, and impediments or restrictions to flow downstream - the reduction of forest and related vegetative covers similarly contributes to the pressure. Efforts to try to restore some of these natural functionalities by reduction of impervious surfaces, wetland restoration, reforestation and distributing runoff to temporary storage are well in-line with the principles behind Living Shorelines (this only broadens the concept of shorelines as the boundary between land and water or saturated environments). Closer to sea level, which ultimately limits shallow groundwater drainage, this capacity should be expected to continue to decrease over time regardless of surface modifications in permeability and land use/cover due to sea level rise.

a) *Short-Term Deliverables*

Convene a panel of experts in storm water retention ponds, storm water management, groundwater, wetland restoration and related areas to consider the potential of integrated hydrologic management. The results would be a series of recommendations related to best practices that are working, could work better and need to be significantly reconsidered. Fall 2019

4. <u>Ocean Front Shoreline</u>

Communities across the state and nation have committed to beach nourishment as a primary means to combat the threat of erosion and flooding to coastal property and communities. Beach nourishment seeks to modify the rate of sediment input to a section of the coast to replace volume of sand lost from the cell from waves and currents to adjacent cells or the active beach system as a whole. One of the first order defenses from property damage and coastal inundation is the presence of a large, healthy sand dune complex forming a barrier to inundation well above mean sea level. Beachfront sand dunes are an example of a Living Shoreline with which the state has some experience and success. Parallels between oceanfront sand dunes and estuarine living shorelines include dunes functioning as important flood reduction barriers and ecosystem features, the presence of a dense growth of living dune vegetation and their roots which help bind sediment.

Communities committed to maintaining sediment volume within the beach/dune system have generally benefited in terms of reduced erosion and inundation to low-to-moderate storm surges. Results are considerably better where there are relatively low long-term erosion rates such as the

Grand Strand areas of South Carolina, where there is high ground directly behind the beach/dune system and away from the influence of tidal inlets.

It is important to note that beach and dune restoration efforts are being sustained through large-scale federal and state investments in the strategy. For example, both the Grand Strand and Folly Beach nourishment projects are federal projects that have been congressionally authorized for a 50-year project life. In fact, the U.S. Army Corps of Engineers is in the process of a new feasibility study to re-authorize the Folly Beach project for an additional 50 years. From a state of South Carolina perspective, the state legislature has appropriated a total of $46M since FY17 in beach nourishment efforts statewide.

Renourishment, however, does not directly address the elevation of the communities and associated infrastructure related to relative sea level, which continues to rise placing increased pressure on these systems. One of the best measures of protection afforded by beach/dune systems is the relative height, width and health of the coastal dune field. Renourishment in many areas seeks to re-establish the functionality of a healthy beach/dune system after that capacity has been significantly degraded or lost. In many projects, coastal dunes exist largely from being constructed as a part of nourishment project construction. Dunes are formed by physically bulldozing sand from nourishment sand into elevated ridges which are supplemented by planting dune grass vegetation or installing sand fencing to emulate the baffling effect of dune grasses helping to trap windblown sands and build dune morphology.

Dunes are naturally formed by wind-driven processes that transport sand along the shore. These wind-driven processes require the sand particles to be small enough to be picked up and transported by the wind. In addition, dry sand is needed, and the upper beach needs to be high enough in elevation to only experience infrequent inundation by tides. Frequent tidal inundation will result in sand particles that are too wet and consolidated for the wind to move and will inhibit dune formation

As a result, an enduring challenge to nourishment strategies is for projects to be sufficiently large enough to allow for a wide dry-sand beach to support wind-blown dune processes. Large-scale nourishment projects along the Grand Strand and other sections of the South Carolina coast were largely successful in initiating and then sustaining functional dune systems. Even those projects with very favorable background erosion rates and coastal land elevations have experienced losses over the last decade as the nature and frequency of storms impacting the coast has changed.

A challenge to reliance on beach nourishment approaches to erosion management and protection of coastal infrastructure is to ensure projects are of sufficient scale to allow for constructed beaches to adopt natural processes such as the building of dune sediment reserves over long periods that are available during large but heretofore relatively infrequent events. The second challenge is the recognition that barrier island settings are pressured from both the oceanfront as well as the landward side of the island from rising sea level. Renourishment as typically practiced to date does not address the progressive thinning and lowering of the land surface relative to the long term rise of the sea nor the overall elevation of coastal communities and infrastructure.

As a result, renourishment and dune restoration strategies should be considered as mid-term strategies to a long-term problem. It is important to note, these are effective only through sustained and large-scale investments in the strategy. It is likely that for some areas these will remain effective for decades to come. For other areas, the costs and relative benefits of renourishment strategies are already approaching marginal returns particularly as increased pressure from storms and competition for sand resources changes the cost of this form of emulating a natural system. Regardless, rising sea levels present a longer-term and fundamental threat to coastal property and economies. Continued review and update of the viability of holding the ocean shoreline through these constructed environments should remain ongoing in the state.

The width of the high dry-sand beach and dune characteristics are a primary underpinning of the health of coastal dune systems which form the state's coastal defense from flooding from storm surges and erosion. Efforts should be made to ensure renourishment projects are of sufficient scale to allow for functional wind-driven processes to sustain and preferably build coastal dune systems. This will have important design and planning influences on renourishment strategies, efficacy and cost.

a. *Short-Term Deliverables*

Compile data on the relationship between high-tide dry-sand beach width and dune height, function and integrity across South Carolina. This can be complied from historical LIDAR data available in the state. Areas with insufficient sediment supply (nourishment) and maintained dry-beach widths to support dune fields may not be expected to sustain past levels of protection and benefit for the associated cost of this strategy; especially in the face of rising sea level. Fall 2019

Similar to estuarine and other environments that may be defined by a "shoreline", the state's oceanfront is not well described as a line, but as a system where the dunes, subaerial beach, nearshore bar and the shoreface all act in concert to support the beach system across multiple temporal and spatial scales. To date, most defenses against coastal erosion are focused only on the upper beach system. Broader consideration of the beach and coastal system is appropriate to coordinate and optimize strategies and potential actions for other pressures on these systems (e.g. water quality).

b. *Mid-Term Deliverables*

- Organize a funding task force to identify and advance funding and financial incentives for oceanfront dune restoration and oceanfront buyouts to maintain the beachfront Living Shoreline and to allow for future beach/dune system movement inland as sea level rises.

- Undertake an economic analysis of relative long-term costs of increasing mitigation bank and other conservation support relative to long term impacts of flooding and other events potentially designed for one level of risk which evolves and increases over time.

- Explore alternative economic activity that could occur in privately owned flood prone areas such as tall tower wind energy production, carbon sequestration etc., that is less vulnerable to storms and rising sea level. Continue exploration and innovation towards developing sustainable natural and human landscape management policies in the future.

- Using data determined in the first Short-Term Deliverable, develop state guidelines for minimum beach width requirements for nourishment projects. Include a requirement for a continuous dune feature in all state cost-shared nourishment projects.

- Reconsider Risk in Development Decisions. Many decisions are based on risk associated with various kinds of impacts. Levels and aerial extent of large but relatively infrequent events such as 100-yr flood levels are embedded in important design and insurance projections. Risk is historically assigned by analysis of past behavior of the system over the long-term. This assumption is being challenged as the system is evolving (base level for watersheds is non-stationary and rising) and our weather/climate system is also evolving and may no longer be well defined by past behavior (non-linear). At present rates of change, the levels of risk for some large-scale infrastructure projects will significantly change over the life cycle of many developments. As a result, new construction can be expected to experience considerably higher levels of risk and cost over the expected life of the construction. The state should re-evaluate risk and cost/benefit decisions for infrastructure decisions, incentivization and investment of public funds.

- Incentivize avoiding future risks in presently undeveloped low-lying flood prone areas and watersheds and sustain the functionality of those environments as Living Shorelines as long as possible.

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State of South Carolina

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South Carolina Floodwater Commission

Infrastructure and Shoreline Armoring Task Force Report

November 8, 2019

INFRASTRUCTURE AND SHORELINE ARMORING TASK FORCE

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APPENDIX A.
Emergency Management Division
Local Floodwater and Drainage Mitigation Projects (REV. Oct. 14, 2019)

I. INFRASTRUCTURE

A. Overview

In the context of the Floodwater Commission, infrastructure is viewed as the drainage system that conveys surface water from where it falls through various channels to a receiving body of water within a drainage basin. The drainage system is typically a combination of natural channels and man-made elements such as ditches, pipes and inlet structures.

A community's drainage system typically covers a large area and includes drainage elements such as pipes, drop inlets, ditches, stream channels and retention/detention ponds before the system empties into a larger body of water such as a river or lake. Since the system can be vast, it will often involve many entities, each with their own level of responsibility with regards to maintenance. It is common for a drainage system to involve privately-owned elements, municipal-owned elements, county-owned elements, state-owned elements and occasionally, elements that fall under the jurisdiction of the federal government.

B. Major Drainage Basins in South Carolina

There are four major river basins or watersheds in South Carolina: The Pee Dee, Santee, ACE and Savannah.

FIGURE 1: SCDNR Major River Basins Map.

There are several rivers within the four major watersheds that convey water to the coast.

FIGURE 2: South Carolina Rivers, Watersheds and River Basins.

C. Deferred Maintenance

As described earlier, a drainage system is typically a combination of natural channels and man-made elements such as ditches, pipes and inlet structures.

A community's drainage system typically covers a large area and includes drainage elements such as pipes, drop inlets, ditches, stream channels and retention/detention ponds before the system empties into a larger body of water such as a river or lake. Since the system can be vast, it will often involve many entities, each with their own level of responsibility with regards to maintenance. It is common for a drainage system to involve privately-owned elements, municipal-owned elements, county-owned elements, state-owned elements and occasionally, elements that fall under the jurisdiction of the federal government.

Deferred maintenance on any of the elements of the drainage system may impact the overall performance of the drainage system. In order for the system to function at its full designed capacity, it is necessary to ensure that the system is clean and clear of obstructions and make repairs to any damaged element. Removal of debris, replacement of crushed pipes and re-establishment of proper slopes on ditches are typical maintenance items encountered with drainage infrastructure. Extraordinary maintenance items would also involve more complex operations such as the removal of logs and other large debris from canals, creeks and rivers.

FIGURE 3: SCDOT clearing accumulating debris adjacent to a major bridge structure.

South Carolina has experienced multiple, successive natural disasters over the past several years which has resulted in the accumulation of a significant amount of debris in some of our communities, including within the drainage systems. The debris issue, coupled with deferred maintenance, has the potential to impact the overall ability of the drainage system to effectively convey water in some communities of the state.

D. Driving Results at the Local Level

The Infrastructure and Shoreline Armoring Task Force has determined that it is appropriate to initially focus its efforts on formulating a systematic process to evaluate, prioritize and coordinate locally identified needs relative to maintenance of the existing drainage infrastructure. This systematic approach is designed to be locally driven and bring the various owners of the drainage infrastructure together in a collaborative manner in order to effectively and efficiently address the prioritized needs. Resident and volunteer groups may also engage in these efforts.

A pilot program for these locally led task forces has been initiated in two counties: Charleston and Marion. The task force in Charleston County was the first one established through the vision of the legislative delegation in order to ensure proper communication and coordination amongst the various governmental bodies and homeowners associations to resolve drainage concerns. Marion County was selected in order to formulate a collaborative approach in counties with small public works departments and limited local government funding available to tackle drainage maintenance.

As mentioned earlier, a locally driven, systematic approach is needed in order to bring the various owners of the drainage infrastructure together in a collaborative manner and prioritize the work. This systematic approach is accomplished through the formulation of Local Task Forces, which is comprised primarily of local and state government technical staff and charged with identifying the areas of concern, prioritizing the needs, developing a work plan and working collaboratively to resource the work plan.

The Charleston Local Task Force has been very successfully operating since its formation. Through July 31, 2019, the Charleston Local task Force has completed work on 69 of the 93 drainage issues identified. Work plans have been developed and schedules have been set for 17 of the remaining 24 sites. The remaining 7 sites were recently identified and will need to be vetted by the Local Task Force.

The Marion County Local Task Force has been focused on outfall ditch maintenance around the entire county. This has resulted in collaboration in cleaning thousands of feet of ditches in the county, removing a large amount of sediment below US 76 in Nichols, cleaning roadside ditches in the Town of Sellers and partnering with the City of Marion on identifying collapsed drainage pipes that need to be replaced. The Town of Nichols has recently taken proactive action by purchasing a small mini-excavator, hired an operator and is addressing several deferred drainage maintenance items.

While addressing deferred maintenance on the existing drainage system will not prevent flooding during significant flooding events, it is expected to aid in properly draining communities during normal weather events as well as enable floodwaters to recede at potentially faster rate in the future.

E. <u>Demonstration Project in Nichols, South Carolina</u>

On June 15, 2019 the Governor’s Floodwater Commission held a demonstration project in the Town of Nichols, South Carolina. The demonstration project showcased the power of the locally-led task forces and their ability to successfully leverage in community volunteer groups to assist with the work plans.

The Nichols demonstration project engaged approximately 350 people and resulted in 25,000 ft of roadside drainage cleaned, 1.5 miles of the main drainage canal cleaned and an undersized culvert underneath Kemper Road was removed and replaced in the same day. Through this collaboration, it is estimated that well over $500,000 was saved.

FIGURE 4: Nichols Canal: before and after Task Force June 2019 cleanup.

F. Major Drainage Projects in Charleston

In addition to serving as one of the pilot program counties for the Locally-led Task Forces, the City of Charleston has also been implementing several major drainage projects associated with their comprehensive drainage master plan for the area.

The Forest Acres Drainage Improvement project is divided into two phases. Phase 1 was completed in 2018, totaling $11.4 million. Phase 2 entails the installation of more pipes and channels being opened (Tecklenburg, 2018). This project won the South Carolina American Public Works Association 2018 Public Works Project of the Year Award. Started in 2011, the estimated completion of the project is 2021 or 2022 and has been determined to be a gravity system, which eliminates a pumping system. Estimated cost overall amounts to $20 million (City of Charleston, n.d.).

The Huger and King Drainage Project began in 2018 and is projected to be completed by 2022. Costing an estimated $800,000, this project will improve the area by lessening the flooding once the final design has been approved for the system (City of Charleston, n.d.).

The Market Street Drainage Improvement Project has been in the works since 1999. Expected to be completed in 2023 or 2024, this tunnel and pump system has been designed to include the renovations to the existing Concord Street Pump Station, over 4,000 linear feet of tunnel for stormwater conveyance, an access shaft, three drop shafts, an emergency outfall, surface collection, and improvements to the streets and sidewalks of Market Street. The tunnel that connects Market Street to the Concord Street pump station has the ability to pump nearly 7.2 million gallons of water out of the city per hour. This project is estimated to cost $32.6 million (City of Charleston, n.d.).

The Spring/Fishburne Drainage Improvement Project has been in progress since 1999 as well, estimated to be completed between 2023-2024. With an estimated cost of $197.5 million, this major tunnel system and pump project included mitigating the flooding in the Spring and Fishburne Drainage Basins, as well as the US Hwy 17/Septima P. Clark Parkway, in addition to neighboring streets and neighborhoods. With more than 500 acres being served in the western peninsula, the completed development "will keep the Septima P. Clark Parkway open during most rain events" (City of Charleston, n.d.). This drainage project comprises over 8,200 feet of deep tunnel for stormwater conveyance, 8 drop shafts, a pump station that is able to pump more than 360,000 gallons of water each minute (located between the Ashley Bridges on Lockwood), a 550-foot long triple-barrel outfall into the Ashley River, more than 18,000 feet of new piping for stormwater, over 500 new structures, and an improved and updated surface collection and conveyance system (City of Charleston, n.d.).

G. <u>Other Potential Flood Mitigation and Drainage Projects</u>

While the main focus of the Infrastructure and Shoreline Armoring Task Force has been on developing operational models for addressing deferred maintenance of the drainage system, the task force also reached out to various stakeholder groups for feedback on other flood mitigation and drainage projects. The initial survey resulted in a potential 244 projects from 31 counties at an estimated cost of over $308 Million. This draft list needs be developed further and reviewed to determine if the formulation of a locally led task force is the appropriate mechanism to further vet some of these suggested projects. This is expected to be an ongoing process with most counties holding multiple stakeholder meetings to identify projects. It is also important to note that some of the communities have suggested pursuing targeted acquisition of repeat damaged properties may be a reasonable and perhaps cheaper alternative than pursuing some of the stabilization options. (See Appendix A for updated report of Local Floodwater and Drainage Mitigation Projects as of October 14, 2019).

TABLE 1: Initial draft list of potential flood mitigation and drainage projects as of August 16, 2019

County/City	Comments	Initial Cost Estimate
Aiken	County potentially will have a project or two	TBD
Berkeley	4 County projects: water system upgrades, buyouts or diversion options, soil and hydrological study, dredging feasibility study	$3,700,000-$33,300,000
Calhoun	1 County Project: improve/regrade 2 roads, and repair or replace culverts	$350,000
Charleston	8 County Projects (some costs still TBD): demolition and rebuilding 2 county buildings, CORS-CRS, installing stream gauges, high water marks, dredging, vulnerability assessment, water shed assessment Potentially will be additional municipal level projects	$4,000,000+
Cherokee	1 County Project-6 road culverts $525,000 1 City of Gaffney Project- 12 road culverts $920,000 1 City of Blacksburg Project-1 bridge improvement and 1 catch basin Improvement $1,560,000	$3,005,000
Chester	2 projects City of Chester: Storm Drainage Improvements and Equipment for maintenance	$662,137
Chesterfield	2 Projects Town of Patrick: clean ditches and install headwalls and modify the drainage system	$727,445
City of Columbia	Gathering data.	TBD
Clarendon	2 County Projects-River channelization and clean up, floodwater diversion	TBD
Colleton	5 City of Edisto Beach projects: Groin maintenance and repair, Beach Nourishment, Arc Street/Billlow Drainage project, Fort Street Drainage project, Lagoon system dredging	$24,375,000
Darlington	Project list received and being verified.	$15,648,600
Dillon	3 Projects County: Canals cleanup, Hydrology study $63,000 3 Project Town of Latta: clean ditches $119,000 4 projects town of Lake View: enlarge culverts, replace drain tiles $585,000	$767,000
Dorchester	TBD	TBD
Fairfield	3 County Projects: dredge a road, purchase mobile generator, construct a dam	$27,700,000
Florence	2 County Projects: Countywide hydrology study, buyout 14 homes	$3,500,000
Georgetown	8 County Projects: $14,145,000 12 City of Georgetown Projects: Drainage system upgrades $20,208,000	$34,353,000
Greenville	3 County Projects: Install a culvert and two bridges	$858,000
Horry	7 County Projects: study raising 10 roads/ highways, clear river of snags, new dam to protect a road, diversion canal study, 3 studies to improve 3 creek watersheds.	$4,500,000
Lancaster	7 County Projects: maintain and/or upgrade dams, replace or retrofit culverts, install stream gauges, FEMA Floodplain study update, and property acquisition.	$68,107,400
Laurens	2 County Projects: New EOC/911 Center and generator for Wastewater Treatment Center	$4,140,000
Lee	3 County Projects: hydrological/drainage studies, drainage ditch	$275,000
Lexington	10 County Projects: 5 projects to improve water rescue capability with equipment purchases- $208,983, 2 bridge retrofits, 3 culvert modifications- Construction estimate is $1,7333,881	$1,942,864.00
Marion	8 County projects: cleaning river and culverts, watershed / hydrology study 4 Projects town of Mullins: cleaning culverts and ditches, 1 project town of Nichols: clean ditches	$7,810,000
Marlboro	4 County Projects: 3 projects to clean 4 creeks and 1 project to clean numerous roadsides	$10,500,000.00
Newberry	1 City of Newberry Project: create a drainage basin to protect major water treatment facility and numerous neighborhoods.	$4,000,000.00
Pickens	Clemson University may have a project	TBD
Richland	1 County Project: improve rural firefighting capabilities	$812,000
Saluda	7 County Projects: hydrologic study, replace bridges, redesign pond relief pipes	$2,235,000
Spartanburg	1 County Project: 9 Bridge replacements and a culvert replacement	$10,261,000
Sumter	1 County Project: revise and implement FEMA Floodplain mapping	TBD
Union	1 County Project: Updating Mitigation Plan for FEMA Approval	$5,000
York	3 City of Rock Hill Projects $13,925,000 1 Rock Hill School District 3 Projects - Storm Drain repair $127,459 1 Town of Cover Project: property buyout $450,000 1 York County Project: Creek Stabilization $605,000 2 City of Fort Mill Projects: bank stabilization and generators $1,800,000	$16,907,459

H. Findings and Recommendations

The Infrastructure and Shoreline Armoring Task Force has determined that it is appropriate to initially focus its efforts on formulating a systematic process to evaluate, prioritize and coordinate locally identified needs relative to maintenance of the existing drainage infrastructure. This systematic approach is designed to be locally driven and bring the various owners of the drainage infrastructure together in a collaborative manner in order to effectively and efficiently address the prioritized needs. Resident and volunteer groups may also engage in these efforts.

1. Since the pilot program counties were strategically selected in order to establish urban and rural models for eventual deployment on a larger scale across the various watersheds and counties of the state, it is important to ensure that these locally led task forces are operating effectively and remain committed to collaboration. To date, it appears that the locally led Task Forces in the rural counties will need assistance in order to steadily fund and resource their locally identified and prioritized work plans. Consideration should be given to establishing options, such as grant or loan programs, for the rural counties to engage in order to progressively advance their work plans in an efficient and effective manner.
2. While the main focus of the Infrastructure and Shoreline Armoring Task Force has been on developing operational models for addressing deferred maintenance of the drainage system, the task force also reached out to various stakeholder groups for feedback on other flood and drainage projects. The initial draft contains 244 projects from 31 counties at an estimated cost of over $308 Million. This draft list needs be developed further and reviewed to determine if the formulation of a locally led task force is the appropriate mechanism to further vet some of these suggested projects. This is expected to be an ongoing process.

II. SHORELINE ARMORING

A. Background

Coastal erosion occurs when the shorelines gradually lose their sediment over time. This process continually reshapes coastlines and can pose serious threats to coastal property. Coastal erosion can result from any number of causes: sediment supply, geologic characteristics, changes in sea level, and the effects of waves, currents, tides, and wind – depending on the location (NOAA, 2018). Across the U.S., approximate 350,000 structures sit within 500 feet of the country's shoreline (NOAA, 2018). While completely stopping erosion along the shore may be nearly impossible, shoreline armoring can be an effective technique to help slow the threat that coastal erosion poses to many citizens.

"Armoring" is the use of physical structures to mitigate the effects of coastal erosion (NOAA, 2018). Two types of shoreline armoring exist, hard and soft, though each has its own set of advantages and drawbacks. Hard shoreline stabilization, including levees, seawalls, groins, and various types of breakwaters, involves building physical objects to hold back ocean water and prevent the loss of sediment (NOAA, 2018). Soft shoreline stabilization, including soil bio-engineering, geotubes/geotextiles, and the use of dunes, often involves using mixed materials to utilize more natural techniques and less invasive techniques to mitigate erosion (Cornell et al., n.d.).

While shoreline armoring can help prevent beaches, wetlands, and other intertidal areas from receding, they also run the risk of disrupting coastal ecosystems and preventing sediment from moving naturally (NOAA, 2018). Because of the significant detriment that armoring can cause to coastal communities, the best designed armoring should be site specific, tailored to the specific needs of that ecological area, to best mitigate the damage the armoring is at risk of causing.

B. Hard Structures

Hard structures are constructed along ocean, estuarine, and riverine shorelines in an attempt to reduce flood- and storm-induced damage to infrastructure. Oceanfront structures are typically built from non-naturally occurring materials including timber, steel, large stones, and concrete (Cornell et al., n.d.). While these structures can prove effective to mitigate storm damage to properties located behind them, their lifespan is typically limited to 50 years and they require regular maintenance. Inland of the immediate coast, levees are typically constructed of natural materials in combination with stone or some hardening. Levees' simple task is to protect infrastructure by keeping the river from flooding adjacent communities during high stage events. (Cornell et al., n.d.).

1. Examples of Techniques

a. *Levees*

Levees are structures onshore that primarily protect low-lying areas from threats of flooding. Levees are typically created using an embankment made of fine materials, usually sand or clay, covered in a surface of grass, asphalt, stones, or concrete to create a gentle slope to reduce the erosion effects from waves (Cornell et al., n.d.).

FIGURE 5: Armored levee in the Netherlands at low tide (Cornell et al., n.d.).

b. *Seawalls*

Another type of onshore structure, seawalls help prevent or alleviate overtopping and flooding of landscapes and shoreline structures from waves or storm surges. Seawalls are built parallel to the coast, aiming to shore up its natural profile. When put in place to protect roads, houses, or walking paths, the seawall structure can project vertically from the profile of the shore. Seawall structures can vary from "vertical face structures such as massive gravity concrete walls, tied walls using steel or concrete piling, and stone-filled cribwork to sloping structures with typical surfaces being reinforced concrete slabs, concrete armor units, or stone rubble" (Cornell et al., n.d.). Bulkheads, revetments, and riprap are various other forms of seawall structures.

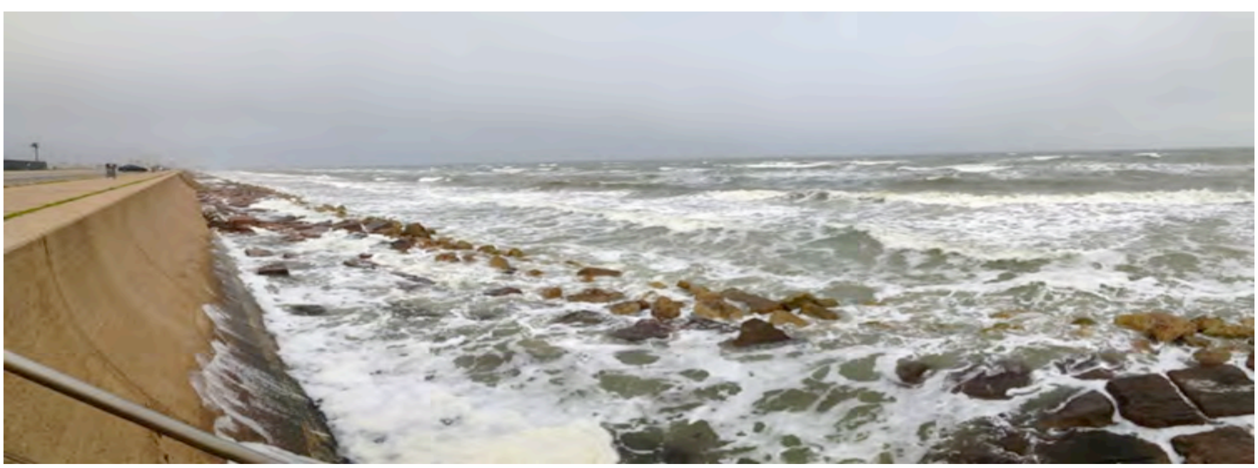

FIGURE 6: Waves breaking against a seawall in Galveston, TX (Cornell et al., n.d.).

c. *Groins*

Groins are designed to alleviate erosion on stretches of natural or artificially nourished beaches, with the sole purpose of mitigating longshore loss of sand or other shoreline materials. These slender, straight structures are erected perpendicular to the pre-project beach. "The effect of a single groin is the accretion of beach material on the updrift side and erosion on the downdrift side; both effects extend some distance from the structure" (Cornell et al., n.d.). Groins are often built in a sequential system, with a series of the structures placed intermittently down the shoreline, though this can result in a "saw-tooth-shaped shoreline" (Cornell et al., n.d.).

FIGURE 7: Orthoimagery of the groins along Ocean City, NJ (Cornell et al., n.d.).

d. *Detached Breakwaters*

Principally designed to slow beach erosion, detached breakwaters are built parallel to the coast just seaward of the shoreline in shallow waters. Breakwaters are typically made of solid concrete structures, piled stones/concrete blocks, or mounds of rubble. Multiple detached breakwaters can provide a substantial amount of protect to larger shoreline frontages, with each individual structure reflecting and deadening some of the energy from incoming waves. The function is to reduce wave height and interrupt sediment transport along the shore to reduce erosion. Typically, material washed along the shore "moves into the sheltered area behind the breakwater where it is deposited in the lower wave energy region" (Cornell et al., n.d.). This runs the risk of causing salients and tombolos to be formed in a manner similar to pocket beaches, though these pockets can cause a refraction of the waves to help in stabilizing the "pocket-shaped coastline" (Cornell et al., n.d.).

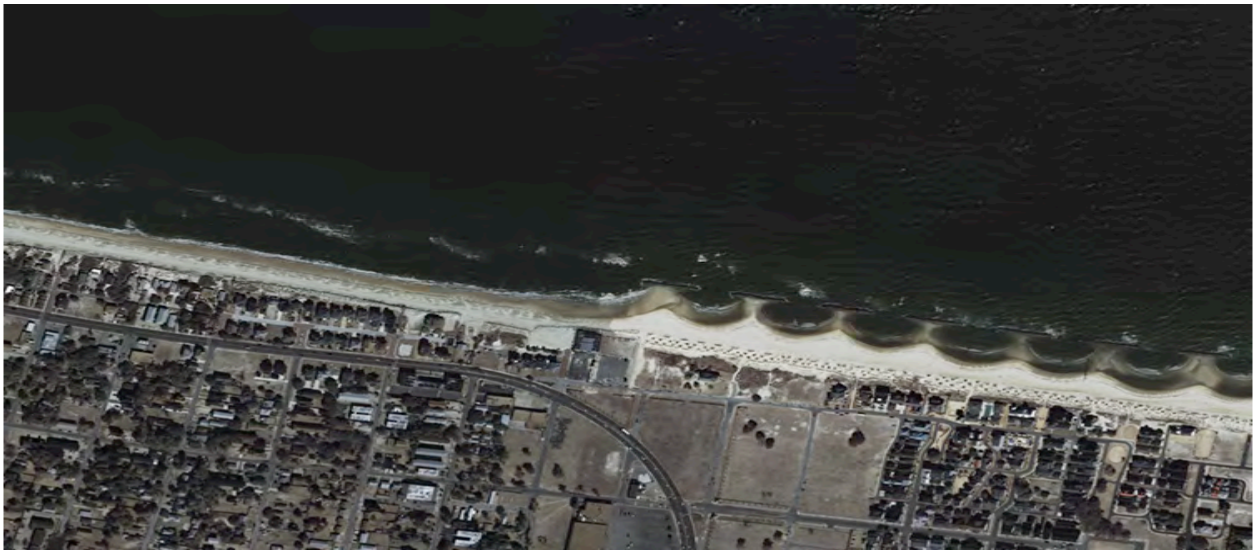

FIGURE 8: Orthoimagery of the offshore breakwaters and tombolos along East Ocean View, Norfolk, VA (Cornell et al., n.d.).

e. *Jetties*

Used for the stabilization of navigational channels at tidal inlets and river mouths, jetties are connected to the shore on one or either side of the channel, perpendicular to the coast and stretching into the ocean. This confinement of stream or tidal flow makes it possible to reduce shoaling along the channel, decrease the necessity for dredging, and can redirect the crosscurrent where strong longshore currents are to lessen hazards to navigation. Jetties can improve the maneuverability of ships by providing protection from strong waves (Cornell et al., n.d.). Unfortunately, jetties can contribute to significant downdrift erosion if the sediment accumulating on the updrift side is not artificially bypassed across the inlet (see the shoreline offset in Fig 9).

FIGURE 9: Jetties at Indian River Inlet, DE with updrift accretion and downdrift erosion (Cornell et al., n.d.).

f. *Geotubes/Geotextiles*

While geotextiles are normally used in conjunction with other soil techniques (as mentioned above) to help stabilize riverbanks and shorelines, geotubes are useful to aid in coastal renourishment, especially in efforts to rebuild dunes. Vegetation can also be added to increase soil stability. As time passes, sand blown from the shoreline accumulates along the seaward side of the dune system, sorting itself into smaller dunes where additional plant life can grow. Ultimately, this technique can be used to provide additional protection along coastal systems from storm surges and waves (Cornell et al., n.d.). A geotube project along these lines was implemented along Grand Isle Beach in Louisiana to help strengthen the shoreline. The U.S. Army Corps of Engineers (USACE) used geotextile tubes in 2009 to help stabilize the dune system with some significant success (Osborn Contract Services, n.d).

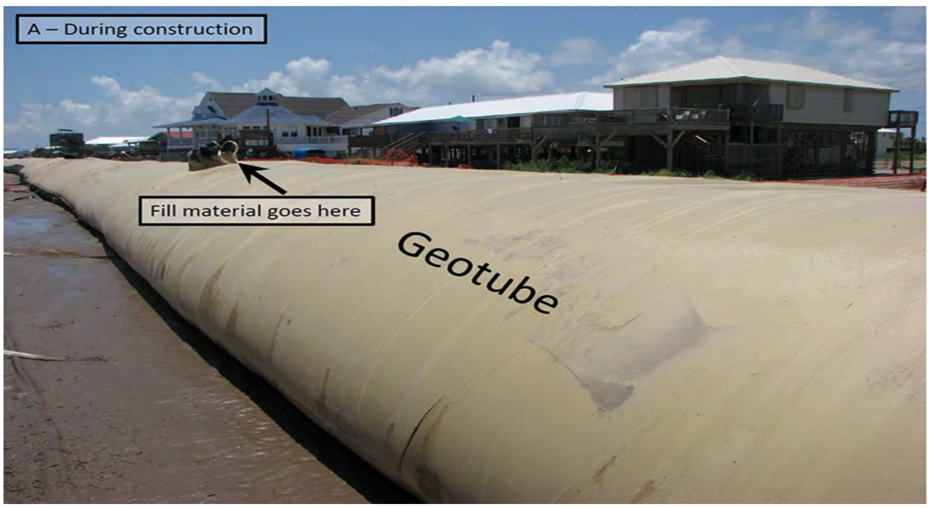

FIGURE 10: The geotube shown after it was positioned and filled with sand. Several openings along the top allow for infilling using pumped sand. Water that may accumulate will drain through the geotube mesh (Cornell et al., n.d.).

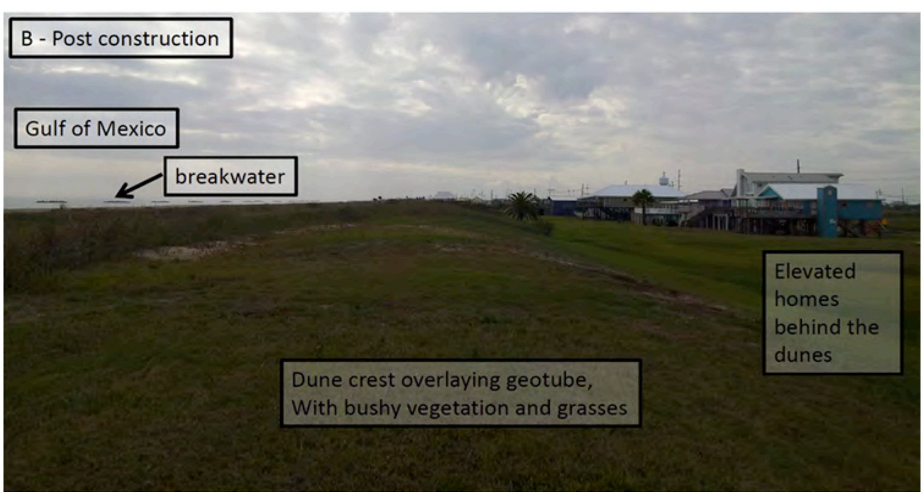

FIGURE 11: Post-construction, a top layer of sand is added to cover the tube, as is vegetation that can grow over time to provide a natural dune cover (Cornell et al., n.d.).

2. Disadvantages

Hard structure stabilization can be the most effective form of mitigating storm damage along a coastline, although this comes at the high price of hindering recreational use of the beach and negatively impacting the coastal ecosystem. Seawalls built on eroding beaches may protect the coast but cause the beach at the base of the wall to erode away almost entirely. Likewise, groins and jetties often result in accretion to one direction, by trapping sediment along the updrift side, resulting in erosion on the downdrift side as longshore transport is interrupted. For this reason, all states limit the use of coastal hard structures and typically encourage the use of soft solutions like beach nourishment and dune building.

C. Soft Shoreline Structures

Soft shoreline armoring aims to use more environmentally friendly methods to help mitigate coastal erosion while simultaneously enhancing the natural function of the shoreline itself. Most soft armoring methods try to incorporate features that will allow natural processes, such as sediment moving, to continue. Much like hard armoring techniques, soft armoring must be planned specifically to each area. Differences in coastal geomorphology, specific sedimentary transportation, physical processes, and local ordinances must be recognized. Groups like NOAA Coastal Services Center have been promoting soft stabilization techniques over potentially detrimental hard stabilization for years and have seen a fair amount of success in implementation (Cornell et al., n.d.).

1. Examples of Techniques

a. *Bioengineered Soil*

The purpose of many soft armoring techniques aims not only to mitigate flooding and erosion, but also to increase the natural value of the environment that is intended to be protected. Soil bioengineering applies hybrid methods of geotextiles and/or plant life and can protect streambanks while capitalizing on water quality and ecological benefits. This technique provides root reinforcement within the soil and can help in modifying drainage patterns where applied. Willows are often used, as they provide many ecological and aesthetic benefits, but would not be useful in coastal settings. In some shoreline settings, coconut fibers (or coir logs) have been utilized to in conjunction with native vegetation. When combined with other simple techniques, like changing the slope angle of the shore, this type of fiber matting has been used to stabilize banks and establish marsh fringes near the base of the slope (Cornell et al., n.d.).

FIGURE 12: Phases of streambank stabilization (A) excavation of undesirable material, (B) new topsoil added, and (C) the final product with stream banks overgrown with lush vegetation (Cornell et al., n.d.).

b. *Dunes*

Sand dunes naturally work to protect coastal environments from erosion and provide a natural supply of sand to beaches as they erode, while also creating a habitat for various plants and animals. Many countries, including the U.S., employ dune protection programs to help maintain and sustain these environments from intentional and unintentional human damage (Cornell et al., n.d.). South Carolina Department of Health and Environmental Control (SCDHEC) was given direct statutory authority within 8 counties along the state's coast (Beaufort, Berkeley, Charleston, Colleton, Dorchester, Georgetown, Horry, and Jasper) for any alterations or structures in areas within the coastal waters, tidelands, beaches and beach/dune systems that are considered critical as noted by the South Carolina Coastal Zone Management Act passed in 1977 (DHEC, 2018b).

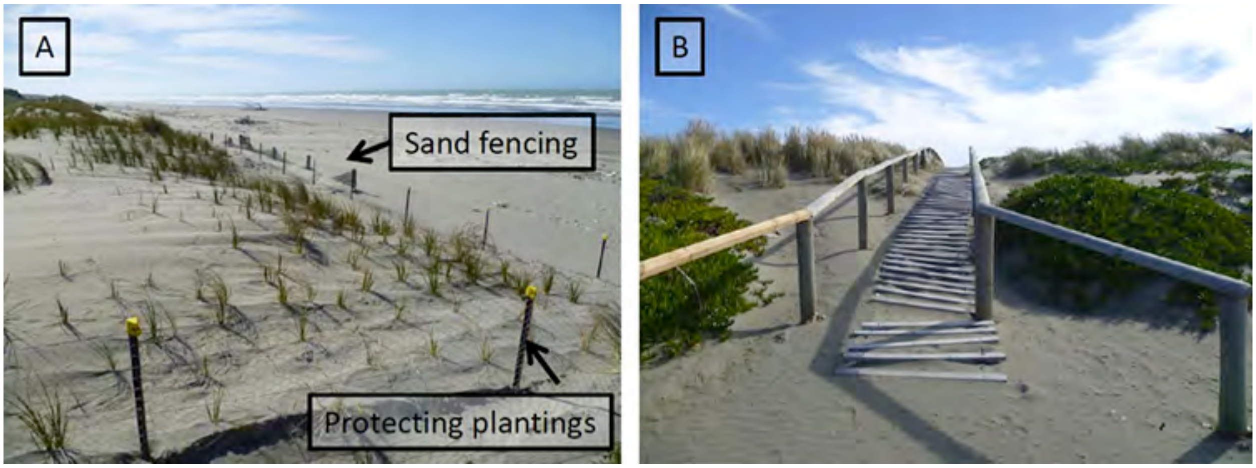

FIGURE 13: (A) Recently planted vegetation along a foredune and sand plain with remnants of old sand fencing and enclosures to protect new vegetation from destruction by foot traffic. (B) A view from the backdune with bushy plant growth and walkways to restrict activity and traffic along the dunes (Cornell et al., n.d.).

c. *Living Shorelines*

Living shorelines are a green infrastructure technique using native vegetation alone or in combination with low sills to stabilize the shoreline. Living shorelines provide a natural alternative to hard shoreline stabilization methods like rip rap or bulkheads, and provide numerous benefits including nutrient pollution remediation, essential fish habitat structure, and buffering of shorelines from waves and storms. Research indicates that living shorelines are more resilient than bulkheads in protecting against the effects of hurricanes (NOAA, 2019). The recommendations within the Governor's Floodwater Commission Living Shorelines Task Force Report is expected to provide helpful information and guidance on potential deployment of this innovative shoreline stabilization technique.

d. *Beach Renourishment*

Beach renourishment is by far the most common method of shoreline stabilization and storm damage reduction on the oceanfront today in South Carolina and around the country. Beach nourishment is the adding of sediment onto or directly adjacent to an eroding beach. This "soft structural" response allows sand to shift and move with waves and currents. Dune restoration is commonly carried out during a beach nourishment project as well.

A wide, nourished beach system absorbs wave energy, protects upland areas from flooding, and mitigates erosion. The beach provides a buffer between storm waves and landward areas, and it can prevent destructive waves from reaching the dunes and upland developments. When sediment is naturally moved offshore from a nourished beach, it causes waves to break farther from the shoreline, which weakens their energy before reaching the shore (US Army Corps of Engineers, Institute for Water Resources).

2. Disadvantages

Soft stabilization methods for shoreline armoring have many of the same benefits as hard stabilization techniques, while also reducing some of the significant costs and environmental impacts that hard armoring can present. However, soft armoring is not appropriate to be used in high energy environments, will not be as effective in areas where shoreline hardening has already occurred, can be more difficult to design and install than traditional hard armoring structures, and has limited information on the effectives of living shorelines for various forms of shorelines, energy regimes, and storm conditions (Cornell et al., n.d.).

D. South Carolina Coastal Laws and Regulations

Following the national Coastal Zone Management Act in 1972, South Carolina developed the SC Coastal Management Program in 1977 by authorizing the Coastal Tidelands and Wetlands Act (CTWA) to balance development, conservation, and appropriate uses of the state's coastal resources (DHEC, 2018a). The CTWA includes everything from the policy to permit construction along the coast to the State's "Adopt-a-Beach Program." In 1988, South Carolina first adopted the Beachfront Management Act (S.C. Code Ann. § 48-29-250 *et seq*) to establish statutory guidance and policies to direct all beachfront activities and decisions across the state. One of the major requirements of the act is for counties and municipalities to coordinate with DHEC's Ocean & Coastal Resource Management (OCRM) to create beach management plans, to be approved by the state and subsequently reviewed every five years. DHEC-OCRM uses "baselines and erosion rate-based setback lines" when determining new beachfront construction or the repair of previously existing buildings, structures, or erosion control implementations (DHEC, 2018c).

DHEC-OCRM also handles all permitting for erecting structures seaward of the determined baseline, including those used for erosion management. While seawalls are banned, other existing structures, such as dikes or groins, may be repaired and new structures can be erected with a permit approved by the department, though only in areas where there will be further beach renourishment efforts.

Under S.C. Code Ann. §48-39-130(D) (2019), exemptions to permitting apply for the following:

- The accomplishment of emergency orders of an appointed official of a county or municipality of the State, acting to protect the public health and safety, upon notification to the department. However, with regard to the beach and dune critical areas, the following techniques or a combination thereof, shall be used in accordance with guidelines provided by the department are allowed pursuant to this item:
    - Sandbags, provided that a bond is supplied to reasonably estimate and cover the cost of removal;
    - Sandscraping;
    - Renourishment;

- Any other technology, methodology, or structure pursuant Section 48-39-320(C), provided that:
    - The emergency order for use is only issued by the department; and
    - A bond is supplied to reasonably estimate and cover the cost of removal; or
  - A combination of these techniques.
- Hunting, erecting duckblinds, fishing, shellfishing and trapping when and where otherwise permitted by law; the conservation, repletion and research activities of state agencies and education institutions or boating or other recreation provided that such activities cause no material harm to the flora, fauna, physical or aesthetic resources of the area.
- The discharge of treated effluent as permitted by law; provided, however, that the department shall have the authority to review and comment on all proposed permits that would affect critical areas.
- Dredge and fill performed by the United States Corps of Engineers for the maintenance of the harbor channels and the collection and disposal of the materials so dredged; provided, however, that the department shall have authority to review and certify all such proposed dredge and fill activities.
- Construction of walkways over sand dunes in accordance with regulations promulgated by the department.
- Emergency repairs to an existing bank, dike, fishing pier, or structure, other than oceanfront erosion control structures or devices, which has been erected in accordance with federal and state laws or provided for by general law or acts passed by the General Assembly, if notice is given in writing to the department within seventy-two hours from the onset of the needed repairs.
- Maintenance and repair of drainage and sewer facilities constructed in accordance with federal or state laws and normal maintenance and repair of any utility or railroad.
- Normal maintenance and repair to any pier or walkway provided that such maintenance or repair not involve dredge or fill.
- Construction or maintenance of a major utility facility where the utility has obtained a certificate for such facility under "The Utility Facility Siting and Environmental Protection Act", Chapter 33 of Title 58 of the 1976 Code. Provided, however, that the South Carolina Public Service Commission shall make the department a party to the certification proceedings for utility facilities within the coastal zone.
- Dredging in existing navigational canal community development by individuals, counties, or municipalities of manmade predominantly armored, recreational use canals and essential access canals conveyed to the State or dedicated to the public for that purpose between 1965 and the effective date of this act if the maintenance dredging is authorized by a permit from the United State Army Corps of Engineers pursuant to the Federal Clean Water Act, as amended, or the Rivers and Harbors Act of 1899. All other department administered certifications for such dredging are deemed waived.

E. Findings and Recommendations

The Infrastructure and Shoreline Armoring Task Force considered shoreline armoring and stabilization methodologies that balance the needs of manmade protection with those of natural systems. These areas may be found along the coast or the state's inland waterways and could involve areas of considerable development or critical infrastructure. Along the coast of South Carolina, hard armoring such as the controversial construction of bulkheads, seawalls, and other barriers have been debated at a policy level for many years. While this Task Force does not desire to wade into the policy debate on hard armoring along the South Carolina coast, the Task Force does desire to provide information on the tools in the shoreline armoring tool box. Additionally, there may be opportunities to identify critical infrastructure and other key areas of concern outside of the coastal zone that could benefit from a shoreline hardening project.

The goal for shoreline armoring for flood hazards is to promote public health, safety and general welfare by minimizing public and private losses due to flood conditions in specific areas. Flood management armoring should be strategically located, designed, constructed and maintained to protect: the physical integrity of the shoreline and properties that may be damaged by alterations to the geo-hydraulic system; water quality and natural groundwater movement; fish, vegetation and other life forms and their habitat vital to the aquatic food chain; and recreation resources and aesthetic values such as point and channel bars, islands and other shoreline features and scenery. Hard armoring should be carefully considered as it typically alters the natural flow patterns of sediment and water.

The City of Charleston is also leading efforts on this key issue for the state. The Storm Surge and Sea Level Rise Protection Project initiated by the City of Charleston is estimated to be $52 million and involves the Battery Seawall undergoing reconstruction. The project will raise the sea wall and its sidewalk to meet the sea level rise standards. Murray Boulevard will also be upgraded to accommodate the adjustments. The streets will also be improved with upgrades to the utilities, curbs, and pavement. The biggest priority and first location of new construction is the western side of Tradd Street, where the seawall is in its worst condition (City of Charleston, n.d.). The Low Battery Seawall Improvements Infrastructure project is currently underway, having been started in 2015 with the hopes of being completed by 2025 or 2027.

1. Hard Shoreline Armoring

While there have been recent attempts in the state to seek exemption to the 1988 ban on seawalls, the policy makers in South Carolina take a dim view of the use of these structures along the coast of South Carolina due to well documented negative impacts to the recreational beach and neighboring properties. This Task Force has sought to provide useful information on the various hard shoreline armoring techniques, but we have not reevaluated state rule or regulation with regards to the use of these structures.

2. Soft Shoreline Armoring

Efforts to progress South Carolina's use of soft shoreline armoring techniques have been prominent in recent years. Collaborations between NOAA, various SC DNR departments, the North Inlet-Winyah Bay National Estuarine Research Reserve, and ACE Basin National Estuarine Research Reserve, have worked to construct oyster-reef-based living shorelines over the last 15 years (NOAA, 2016). Pursuing similar projects, utilizing bioengineered soil and geotextiles, as well as utilizing the recommendations developed by the "Living Shorelines" task force are highly recommended as a more sustainable alternative to preserve the natural ecosystems of coastal environments while also working to mitigate coastal erosions. Protecting oceanfront property through beach nourishment continues to be the preferred approach of the coastal communities in the State of South Carolina.

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State of South Carolina

GOVERNOR HENRY MCMASTER

THOMAS S. MULLIKIN, CHAIRMAN

South Carolina Floodwater Commission

Smart Rivers and Dam Security Task Force Report

November 8, 2019

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I. SMART RIVERS

Executive Summary

As you read the Task Force's report, it is tempting to view modeling as an end product and dam security as a sperate subject. We have found modeling is just the beginning. Many agencies have been modeling SC river and coastal flooding for many years. The effect of that modeling has helped the state in very specific areas, but the data is not widely known or utilized. We must begin sharing the data, optimize the modeling and then use the results for development planning, emergency planning, and emergency operations. Shared modeling allows SC to develop in an ecologically friendly manner that reduces the potential for damage from flooding. Control structures can be built into development and operated as part of the Smart River Operations. Operation of new and existing control structures must be coordinated across all levels of government and the private sector. Keys to successful use of modeling lie in model coordination, sharing and optimization; use of models to guide development; providing control structures at every level to include automation according to the modeling; and coordination of actions by states, counties, local authorities and private companies and individuals based on modeling before, during, and after emergencies. The Task Force has some very specific findings and recommendations. We acknowledge that this study is just the beginning of what should be a continuing effort to incorporate the effects of water in an ever-changing environment into the life of our state.

A. Overview

From 2015 through 2018, South Carolina (SC) experienced five wet hurricanes that deluged the state in flooding from the coast to the mountains. The floods occurred over periods of hours to days to several weeks. Flooding scenarios literally extended from the coast to inland to upland areas for the same individual events. Unfortunately, the floods were in many cases poorly forecasted and many lives and property were lost and destroyed. In response to these events and the prospect of more to come, in December 2018, SC Governor Henry D. McMaster convened a meeting and commissioned a team of State, Federal, industry and academic flood experts to address the entire issue of flooding and all entailed. The Governor charged the group with developing a deep study report, intended to detail the steps to be taken to prepare the state for future events-in-kind. One of the Task Forces that the Governor created was that of Smart Rivers and Dam Security (the TF-SR&DS). At a subsequent meeting of the TF-SR&DS, the Task Force was split into two committees, one on Smart Rivers (C-SR) and one on Dam Security (C-DS). Myra Reece of the SC Department of Health and Environmental Control (DHEC) was appointed Chair of the C-DS and Len Pietrafesa of Coastal Carolina University (CCU) was appointed Chair of the C-SR.

In addition to the massive flooding experienced across SC from the five recent hurricanes, coastal flooding is now occurring during higher high tides, as so-called "nuisance flooding" and the potential for coastal inundations due to offshore events, such as tsunamis and meteo-tsunamis, also exists. Finally, public health issues cannot be overlooked as both floodwaters and standing waters can result in conditions deleterious to the health of the public. These types of events and conditions must be addressed as well. In order to assess the state of knowledge in natural hazard modeling for risk assessment, the Committee on Smart Rivers will also focus on building a next-generation cyberinfrastructure and a community for modeling and analysis practices, to better inform the citizenry of SC. As such, the Committee on Smart Rivers has embarked on the Governor's mission to make recommendations regarding the data sets, in addition to what is already being collected and available on-line, and for numerical modeling and model output real-time realizations that are necessary to "weather proof" South Carolina from future flooding events of all kinds.

This report will describe the charge and recommendations of the Smart River Committee of the Task Force charged with studying and recommending various kinds of numerical modeling architectures that should be adopted or developed for SC during periods of high intensity, wet, atmospheric storms and other types of flooding events. The modeling is expected to cover periods prior to the arrival of a storm and then during and following the storm's passage. The intention is to provide visualized, validated model guidance to emergency managers and decision makers, up to the Office of the Governor, for informed planning and evacuation scenarios to save lives and property of residents of SC utilizing cyberinfrastructure. The report will cover:

- What defines a "Model";
- Explanation of the necessary models including purposes and limitations;
- Coverage of current models;
- Gaps in models and what is needed to fill in the gaps;
- Needed models including areas that need to be modeled and new forms of modeling;
- How to coordinate modeling and prevent or circumvent duplication;
- Planning models versus Emergency Models;
- Access to models and model output by all interested parties;
- Existing data required to initialize the models and to validate the model outputs;
- Additional data required to conduct the modeling;
- Computer platforms required to conduct the modeling;
- The likely team of players and their Roles in a sequential wiring diagram;
- Examples of various model outputs;
- The conduct of model retrospectives;
- Real-time visualization of model outputs;
- Hierarchy of players that will communicate and explain the model outputs;
- Public health issues;
- Utility of artificial intelligence;
- Communication of model outputs;
- Explanation of model outputs;
- Estimated costs of the enterprise to fill the data gaps;
- Estimated costs of the entire modeling enterprise;
- Proof of application of the various models and model systems under prior well-documented storm events such as Hurricanes Joachim (2015), Matthew (2016), Irma (2017) Florence (2018) and Michael, by ways of example. One size does not fit all.

It is of note that the Committee on Smart Rivers (C-SR) and the Committee on Dam Security (C-DS) addressed four major topics and an overall goal, which emerged from its face-to-face meetings and its conference calls. They are:

- The need to better integrate extreme events in flood modeling, broadly defined is critical. Low-probability, high-magnitude events often dictate landscape form and have the potential to reset the directionality for long-term change. However, presently existing and operational models might not run on spatial or temporal scales that capture such a hazard.
- Human actions across SC can trigger or magnify natural flood hazards in an evolving landscape. A "cyberinfrastructure" to better integrate multiple models and data is required. For example, cascading natural flood hazards are common. Although many single-hazard models exist, almost none are capable of integrating across hazards, which is a necessity to truly assess risk. Coupling frameworks can accommodate for this.
- Interdisciplinary research is necessary. Modeling the evolution of landscapes for risk assessment requires incorporating human dynamics. Human actions can trigger or magnify natural hazards in an evolving landscape. There is value, therefore, in having the human factor integrated or coupled to environmental models.
- Developing strategies for model testing, validation and benchmarking against natural flood disasters, as they happen and immediately thereafter, with the recent explosion in data acquisition, remote sensing data would provide insight into model uncertainty and to what extent models can be implemented.
- The overall goal of the C-SR is to "weather proof" SC, in the sense of providing validated trustworthy and dependable, advanced, visualized and detailed numerical model output across SC.

So, where are the SC watersheds and rivers? Figures 1 and 2 illustrate those. Figure 3 shows major highways in proximity to the rivers.

FIGURE 1: The eight surface-water basins in South Carolina.

FIGURE 2: The SC Rivers and Lakes.

FIGURE 3: The major highways and rivers of SC.

B. Models

- The Definition of "numerical modeling", as relates to flooding, is that numerical models are mathematical models that use some sort of numerical time-stepping or integration procedure to obtain the behavior of the entity being modeled, in this case flooding, over time and space. The mathematical solution is generally represented by a generated table and/or graph, but in the context of flooding the model would be expected to be spatially and temporally expansive and diagnostic. Computational modeling provides an essential tool to better understand the fundamental surface and sub-surface processes causing natural hazards.
- As such, computational modeling provides an essential tool to better understand the fundamental surface and sub-surface processes causing natural hazards and their effects on Earth's surface change, especially where observations fall short. In general this is virtually everywhere, even with remote sensing coverage. As such, Earth surface and sub-surface models can contribute to quantitative pre-event risk assessments. Yet such assessments are appropriate only if models capture the important physical processes, are well tested and vetted, and are proven to be accurate.
- The models utilized for flooding, broadly defined, derive from the Navier-Stokes (N-S) Equations which are highly non-linear and have non-linear boundary conditions. Many reductions of the N-S Equations have been developed to simplify the tasks of

finding solutions to these difficult equations, since non-linear equations do not yield closed form solutions in general.

- Flood modeling can be deterministic, statistical or empirical in its basis, and is intended to be used either retrospectively and diagnostically, to aid in understanding of what occurred, or prognostically, to predict, i.e. forecast, what will occur.
- The intended purposes of numerical flood models are to diagnose what occurred previously and to predict what will occur in the future. The intention of the Committee on Smart Rivers is to provide visualized, three-dimensional spatially intensive, hourly, time sequenced model output, superimposed on GIS and Google Maps of SC at statewide to local community levels.
- A fundamental problem in the analysis of complex environmental systems, including surface and groundwater systems, is the interplay of data and modeling, both when testing fundamental theories and when calibrating models. Improving how data and models are used has proven to be exceedingly difficult, however, partly because models are commonly plagued by spurious numerically-based nonlinearities in addition to fundamentally important process-based nonlinearities, and partly because models are not used to as much advantage as they could be. One of the most difficult problems is that though environmental model calibration methods are maturing to include rigorous methods of relating models to the calibration data and the predictions of interest, it is still often unclear how to attain good model predictive ability, as needed for resource planning. A basic question is what level of model detail and parameterization is likely to yield the most accurate predictions. Additionally, in groundwater models, the use of geologic principles to constrain model characteristics such as the geometry of interconnections and barriers is critical. Yet the geology is often poorly known, leading to groundwater flow patterns that are often grossly in error, and resulting errors in estimated parameter values. This then obscures the ability to derive any general understanding of processes from a set of studies.
- The charge of the Smart River Committee seeks to improve how data and models are used together to obtain useful system characterization and predictions by improving the transparency and refutability of models. Transparency is improved by creating and evaluating statistics that reveal observations important to parameters, and observations, parameters, and system processes important to predictions and prediction uncertainty. Evaluation of the statistics developed on the project and by others is essential because of the proliferation of such statistics. At this point, nearly every report employs a different set of statistics, making it nearly impossible for those using models to compare different modeling efforts. In such an environment transparency is often diminished instead of enhanced by the methods available. Refutability is improved by closely considering data errors and model fit to data to obtain a measure of model error. Evaluation of multiple alternative models is encouraged to test hypotheses and include the views of many stakeholders in the modeling process. The following list addresses a number of issues that the Smart River Committee must consider, including:
- Limitations of models:
    - Current models.
    - Gaps in models.

- What kinds of models are needed?
  - Models of atmospheric state variables.
  - Models of oceanic state variables.
  - Models of hydrologic flows.
  - Models of hydraulic flows.
  - Models of river environmental variables
  - Artificial Intelligence models.
  - Emulation models.
  - Ensemble modeling.
- What are the geographic areas that need to be modeled?
- What are the new forms of modeling?
- How can modeling activities be coordinated to prevent duplication?
- Are there planning models versus emergency models?
- What models can data be assimilated into?
  - Will there be access to model outputs by all interested parties?
  - Who will provide explanations in understandable terms of model outputs to Emergency Managers and the Governor's Office?
  - Coordination of these communications.

C. <u>Data and Data Gaps</u>

What data are needed for the array of models and model systems, including data sources for data assimilation, modeling, validation, including but not limited to: NOAA, USGS, NASA, Euro-Met and non-federal assets: Table 1 includes archived and real-time data and also identifies geographic data gaps.

TABLE 1: Data that will be used in SC flood modeling.

	Data	Source	Usage
1	LiDAR topography and bathymetry	Federal, state and local	High accuracy LiDAR across all of SC would greatly improve all flood models, regardless of type and objective. For the Record: the NOAA –NREL WRF Atmospheric Forecast Model has datum built into it; so LiDAR works well for interactively coupled model systems
2	Ground station data (Figure 1)	NWS and FAA	The moisture, wind, temperature, rainfall, snow and other meteorological data are used for atmospheric modeling
3	WSD radar data	NWS	Radar data are used for estimating rainfall
4	Coastal water level data	NOS	Water level data are used for ocean modeling
5	IOOS data	NESDIS	Could be used for modeling but non-existent off SC
6	Marine buoy data;	NDBC and CCU/FAU	NDBC Buoy data are used for ocean modeling but sparse and distant off SC. However, three additional real-time reporting Air-Sea Buoy Stations

			maintained by CCU/FAU need to be established for advanced oceanic-atmospheric modeling required for Weather-Proofing SC
6	Satellite and other remote sensing data	NESDIS NASA and others	Remote sensing data are used for flood detection and model validation
7	Rainfall estimate data including MRMS and HRRR	NOAA ESRL/GSD	GSD model output are used to drive oceanic and hydrologic models
8	River gauge data and river environmental variables	USGS, USC/CCU	River gauge data are used for hydrologic model validation. There is a need for more stream gauges. The state lacks a complete coverage network of stream flow and stream depth gauges and environmental variables. At least 150 additional gauges are needed in the watersheds
9	SEA EcoNET and MESO (Figure 1)	CCU, FAU	A real-time reporting station at ~ 70 locations in SC. However, many more real-time reporting stations are required across SC to meet local needs. Nominally an additional ~150 stations are necessary.
10	SAR data and imagery	NESDIS, NASA, Euro-Met	SAR data can be used for Artificial Intelligence retrospective and prognostic studies
11	Storm water pond survey data (eight South Carolina coastal counties);	SC Sea-Grant	Stormwater ponds have impact on hydrologic and hydraulic modeling. CCU studying roles of 20,000 Ponds in 8 SC coastal counties during recent 5 storm events and USC studying 6,000 Ponds in 2 SC coastal counties under different Sea Level Rise (SLR) scenarios
12	National Hydrography Dataset	USGS	Hydrograph data can be used for hydrologic modeling validation
13	Coastal elevation model data; Coastal relief model (CRM) data; ETOPO1 global relief model data;	NOAA	Important for areas where the LiDAR data are not available

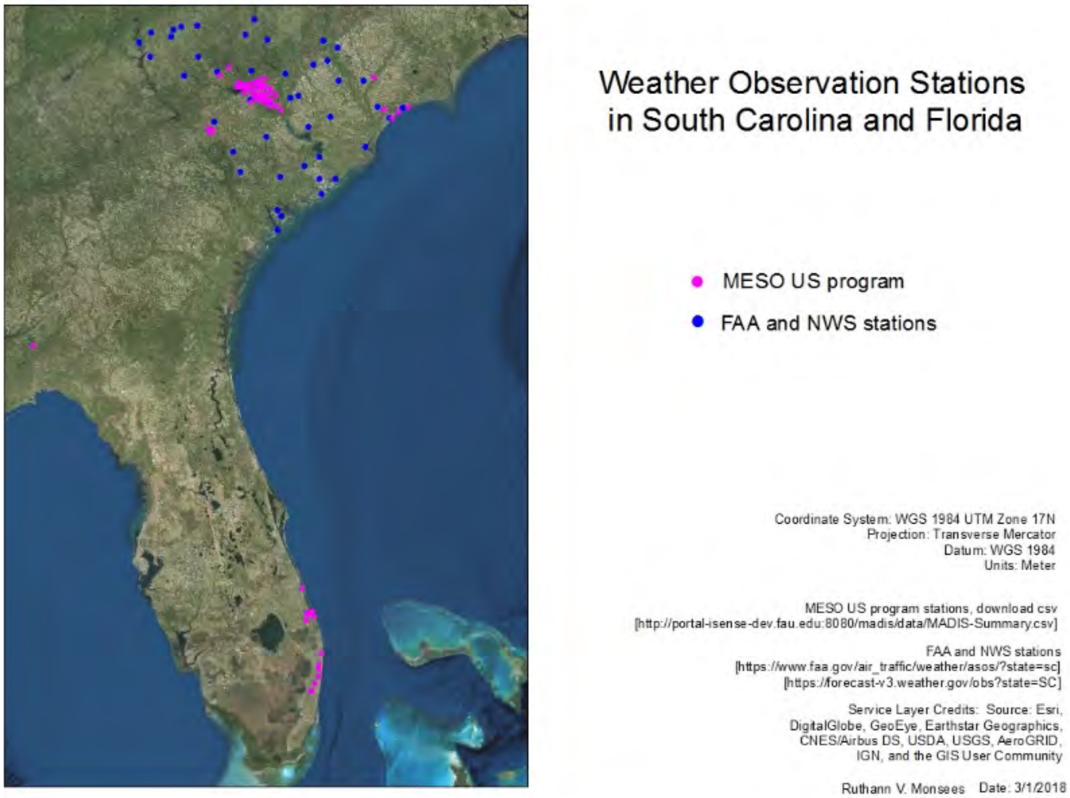

FIGURE 4: The NWS, FAA and CCU-FAU SeaEcoNet Real-Time Monitoring Stations.

D. <u>Existing Non-proprietary Community Models</u>

Descriptions and Applications Appropriate to SC Floods *(Community implies that the model codes are publicly available). Availability of codes for each model is listed by institution or organization.

1. <u>NOAA - SLOSH</u>

A 2-D vertically averaged linearized numerical model, which solves the Shallow Water Equations. It does not contain physically consistent bottom boundary conditions or fluid mechanically correct inundation (wetting) or retreat (drying) boundary conditions. All water level observations, including SLOSH storm surge heights, are referenced as height above a vertical datum. A vertical datum is an established surface that serves as a reference to measure or model heights and depths. Currently, the SLOSH model utilizes the National Geodetic Vertical Datum of 1929 (NGVD29) and the North American Vertical Datum of 1988 (NAVD88). All basins in the contiguous U.S. have been updated to NAVD88. SLOSH does not contain interactively coupled waves and is not interactively coupled with the atmosphere. It cannot produce accurate prognostic results but can be run quickly as its physics is simply formulated. Its wetting (inundation) and drying (retreat) schemes are simply line-of-sight, so are not topographically, physically or mathematically based. The model was developed By C. Jelesniansky in the early 1970’s based on the prior work of P. Weilander. Available from CCU.

2. ACE - ADCIRC

A 2-D vertically averaged numerical model, which solves the Shallow Water Equations. It does not contain physically consistent bottom boundary conditions nor fluid mechanically correct inundation (wetting) or retreat (drying) boundary conditions. ADCIRC does not contain interactively coupled waves. ADCIRC is not interactively coupled with the atmosphere. It cannot produce accurate prognostic results but can be run quickly as its physics is simply formulated and is not very accurate in real-time. It uses a finite difference spatial code. It was developed at the University of Notre Dame. It can be run in an ensemble mode on a conventional laptop as the model is simply formulated. Available from CCU.

3. POM

POM was developed at Princeton University and solves the 3-D Navier-Stokes primitive equations. The POM model has realistic boundary conditions and inundation and retreat schemes, adopted from the codes developed at North Carolina State University (NCSU). POM uses a stretched coordinate spatial system. POM has been interactively coupled with waves and the atmosphere by NCSU. It is quite accurate and can be coupled to waves, the atmosphere and rivers. Available from CCU.

4. ROMS

ROMS, the Regional Ocean Model, was developed at Rutgers University and is a next-generation POM. ROMS is more versatile than POM as it has plug-in capabilities with multiple ecological modules and hydrologic modules, both very germane to issues related to high intensity, severe storms and flooding. It has a different Bottom Boundary Layer Scheme than POM. It is quite accurate and can be coupled to waves, the atmosphere and rivers, etc. CCU has interactively coupled ROMS to the Weather Research Forecast Model (WRF) and the Shallow Water Wave Model (SWAN) with wave breaking and reformation physics. WRF was used as it was the operational backbone of the National Weather Service. Available from CCU.

5. EFDC

A primitive equation code, like POM and ROMS. It is very versatile. Available from the University of Maryland-Eastern Shore (UMES).

6. FVCOM

A volume preserving primitive equation code. FVCOM has many plug-in ecological modules, which could be important during the passage of high intensity, severe storms. FVCOM has been interactively coupled to SWAN, the breaking wave model. Available from UMES.

7. WRF-HYDRO

A model that simulates a wide range of hydrologic processes that cover a complete water cycle including rainfall, soil moisture, evaporation, infiltration and exfiltration, subsurface flow base flow, one and two spatial dimensional (1D and 2D) river channel flow, etc. The model is employed as the basis for the U.S. National Water Model (NWM) and includes a land-surface-model. WRF-HYDRO is a part of the CCU interactively coupled model system. WRF HYDRO is a necessary component during flood events. Available from NCAR, NWS and CCU.

8. HEC-RAS

The HEC-RAS model was developed by the U.S. Army Corps of Engineers (USACE) and models the hydraulics of water flow through natural rivers and other channels. Note that many organizations and institutions employ HEC-RAS directly to model flooding, but the model system does not utilize real time spatially and temporally precipitation information. As quantitative precipitation estimates are very variable, even during storms, this is problematic. HEC-RAS cannot physically connect to the Coast. Available from the USACE, USC and CCU.

9. NOAA National Water Model (NWM)

The core of this system is the National Center for Atmospheric Research (NCAR)-supported community Weather Research and Forecasting Hydrologic model (WRF-Hydro) and ingests forcing from a variety of sources including Multi-Radar/Multi-Sensor System (MRMS) radar-gauge observed precipitation data, and High Resolution Rapid Refresh (HRRR) , Rapid Refresh (RAP) , Global Forecasting System (GFS) and Climate Forecast System (CFS) Numerical Weather Prediction (NWP) forecast data. WRF-Hydro is configured to use the Noah-MP Land Surface Model (LSM) to simulate land surface processes. Separate water routing modules perform diffusive wave surface routing and saturated subsurface flow routing on a 250m grid, and Muskingum-Cunge channel routing down National Hydrography Dataset (NHDPlusV2) stream reaches. The system includes an analysis and assimilation configuration along with three forecast configurations. USGS streamflow observations are assimilated into the analysis and assimilation configuration and all four configurations benefit from reservoir inclusions. However, the NWM cannot connect physically to the coast which limits its utility to inland states. The code is available from NOAA and CCU.

10. CCU

Developed an Interactively-Coupled Numerical Model System for flood forecasting and diagnostic assessments. The interactively-coupled numerical system mathematical architecture (shown in Figure 5) is based on model elements that have been applied widely for coastal ocean and coastal environment modeling and forecasting. Fortunately, a recent break-through in the development has implemented a prototype river-ocean interaction process. The atmospheric component of the CCU Interactively-coupled model system is the Weather Research and Forecasting (WRF) model, a non-hydrostatic primitive equation model with comprehensive atmospheric physics parameterization schemes. WRF is used by the NWS and worldwide to simulate and forecast nearly the full suite range of weather events including hurricanes and severe rainfall events. The WRF code is available from NCAR, NWS and CCU. ROMS is the ocean model, SWAN is the Waves model, WRF-HYDRO, the latter based on the NWM, and HEC-RAS are the other components of the CCU Model System (the CCMS). We note that SWAN includes wave breaking mechanisms and dissipation and computes irregular waves in coastal environments, based on deep-water wave conditions, wind, bottom topography, currents and tides and explicitly accounts for all relevant processes of propagation, generation by wind, interactions between the waves and decay by breaking and bottom friction. Oceanic waves can create and exacerbate coastal and inland flooding. Further, simply adding waves to current model output is not fluid-mechanically correct. Rather, Pietrafesa showed (Figure 6) that for Hurricane Hugo in 1989, interactively-coupled wave-current interactions was able to correctly model the inundation in Charleston SC, in agreement with NWS validation data. Code available from CCU.

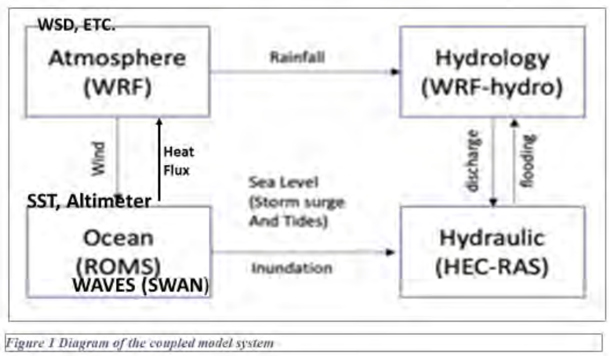

FIGURE 5: The CCU Interactively coupled Real-Time Numerical Model System (CCMS).

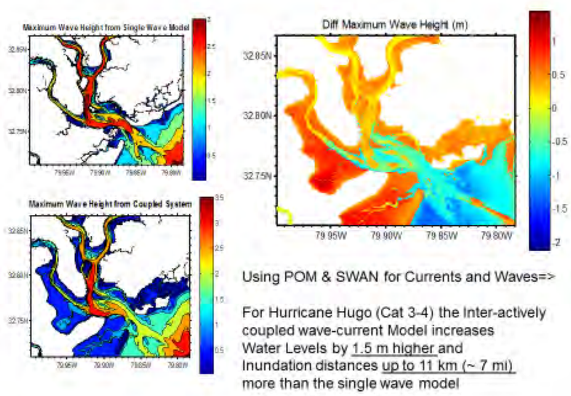

FIGURE 6: The important value of interactively coupling waves (SWAN) and currents (POM, ROMS) in a numerical model system. The Upper Left shows the inundation of Charleston Harbor and the Ashley, Cooper and Wando Riverbanks due to a Simple Wave model. The Lower Left shows the real inundation from an interactively-coupled Wave Current Model. The Right shows the true addition inundation between the Lower Left Minus the Upper Left. It is significant. (Figure from an NC State Report of Pietrafesa to NOAA, available upon request).

Figure 7 depicts the ecological components of the ROMS (CCU) and FVCON (UMES) model systems. The FVCON Ecological Modules are shown by way of example (ROMS are not).

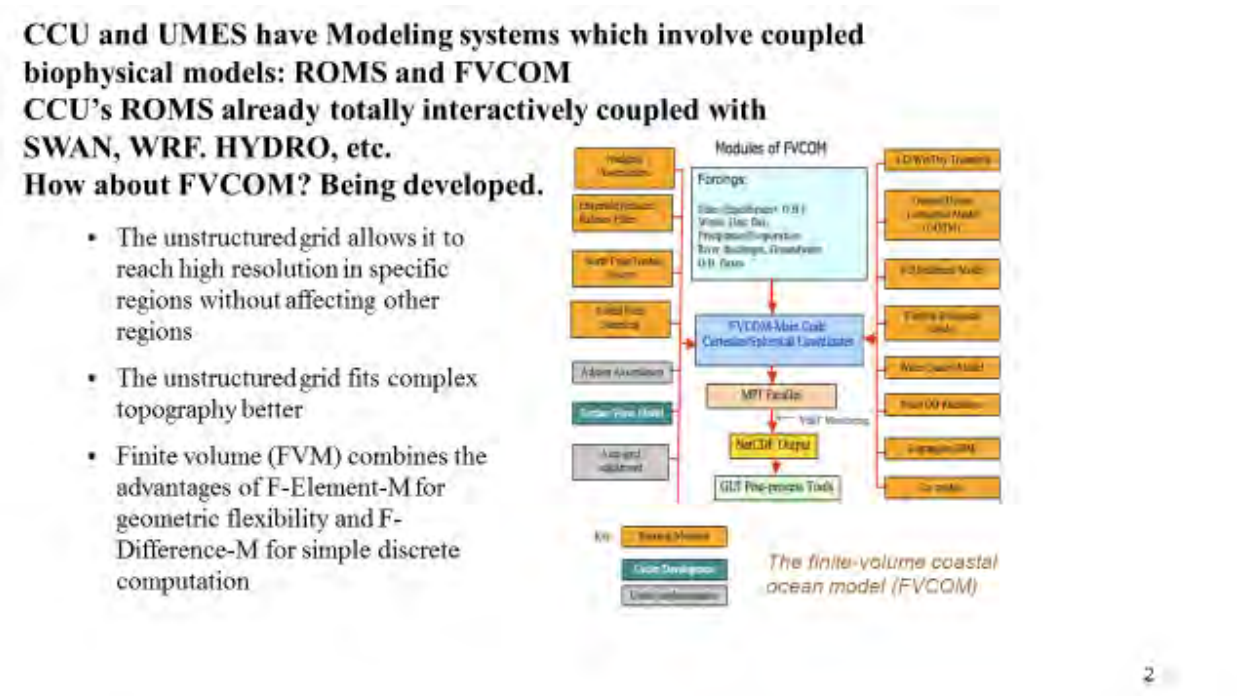

FIGURE 7: CCU and FVCON Ecological Modules.

11. Wave Watch (WWIII)

A NOAA linear wave model that can be run quickly but lacks complete physics, such as wave breaking, dissipation, etc. Available from NOAA/NOS and CCU.

12. Artificial Intelligence Modeling

AI-based modeling of inundation and flooding requires Synthetic Aperture Radar (SAR) derived satellite imagery and an area mapping framework and data preprocessing. The aims of the data preprocessing are radiometric calibration and geometric correction. After the data preprocessing, one must select the features within a SAR image that can be matched with known ground truth from Copernicus EMS rapid mapping products to train and validate the developed algorithm. USC and CCU both have active AI research and development programs.

13. Emulation Model

Probabilistic flood hazard assessment is a promising methodology for estuarine risk assessment but currently remains limited by prohibitively long simulation times. However, through the development of an emulator, or surrogate model, which replaces the simulator, with a statistical representation that is able to rapidly predict estuarine variables relevant to flooding coastal harbors and estuaries. This type of model is not recommended.

14. Ensemble Modeling

The process of running two or more related but different analytical models and/or the same model with different initial conditions, and then synthesizing the results into a single score or spread in order to improve the accuracy of predictive analytics and data mining applications. In predictive modeling and other types of data analytics, a single model based on one data sample can have biases, high variability or outright inaccuracies that affect the reliability of its analytical findings. Using specific modeling techniques can present similar drawbacks. By combining different models or analyzing multiple samples of the same model, one can reduce the effects of those limitations and provide better information. Running ensembles of complicated models, such as the CCU Flood Model System requires a high capacity, high performing HPC platform with dedicated processors.

15. Tsunami Modeling

Tsunamis are created by underwater earthquakes, underwater volcanic eruptions and underwater landslides. These could strike the SC coastal and inland areas and require an offshore monitoring network to be described below.

16. Meteo-Tsunamis

Tsunami-like water levels that can be triggered by atmospheric conditions and offshore weather. These phenomena could have an impact on coastlines all along the East Coast of the U.S. They can lead to persistent nuisance flooding events and many have gone unnoticed and are not well documented. Nonetheless, in Figure 8, an estimate of the number of events/year and their maximum amplitudes for the U.S. Eastern Seaboard based on a NOAA finding (pc. Dr. M. Peng, NOAA/NOS) are shown.

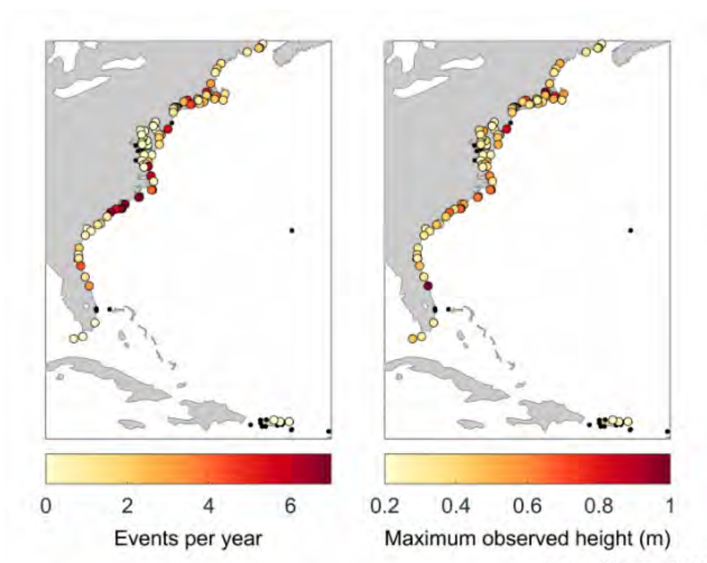

FIGURE 8: Given (10) and (11), there is a need to create an Offshore SC Bottom Pressure Sensor Alert System that will ring an alert that either a Tsunami or a Meteo-Tsunami is incoming.

17. Others

a. In addition to the models and studies already mentioned, if not already incorporated, the report should note flood studies from College of Charleston's Low Country Hazards Center and the South Atlantic Coastal Study from the US Army Corps of Engineers (USACE).
b. There is also the NOAA CI-FLOW program. https://www.nssl.noaa.gov/news/factsheets/CI-FLOW_2014.10.16.14.pdf In its inception, (Kelleher and Pietrafesa, 2000) the Coastal & Inland - Flooding Observation & Warning (CI-FLOW) System was intended to be a highly accurate, timely "Risk Forecast System". In its present form, the NOAA National Severe Storms Laboratory (NSSL) produces highly accurate and real-time updated precipitation forecasts that are used to generate flood maps for a number of southeastern states to drive CI-FLOW. Unfortunately, the on-the-ground flood forecasts are produced via the utilization of the ACE-ADCIRC Model (see D2 above) which produces fast but inaccurate results, as it is a vertically averaged model with artificial bottom boundary conditions and non-fluid mechanically correct wetting and drying schemes. The input information is excellent, but the output information is actually dangerous and puts people and property at risk.
c. River environmental variable models are available from the University of Maryland-Eastern Shore.

E. Baseline Resilience Indicators for Communities (BRIC) and Hazard Studies

The BRIC index considers six broad categories of community disaster resilience: social, economic, community capital, institutional, infrastructural, and environmental at the county level. Used as an initial baseline for monitoring existing attributes of resilience to natural hazards, BRIC can be used to compare places to one another, to determine the specific drivers of resilience for counties, and to monitor improvements in resilience over time. BRIC for SC is shown for 2015 (Figure 9).

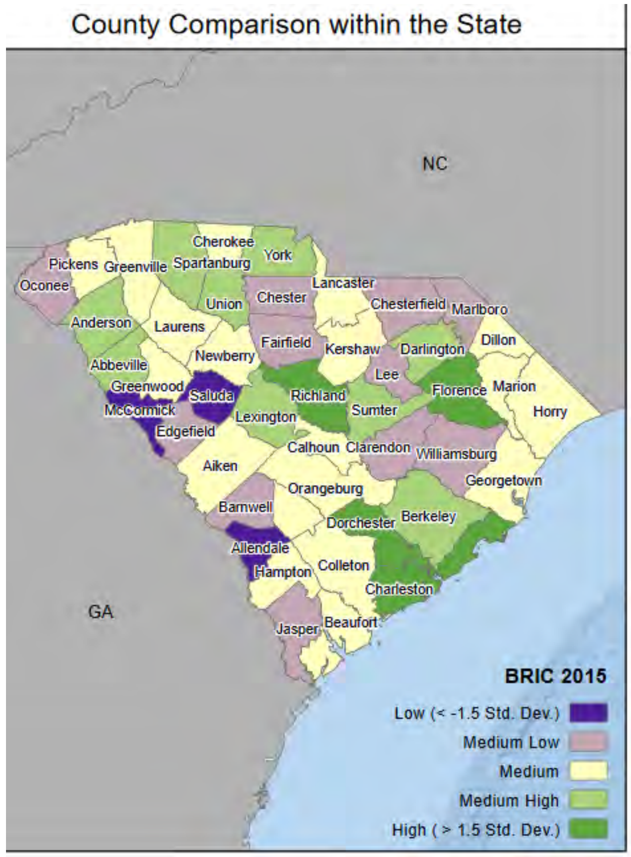

FIGURE 9: BRIC for SC for 2015.

1. <u>Hazard Prediction Studies</u>

a) *Overview*

While Hazard Prediction capabilities have generally improved in the past decade, there are serious issues. According to two recent reports [1, 2] from the National Academies of Sciences, Engineering, and Medicine (NASEM), communication of incoming hazards, such as extreme precipitation related flooding, via emergency alert and warning systems, have not kept pace with advancements in cyberinfrastructure. The reports state that the evolution of SC hazard alert systems will need to be informed jointly by both scientific and technical research and social and behavioral science research. While research increasing the accuracy of NWS weather forecasts has continued to improve, Federal and state-based hazard forecasts really have not. However academic-based hazard forecasts have improved greatly. Thus, to make the best use of forecasts, SC's alert capabilities will need to evolve and progress as the capabilities of web-based model output, smart phones and other mobile broadband devices improve and newer technologies become available. This evolution will need to be informed by both physical scientific, technical research and social and behavioral science research. To reduce risks, including loss of life, national weather alert systems that incorporate social and behavioral sciences and new technology must be developed. We note that social and behavioral science research seeks to understand why people choose to drive in hazardous conditions despite receiving accurate weather forecasts and alerts. These reports recommend using this research to tailor alert messages so that people in various socio-economic strata are more likely to heed impending hazard condition warnings. This proposed storm-related research and development need will push the collective research envelopes in the directions recommended by the NASEM.

This write-up addresses the utilization of cyberinfrastructure advancements to communicate what needs to be further developed and implemented as highly accurate, validated forecasts of impending hazards in the all counties of SC. An inter-actively coupled atmospheric-oceanic-land numerical model system, with an embedded hydrological module, and with capabilities to assimilate data from Federal and non-federal in-situ and remote observing systems would create reliable forecasts for site-specific locales for flooding in SC. It is of note that this is especially true for coastal states in general, since existing Federal agency water models do not connect their watersheds downstream to the Atlantic or Pacific Ocean Basins, Gulf of Mexico or Great Lakes. Pietrafesa et al (2019) finds that this is a serious flaw in the numerical model architectures and results in seriously flawed prognostications of what can be explosive coastal, inland and upland flooding over periods of hours to minutes to delayed floods of periods of days to weeks (Bao et al., 2015).

Socioeconomic surveys, data analyses and the development of risk warning tools must also be objectives. Our communities consist of multi-socio-economic groups of citizenry who respond to information and hazard queues in different ways, both spatially and temporally. Given SC's recent experiences with Hurricanes Joaquin, Matthew, Irma, Florence and Michael, the CCU team discovered that the ability to communicate experimental numerical model output to decision makers was compromised and diminished by an inability to explain the model results over the phone, particularly in timely ways as the event lingered and changed paths and directions.

b) *Proposed Course of Action*

The Smart River Committee's proposed course of action contains 9 sub-objectives and a 10th, overall objective. They are:

1. Collect all ground-truth data, both geophysical and socio-economic, to document the timing and amount of flooding which occurred during and following a series of five recent floods due to five hurricanes from 2015 – 2018 which struck SC;
2. Determine data needs and propose additional data sources to fill the voids and cover the state;
3. Utilize an interactively-coupled atmosphere, land, ocean, hydrology numerical model system to couple all diagnostic and prognostic environmental physical model elements, and to conduct ensemble retrospective studies, including Data Assimilation (DA) of the five different hurricane flood events, from coastal to inland to upland;
4. Evaluate the utility of employing satellite imagery (e.g. SAR) and artificial Intelligence (AI) to the five flood events to identify floodwaters on land throughout SC;
5. Employ on-the-ground socioeconomic data collection methodologies and tools to interrogate and document the responses and needs of the various societal sectors affected by the five flood events;

6. Based on (1), (2), (3), (4), (5), develop societal risk warning tools;
7. Develop real-time ensemble numerical model output of incoming events on an hourly basis, 7 days out;
8. Test the risk warning tools developed in (6) and the technology developed in (7) during actual events if they occur over the period of this proposed study.
9. Achieve the overall objective of the creation a flood risk-warning visualization and communication set of tools that would become operational for SC, and could serve as a prototype model for other coastal states in-kind in the U.S.; and
10. Provide this capability to the state of South Carolina.

2. Overview

The 4th Climate Assessment Report was released by the U.S. White House on 11/23/2018. The report states, "Higher sea levels will bring more and worse coastal flooding, a warming ocean will result in stronger storms and extreme heat waves will become longer and more frequent in the Southeast (U.S.)". The report lays out dire warnings for SC and the entire Southeast on the coming impacts of the changing climate. "Throughout the southeastern U.S., there will be numerous consequences for human health, the built environment and the natural world". "The number of extreme rainfall events is increasing, with the number of days the region has seen at least 3 inches of rain/event/year at historic highs….with the potential to cost up to $60B/year…..by 2045 Charleston could face nearly 180 tidal floods/year vs. 11 in 2014. By 2050, the Southeast is the region expected to have the most vulnerable bridges". On Saturday, 11/24/2018, following Thanksgiving, the tide in Charleston hit ~ 9 feet, flooding roads and low-lying areas around the entire city. These are very serious projections, based on facts, for a public at risk.

3. Charge

The purpose of the work proposed by the Smart River Committee is to provide SC decision makers with a new set of operationally based, easily communicated and easily accessible tools to warn citizens and decision makers of statewide and local threats of flooding, using an easily understandable index for emergency managers to communicate the level of risk that the public can understand. This new warning tool can be designed to be downloaded as a free smartphone app. Critically, the tool would enable more informed decision-making for ensuring the safety of the SC's coastal, inland and upland lives and property. We propose the development of a highly accurate, local and socioeconomically-conscious flood risk tool. There are resources and assets within the state that should be supported and utilized for this purpose.

Inaccurate or overstated scientific modeling of environmental and natural hazard flood risk can have deleterious effects on public safety. When faced with a flood risk, for example, individuals must assess whether and when to evacuate their homes or take other precautions. If citizens do not take warnings or evacuation orders seriously, they may put themselves and others in danger. The ways in which individuals calculate risk is complicated. For example, people take risk more seriously if it is perceived to be close to them, but less seriously if it is a familiar risk rather than a rare event (Pietrafesa et al., 2019). Individuals are more concerned about risks that receive media attention, but fear-based approaches to encourage citizen action may backfire (DeLameter & Daniel, 2010). Moreover, individual risk assessment is taking place in a national cultural context in which faith in experts is declining overall (Hildebrand, 2000). In the case of floods, studies indicate people are less motivated to take precautions if scientific models have overestimated risk in the past and/or if previous warnings about risk went unheeded with few or no consequences. This underscores the need for increased accuracy in forecast modeling and rapidly communicating risks associated with natural disasters (National Academies, 2018a; National Academies, 2018b).

This lack of precision in flood forecasting presents significant risks to the safety of communities and underscores the need for quicker, more accurate, and easier to understand information for local and state decision-makers. Failure to predict significant flooding is of obvious concern, but the risks associated with perpetually inflated forecasts could be equally damaging. Depending on the storm, that decision could be an enormous mistake. The national communication package for coastal surge, inundation, flood forecasting and inland terrain flood forecasting are deemed to be presently insufficient to safeguard against these possibilities. The proposed innovation will directly address current flood forecasting limitations with a rapid and updated communication tool using a well configured smartphone app.

Storms such as Irma, which were initially forecast to follow a coastal track along the coast of SC, instead turned and rerouted itself down the eastern side of the Appalachians and battered Atlanta GA, Columbia and Greenville SC with heavy precipitation affecting the piedmont and mountains, leading to inland and upland flooding. In these circumstances we have not improved our ability to provide warnings of impending flooding to the present time. Moreover, a study of hurricane-related damage in NC showed that 15% was due to storm surge, 25% was due to wind and 60% was due to flooding (Hildebrand, 2000). While there is presently a NOAA flood risk tool that projects "low, moderate and high risk of flooding", there is not a more comprehensive flood risk warning scale and a site-specific representation of the timing and amount of flooding that can be communicated. It is of note that all Federal and state forecasts of coastal flooding in SC during the passage of Florence in September 2018 were misleading and incorrect. This created massive confusion among coastal residents and visitors to SC coastal counties. The SC State Guard was at a loss to respond intelligently given the inadequate flood forecasts that were being provided to the agency.

Accurately calculating and communicating risk, with visualized, time sequenced color-coded templates of levels of water and timing of water flow can reduce injuries, fatalities, and property damage associated with flooding in coastal states. There is a dearth of research on the importance of effective messaging and public education in warning the public to prepare for and take action during natural disasters (Beck, 2014; Delameter et al., 2010; Paul & Huang, 2004). What we do know is that the warnings most often heeded are clear, specific, accurate and consistent (Terpstra & Lindell, 2013)), and people are most likely to engage in protective action when warnings clearly and accurately define vulnerability and convey a sense of personal efficacy to the public (Sorensen, 2000; Blanchard-Boehm & Cook, 2004). Message delivery during a natural disaster is complex. Disaster warnings are refracted through individual and community characteristics such as age, race, gender, socio-economic status, health/ability status, culture, geography (urban/rural), and even more factors (Pietrafesa et al., 2019; DeBoer, 2018; Cutter et al., 2003;

Slovic, 1993). Creating a well-understood scale of impending flood risk maximizes the potential to clearly communicate public vulnerability and recommended actions (i.e. evacuate vs shelter in place) through multiple channels to a diverse population.

Despite its life saving potential, existing flood forecasting from the mountains to the piedmont to the coast is extremely limited, and the early warnings from various sources are confusing at best, and often contradictory, as evidenced by the recent passing of Hurricane Irma. As Irma bore down on the Florida Keys and the mainland peninsula, high-resolution forecasts were significantly hindered by a lack of on-the-ground information and inadequate numerical modeling. Speculation concerning the anticipated surge on both the Atlantic Eastern Seaboard and the Gulf of Mexico coastline ranged from 5 feet to 20 feet, rendering the forecasts of limited value to community decision-makers and private citizens. And the range itself was incorrect. At the same time, the potentially catastrophic impacts of "blow out tides" were not disseminated through official channels. A similar storm with a different angle of approach and different forward speed could cause such an extreme surge but not Irma. In fact, many locals refused to leave as they considered these official forecasts to be lacking credibility and merit. A citizen who evacuated Hurricane Irma's path based on storm surge warnings, only to return home to little or no flooding, after contending with limited fuel, limited shelter, and extraordinary traffic might consider ignoring future surge forecasts. This can produce disbelief in future official forecasts which could be disastrous. Exactly this occurred and is described above for eastern NC in 1999, when 56 people died in localized flooding that was not forecast.

When disaster models underestimate risk and leave people in danger the results are obvious. However, it also is imperative to limit the extent to which models overstate risk. Erosion of public trust caused by inaccurate forecasting and communication may be devastating if subsequent warnings are ignored. While some studies indicate public response to disaster warnings may not diminish after a false alarm if the reason behind the discrepancy is clearly explained, there is evidence that repeated false alarms decrease likelihood of people taking protective action in the future. The most consistent predictors of preventative or protective action consider risk, feeling of vulnerability, and previous experience (Paul & Huang, 2004; Blanchard-Boehm & Cook, 2004; De Boer et al., 2013). If previous experiences with flooding are such that risk and vulnerability have been overstated, persons may underestimate risk in the future and thus be less likely to heed warnings or engage in protective action. Indeed, studies find that knowledge or familiarity with environmental or natural hazards decreases protective action (Beck, 2014; Cutter et al., 2003). Accurate prediction and communication of flood risk is particularly important because many people already underestimate danger caused by flooding (Blanchard-Boehm & Cook, 2004).

The storm surge forecasting during Irma's recent passage through the FL peninsula was dismal, at best. Reports from the Naples–Tampa Bay FL areas were that residents received advisories of storm surge forecasts of 15' to 18' which continued throughout passage of the storm. These were erroneous. While those FL west coast residents were fortunate in the case of Irma, a similar storm with a different angle of approach, location relative to the coastline, and translational direction and speed could cause extreme surges, inundation and flooding. We are also concerned that if such a scenario should occur in the future, the public might think that the last time, when they were informed that the surge would be 15' to 18', it was only several feet from storm related rainfall, they had evacuated for no reason at all. Thus, they might assume that the forecasts were "crying wolf". Depending on the storm, that could be a huge mistake. We propose to help correct this existing situation.

Storm-induced coastal and inland flooding is a complex process that is affected by many factors and not just wind speed, as was the basis for the original Saffir-Simpson Scale. From 1973 to 2009, storm-induced coastal flooding risk was represented and communicated via the Saffir-Simpson Hurricane Scale (SSHS), which was developed in 1971 and introduced to the general public in 1973. At the onset, the SSHS included the expected coastal flooding damage by category. The scale was based on only one parameter, the maximum observed wind speed in a tropical storm, a unique, easily understood and visionary concept. Unfortunately, due to the complexity mentioned above, the SSHS did not correctly forecast coastal surge, inundation and flood levels. The storm surge and coastal flooding forecasts associated with the SSHS, which were based on worse case scenarios in overly idyllic coastal zone situations, were very inaccurate. This deficiency in the SSHS was first realized in a pioneering study (Sheppard et al., 2012). In that study, the speed of the alongshore wind component of the storm, with the coastline to its right, was employed to create far more accurate coastal water levels during storm passage then could the SSHS. While the scholarly publication provided a diagnostic and prognostic tool for coastal surge, it did not suggest a risk scale. However, it showed that the SSHS was not a good tool for predicting coastal and inland flooding and could not communicate incoming and oncoming floods to the public with any confidence.

Our suggested modeling approach would be a numerical model system that generates coastal surge, inundation, upland and inland flooding estimates, both spatially and temporally, in a GIS format. The proposed system could rely upon existing numerical model systems, comprising a suite of interlinked numerical simulation components, including, by way of example, the NWS WRF atmospheric model (Janowitz et al., 2015), the oceanic ROMS and HYCOM models (Bao & Pietrafesa, 2004), the SWAN wave model (Pietrafesa et al., 2015), and the hydrologic WRF-hydro model, all interactively coupled (Sheppard et al., 2012); see Figure 3. This model system would also produce the predictions of the variables listed in Table 1 that would be cast as presented above. The model system could be extended to assimilate storm surge information from NWS, NOS and NDBC data sources, such as the NOAA Earth System Research Lab/Global Systems Division (ERSL/GSD) MRMS Rainfall Estimate Output, which is "operational", along with High Resolution Rapid Refresh (and RAP) model(s) as they will be used in real-time to provide critical rainfall estimates. The central simulation component is a deterministic hydrological model coupled to atmospheric, coastal current/wave, and storm surge/inundation models and to the land runoff, land absorption and water table flow hydrology-based module that has been plugged into WRF (Bao et al., 2019).

An example of model river discharge output vs. actual observations is shown in Figure 10 (from Dr. S. Bao at CCU). One important aspect of the storm surge/inundation model is that it provides the hydrological model with a non-local, downstream boundary condition (BC). This BC, consisting of coupled currents and waves, is ignored in current Federal hydrological models, yet is critical for accurate flood forecasting well inland as it can "back up" the river systems. In impervious environments it has been reported that 93% of the rainfall runs off into the adjacent water bodies, streams, tributaries, rivers, harbors, etc., and 7% runs into the catch basins. But in heavily permeable soils, 97% is absorbed into the ground water table only to appear downstream at a later date (Bao, 2015). When, where and how much are all important facts of information for emergency managers and the public to know. These would be part of the downloadable smartphone app. These model outputs would be cast into socio-economic GIS overlay(s) as a function of locale and produce fast and easy to understand output.

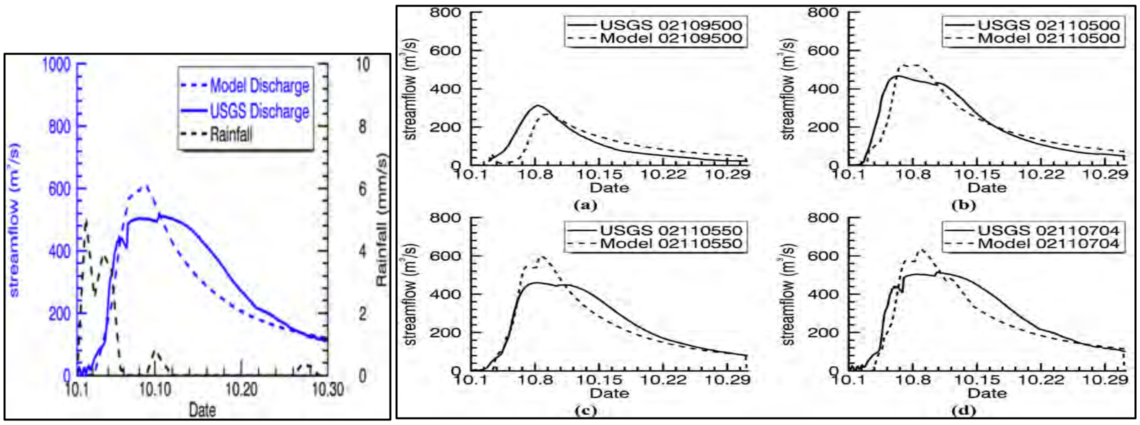

FIGURE 10: Left panel is rainfall plus CCU Model River Discharge. Right panel is model output vs. USGS data in four different SC Waccamaw River locales during the passage of Joaquin 2015. (from Dr. S. Bao at CCU).

Examples of Street Level Flood Maps and Animations that could be created (Figures 11 and 12).

FIGURE 11: An example of an Animated Street Level Model Output of the proposed SC Model System to be time and space sequenced and then communicated with GIS overlays to the public using a smartphone app.

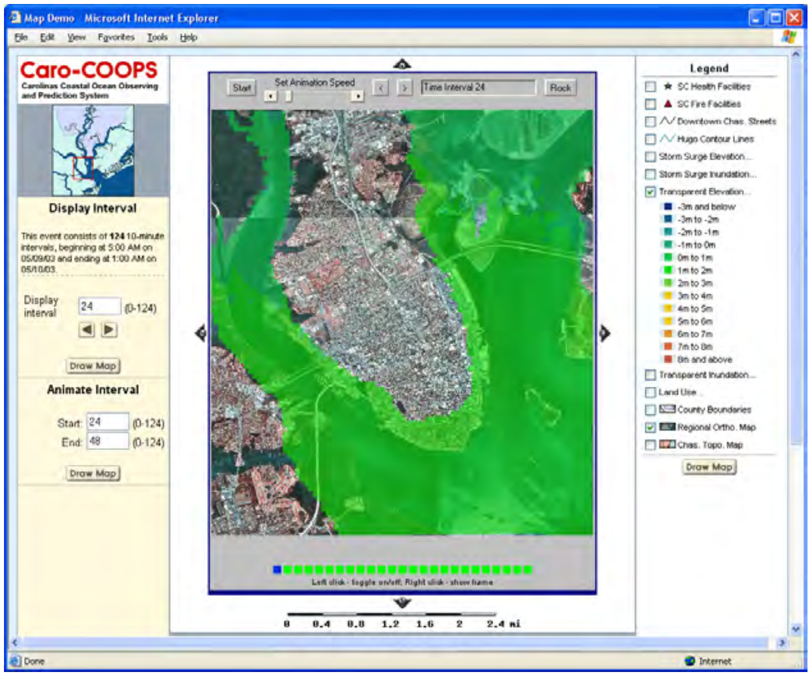

FIGURE 12: Animated Output of flooding in Charleston (animation version available from Dr. L. J. Pietrafesa at CCU).

As Table 2 indicates, to properly initialize water levels in both of these approaches, we must account for changes in sea level along the coastline of SC. While sea level has been rising globally (Janowitz & Pietrafesa, 1996), it has been rising more rapidly along the Southeastern Coast than other coastal areas. Initializing coastal flood models with out of date “zero” water levels at sub-regional scales can in and of itself result in an underestimation of coastal inundation and flooding. Knowing the local SLR trend is necessary for adequately initializing the model system. This is an example of a local fixed variable. High quality archived data are available from the NOAA Center for Environmental Information (NCEI), and in real-time from NOS, ready to be assimilated into a model system, such as the CCU model system. Examples of non-fixed regional values are realistic rainfall estimates, which will be obtained from NOAA rainfall potential projections; specifically from the MRMS, HRRR-RAP model system. Wave data can be obtained from NOAA National Data Buoy Center (NDBC) on-line, real-time data. The Astronomical Tides are well documented, are deterministic, and will be incorporated into the model.

TABLE 2: Factors potentially affecting storm-induced coastal, inland and upland flooding. Note some are interrelated. DP = directly proportional. IP = inversely proportional. * Highly Important)

No.	Factor	Note	Relation	Importance
1	Storm Intensity	max wind speed	DP	*
2	Storm Central Pressure		IP	
3	Sea Level Rise	use modern datum, including Polar ice melting	DP	*
4	Steric Effects	long term effect, oceanic heat content	DP	*
5	Sea Level Variability	Seasonal to Annual to Decadal to Multi-Decadal Signals	DP/IP (depending on phase)	*
6	Coastal Surface Gravity Waves	Oceanic,	DP	*
7	Precipitation	Rainfall	DP	*
8	Storm Size		DP	*
9	Storm Translational Speed		IP	*
10	Tides	Semi-Diurnal and Diurnal	DP/IP (a fn of phase)	*
11	Angle of Attack	0 deg. highest, and 90 deg longest fetch	N/A	
12	Width of Shelf		DP	
13	Slope of Bottom		IP	
14	Coastline Curvature	DP to Concave, IP to Convex	DP/IP	
15	Slope of Land	Geodas vs LiDAR topo data	IP	*
16	Local Hydrology,	Surface Conditions	DP/IP	*
	Degree of Accommodation Space			TBD
17	Anthropogenic Factors			

The proposed work will resolve this significant and challenging issue of communicating reliable coastal flood risk information. Observational and model-generated data will be used to develop a validated and localized “flood risk index”.

The main outcomes of this conceptual program are expected to be: 1) flood risk would be estimated in terms of a “category” of potential flooding conditions, much as the SSHS category scale; and 2) flood risk could be packaged, using GIS overlay templates, so that decision makers and the public can easily understand the potential risk in their local areas and receive updated information on a free downloadable smartphone app.

CCU has vast experience with transmitting data in real-time, via “cloud” technology and will develop the methodology of the transmission of data and model results, from the flood risk approach, in “near real-time”. This is of the utmost importance because data must be assimilated in real-time for an incoming event or for a passing event to produce a reliable forecast. (It is of considerable note that “near real-time” must be defined and will be defined during the period of the retrospective study phase of the project.) Data will be assimilated from the NWS observing network, including NWS sites and WSD Radars in Charleston SC, Greenville SC and Wilmington NC, and from the CCU SEA EcoNET.

This proposed approach has been triggered and catalyzed by recent hurricane events, the coastal modeling advances at CCU, and is strengthened through the collaborative work between CCU academic programs in Sociology and Marine & Coastal System Sciences that provides the enabling foundation. In the coming decades, coastal states' urban centers are expected to continue to grow (Hildebrand, 2000; Maythen & Walklate, 2006; NOAA, 2017). The resulting population density presents significant challenges to local and state governments. The ability of state and local governments to efficiently prepare for and respond to heavy precipitation storm events is critical in mitigating potential financial and human impacts. The proposed effort will support significant progress toward the development of reliable storm monitoring and modeling.

4. <u>Pond Retention Studies at CCU and USC</u>

a. *Pond Studies of Mr. H. Zhang of CCU*

Part of the CCU PhD Dissertation of Mr. Hongyuan Zhang considers the role of the 20,000 ponds in the 8 SC counties (Figure 13) during the passages of Hurricanes Joaquin, Matthew, Irma, Florence and Michael. This is funded by CCU and NSF Awards CSR 1714015 & CSR 1763294.

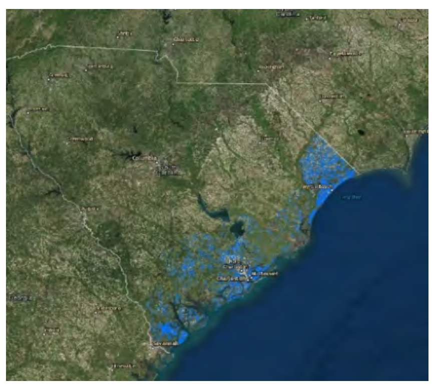

FIGURE 13: Eight SC Coastal Counties 20,000 Ponds-Role-Study of CCU PhD Student H. Zhang under the direction of Drs. X. Li and S. Bao.

b. *Pond Studies of Dr. E. Goharian of USC*

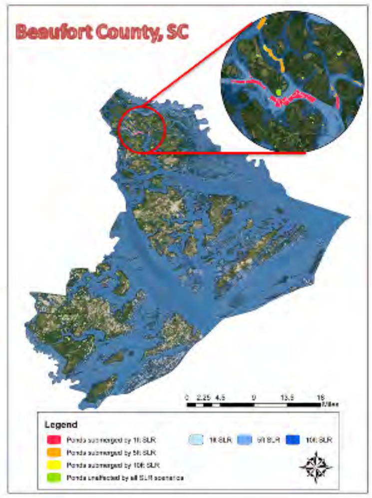

FIGURE 14a: Beaufort County Ponds.

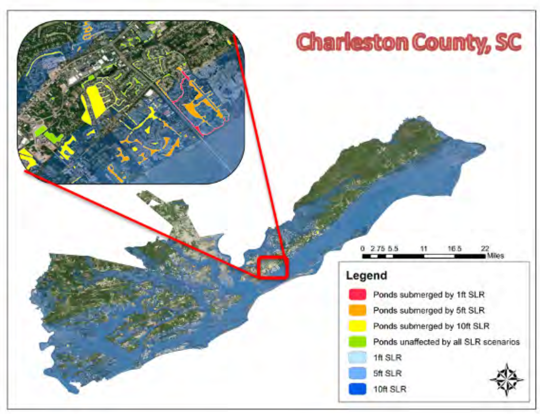

FIGURE 14b: Charleston County Ponds.

Tables 3 and 4 show ponds in Beaufort and Charleston counties under various future SLR Scenarios.

TABLE 3

	Beaufort County (2494 Ponds)					
	Area		Number			
SLR	SUBM	No Effect	SUBM SUM	No Effect	% Area SubM	% of # of SubM
SLR 1	1575909	15275356	84	2410	9.4	3.4
SLR 2	2223920	14627345	203	2291	13.2	8.1
SLR 3	3156940	13694325	390	2104	18.7	15.6
SLR 4	5612071	11239194	690	1804	33.3	27.7
SLR 5	6774545	10076720	868	1626	40.2	34.8
SLR 6	7253123	9598142	984	1510	43.0	39.5
SLR 7	7587736	9263529	1058	1436	45.0	42.4
SLR 8	8770963	8080302	1145	1349	52.0	45.9
SLR 9	9466386	7384879	1253	1241	60.6	50.2
SLR 10	10207469	6643796	1366	1128	60.6	54.8

TABLE 4

	Charleston County (3724 Ponds)					
	Area		Number			
SLR	SUBM SUM	No Effect	SUBM SUM	No Effect	% Area SubM	% of # of SubM
SLR 1	1224735	16771914	164	3560	6.8	4.4
SLR 2	2410708	15585941	430	3294	13.4	11.5
SLR 3	4766329	13230320	794	2930	26.5	21.3
SLR 4	6283381	11713268	1172	2552	34.9	31.5
SLR 5	7534834	10461815	1447	2277	41.9	38.9
SLR 6	8543032	9453617	1689	2035	47.5	45.4
SLR 7	10099713	7896936	1912	1812	56.1	51.3
SLR 8	10691151	7305498	2092	1632	59.4	56.2
SLR 9	11517863	6478787	2257	1467	64.0	60.6
SLR 10	12225574	5771075	2402	1322	67.9	64.5

5. <u>Artificial Intelligence Studies are Being Conducted at Both CCU and USC</u>

a) *CCU*

This research is being conducted by PhD student D. Shen and is presently funded internally by CCU and involves Drs. X. Li, S. Bao, L.J. Pietrafesa and P.T. Gayes.

AI-based modeling of inundation and flooding requires Synthetic Aperture Radar (SAR) derived satellite imagery and an area mapping framework and data preprocessing. The aims of the data preprocessing are radiometric calibration and geometric correction. After the data preprocessing, one must select the features within a SAR image that can be matched with known ground truth from Copernicus EMS rapid mapping products to train and validate the developed algorithm. The flowchart of the data preprocessing is shown in Figure 15. It is worth mentioning that, if the matched scene with the Copernicus EMS rapid mapping product is covered by two or more SAR images, image mosaicking is also performed.

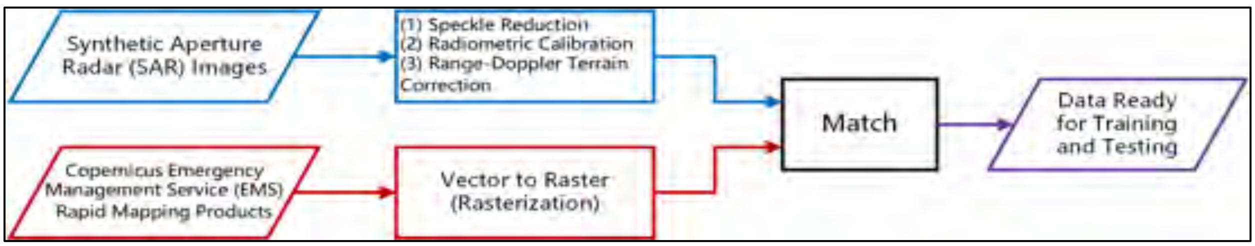

FIGURE 15: Flowchart of the preprocessing at CCU

b) *AI-DCNN*

The AI-DCNN framework is shown in Figure 16. The DCNN integrates the multi-dimension information in a unified framework, and provides an end-to-end classification solution. The most prominent classification features are not pre-designed by humans but rather are learned from the data. The AI-DCNN design performs pixel-level classification. After the DCNN method generates flood extend mapping, a high-resolution topography data set can be used for each domain to get the floodwater depth mapping.

FIGURE 16: Flowchart of the CCU-DCNN design at CCU

c) *USC*

This AI work is funded internally at USC and is directed Dr. E. Goharian. The current state of knowledge on developing early warning and monitoring systems for flooding mainly relies on either gauge sensing or pre-developed flood risk maps. In response to the challenges we face in detecting and monitoring flood events, especially in urban areas, in situ gauge measurements which employ images provided by satellites, remote sensing (RS) observations, unmanned aerial vehicles (UAV), and surveillance cameras would benefit flood detection, monitoring, and modeling. Utilizing remote sensing observation for inundation mapping is currently an inevitable part of the flood management process. RS-based flood monitoring is an elegant and practicable solution for flood hazard analysis that can be broadly classified in active (radar satellite) and passive (optical or near infrared satellite) imagery. For flood monitoring optical satellite images e.g., Landsat ETM+/ TM and MODIS imagery are commonly implemented (Table 4). Considering limitations of optical satellite, active imagery or synthetic aperture radar (SAR) is all-weather operational and capable to observe during day/night. SAR has a large wavelength e.g., X-band able to surpass the smaller cloud particles and snow particles. For flood monitoring L, C and X band SAR is frequently used to detect water and non-water objects. Moreover, by employing AI techniques, such as image detection and segmentation using convolutional neural networks (CNN), we can process images and videos provided by satellites, surveillance cameras, UAVs, and crowdsourced data, and can provide unique near real-time information and data for multiscale hydrologic and hydraulics modeling (Figure 17). This system can detect and monitor flood events and estimate post-flood damages as well. The system will be responsive to the abrupt and fast-growing floods without any delay in sending signals and information about the formation, inundation, and prediction of changes in flooding. Near real-time products will be valuable to inform decision makers, update inundation maps, and for risk assessment.

TABLE 5: Summary on advantages and limitations of available space borne observations for flood monitoring.

Satellite images	Type	Resolution	Public/ Commercial	Operation period	Advantages	Limitations
MODIS	Passive and Optical	250 m or 500 m	Public	Terra (Dec 1999 – present) Aqua (May 2002 – present)	Among the publicly available optical satellites it has wide band spectrum (36) to apply spectral indices and 1 - 2 days orbital period to provide frequent measurement.	Coarser resolution not sufficient to map urban flood.

Satellite images	Type	Resolution	Public/ Commercial	Operation period	Advantages	Limitations
LANDSAT		30 – 60 m	Public	July 1972 – present	Long temporal span, widespread availability and fine spatial resolution make it appropriate to apply urban or regional flood monitoring.	Cloud cover is a significant challenge and often required to engage a suitable cloud masking technique.
Sentinel 2		10 m	Public	June 2015 – present	Green and shortwaves infrared bands have resolution 10 and 20 m respectively that makes more appropriate to apply spectral indices (MNDWI, NDWI) for water detection.	Pan sharping algorithm requires modification due to varying band resolution i.e., 10 and 20 m.
VIIRS		375 m	Public	Oct 2011 – present	SNPP/VIIRS has moderate resolution (375 m) and large swath width (3000 km) with no swath gap while scanning global land surface. This satellite product improves MODIS multiple day composite flood mapping process to near real time flood maps.	Flash floods are not well detected by the products. The images also sensitive to cloud heights when cloud detection.
SMAP	Passive microwa	3 km or 9 km	Public	Jan 2015 – present	Usually soil moisture increase before a flood event which is an indication of flood	It represents volumetric soil moisture

Satellite images	Type	Resolution	Public/ Commercial	Operation period	Advantages	Limitations
					susceptibility. This indirect measurement of soil moisture can help to get the area of inundation.	rather the flooded area.
AMSR-E		5.4 km	Public	May 2002- Oct 2011	The emissivity difference of polarization provides an estimation of fractional area of water surface. The difference of polarization can be used to estimate polarization ratio which has an empirical relationship with soil moisture.	The extreme rainfall events can hamper the passive microwave signal which may lead to error to detect flooded region.
ALOS-2	Active Radar or SAR	100 m	Commercial	May 2014 – present	When combined with RADARSAT-2 the cross-sensor image can provide improved detection of flooded region with L band and HH polarization.	The L band-HH signal make seasonal disturbances difficult to differentiate the land classes in floodplain.
Sentinel-1		5 x 20 m	Public	Apr 2014 – present	It can provide frequent measurement from bands VV and VH polarization for flood mapping. VV polarization is more effective to penetrate canopy or tree trunks that make sentinel 1 A/B more effective to apply to floodplains having forested or farmland.	Narrow swath width and long revisit period may not be suitable to monitor a short term flood event. The VH polarization may provide deficient signaling due to volume scattering.
RADARSAT-		3-100 m	Commercial	14 Dec,	High resolution and 4	Open water

Satellite images	Type	Resolution	Public/ Commercial	Operation period	Advantages	Limitations
2				2007-present	polarization bands i.e., VV, HV, HH, VH provide enhanced flood water detectability.	when smooth HH radar gets error in signal that precludes HH band application to flood detection.
TerraSAR-X		0.24-40 m	Commercial	Jun 2007 – present	The satellite image has sufficient high resolution and an alternative to aerial photography such as LASER scanning. This satellite images can be applied for urban flood mapping due to complex landuse features of urban area. Moreover, it has X band SAR and 5-200 km swath width to cover large region. It provides X band HH polarized data which often considered as superior to other SAR polarization.	The shadow effect from man-made structures in this satellite image requires complex masking process or cross sensor validation.
ENVISAT (ERS-1/2)		30-1000 m	Public	June 1991 - July 2011	This satellite was found effective for mapping seasonal flooding. The change detection technique can be individualized for this satellite for mapping regional flood. It can also supplement the ocean altimetry.	The thematic adequacy on the landuse themes require adjustment to differentiate water and non-water pixel

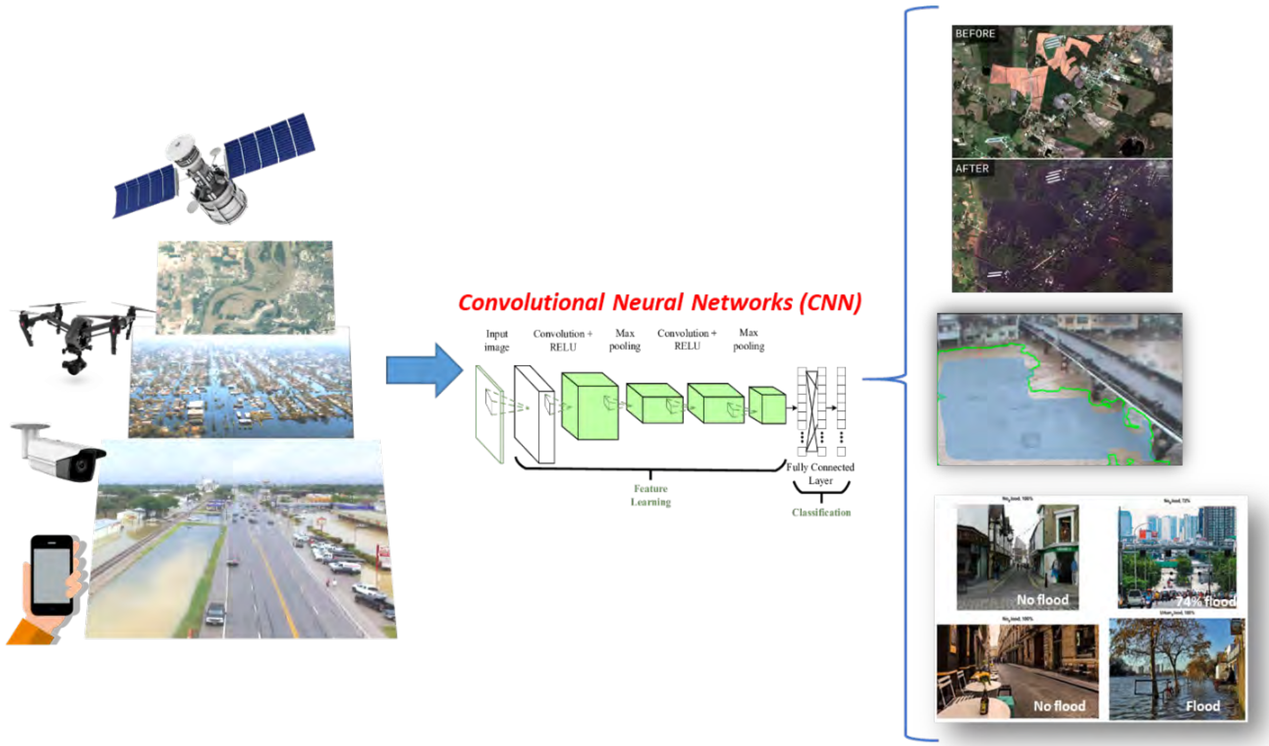

FIGURE 17: Multi-scale AI-Based Flood Detection and Monitoring System at USC

F. The Hurricane Genesis & Outlook (HUGO) Program

The Need for a Hurricane Seasonal Outlook

There is considerable demand for a seasonal hurricane landfall prediction for the U.S. The storms that most people really worry about are those that actually make landfall, which can have significant or little correlation to the total number of storms in any given season. For example, 2010 was an extremely busy storm season, with 19 named storms including 12 hurricanes. However no hurricane, and only one tropical storm, made landfall in the U.S. that year.

Yan (2006), Yan and Pietrafesa (2006), Yan, Pietrafesa, Bao and Gayes (2010) presented new methodologies for selecting predictors to predict the overall North Atlantic Ocean Basin (NAOB) Tropical Cyclone (TC) activity. The algorithms were quite accurate. In 2015, the team began also predicting the number of hurricanes (NH) that would make landfall along the U.S. Eastern Seaboard (the "ECLF"), and the U.S. coastline of the Gulf of Mexico (the "GMLF"). The forecasts have been very accurate. No other institution or organization makes such forecasts. Integer numbers are predicted, not percentages.

The CCU team's analysis of two-dimensional (2-D) climatic-oceanic and atmospheric data and their correlations with North Atlantic hurricane activity provide a new way to identify hurricane-related climate factors. Additionally, a new Atlantic Cyclone Energy (ACE) based methodology addressed the seasonal landfall prediction challenge for the U.S. A set of mathematical models applied with this methodology was tested and showed excellent hind-casting skills over the past six decades on a year-by-year basis. The key to this new methodology is the classification of hurricane season types and the assumption that landfall hurricane distributions not only depend on overall Atlantic hurricane activity (season types of hyperactive, active, above normal, near normal, and below normal), but also on specific hurricane track-related climate parameters that also correlate closely with overall hurricane activity. The statistics of ACE and hurricane activity over the past 69 years (1950-2018), shows that landfall hurricane frequency is closely associated with hurricane-track related climate factors and weather patterns that link up to overall hurricane activity in the NAOB.

CCU Prediction Categories
The following variables are predicted:

- North Atlantic Accumulated Cyclone Energy (ACE)
- The total number of "Named" Tropical Storms (TS)
- The Number of Hurricanes (NH)
- The number of Major Hurricanes (Saffir-Simpson Categories 3, 4, and 5) (MH)
- The number of land-falling hurricane strikes along the U.S. Eastern Seaboard (ECLF)
- The number of land-falling hurricane strikes along the U.S. Gulf of Mexico (GMLF)

Table 6 presents the CCU forecast ranges, CCU specific numbers and the CCU landfall forecasts. The actual season outcomes are shown also. Finally, the Colorado State University and NOAA Forecasts are presented in the two columns to the right. In summary, as shown quite clearly in Table 6, the CCU forecasts greatly outperform NOAA's and CSU's in every category. Plus, neither NOAA nor CSU predict the integer number of hurricane landfalls. CSU uses regressions while NOAA employs an early version of Yan and Pietrafesa (2006) software. We note also that the column marked by ** are the CSU landfall (August) forecasts from 2015-2018).

[They are: a) 2015 PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS: 1) Entire U.S. coastline -28% (average for last century is 52%;) 2) U.S. East Coast including Peninsula Florida -15% (average for last century is 31%) 3); Gulf Coast from the Florida Panhandle westward to Brownsville -15% (average for last century is 30%); b) CSU 2016 PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS: 1) Entire U.S. coastline -50% (average for last century is 52%); 2)U.S. East Coast including Peninsula Florida -30% (average for last century is 31%); 3) Gulf Coast from the Florida Panhandle westward to Brownsville -29% (average for last century is 30%); c) CSU 2017 PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS: 1) Entire U.S. coastline -62% (average for last century is 52%); 2) U.S. East Coast including Peninsula Florida -39% (average for last century is 31%); 3) Gulf Coast from the Florida Panhandle westward to Brownsville -38% (average for last century is 30%); and d) CSU 2018 PROBABILITIES FOR AT LEAST ONE MAJOR (CATEGORY 3-4-5) HURRICANE LANDFALL ON EACH OF THE FOLLOWING COASTAL AREAS: 1) Entire U.S. coastline -39% (average for last century is 52%); 2) U.S. East Coast Including Peninsula Florida -22% (average for last century is 31%); 3) Gulf Coast from the Florida Panhandle westward to Brownsville -21% (average for last century is 30%).]

We note that CSU employs percentages for potential landfalls while CCU presents actual integers. You do not purchase 39% of a car. You either get 0 or 1 or 2 and so on. This is the Poisson Integer Mathematical Approach.

Table 6 displays the CCU team forecast (in red), the actual season outcomes (in black), the CSU forecasts (in orange) and the NOAA forecasts (in blue) and their accuracy, or the lack thereof, all in the past 4 years, 2015 – 2018. We note that CSU adopted the CCU title of an "Outlook". We note that NOAA does not predict landfalls in any context. This work has been supported internally by CCU.

TABLE 6

HUGO Predictions vs. Actual Outcomes for 2015, 2016 2017, 2018 By Category	69 Year Average	Year	CCU Forecast Range	CCU Forecast Number	CCU Order of Potential Landfalls	Actual Season Outcome	CSU	NOAA
TS	**12.0**	**2015 2016 2017 2018**	**8 – 11 11 – 15 14 - 18 11-18**	**10 13 15 15**		**11 15 17 14**	8 15 16 12	**6-11 12-17 11-17 9-13**
NH	**6.1**	**2015 2016 2017 2018**	**3 – 5 6 – 10 7 – 11 5 - 9**	**4 7 8 7**		**4 7 10 7**	2 6 8 5	**3-6 5-8 5-9 4-7**
MH	**2.6**	**2015 2016 2017 2018**	**1 – 2 2 – 5 3 - 6 2 - 5**	**1 3 4 3**		**2 3 6 2**	1 2 3 2	**0-2 2-4 2-4 0-2**
ACE	**102**	**2015 2016 2017 2018**	**30 – 60 120 – 180 110 – 180 100 - 140**	**45 145 170 120**		**59 129 226 120**	35 100 135 64	**36-76 80-110 100-115 45-90**
ECLF	**0.63**	**2015 2016 2017 2018**	0 – 1 – 2 1 – 2 – 0 1 – 2 - 0 1 – 0 - 2		**0 1 1 1**		** ** ** **	N/A N/A N/A N/A
GMLF	**0.95**	**2015 2016 2017 2018**		0 – 1 – 2 1 – 2 – 0 1 – 2 - 0 1 – 0 - 2	**0 1 2 1**		** ** ** **	N/A N/A N/A N/A

G. SC and NC (FIMAN and FRIS) Agencies That Utilize Model Output of Flood Forecasting for Planning and Response

The South Carolina Emergency Management Division (SCEMD) uses flood modeling before, during, and after hazard events to inform and guide support for disaster preparedness, mitigation, response, and recovery activities. Flood modeling assists in identification of areas for which increased preparedness and mitigation, including planning, public outreach, training, and hazard avoidance or reduction efforts, are needed. In response and recovery, flood modeling that incorporates real-time data provides projections to guide staging and deployment of response resources, estimate flood damage, and identify areas in need of response and recovery support.

SCEMD recommends the following:

- South Carolina needs statewide LiDAR coverage. High accuracy LiDAR would greatly improve all flood models, regardless of type and objective.
- The need for more stream gauges is essential. The state lacks a complete coverage network of stream flow and stream depth gauges.
- In addition to the models and studies already mentioned, if not already incorporated, the report should note flood studies from College of Charleston's Low Country Hazards Center and the South Atlantic Coastal Study from the US Army Corps of Engineers (USACE).
- One goal should/would be to have a product/platform similar to North Carolina's Flood Inundation Mapping and Alert Network (FIMAN) and Flood Risk Information System (FRIS) tools (Figures 18a, b). Such tools would allow users to track real time potential flooding but also to model flood stages. (Flood Inundation, 2016)

FIGURE 18a: The Statewide coverage of NC.

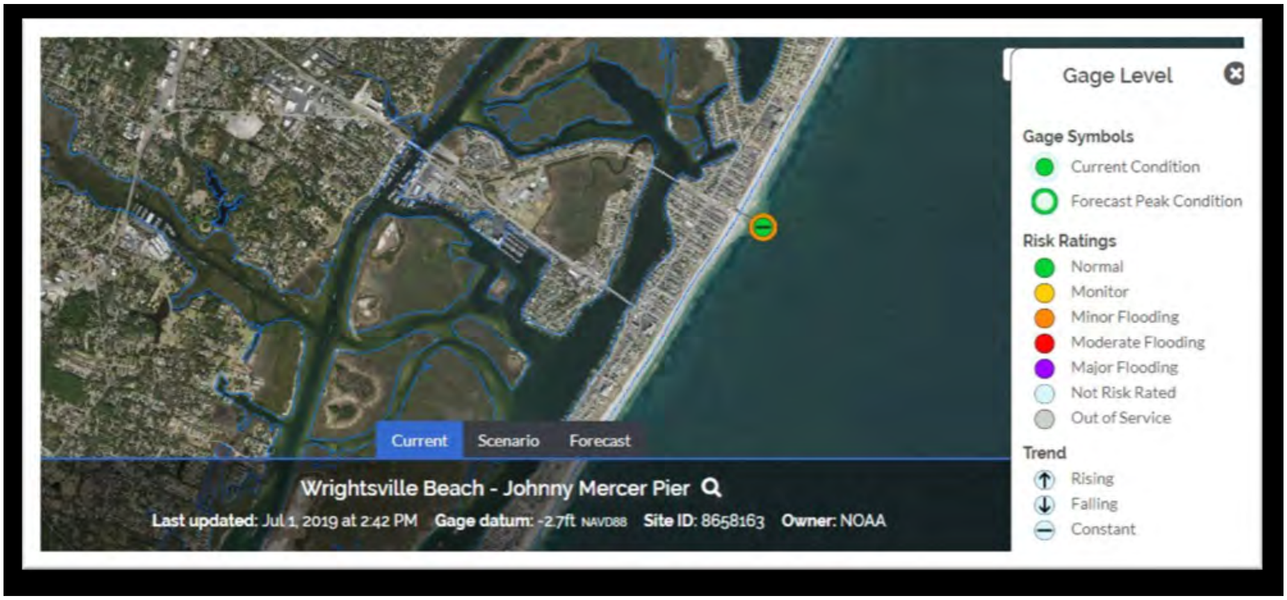

FIGURE 18b: The Zoom-In to one of the Green Dot Locations. The plan is to create a SC In-Kind Flood Locale Click-On.

The Figure 18 type of Click-On Web-site could be in addition to the types of model output shown in Figures 6, 7. Public Sites are: https://fiman.nc.gov/, https://fris.nc.gov/fris/Home.aspx?ST=NC

- Other SC Agencies, TBD

H. Roles of Agencies and Organizations, and Coordination

- AI research and applications can be coordinated between CCU and USC.
- Pond Research can be coordinated between USC , CCU and others.
- Model system output can be coordinated by CCU and USC with the SCEMD, SCSG, USGS, SCDNR, SCDHEC, and SCDOT
- Real-Time Numerical Model Ensemble Output will be provided by CCU to the Office of the Governor of SC to be disseminated thereafter as per the order of the Governor
- The South Carolina Emergency Management Division (SCEMD) uses flood modeling before, during, and after hazard events to inform and guide support for disaster preparedness, mitigation, response, and recovery activities. Flood modeling assists in identification of areas for which increased preparedness and mitigation, including planning, public outreach, training, and hazard avoidance or reduction efforts, are needed. In response and recovery, flood modeling that incorporates real-time data provides projections to guide staging and deployment of response resources, estimate flood damage, and identify areas in need of response and recovery support and will be provided by CCU directly.
- The state of SC owns the $1M Coastal Explorer Vessel that is operated by CCU and berthed at the North Myrtle Beach and Georgetown marinas. The Coastal Explorer can be

used to deploy, recover and service the three offshore moorings at the direction of CCU on behalf of the state.

- The SC River Gauge Network can be coordinated by CCU, USGS, and other agencies
- The Transportation Infrastructure Meteorological Network can be coordinated by CCU and SCDOT.

A continuation of this discussion which is a detailed plan of action for the development of the necessary accurate forecasting and communication tools provided in this section is included in Appendix B to this report. It contains a detailed budget. There may be other participants which should be considered for inclusion in the action plan. The plan was developed based on the information made available to the Task Force during its deliberations. The Committee on Smart Rivers considers Appendix B as its primary Deliverable.

SHORT-TERM DELIVERABLE

Provide for the distribution and installation of meteorological stations for all areas in the state that currently are without these critical data. The stations are central to being able to support the modeling effort required to respond to the existing and projected floodwater threat. The Task Force recommends that the SC Legislature be approached and requested to provide the necessary funding to support this fundamental requirement.

II. DAM SECURITY/STATE OF SOUTH CAROLINA'S REGULATED DAMS

A. Introduction to Dam Safety

South Carolina's General Assembly passed the Dams and Reservoir Safety Act (S.C. Code Section 49-11-110 through -260) initially in 1977 following a series of dam failures nationally. Since 1996, the South Carolina Department of Health and Environmental Control (DHEC) has been charged with implementation of the state's Dam Safety Program.

The Act defines a ***dam*** as any artificial barrier, together with its accompanying structures, including but not limited to dams, levees, dikes or floodwalls for the impoundment or diversion of water or other fluids where failure may cause danger to life or property. Structures are regulated if they meet any one of the following three criteria, unless it is subject to an applicable exemption.

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

The Act is implemented with the support of the South Carolina Dams and Reservoir Safety Regulations (R. 72-1 through R. 72-9). Once a dam is determined to be subject to South Carolina's Dam Safety Program, DHEC's next duty is to "classify" the dam based on the structure's potential for causing property damage or loss of human life in the event of failure or improper operation of the dam or reservoir. "Hazards" may include homes, roads, critical utilities (water, sewer, gas lines) that might be damaged or flooded when a dam fails. Like most states, South Carolina's regulations divide dams into one of three hazard classes:

TABLE 7

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

B. The Role of Dam Owners in Dam Safety

South Carolina's Dams and Reservoir Safety Act places the owner of a dam or reservoir constructed in the state as the sole individual or entity that is responsible for maintaining the dam or reservoir in a safe condition throughout the life of the structure. The Act defines an owner as those who own, control, operate, maintain, manage, or propose to construct a dam or reservoir. Dam ownership comes in many different and distinct formats and arrangements. These may include:

- Dam or reservoir under ownership of a single individual, entity or political body
- Dam or reservoir ownership split between two parties where one may own portions or parts of the dam or reservoir
- Dam or reservoir ownership where one entity/individual owns the earthen structure and owns the body of water and outlet structure(s)
- Watershed dams where individual(s) own the property with the dam or reservoir; however, through agreement, the structure is operated and maintained by a Watershed District
- Dam or reservoir ownership is established through easement or other recorded document to be the responsibility of multiple property owners surrounding the impoundment
- Others

Throughout the life of a dam, it is imperative that the owner provide for or undertake proper maintenance so that the dam is in a safe condition. Maintenance activities are generally superficial and do not result in excavation into the earthen structure. Most routine maintenance is performed by hand or with gasoline-powered machines (chainsaws, lawnmowers, etc.). Routine maintenance is necessary to prevent the growth of trees and brush on the embankment and within the spillway system. The vegetation in areas surrounding dams should be maintained in such a manner to allow adequate visual inspection of the embankments, spillways and crest of dams. Maintenance as is necessary to remove debris or other deleterious materials from the spillway system. If gates or valves are operational, proper maintenance should include exercising the control structure to insure it remains in good repair.

Once it has been determined through inspection that repair of a dam is necessary, it is the owner's responsibility to procure the services of a qualified South Carolina Professional Engineer to develop a repair plan. The owner then must implement the plan under a permit issued by DHEC's Dam Safety program.

One of the most critical responsibilities of dam ownership comes when a dam is at imminent risk of failure. The South Carolina Dams and Reservoir Safety Act requires owners of High and Significant Hazard dams to develop and maintain an Emergency Action Plan (EAP). An EAP guides dam owners through who to call and potential mitigation actions to take in the event of imminent or actual dam failures. EAPs should include the names and phone numbers of residents and business located in the potential flood wave inundation path, as well as contact information for local and state emergency officials.

C. Description of South Carolina's Regulated Dams

The data provided below reflects the condition, age, ownership, hazard classification as reported by DHEC to the U.S. Army Corps of Engineer's National Inventory of Dams in August 2018.

TABLE 8

Hazard Class	
High	308
Significant	416
Low	1489
	2213

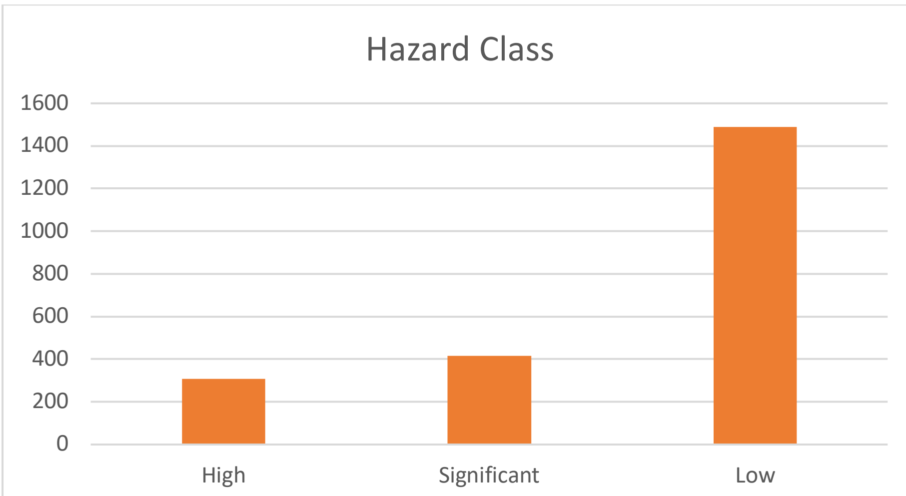

FIGURE 19

TABLE 9

Age of Dam				
Age Range	All Classes	High	Significant	Low
100 +	154	19	38	97
80 - 99	117	21	29	67
60 - 79	639	78	125	436
40 - 59	829	119	131	579
20 - 39	250	36	47	167
19 -	28	1	9	18
Unknown	196	34	37	125

TABLE 10: Average Age of Dams – 61 years

Primary Purpose				
	All Class	High	Significant	Low
Irrigation	100	9	14	77
Flood Control	103	27	23	53
Water Supply	37	19	9	9
Recreation	1756	231	336	1189
Fire Protection, Stock, Or Small Fish Pond	49	4	13	32
Fish and Wildlife Pond	39	4	2	33
Debris Control	7	0	1	6
Tailings	4	0	2	2
Other	99	6	13	80
Hydroelectric	5	4	1	0
Unknown	14	4	2	8

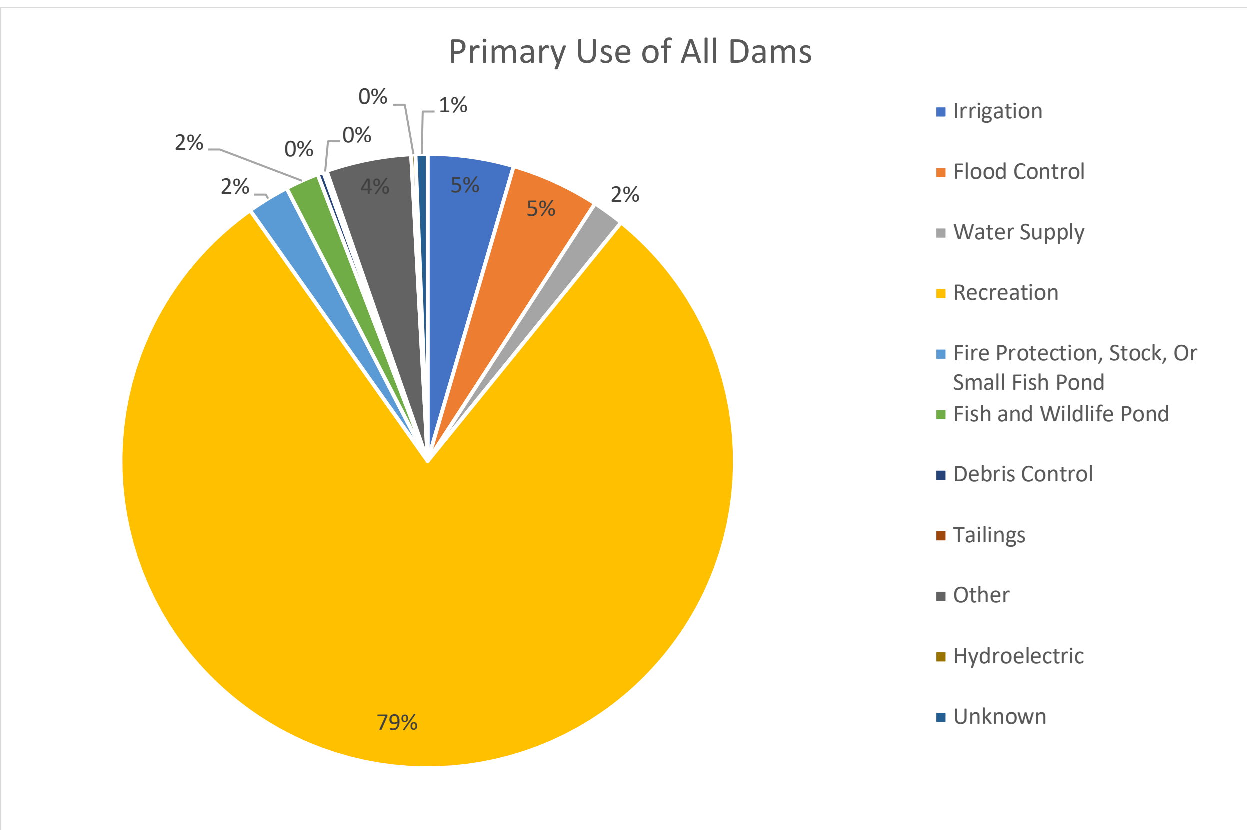

FIGURE 20

TABLE 11

Dam Ownership				
	All Class	High	Significant	Low
Local Government	82	29	15	38
Local Government & Private	77	28	6	43
Not Listed	12	4	3	5
Private	1943	233	373	1337
Public Utility	20	4	2	14
State	77	10	15	52
State & Local	2	0	2	0

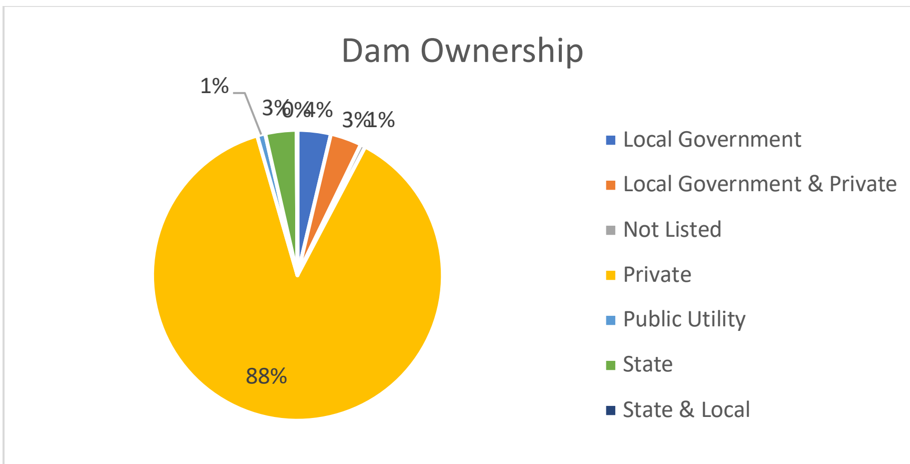

FIGURE 21

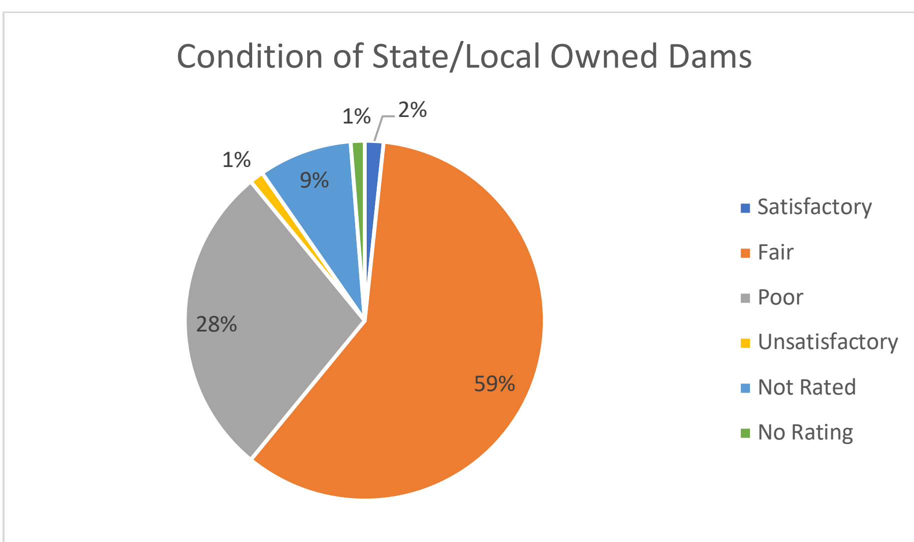

FIGURE 22: Example of how data may be sorted and evaluated across data values.

D. Dam Safety Incidents – Widespread Weather Events and Isolated Severe Thunder Storms

Throughout the past decade, dam safety incidents caused by isolated severe storms, widespread torrential rainfall and "sunny day" events have highlighted how rapidly the condition of a dam may deteriorate to the point that failure is imminent, or failure occurs. Following is a synopsis of key events at dams in South Carolina throughout the past decade:

Fall 2014 – Langley Pond Dam, Aiken County - Dam was found to be in failure mode due to piping around and under primary spillway. Water level was lowered and has remained at a significantly reduced level while it is undergoing repairs.

June 2015 – Old Mill Dam, Lexington County – A void was found adjacent to spillway. Water level was lowered. It should be noted that the pond was drained at the time of the 2015 Historic Rainfall. The impoundment refilled and breached as a result of that storm.

September 2015 – Upper Rockyford Lake Dam, Richland County – Void was found in the auxiliary concrete chute spillway the week before the 2015 storm. The water level was reduced, and dam owners downstream were alerted to potential for failure. Just as with Old Mill Dam in Lexington County, the reservoir of the pond refilled and breached as a result of the storm.

October 2015 – Historic Rainfall, Statewide – Rainfall in excess of 20 inches impacted large swaths of the state. As a result, 51 state-regulated dams and an untold number of un-regulated dams were found to have failed.

September 2016 – Hurricane Matthew, Statewide – Hurricane Matthew tracked north and east across the coastal plain of South Carolina. Rainfall accumulations from the storm exceeded 15 inches in the Pee-Dee and Grand Strand. The storm resulted in the failure of 20 regulated and 5 unregulated dams in the state.

March 2018 – Springwood Lake Dam, Richland County – A citizen reported a hole in the roadway surface atop the dam crest. DHEC Dam Safety staff responded and found a large void along the secondary spillway. The water level was lowered to reduce the potential for dam failure.

May 2018 – Fiddlers Cove Dam, Oconee County – The dam was found to be at risk of failure due to a separation in the primary spillway pipe near the outfall. The water level was lowered to reduce the potential for dam failure.

September 2018 – Hurricane Florence, Statewide – Hurricane Florence made landfall in the state in Horry County. The system tracked south and west through the state dropping rainfall totals between 7 and 23 inches throughout the Pee Dee. The storm resulted in the failure of 11 state regulated dams.

E. Role of Regulated Dams in Flood Management

The Watershed Protection and Flood Prevention Act (Public Law 83-566) authorized the Secretary of Agriculture to provide technical and financial assistance to entities of state and local governments and tribes (project sponsors) for planning and installing watershed projects. The USDA agency responsible for program management is the Natural Resources Conservation Service (NRCS). There are currently **106** PL-566 dams in the state regulated by DHEC's Dam Safety Program. While many dams provide some manner of flood protection to infrastructure, residents, and businesses downstream, most regulated dams in South Carolina are not designed to provide flood protection for a design storm event.

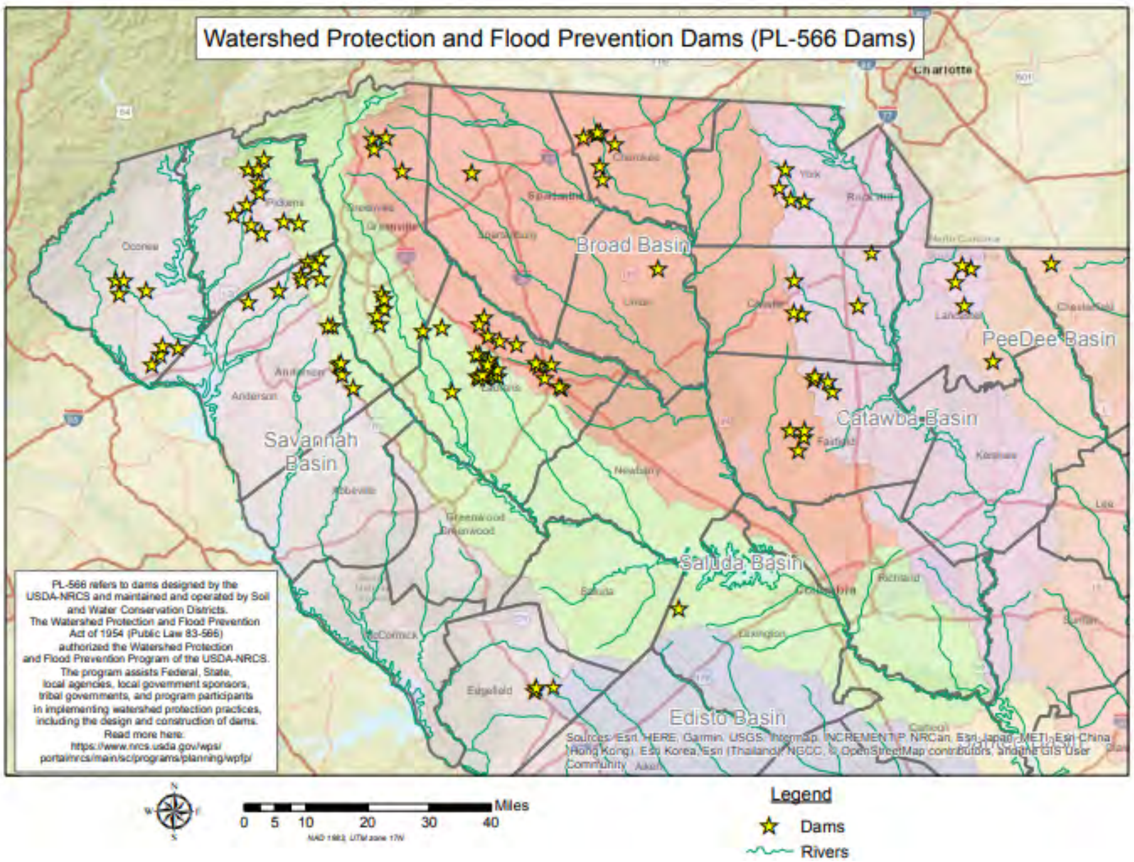

FIGURE 23: Watershed Protection and Flood Prevention Dams

F. Unregulated, Federally Regulated, and Out of State Dams

It is estimated that there are as many as 25,000 ponds, lakes and reservoirs in South Carolina. Only a very small percentage, approximately 2300 of those, fall under the regulatory scope of DHEC's Dam Safety Program. Most of these are small impoundments with either a small dam or that have been dug into the ground with no earthen embankment, particularly in South Carolina's coastal plain.

Though small ponds and lakes may not be regulated by the state of South Carolina, during a significant rainfall event, it is incumbent for the pond's owner to coordinate releases with downstream property and pond owners. Owners of these structures should also be aware that although failure of the dam may not result in loss of life of damage to roads and other infrastructure, the possibility remains that an uncontrolled release of water could result in localized flooding or damage to their neighbor's property.

On the opposite end of the size spectrum are the dams regulated or owned by the Federal Energy Regulatory Commission (FERC), U.S. Army Corps of Engineers or other agencies. Examples of these in South Carolina include the dams impounding Lakes Hartwell, Marion, Wateree, Murray, Moultrie, and Murray. These dams were constructed in the early part of the twentieth century for production of hydropower and flood control. It is critical during times of significant rainfall and flooding that the operators of these dams must keep local emergency management officials, as well as citizens, abreast of their status throughout the event.
Another group of dams with potential to impact the property and residents of South Carolina are dams located on waterways in North Carolina that drain into South Carolina. During the recent rash of significant rainfall events, there was heightened concern that these dams were at risk of failure and could result in additional flooding within already swollen river systems in South Carolina. Emergency and Dam Safety Officials in each state should keep lines of communication open throughout significant rainfall events.

III. SUMMARY OF FINDINGS

Group discussion exposed the consensus of the critical nature of sharing modeling across all stakeholders. Modeling should not be used just to drive emergency operations but help all stakeholders make appropriate development decisions. This Predictive Intelligence may be used to guide development and property use, proactive preparation for water events, response to water events and recovery from water events.

If modeling is to have the maximum effect, all forms of modeling must be examined and used in applicable areas. The results must be shared among all stakeholders. Stakeholders include individuals, private and public entities, whether large, medium or small, and government from the local government to the federal government.

If properly shared, modeling data can guide the most important element of floodwater mitigation, intelligent development. Intelligent development begins with good knowledge properly applied. Most developers, to include statewide infrastructure, want a product that compliments the environment and does not create problems. Water can be an asset or an uncontrolled destructive force. Knowledge comes from proper modeling of the state as a whole and sharing this knowledge through education. The state is in an excellent position to encourage coordinated modeling at state agencies, universities and private organizations. To create this level of coordination will require a full-time effort that is able to reach across all stakeholders and gain their trust. This entity cannot be a regulatory or enforcement agency and not an agency that actually performs the modeling. The purpose of this entity would be to coordinate and disseminate the information.

Once the information has been developed and disseminated, it can be used by the stakeholders for their own purposes. Local governments can use it to develop good zoning that compliments state level efforts to control water quality and quantity. Private industry along with environmental groups can use informational arguments to create smart development that meets the desired results of all involved. Boeing in Charleston used such information from Palmetto Green to drive an environmentally friendly expansion. The result of such planning resulted in development welcomed by the total community rather than just a segment. More importantly, it maintained the ecological balance that resulted in a betterment of the conditions rather than development at the expense of the environment or worsening storm water effects.

Predictive Intelligence can be used to prepare for floodwaters. Models should be run continuously for all areas of the state with different plausible scenarios. This information can be used by municipalities, counties and the state to develop contingency plans for floodwaters. These plans would not be just emergency plans but identifying areas that are vulnerable and creating strategies to deal with those areas. Plans would include such things as areas that should be under a conservation easement, areas that should be green space, the need for water control structures, the need to revise infrastructure, etc. The modeling would also give a good look at the value of coordination among dam owners, from private to FERC regulated. During the recent flooding events, most owners prior to the floods did not coordinate with each other even at the FERC level. The modeling information would give responsible agencies the information to make regulatory changes and recommended legal changes. It could even drive coordinating private dam water release for water quality and quantity along major tributaries. It would certainly provide conversation between state agencies, major dam owners and states about water release coordination pre-, during and post events.

Multiple model runs can be used to actually prepare the emergency force for employment. Rather than generating a list of generally needed capabilities, the modeling would drive the actual quantities needed to mitigate certain scenarios. State resources can be applied against those actual scenarios versus a general scenario to develop deltas in capabilities. Once an emergency does occur, the plan that was driven and resourced by predictive intelligence can then be applied across all available resources. This action would be an enhancement of the already highly effective Predictive Intelligence Analysis Cell at the Emergency Management Division made up of representatives from all applicable state agencies. This difference between the current organization and the proposed organization is that the information would come from many more sources and overcome the weaknesses of each individual model and be more readily available.

The Task Force believes the key to dealing with flood waters and other natural events is intelligent development by private and governmental entities that works with the environment to control the quantity and quality of water and enables the channeling of those events where possible. That intelligence should be coordinated by an entity that has the ability to influence public and private partners to prepare the information. That entity should have no agenda other than to provide the best information to all parties and to encourage collaboration across all sectors. Other parties and agencies have the responsibility to properly respond to the information provided by the modeling.

APPENDIX A

GENERAL OVERVIEW OF SURFACE WATER MODELING

Background

Two principal types of models are used in South Carolina to evaluate surface waters and impoundments (dams):

- Hydrologic
  - Hydrologic models are used to quantify flows in a river system at any given point using rainfall, evaporation, baseflow, surface runoff and flow (volume)
- Hydraulic
  - Hydraulic models address physical properties of lakes and rivers such as depth and flow (velocity and areal coverage). These models use topography, rainfall and river/stream dynamics to predict the timing, crest height and duration of flood-water. These models are applied in flood inundation evaluations to aid in decisions for evacuations, evacuation routes, potential damage to structures and long-term planning for flood risk.

Current Applications

Hydrologic Modeling

The Department of Natural Resources and Department of Health and Environmental Control contracted CDM-Smith to produce basin-wide water allocation models (Surface Water Allocation Model or SWAM) for eight sub-basins in South Carolina. This modeling effort has also consolidated all the basin hydrologic data in one area. Data from this modeling application such as Unimpaired Flow (UIF) simulations for streams, gauged and ungauged stream runoff coefficients, and historic river gauge hindcasting of flow, historic gauge data and reservoir operation rules can be valuable information that may save time and resources for future modeling efforts.

- Water allocation models are hydrologic models and are developed to determine water availability, test water management strategies, and evaluate impacts of future withdrawals.

Hydraulic Modeling

The United States Army Corp of Engineers (USACOE), SC Department of Natural Resources (SCDNR), and United States Geological Survey (USGS) have developed several Low Flow and Flood Frequency studies and flow models for the Savannah River Basin over the years.

APPENDIX B

I. A Comprehensive Modeling Effort That is Retrospective and Diagnostic, Prognostic, Statewide and Locally Applicable in Real-Time

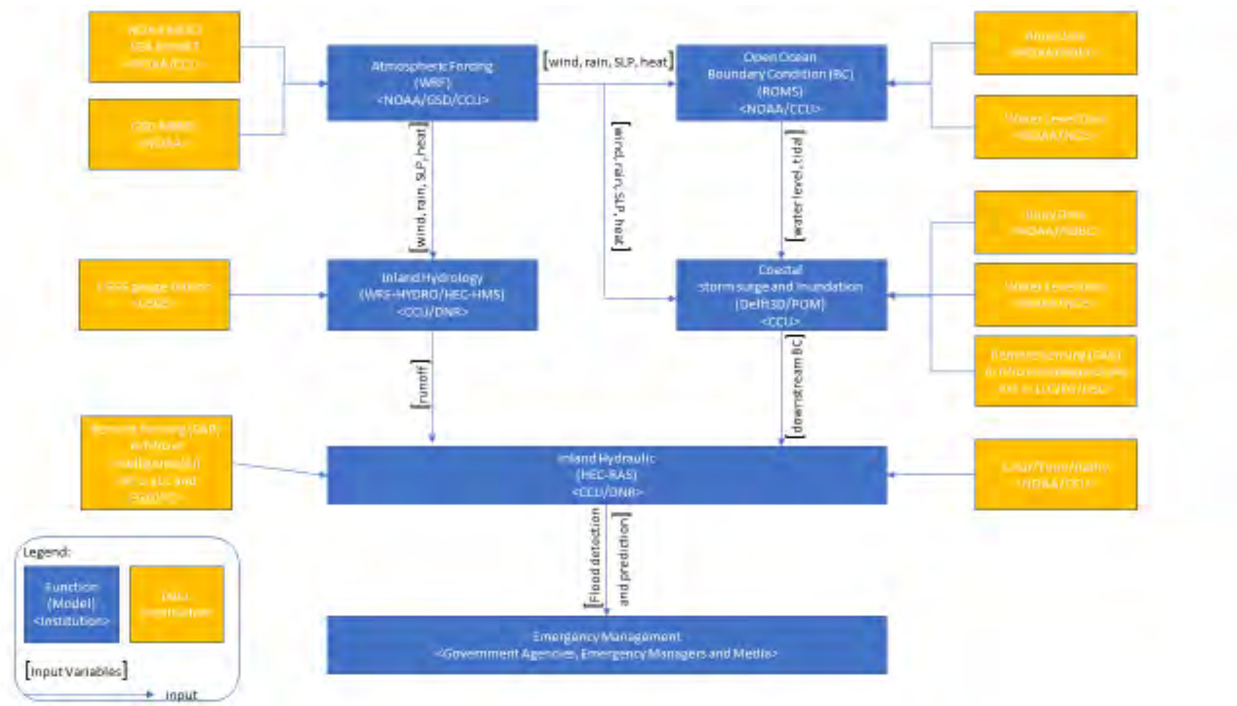

FIGURE 24: The Proposed Comprehensive SC Retrospective, Diagnostic and Prognostic Model System (X LI and EG are Xiaofeng Li (LLC) and Erfan Goharian (USC), respectively).

- Cost to Implement Figure 13 AI: $60,000/Year to X. Li; EG, USC Internal Support = $60,000/Year Continuing.
- Cost to Implement the End-to-End Comprehensive Numerical Modeling System with Ensembles (cf. #10, 11)

II. Automated Real-Time Data Assimilation into the Community Model Systems

Shown in Figure 18, from the Data List in Item # 3 Above: 1-time Cost $100,000 dedicated computer processors @ CCU + Costs of $320,000/year X 2 years @CCU = $420,000 in Year 1 and $320,000 in Year 2.

III. Real-Time Visualization of Numerical Model Output:

- 1-time cost of $50,000 @ CCU;

- Continuing costs of technical support to operationalize the computational model system shown in Figure 13 at $85,000/year.

IV. Data Needs to Drive the Modeling and Model Visualization Outputs of the CCMS in Real-Time

- NOAA National Weather Service Stations: 3 land-based stations in 46 counties available from: https://forecast-v3.weather.gov/obs?state=SC
- NOAA MESO CCU-FAU SEA EcoNet: ~ 70 land-based stations in 46 counties
- NOAA MESO CCU-FAU SEA EcoNet: 3 offshore perpendicular conventional CCU met buoys with bottom pressure sensors
-
- Needs:
  - FAU Intelligent River Type River Gauges: 150 stations in all SC rivers. Cost at $5,000/station = $750,000 1-time cost + continuing costs @ 2 full time field and lab Instrument technicians @ $180,000/year + travel @ $10,000/year + Instrument replacements @ $10,000/Year=
  - $750,000 1-time + continuing $200,000/year =
  - TOTAL of $950,000 in year 1 and $200,000/year thereafter.

  - 150 - 1st Order SEA EcoNET ground stations along key transportation infrastructure points @ $15,000/ station = $2,250,000 for equipment (1-time cost) + continuing costs @ 2 full time field and lab instrument technicians @ $180,000/year + travel @ $10,000/year + Instrument replacements @ $10,000/year=
  - $2,250,000 1-time + continuing $200,000/year =
  - TOTAL of $2,450,000 in year 1 and $200,000/year thereafter.

  - 3 met buoy stations with bottom pressure sensors in a perpendicular configuration to detect incoming tsunamis and meteo-tsunamis and to drive the CCMS Interactively coupled model system @ $100,000 (1-time cost) + continuing costs @ $270,000/year instrument servicing (CCU), communications (FAU), ship costs (CCU), and instrument replacements.
  - TOTAL of $370,000 in year 1 and $270,000/year, thereafter.

V. Risk Analyses Studies Required for Socio-Economically Designed Information

- USC Socio-Economic Studies at $100,000/year for 2 years
- CCU Socio-Economic Studies at $100,000/year for 2 years
- Total costs of (a) + (b) = $400,000

VI. Total Costs of Creating and Implementing an End-to-End Real-Time SC Capability to Meet the Vision and Expectations of the SC Floodwater Commission charge (Table 13)

TABLE 13

1.Instrumentation All Real-Time Reporting	#	Cost Per in Dollars ($)	Total in Dollars ($)	Organizations Assigned
a. River Gauges	150	5,000 FAU	750,000	USGS/CCU/FAU
b. Meteorological	150	15,000 CCU/FAU	2,250,000	CCU/FAU
c. Computer Processors	100	1,000	100,000	CCU
d. Visualization	1	50,000	50,000	CCU
TOTAL #1			3,150,000	
1. Personnel	Cost per year in $	Years	Total in $	
2. For Creation of Validated Model Output of System shown in Figure 13	320,000	2	$640,000	CCU/USC
3. For Model Output Visualization in Real-Time	85,000	Continuing	85,000	CCU/USC
4. For 12c River Instrumentation Maintenance	200,000	Continuing	200,000	CCU/FAU
5. For 12d Met Station Instrumentation Maintenance	200,000	Continuing	200,000	CCU/FAU
6. For Artificial Intelligence in #5c in Text	60,000	Continuing	60,000	CCU/USC
7. HUGO Outlook in Item #7 in Text	60,000	Continuing	60,000	CCU
8. Risk Analysis in Item #13 in Text	200,000	X 2 years each	400,000	USC/CCU
9. Offshore Moorings for CCMS Forecasting and Tsunami and Meteo-Tsunami Detection	370,000 In Year- 1	270,000 Continuing		CCU/FAU
10. Ship to be used for Item # 9 is the SC State Owned Coastal Explorer Vessel	Fuel	Fuel	Fuel	SC/CCU

Housed at North Myrtle and Georgetown Marinas				
11.YEAR -1 – COSTS			**5,165,000**	**CCU/USC/FAU**
12.YEAR - 2 COSTS			**1,395,000**	**CCU/USC/FAU**
13.CONTINUING COSTS			**875,000**	**CCU/USC/FAU**

VII. Roles of Agencies and Organizations, and Coordination

- AI research and applications can be coordinated between CCU and USC.
- Pond Research can be coordinated between USC, CCU and others.
- Model system output can be coordinated by CCU and USC with the SCEMD, SCSG, USGS, SCDNR, SCDHEC, and SCDOT
- Real-Time Numerical Model Ensemble Output will be provided by CCU to the Office of the Governor of SC to be disseminated thereafter as per the order of the Governor
- The South Carolina Emergency Management Division (SCEMD) uses flood modeling before, during, and after hazard events to inform and guide support for disaster preparedness, mitigation, response, and recovery activities. Flood modeling assists in identification of areas for which increased preparedness and mitigation, including planning, public outreach, training, and hazard avoidance or reduction efforts, are needed. In response and recovery, flood modeling that incorporates real-time data provides projections to guide staging and deployment of response resources, estimate flood damage, and identify areas in need of response and recovery support and will be provided by CCU directly.
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- The SC River Gauge Network can be coordinated by CCU, USGS, and other agencies
- The Transportation Infrastructure Meteorological Network can be coordinated by CCU and SCDOT.

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State of South Carolina

Governor Henry McMaster | Thomas S. Mullikin, Chairman

South Carolina Floodwater Commission

Grid Security Task Force Report

November 8, 2019

GRID SECURITY TASK FORCE

MEMBERS

Keller Kissam (Chair)
President of SCE&G

Senator Thomas C. Alexander (Secretary)
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Babs Warner
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James Clark
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Ben Duncan
SC Disaster Recovery Office

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SC Military Department

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Senior Vice President and Chief Transmission of Duke Energy

Harry Sideris (Liaison)
Chief Distribution Officer of Duke Energy

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I. INTRODUCTION

A. Background

Electrical power is typically generated through a variety of renewable and non-renewable means and sent via transmissions lines to substations, which condense the voltage levels so power can be supplied through distribution lines to end use customers. Generation, transmission, and distribution are the three major systems involved in ensuring that customers will have reliable power at all times.

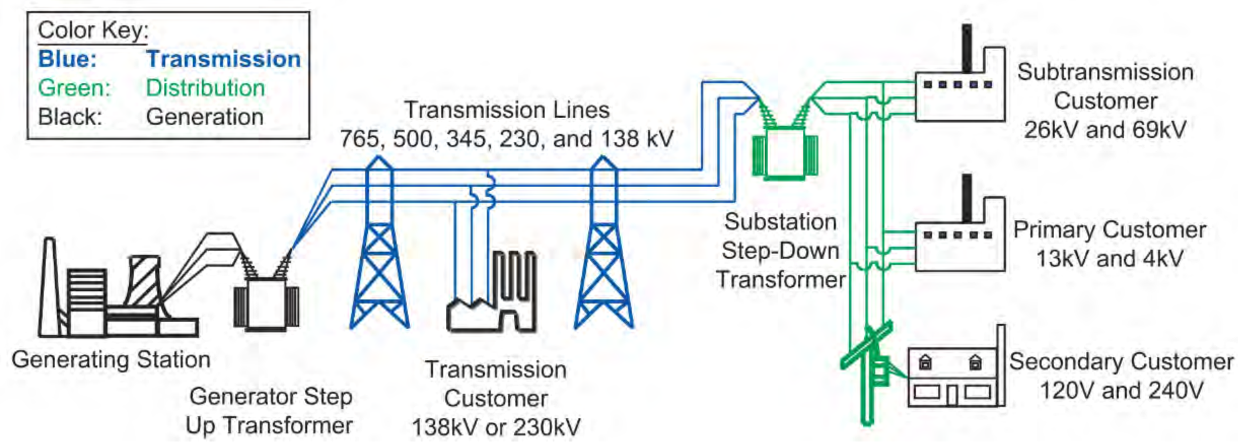

FIGURE 1: Schematic of the US electrical power system, from generation to transmission to distribution (National Parks Service, n.d.).

South Carolina's bulk electrical, intermediate, and small voltage systems span over 16,700 miles of transmission lines, sending power from power plants to the various networks. Approximately 125,000 miles of distribution lines across the state supply power directly to customers. Together, these lines dispense power from the various power plants, supplying power from, nuclear, coal, natural gas, hydroelectric, and renewable power sources around the state (South Carolina Energy Office, 2019). Understanding the potential vulnerability of South Carolina's electrical grid is vital to assessing the outage problems that citizens stand to face and to building resiliency within the state's infrastructure.

The United States' electricity delivery system is more than 100 years old and many of the transformers, capacitators, and voltage regulators have been in place for several decades. This infrastructure is fundamental but shows signs of an increasing difficulty to maintain as it continues to age. In addition to this, several factors are having a significant impact on the state's energy grid, including: population and business growth, heavily concentrated in urban and suburban areas; rapidly advancing technology in areas of renewables and distributed energy resources -- new types of load and resources impacting grid; technology advancing rapidly within devices and systems that operate and manage T&D grids; customer expectations and use of grid are different from past generations; increase in environmental commitments from the international to local level; the number, severity, and impact of weather events on customers has significantly increased; and the threat of physical and cyber-attacks on grid infrastructure is more sophisticated and on the rise.

As a result, our current power grid faces demands to create a more reliable and resilient electrical system, and continue hardening/securing the grid as new requirements come to light (Office of Regulatory Staff, 2016). South Carolina has a unique opportunity to create a more resilient, reliable, smart and modern energy grid for the benefit of all its citizens and the economy.

Weather related power outages remain the leading cause of outages on the bulk electrical system (Swift Engineering, n.d.). Natural events, including severe storms and flooding, have traditionally posed the greatest challenge to the reliability of the electrical grid (Marston, 2018). A 2018 Department of Energy study noted that while severe weather only accounted for 51 percent of outage events, they affected 92.4 of all customers (DOE, 2018). A 2009 study noted that an eight-hour interruption cost the average residential customer $10.60 but increased to $5,195 for a small commercial customer and nearly $70,000 for a medium industrial customer (Sullivan et al., 2009).

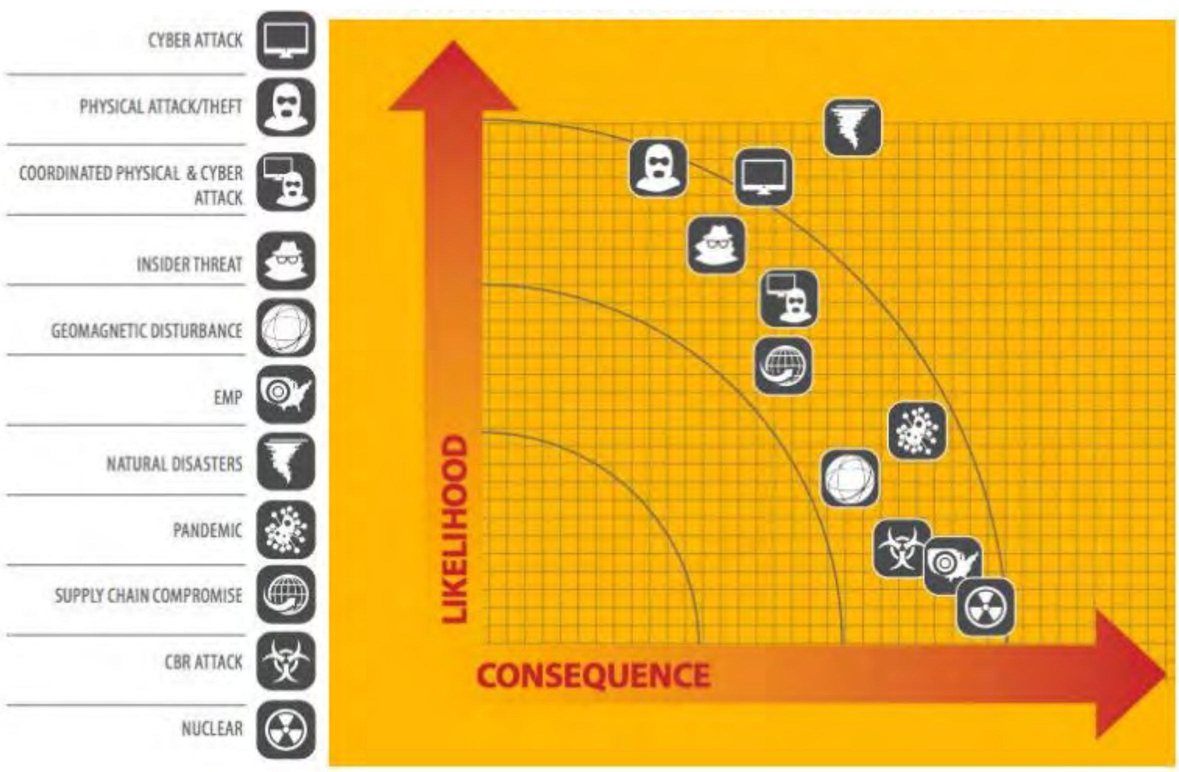

FIGURE 2: Threat Landscape: Electric Utility Sector (ConservAmerica, 2016).

Electric system component	High risk	Moderate risk
Generation	Large earthquakes[a]	Intense hurricane Extensive drought Extreme heat Moderate wildfires Sea level rise and major floods Strong geomagnetic storms Major equipment failures
Transmission	High-category hurricanes Major winter storms	Low-category hurricanes Minor winter storms Floods (100-year) Major wildfires Large earthquakes
Substations	Large earthquakes Strong geomagnetic storms Cyberattacks	Hurricanes (all) Minor winter storms Extreme heat Floods (100-year) Major wildfires Moderate earthquakes
Distribution (aboveground)	Hurricanes (all) Minor winter storms	Floods (100-year) Major winter storms Major wildfires Earthquakes (all) Cyberattacks
Distribution (belowground)	Large earthquakes	High-category hurricanes Floods (all) Earthquakes (small) Cyberattacks

[a] >7 on the Richter scale

FIGURE 3: High and Moderate Risks for the Various Electrical System Components (Marston, 2018).

While downed distributions lines can result in the simple loss of power to a handful of individual customers at a time, the larger reality of the state's electrical grid carries a far greater weight. Prolonged outages can result in devastating effects to communities and their economies throughout our state. As water treatment facilities begin to fail, raw sewage could be released directly into local waterways, contaminating drinking water. Hospitals can be forced to evacuate all of their patients with a risk to those in delicate conditions as power is lost. Cell phones and internet accessibility can fail, making it difficult to communicate with those in flooded areas. In urban areas, high rises can face struggles as large populations lose power at once; while in more rural environments, well water will be difficult to recover. Elderly, disabled, and low-income citizens may be hit harder than most as they, and the rest of South Carolina's flood impacted citizens, struggle to overcome the devastating effects that such natural disasters can impose (Union of Concerned Scientists, 2015).

B. Identification

1. Generation

South Carolina produces about 170 trillion British Thermal Units (BTU), or approximately 208 thousand Megawatt hours (MWh), of energy annually. The majority of this, 59.3% comes from the state's 5 nuclear power plants. Natural gas fired power plants provide 22.1% of South Carolina's power, while coal fired plants account for 12.6% of energy production, and petroleum fired plants provide 0.1%. Collectively, renewable energy plants, such as hydroelectric, pumped storage, biomass, and solar power, contribute only 6.7% of the state's energy production (U.S. Energy, n.d.). The majority of this power is used within the state, although some of it is distributed beyond our borders to North Carolina (South Carolina Energy Office, 2019).

The existing nuclear generation fleet in the state is well prepared to address extreme flooding events, as is Duke Energy's Jocasse dam.

The Carnegie Endowment 2012 research study (Action and Hibbs 2012), determined that the tsunami that caused Fukushima event was a one in a thousand-year event. After Fukushima, Duke Energy and SCANA, along with the entire nuclear industry, were required by the NRC to perform an extensive analysis for extreme flooding events at all nuclear stations. The extreme flooding events assumed for the analysis far exceeded any known events in history including assuming dam failures without any probable cause. Those events were used to develop mitigation strategies to provide additional protect for nuclear sites. Those flooding mitigation strategies have been incorporated into plant modifications and procedures as required by the NRC for the industry Fukushima response. Action, J.M., Hibbs, M (2012, March). Why Fukushima Was Preventable, The Carnegie Papers, Carnegie Endowment for the International Peace. Retrieved from: https://carnegieendowment.org/files/fukushima.pdf

An independent study on the probability of a Jocassee dam failure determined that the probability of a failure of the Jocassee dam is 2.6 in a million years (RAC Engineers & Economist 2010). Based on the above studies, a failure of the Jocassee dam is 2600 times less likely than the tsunami that caused the Fukushima event.

2. <u>Transmission</u>

Transmission lines within an electrical grid are primarily designed to transfer power over great distances, usually from a power plant to areas with dense populations, like towns or cities throughout the state. This high-voltage transmission system (HVTS) is comprised of many control systems, switches, circuit breakers, and transformers, in addition to the towers and conductors that are essential to moving large amounts of power. The transmission system also requires a series of substations to step up power from generators and later to step it down to distribute out to customers (Marston, 2018).

Transmission lines are higher in voltage and generally run along tall structures, often made of wood, concrete or steel. These overhead lines themselves can fail as time progress, as can the insulation and towers. Harsh weather conditions and a shift in climate can have a direct impact on the structure of transmission towers. Wood towers can be more susceptible to rot after 40 years of continual service, while steel towers can corrode depending upon their location (Dehghanian et al., 2018).

Wood transmission towers are typically capable of 50-75 mph winds with the exception of large trees fall from outside the existing rights-of-way. Such up-rooting can occur within wind speeds of 30-50 mph given ground saturation levels. Concrete structures can typically bear wind load above 100 mph, but the weight of concrete can make construction costly and difficult due to the sheer weight of a solid concrete structure. Steel transmission is the most improved material for transmission. Light, flexible, and sturdy steel structures, whether directly imbedded or bolted to foundations provide wind loading up to 150 mph. Their slip-jointed construction also avoids the weight of concrete poles. As long as these structures are not located in vulnerable areas, such as high velocity water run areas, they do not represent a significant risk to the grid regarding a flood. Finally, there are very limited underground electrical transmission facilities that would be subject to the same risks as natural gas pipelines.

Substations can be prone to inundation and flood damage. South Carolina's Lowcounty alone has 54 substations that could be susceptible to major damage from severe storms along the coast. Replacing damaged substations can cost millions of dollars and take over a year to repair (Union of Concerned Scientists, 2015).

3. Distribution

While damage to transmission lines are responsible for large scale power outages, damaged distribution lines are more likely to cause service interruptions for individual customers (Campbell, 2012). Distribution lines are lower in voltage and run along more traditionally recognizable electric power poles. These lines are the final stage in transferring power to citizens around the state. The distribution network within an electrical grid often encompasses medium-voltage power lines, substations, pole-mounted transformers, low-voltage distribution wiring, and meters (Dominion Energy, 2019). Eighty percent of electrical distribution lines are above ground, with approximately 20% underground. Undergrounding has traditionally only been implemented in high-density neighborhoods, representing a non-standard service. Impacts from flooding to overhead distribution is minimal unless facilities are in vulnerable areas such as high waterflow areas, resulting in sever erosion. Flooding, coupled with wind, can begin impacting distribution when wind speeds reach up to 35-40 mph.

C. Comparison

In recent years, the System Average Interruption Duration Index or "SAIDI", one of a number of ways the industry measures reliability, has been trending up in South Carolina due to the factors noted in section I.A.

The U.S. Energy Information Administration reports that South Carolina had the highest number of total outage duration hours for 2016. Hurricane Matthew caused clients to have an average of 20 hours of outage per customer. This number is striking in comparison to the year's national average of 4.2 hours per customer for outage occurrences (U.S. Energy, 2018). The 2018 Grid

Modernization Index lists South Carolina at 34, with a score of only 23 out of 100 when looking at state support of grid modernization, rate structures, customer outreach, data collection practices, and deployment of modern grid technologies, like sensors and smart meters (GridWise Alliance, 2018).

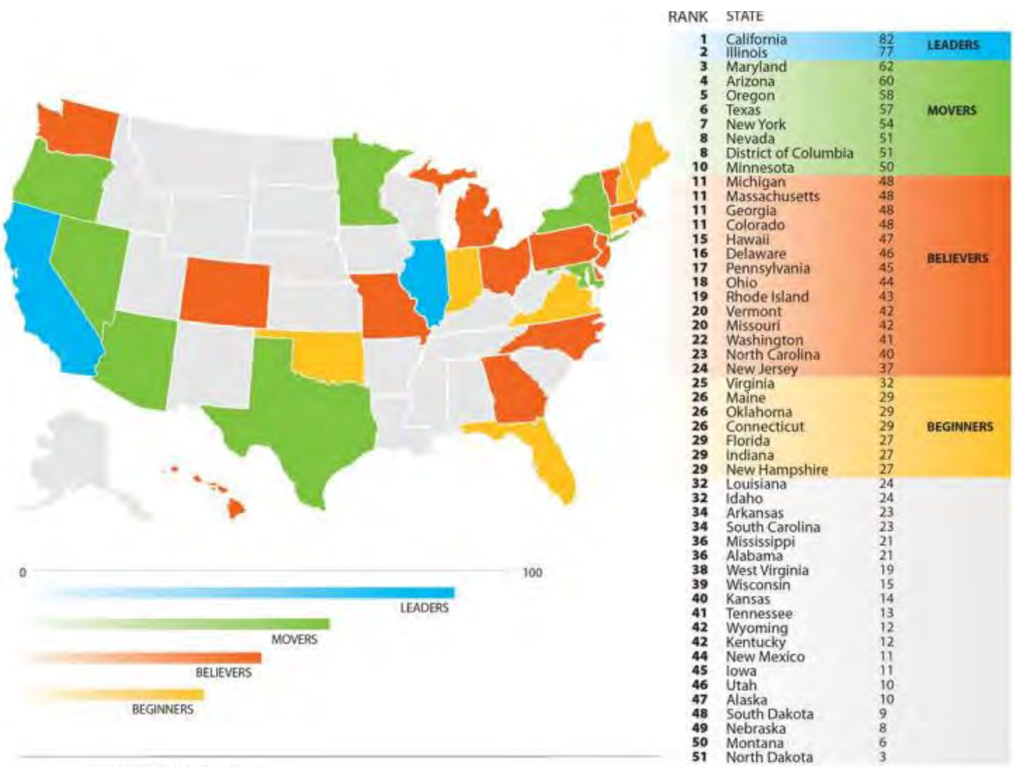

FIGURE 4: GridWise Alliance ranking of states by level of grid modernization (GridWise Alliance, 2018).

D. <u>Objective</u>

To best mitigate flooding issues related to South Carolina's electric grid, high priority should be given to efforts directed towards hardening and modernizing the grid itself to make it more reliable and more resilient. In doing so, there should be an emphasis on disaster prevention, service survivability, and rapid recovery in the wake of disasters (Shea, 2018). South Carolina is not behind on these issues. Several steps, by both public and private entities, have already begun to start the process of hardening the gird and planning for disaster, keeping lights on, and minimizing the danger, disturbances and economic impacts caused by power outages. By focusing on the legislation and progress that has already been put in place, as well as looking towards additional solutions, South Carolina can begin to reduce the vulnerabilities that place many citizens in danger due to the loss of power during flooding events, and which can have a devastating impact on the State's economy.

II. PLANNING FOR POWER OUTAGES

A. Life Cycle of a Power Outage

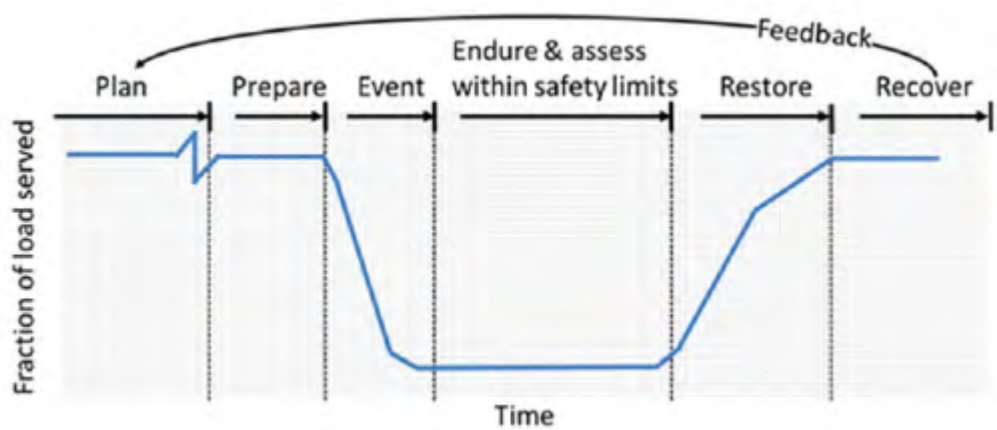

FIGURE 5: Notional time series of a major power outage divided into six stages (National Academies of Sciences, 2017).

1. Plan

The majority of time in the life cycle of a power outage is spent in the planning stage. Most providers are generally aware of the threats their systems face and which areas within their physical system are most susceptible to damage. By combining their own experience with data from scientific services, such as the National Oceanic and Atmospheric Administration (NOAA) or the National Weather Service, states can make informed predictions about pending threats.

During this period, both preventative and preparatory actions should be taken. Investments can be made to harden distribution systems from storm and flooding damage, including installing additional guy wires to overhead lines or undergrounding distribution lines to allow them greater protection from potential damage in a severe weather event, replacing wood poles with hardened steel and concrete poles, installing new technologies like self-optimizing grids, that can intelligently shift power to avoid outages before they happen, and, in outage prone locations where the benefits outweigh the cost, implement targeted undergrounding of overhead distribution facilities.

Additionally, the transmission system must be maintained and hardened, for example, replacing wood poles with more storm resilient concrete and steel structures, to keep up with the ever-increasing demands required by customers. By entering into mutual assistance agreements with other power suppliers to aid in recovery, investing in systems to share spare parts during disaster scenarios, and coordinating restoration exercises and drills, utilities can mitigate the damage a recovery time to a transmission network. As smart grid technology develops, distribution and transmission systems can be integrated into a cyber-physical network that will allow grids to "fail gracefully" and avoid catastrophic levels of power outages by diverting power when needed and making it easier to pinpoint areas that need repairs.

Utilities should also continue their efforts with local communities to coordinate preparation and plan for recovery with the people most directly affected. By working seamlessly with local emergency services, joint efforts can be made to integrate planning in preparation of potential threats and coordinated recovery efforts. By engaging end use customers, utilities can also begin to note the features and sites of critical loads throughout service areas and work to guarantee suitable backup power when the need arises (National Academies of Sciences, 2017).

2. Prepare

Once a specific threat has been identified, such as the formation of a hurricane that is tracked to make landfall, this phase begins. While some hazards have no advanced warnings, coastal and inland flooding can often be predicted. During this phase, preparations from all parties can begin. Utilities may begin to check for spare equipment, assess critical components, enact mutual assistance agreements, or begin pre-staging supplies and repair crews in areas that are more vulnerable to damage and outages. At generators, assessments can be made to the level of generation available and additional reserve generation can be accessed if necessary. Operators at these sites may also be able to evaluate the suitability of supply chains and various fuel stocks and confirm the state of charge on any storage assets available. This is also the phase where utilities should begin to contact any partnerships they have made with customers, disaster response groups, and emergency management organizations. Customers can begin to prepare backup generators and purchase fuel, while responders can begin to coordinate efforts to shorten response time. This could also be a good time to engage distributed energy resource owners (DERs), such as people with small scale solar power generators (National Academies of Sciences, 2017).

3. Event

This phase can be dependent on the event itself. While some events, like earthquakes, are relatively short in their duration, flooding can last for weeks at a time. The primary focus during this phase is to monitor damage for the length of the event. If distribution systems are equipped with digital sensors, then outages can be detected as they occur, whereas other utilities may need to be contacted by customers to be aware that power has been lost. In generation and transmission systems, operators can balance generation and load through rolling blackouts, generation dispatch, and intentional islanding, where individual generators are left on to power a location despite the grid power not being present. In some circumstances preparation may continue, though this may be limited by the nature of the event (National Academies of Sciences, 2017).

4. <u>Endure</u>

Depending on the length and nature of the event, restoration can begin immediately. In flood scenarios however, time may have to pass before utility crews can make their way to affected areas. Where cyber monitoring is available, utilities can continue to assess situations, allowing them to prioritize repairs and create efficient schedules to enact efforts once the circumstances allow the process to start (National Academies of Sciences, 2017).

5. <u>Restore</u>

Restoration is the most publicly visible phase of the timeline. When conditions allow this phase to fully begin, utilities normally follow priorities to begin repairing outages. Despite best efforts, when critical components are damaged, like essential transformers, power may only return at a reduced rate until parts can be replaced. During this period, utilities normally make large efforts to stay in contact with their customers, while simultaneously supporting field crews by supplying essential materials, replacement parts, equipment to complete repairs, and experienced workers. This period may often see utilities working with federal and state officials to waive regulations or to allow the use of military resources. In some cases, where regions of the grid interconnect, restoration will begin at the edge of the outage, while other instances may call for a black start, restoring the grid without relying on any external transmission networks. If there are any DERs available within affected areas, they may be used to aid in restoring power and may even be used during blacks starts (National Academies of Sciences, 2017).

6. <u>Recover</u>

Once the grid has been repaired and service is once again restored, it is common for utilities and officials to assess what caused various outages and recognize opportunities where future grid performance can be enhanced. This becomes a crucial stage in the timeline, as the feedback during recovery will affect future efforts in planning and preparation. With the predictable nature of flooding events, this phase is one South Carolina can take particular advantage of as we continue to prepare our electrical grid to be more resilient in the face of oncoming hazardous events (National Academies of Sciences, 2017).

B. <u>Disaster Preparedness</u>

In the last ten years, NOAA estimates that the United States has seen 16 major flood events and 66 severe storms (measured as billion-dollar events), together totaling an average cost $5 billion and resulting in 1,052 deaths. These events show no sign of slowing down. Severe storms have increased in event frequency from 39.1% (1999-2009) to 57.9% in the last decade, while flooding events have increased from 4.7% (1999-2009) to 14% (2009-2019) (NOAA, 2019). In comparison, 2016's Hurricane Matthew, accrued approximately $320 million in infrastructure repairs, resulting in nearly 861,000 citizens losing power throughout the state.

Mitigating damage to the electrical grid is a process that can stretch from small projects, like updating tree trimming practices to be more effective, to large scale investments to update the grid. Paying for these updates and advancements can, at times, seem like a costly measure, and the fear that some of these costs may be passed directly on to consumers is not wholly unfounded. However, it is important to understand that an analysis of 23 years of data from Federal Emergency Management Division (FEMA), U.S. Economic Development Administration (EDA), and U.S Department of Housing and Urban Development (HUD) shows that, on average, every $1 spent on utility and transportation infrastructure saves $4 on recovery, with savings on inland flooding equaling $8 for every $1 spent (National Institute of Building Sciences, 2018). Many states have already begun to consider legislation related to disaster preparedness and enact various strategies and plans relating to their electrical girds that could aid in disaster prevention, service survivability, and rapid recovery.

1. Disaster Prevention

States have begun to mitigate extreme weather damage by encouraging investment in upgrades, upkeep, and preparation for more resilient infrastructure. In some areas, this has looked like requiring utilities within the state to create more thorough flood plans to better address vulnerabilities within individual grids. Other states have asked the federal government to update the standards for reliability and redundancy for better grid security (Shea, 2018).

Physical improvements to the grid also fall under this area of mitigation, including undergrounding of transmission and distribution lines and further stabilizing towers with guy wires. These solutions have many proponents. House Bill 3628 was introduced in 2019 to the SC House of Representatives to require all electrical lines be buried under ground by 2025. The practicality and cost of such solutions are often criticized. Estimated costs to bury one mile of electric line would cost about $1 million (Shea, 2018). Underground lines have been noted to be more susceptible to damage in flooding scenarios, and harder to repair as they must be unearthed and reburied, before and after maintenance.

2. Service Survivability

Power loss in many scenarios may be inevitable. However, investing in solutions like backup generators and microgrids can help keep some loads powered and active. This could be effective at vital facilities, such as hospital or waste treatment plants, that stand the chance of facing loss of power or evacuation during grid failure (Shea, 2018).

Connecticut has developed a post-Superstorm Sandy program that touches on microgrids in four different areas. First it offered $18 million, and later a second round of $30 million, towards nine critical facilities in the state. Second, it is including microgrids under the classification of “energy improvements” that Connecticut’s green bank could finance. Third, it passed legislation that allowed microgrids to be included under projects that local governments can develop as "energy improvement districts." And finally, they passed legislation that allowed microgrids to be considered in its Property Assessed Clean Energy financing program (Shea, 2018).

State legislatures across the country have also made requirements that critical facilities and new residential developments must include backup generators. Natural gas-powered cogeneration has also been incentivized in certain areas to anchor microgrids and depend on pipeline infrastructure, which is normally more resilient than underground electric lines (Shea, 2018).

3. Rapid Recovery

Stunted recovery efforts can leave water systems in failure, cause food to spoil, and cause the economy to come to a standstill. Quick recovery efforts are essential to responding to major power outages. When power utilities are easier to access, recovery efforts often move swifter and more efficiently. Creating more stringent requirements on the trimming of trees and vegetation can lessen initial causes of outages and make recovery efforts quicker. Additionally, granting tax breaks for out-of-state workers can help speed up recovery processes, by allowing additional crews on the ground to help with efforts (Shea, 2018).

III. GRID MODERNIZATION

Grid modernization is simply the process of updating and enhancing the electrical grid with software and communication technology that will allow it to better support the demands of a growing and changing customer base (GridLab, 2019). Smart grid technology can allow utilities to avoid outages altogether and assess and recover from damage related to natural disasters more quickly than with prior technology. Grid operators can use such systems to make energy more efficient for customers to use and allow for more effectual management of resources. By utilizing smart meters, self-healing grid and other technologies, distributed generation, demand response, and distribution management systems, amongst other resources, utilities can ultimately create a more reliable and resilient electrical grid (Shea, 2018).

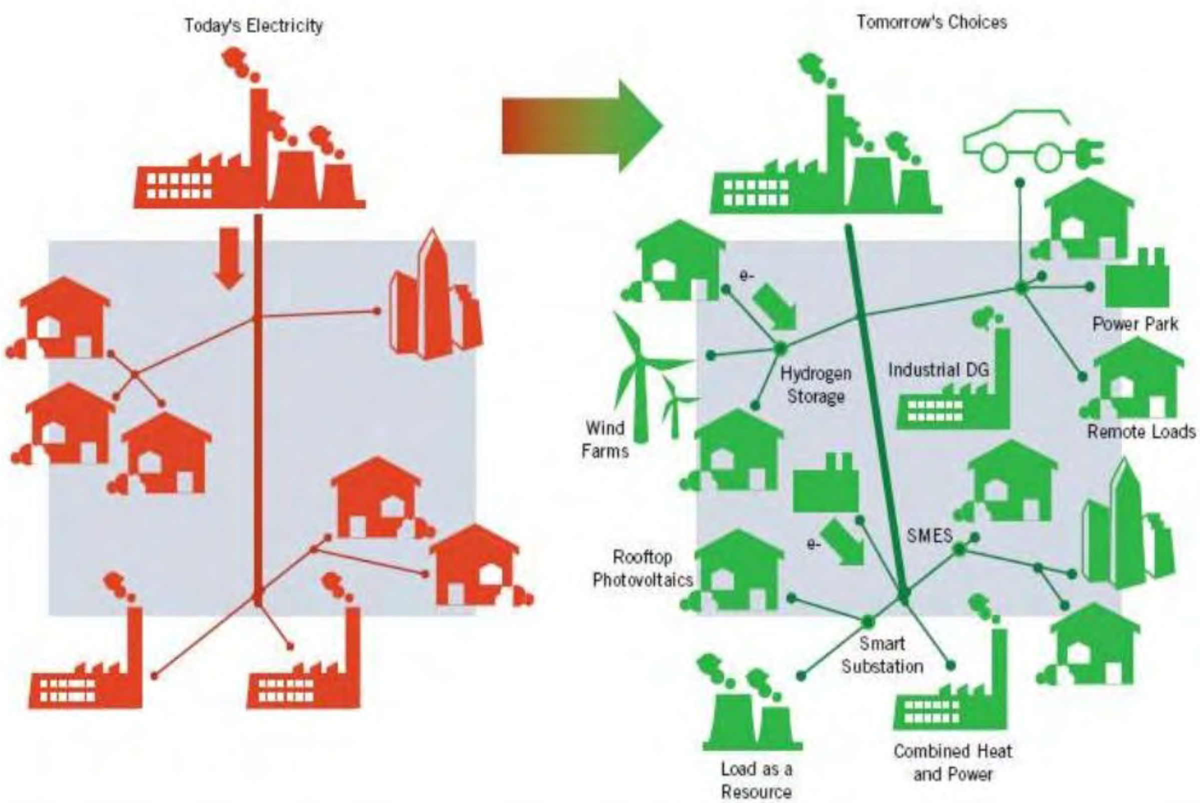

FIGURE 6: IEEE version of Smart Grid distributed generation, information networks, and system coordination (Kienle & De Schryver, 2012).

While customers might have the concern that the cost of such improvements will be passed solely to them through providers, some states have made additional funding available as an incentive for utilities to begin smart grid advancements. Through legislation, states can pass laws that will require utilities to make investments and deliberations that meet state appointed goals (Shea, 2018).

IV. ENERGY STORAGE

Electrical Energy Storage (EES) is the process by which electrical energy is converted into a stored form which can later be converted back to useable energy when needed. This process principally relies on batteries to store energy, a procedure that dates back to 1800 and first used in 1929 at the Rocky River Pumped Storage plant in Connecticut. Energy storage projects in the United States have increased by 174% between 2013-2018. California leads the country with 220 operation projects and storing the most power, accounting for 4.2 GW of the total 25.2 GW of rated power in the U.S. (University of Michigan, 2018). Despite only having three projects, South Carolina trails by only a small amount, storing 2.28 GW of rated power (DOE, n.d.).

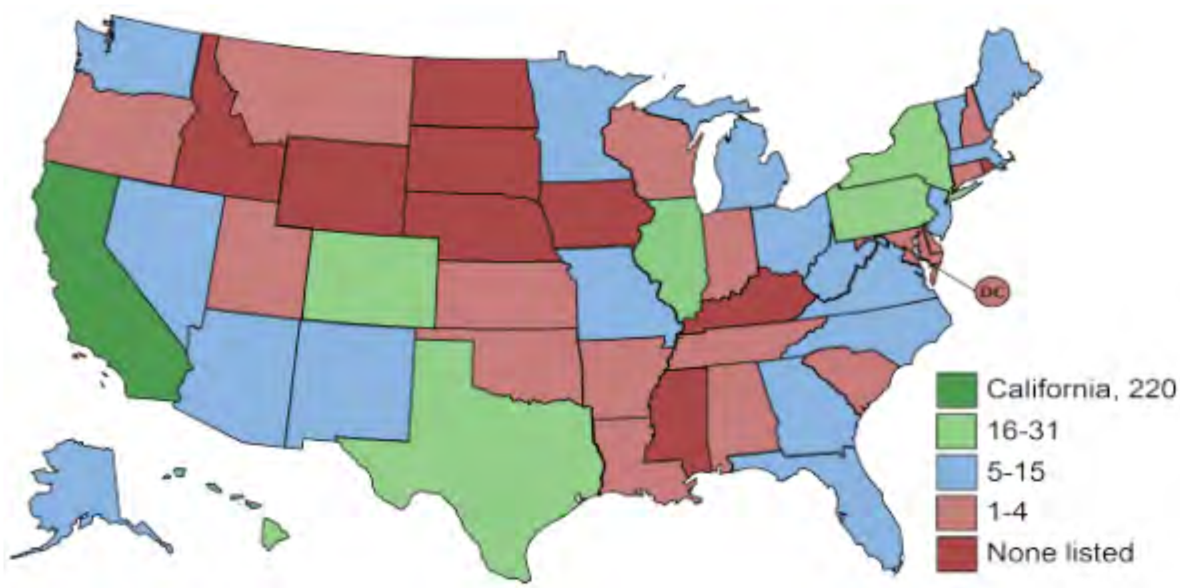

FIGURE 7: U.S. Grid-Connected Energy Storage Projects by State in 2018 (University of Michigan, 2018).

While there are multiple EES technologies in research and development, four main storage types are currently deployed. Pumped Hydroelectrical Storage and Compressed Air Energy Storage are capable of large-scale discharge but are limited by the geographical space they require, while Advanced Battery Energy Storage and Flywheel Energy Storage have a lower power discharge but not often limited by location. Pumped Hydroelectrical Storage projects, which generate electricity by pumping water from low elevation to a high elevation reservoir and then releasing the water back to the low reservoir through hydroelectric turbines, account for 94% of the United States' energy storage. Compressed Air Energy Storage stores compressed air in underground caverns by heating pressurized air and expanding it in an expansion turbine. Advanced Battery Energy Storage projects use a process similar to common, household batteries by storing electrical energy in the form of chemical energy to later be drawn out as electricity again. Finally, Flywheel Energy Storage is mostly used for power management as opposed to long-term storage, storing electric energy by rotating a propeller in a frictionless enclosure to move power to and from the grid (University of Michigan, 2018). The three EES projects in South Carolina are all Pumped Storage facilities, two near the Jocassee watershed and one near Fairfield (DOE, n.d.).

1) Electric Supply	g) Voltage Support	m) Demand Charge Management
a) Electric Energy Time-shift	**3) Grid System**	n) Electric Service Reliability
b) Electric Supply Capacity	h) Transmission Support	o) Electric Service Power Quality
2) Ancillary Services	i) Transmission Congestion Relief	**5) Renewables Integration**
c) Load Following	j) Transmission & Distribution Upgrade Deferral	p) Renewable Energy Time-shift
d) Area Regulation	k) Substation On-site Power	q) Renewables Capacity Firming
e) Electric Supply Reserve Capacity	**4) End User/Utility Customer**	r) Wind Generation Grid Integration
f) Voltage Support	l) Time-of-use Energy Cost Management	

FIGURE 8: Five Categories of Energy Storage Applications (University of Michigan, 2018).

The applications of EES projects are extremely diverse, affecting the grid systems, end users, and electrical supply, amongst other uses. EES does not only help manage energy costs at a potential savings to the consumer but can also help maintain power grids during severe weather events and even assist in rapidly returning service after an outage, such as helping with black starts. As storage technology advances to become more effective and economically feasible, their value continues to rise; projected market potential sits around $228.4 billion in the United States. Government investment has been made to increase research and development of EES projects. In 2010 California passed legislation to set and meet energy storage goals, setting a rated power goal for investor-owned utilities.

V. VEGETATION MANAGEMENT

"Vegetation management" generally refers to the process of maintaining trees, bushes, or other plant life that grow in or along the border of right-of-ways (ROWs); utilities use the corridors to provide power to end use customers. When the various ecosystems surrounding right-of-ways begin to dangerously encroach upon transmission and distribution lines, they threaten cascading failure across electrical systems. . Maintaining these ROWs not only can increase public safety and help promote healthier woodlands but can also aid in mitigating damage to utility infrastructure cause during natural disasters. Approximately 90,000 miles of transmission and distribution are constructed in right-of-ways throughout the U.S. Forest Service and Bureau of Land Management alone (Vegetation Management, 2017). In response to the need for greater vegetation management in areas along the interstate transmission system, Federal Energy Regulation Commission (FERC) has implemented FAC-003-4, a standard intended to prevent vegetation related outages (Federal Energy Regulatory Commission, n.d). Mandating minimum vegetation clearance distances determined by the voltage of the line in question, the standard generally addresses seven requirements to help better mitigate damage to electrical transmission lines:

Requirements R1 and R2

- Notes the distance to which vegetation should be trimmed away from transmission lines to best protect the lines themselves.

Requirements R3

- Defines maintenance strategies and processes to be used by applicable Transmission Owners and Generator Owners.

Requirements R4

- Encompasses the notification of dangerous conditions posed by the ecosystem. This includes coordinating actions before, during, and after repairs of threats.

Requirements R5

- Noting preventative actions to take by an applicable system owner to stop the risk of cascading system failure and extended outages.

Requirements R6

- Implements specific time periods for carrying out inspections of lines and systems for vegetation threats.

Requirements R7

- Requires the completion of yearly work plans to address threats from vegetation (From Federal Energy Regulatory Commission, n.d.)

South Carolina has no state scheme in place to address the threat that vegetation poses to the electrical grid within the state. While FERC FAC-003-4 only regulates what Generator and Transmission Owners must do in regard to transmission lines, the distribution network in South Carolina could be addressed in a similar manner. A study by Nowak and Ballard outlines the six steps of the Integrated Vegetation Management system that could be applied:

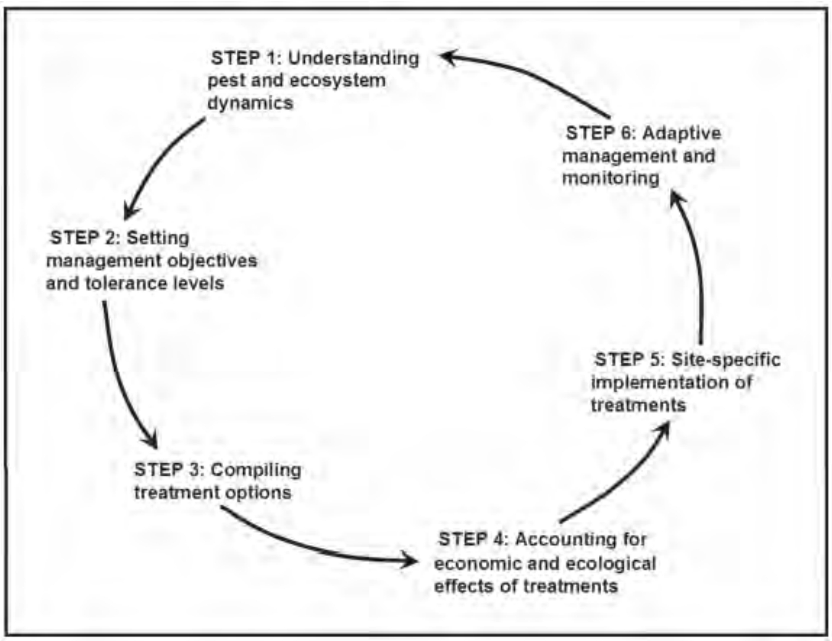

FIGURE 9: Competent steps of Integrated Vegetation Management (Nowak & Ballard, 2005).

These general concepts would have utilities and legislatures focus on the ecosystems, including plants and wildlife that surround electric lines, setting objectives to meet the needs of utilities and shareholders alike to create a set of options that can be used to treat potential threats from living systems that are naturally a part of most ROWs. This process requires all parties to address both the socioeconomic and environmental impacts that result in managing vegetation, so that the appropriate treatments can be planned for each site specifically. When treatments of each individual area are complete, the data gathered in the process should be collected and analyzed to better plan for future maintenance (Federal Energy Regulatory Commission, n.d.).

VI. FINDINGS AND RECCOMENDATIONS

A. Flood Zone Mapping

NOAA, National Weather Service (NWS), and several other groups possess data driven maps related to flooding across the United States. However, with more resources available to South Carolina's scientists, planners, and citizens, preparing for flooding disasters throughout the state could become even more effective. In this regard, several mapping models could be emulated throughout our state.

1. Flooding Inundation Mapping and Alert Network

The Flooding Inundation Mapping and Alert Network (FIMAN) provides rain and stage gauge dates with real time inundation maps, impact data, and alerts. The goal of FIMAN is not only to amass consistent data, but to help prevent property damage and loss of life through the implication of its findings. Combining data from gauges operated by the North Carolina Division of Emergency Management and U.S. Geological Survey (USGS), the system provides information to the FIMAN website (fiman.nc.gov) and the NWS as well to assist their forecasts and alerts (About, n.d.).

2. Coastal and Inland Flooding Observation and Warning Project

The Coastal and Inland Flooding Observation and Warning Project (CI-FLOW) uses radar and rain gauges to create flood models that stretch from rivers all the way to the coast as a part of NOAA's National Severe Storm Laboratory (NSSL). After Hurricane Irene in 2011, CI-FLOW predictions were tested against results from USGS and other partners to determine that "81% of the high-water marks were within +/-0.5 meters of the predicted water levels." The systems make routine predictions of total water levels and of smaller components along North Carolina's coast, ultimately designed to protect life and property throughout the state during devastating storm and flooding events (CI-FLOW, 2014). Unfortunately, this is only a 2-dimensional model so its application is limited and because of underlying flaws in its physics' platform, CI-FlOW is not highly accurate. Still it could be a helpful tool if no other model is available. *[NOTE: 81% with a +/-0.5 meters of predicted water levels means that at any given site the prediction may be off by as much as a meter. This could have serious implications for the amount of inundation given the relatively flat coastal terrain in both Carolinas.]*

3. Flood Risk Information System

The Flood Risk Information System (FRIS) creates a similar resource to provide data available flood maps, hazard data, and assessments for North Carolina and Florida. FRIS uses LiDAR information, as well as hydraulic and hydrologic models to provide accurate information (North Carolina Flood, n.d.).

4. The Hurricane Genesis and Outlook (HUGO) Model and the Southeast Atlantic Econet (SEA Econet)

The state of SC has an effective prototype model upon which to build -- the HUGO model (Hurricane Genesis and Outlook). This 3-dimensional prototype model, developed and run by the Burroughs and Chapin Center (Center) at Coastal Carolina University, is highly accurate in predicting hurricane tracking, timing, and storm surge. The model incorporates the same atmospheric drivers that CI-FLOW uses, NWS forecasts, produces hourly model output, and is updated with every NWS advisory update, typically every 6 hours. These updates are then made available for emergency managers during extreme weather events. The developing flood model output assessments have been demonstrated to be within +/- 5 centimeters and in sync with the actual timing of flooding. The advantages of the CCU model system over CI-FlOW and other models cited are based on the accurate representation of the fluid dynamics of the fluid processes versus grossly simplified representations. The Center is currently looking for funding to continue developing a module for high resolution riverine flooding affecting not only the coast but also inland areas.

The Center also operates the NWS's Mesonet program for South Carolina, Georgia, and Florida (Southeast Atlantic Econet or SEA Econet), and currently has a prototype map with all known meteorological stations, river gauges, and state-supported environmental monitors incorporated. A version of the map of the state is expected to be available for emergency managers and the public this year. CCU will be seeking additional funds to link the model output with the map so that potential inundation levels can be shown.

5. Recommendation

Elements of the North Carolina mapping and alert systems may be useful for South Carolina to build upon by partnering with groups like USGS, NSSL or FRIS to gather more data from rivers and coastal waterways. Creating better mapping and alert systems for floodplains throughout South Carolina will allow more effective preparation to protect life and property during future flooding scenarios. It is recommended that support be made available for the riverine model being developed at CCU as well as the linkage between the model and the SEA Econet map.

B. Distributed Energy Resources (DERs)

DERs "include demand response, efficiency programs, and other demand-side management tools, solar photovoltaic installations, small wind turbines, combined heat and power, fuel cells, micro-turbines, and storage devices such as large lithium batteries or grid-connected electric vehicles (EVs)" (Distributed Energy Resources, n.d.). Between 2013 and 2015, 35% of U.S. total energy capacity growth was supplied by DERs. In recent years, Denmark has moved from centralized power generation to self-sufficient energy, primarily local combined heat and power along with small wind farms (Distributed Energy Overview, 2015). This has been accomplished in part by the inclusion of specific financial incentives, including tax and feed-in tariffs

(Distributed Energy Overview, 2015). As it becomes more cost effective and the technology allows for longer duration storage, battery and other energy storage technologies can help address the intermittency of wind and solar renewable resources to produce both cleaner energy, but also store energy to be used in the event of major power outages (OSHA, 2015).

1. Distributed Energy Resources Program Act

South Carolina's Distributed Energy Resources Program Act was passed in 2014 (Act 236) to address the growing need within the state to develop and integrate DERs. Since the passage of the Act, South Carolina's residential rooftop solar capacity has seen a 9000% increase from July 2015 to July 2018, rising from approximately 5MW to 470MW. In part, this was accomplished not only by Act 236, but by federal Investment Tax Credits for solar, state tax credits, the declining cost of renewable energy, utility incentives, and the involvement of the Public Utility Regulatory Policies Act of 1978 (PURPA). As of 2017, South Carolina was only second, behind Florida, in installed residential rooftop solar capacity (see FIGURE 10) (Discussion of South Carolina, 2018).

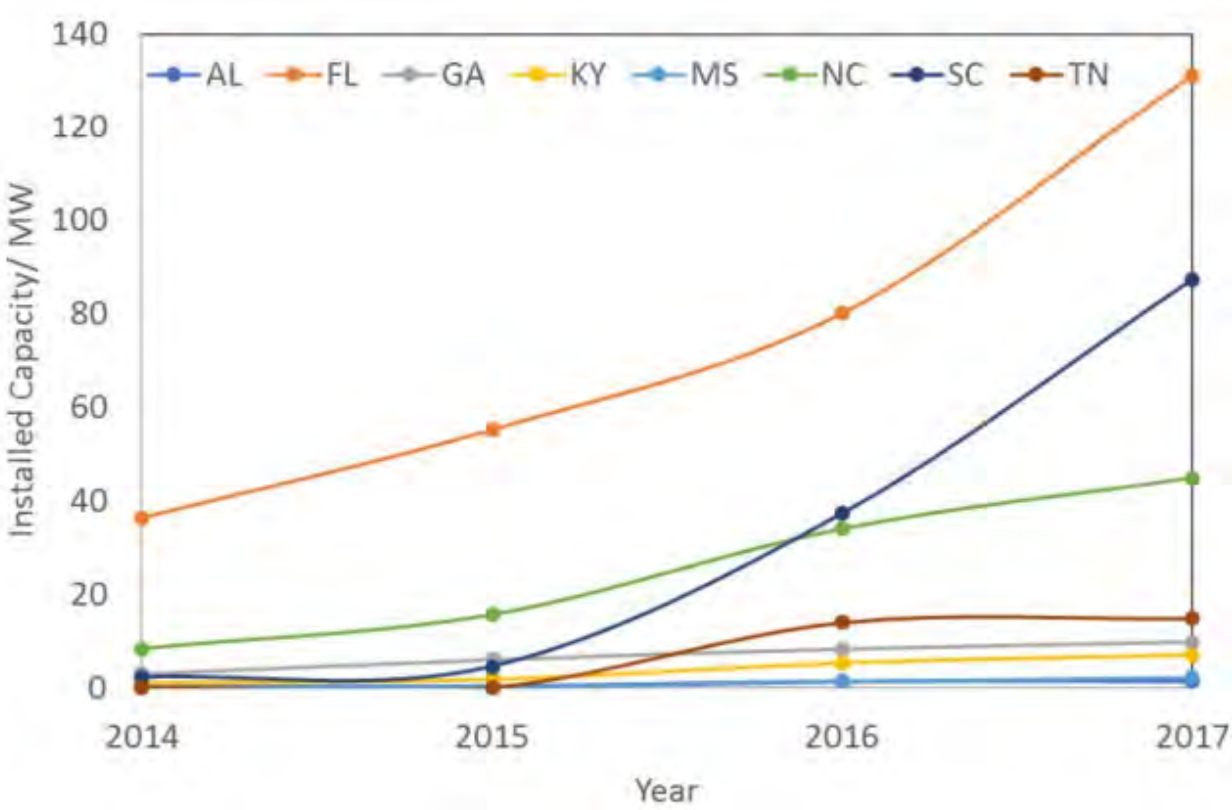

FIGURE 10: Residential Solar Installations in the Southeast. (Discussion of South Carolina, 2018)

2. Recommendation

While Act 236 has been essentially updated with the passage of Act 62 in 2019, continuing to develop activity to benefit both the development of DERs and utility scale and dispatched energy storage could be beneficial to mitigate power outages and bolstering the electric grid within South Carolina.

C. Integrated Planning

Joint efforts between local governments, emergency services, utilities and community stakeholders can help mitigate loss of life and property damage during natural disasters, such as flooding or severe storms.

1. U.S. Department of Labor

The U.S. Department of Labor notes that a detailed evacuation plan should involve:

- What conditions or events will trigger the plan
- A defined chain of command
- Who will perform required emergency functions
- A communication plan
- Planned evacuation routes and evacuation procedures
- Measures to account for personnel, customers, and visitors
- All necessary equipment for personnel
- A process to review plans with all necessary individuals

Additionally, stakeholders should be made aware of all warning systems and their meanings (Flood Preparedness and Response, n.d.). The Occupational Safety and Health Administration (OSHA) provides resources to help businesses and their surrounding communities with their "Evacuation Plans and Procedures eTool," available through their website (n.d.).

2. Recommendation

Each community in South Carolina is recommended to have a clear and concise community plan that will cover response to natural disasters and recovery efforts in their aftermath. Communities should take special effort to include emergency services in this planning process to help ensure a clear response and recovery effort from all parties involved.

D. Undergrounding

Undergrounding of electrical distribution lines has become common practice in recent years. In modern urban areas, undergrounding has become a standard practice for distribution and end-user lines. While some estimates of the process can be costly, studies note that when underground installation of electrical lines are entrenched with other utilities, like natural gas or telephone, the cost can be significantly less. (Facts About Undergrounding, 2017).

1. SC House Bill 3628

Proposed 2019 House Bill 3628 would require that all electrical utilities operating in South Carolina bury all new transmission lines beginning January 2, 2020 and bury all existing transmission lines no later than January 1, 2025. This Bill could drastically decrease the states risk of cascading outages from downed or damaged transmission lines but would be extremely costly. In addition, 80% of all power outages are cause by damage to distribution lines. When distribution lines are underground, there is a 10-fold improvement (NEI, 2009, slide 14). Though the cost could be high, for example, a 2010 study showed that it would cost approximately $5.8 billion to underground the distribution lines around Washington D.C., despite that fact that 35% of the projects would cost $4.7 billion while the other 65% would only be $1.1 billion. One projection estimated that a $1 billion project to harden the grid in D.C. would increase customer bills by an average of 3.2% over the course of seven years. Based on the inconsistent nature of the costs associated with undergrounding distribution lines, some suggest that such projects be assessed on an individual basis (Kury, 2017).

2. Recommendation

Current proposed legislation aims to underground transmission lines in hopes to prevent the large-scale blackouts that stand the chance to leave many customers around the state without power. Such a bill could be beneficial to mitigate such problems within the state due to flooding and severe storms. A cost/benefit analysis should be undertaken prior to the implementation of any such legislation. Additionally, encouraging the undergrounding of some distribution lines could greatly increase the stability of the grid in areas where vegetation or other causes lead to frequent outages.

E. Emergency Power Supply Systems

Loss of power to necessary facilities can be extremely detrimental to patients in medical facilities and nursing homes in critical care and cause precarious evacuations to occur in hopes of preserving lives. In the wake of Hurricane Irma, 12 Florida residents died due to heat stroke when the power to their nursing facilities was off for several days (Allen, 2017).

1. SC House Bill 3282

House Bill 3282 of the 2019-2020 Session of the South Carolina Legislature would require nursing homes and community care facilities to be equipped with an emergency generator. H. 3282, 2019 Leg., 123rd Sess. (S.C. 2019). In addition to healthcare facilities, some municipal buildings, police stations, records facilities, fires stations, emergency dispatch centers, prisons, mental health facilities, locations involving any number of hazardous materials, some highrises, and airport traffic control towers all have some varying need for emergency power (Midwest Generators, 2017). For example, 2017 legislation in New Jersey proposed that emergency power systems would be required in certain common areas of all new real estate developments and the state would offset the cost with tax incentives. Such a concept could be applied to a wider scale of necessary facilities around South Carolina.

2. Recommendation

Furthering legislation to require necessary facilities to have some form of backup generation will help protect the essential systems that can be detrimentally affected in the case of natural disasters. Backup generation can make the difference between life and death, whether by powering hospitals to avoid dangerous evacuations or to keep emergency services active when they are needed most.

F. Microgrids

Microgrids are small scale energy systems that are capable of maintaining stable service within a limited area. Microgrids can be used to power very small communities, with operators sharing power to others, or as a form of backup power to be used in case of emergencies. Microgrids are in the early stages of technology development. For example, Duke Energy has installed a small solar plus storage microgrid in Mount Sterling, North Carolina and is installing another in Hot Springs scheduled to begin operation in the first quarter of 2020 to serve a remote mountain community. The company is also working on installing a microgrid around the Anderson Civic Center in Anderson County, South Carolina. When operational in 2020, the microgrid will enable the Civic Center, which is the largest Red Cross shelter in the area to run off grid for more than a day. These types of pilot programs should be encouraged by the State.

1. Recommendation

Developing legislation to expand the use of microgrids throughout South Carolina that could increase the amount of renewable energy produced by the state and help increase service survivability during natural disasters that threaten the security of a large distribution grid.

G. Vegetation Management

Tree-related outages make up 20%-30% of all electricity outages. Of those tree-related outages, 50% are caused by trees outside of the utility's right-of-way. Trimming trees outside of the rights-of-way could help improve reliability. As part of any review, a study of additional ways to enable vegetation management should be conducted to improve electric reliability.

H. Funding

Funding can prove to be one of the largest challenges to creating a more secure grid. Microgrids and underground power lines can have a high upfront cost, though there benefits to could save funds through years of mitigated damage and outage response costs.

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State of South Carolina

GOVERNOR HENRY MCMASTER

THOMAS S. MULLIKIN, CHAIRMAN

South Carolina Floodwater Commission

Landscape Beautification and Protection Task Force Report

November 8, 2019

LANDSCAPE BEAUTIFICATION AND PROTECTION TASK FORCE

MEMBERS

Duane Parrish (Chair)
Director of the South Carolina Department of Parks and Recreation

Bill Bruno (Secretary)
SC State Guard

Hugh Weathers
Commissioner of the South Carolina Department of Agriculture

Senator Tom Davis
South Carolina Senator

Representative Leonard Stavrinakis
South Carolina House of Representatives

Sharon Richardson
Audubon Society

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I. ISSUE STATEMENT

Introduction

South Carolina has experienced catastrophic flooding over the past decade, both related to large-scale storm events and to sea level rise. Urbanization, deforestation, draining of wetlands, and construction of impermeable surfaces have amplified flooding events across the state of South Carolina. This has resulted in billions of dollars' worth of damages across the state, and major losses of beachfront along coastal areas where flooding has eroded beach and dune sand. This is especially significant during tropical storms, hurricanes, and king tide events. Development along beaches, rivers, and waterways is particularly susceptible to damage from flooding, and the cost of damages will continue to increase if measures are not taken to address this flooding. The South Carolina Floodwater Commission's Landscape Beautification and Protection Task Force will integrate urban and rural environmental aesthetics and risk reduction as a strategy in response to the conflict between the conservation of green spaces and urban development.

Landscape beautification and protection are critical elements for the development of successful and sustainable green infrastructure that can provide natural and man-made flood mitigation benefits. Green infrastructure uses a nature-based approach to flood reduction by maximizing flood retention benefits from wetlands, greenways, open spaces and other natural elements. The design, installation, and maintenance of permanent landscaping around properties and public rights-of-way allow for the transformation of raw property into a landscape that provides greater efficiencies and a higher aesthetic value. Landscape beautification also provides value-added opportunities to use plants in new ways to improve the local quality of life, instilling a greater sense of "pride of place" and ownership among area residents and solidifying the connection between people and their surrounding natural environment. Just as important, these investments protect lives, property and economic livelihoods in both urban and rural parts of South Carolina.

Increased urbanization, the clearing of trees, draining of wetlands, and increased paved surfaces have greatly exacerbated flooding in the state's coastal and inland areas. In addition, chronic erosion and the reduction of sand dunes along the state's coastal communities have created heightened vulnerabilities to tidal flooding, especially during tropical storms, hurricanes, and king tide events.

A. Urbanization

Over the past two decades, South Carolina has become increasingly urbanized. New residents poured into South Carolina's coastal and upstate towns and cities in 2017, adding to a population that has passed the 5 million-mark, new census estimates show in Figure 1 below. The surge in population cemented Charleston's recent title as the state's largest city and gave Mount Pleasant and Greenville some of the most rapid large city growth on the East Coast. The changes in land use associated with urban development affect flooding in many ways. Removing vegetation and soil, grading the land surface, and constructing drainage networks increase runoff to streams from rainfall. As a result, the peak discharge, volume, and frequency of floods increase in nearby streams and river channels. Changes to stream and river channels during urban development can limit their capacity to convey floodwaters. Roads and buildings constructed in flood-prone areas are exposed to increased flood hazards, including inundation and erosion, as new development continues. Information about streamflow and how it is affected by land use can help communities reduce their current and future vulnerability to floods.

Streams are fed by runoff from rainfall moving as overland or subsurface flow. Floods occur when large volumes of runoff flow quickly into streams and rivers. The peak discharge of a flood is influenced by many factors, including the intensity and duration of storms and snowmelt, the topography and geology of stream basins, vegetation, and the hydrologic conditions preceding storm and snowmelt events.

Land use and other human activities also influence the peak discharge of floods by modifying how rainfall is stored and delegated off the land surface into streams. In undeveloped areas such as forests and grasslands, rainfall collects and is stored within vegetation, in the soil column, or in surface depressions. When this storage capacity is filled, runoff flows slowly through soil as "subsurface flow." In contrast, urban areas, where much of the land surface is covered by roads and buildings, have less capacity to store rainfall. Construction of roads and buildings often involves removing vegetation, soil, and depressions from the land surface. The permeable soil is replaced by impermeable surfaces such as roads, roofs, parking lots, and sidewalks that store little water, reduce infiltration of water into the ground, and accelerate runoff to ditches and streams. Even in suburban areas, where lawns and other permeable landscaping may be common, rainfall can saturate thin soils and produce overland flow, which runs off quickly. Dense networks of ditches and culverts reduce the distance that runoff must travel overland or through subsurface flow paths to reach streams and rivers. Once water enters a drainage network, it flows faster than either overland or subsurface flow.

With less storage capacity for water in urban basins and more rapid runoff, streams rise more quickly during storms and have higher peak discharge rates than less urbanized areas. The total volume of water discharged during a flood tends to be larger for urbanized areas. Differences in urbanized streamflow cannot be attributed solely to land use, but may also reflect differences in geology, topography, basin size and shape, and storm patterns (USGS).

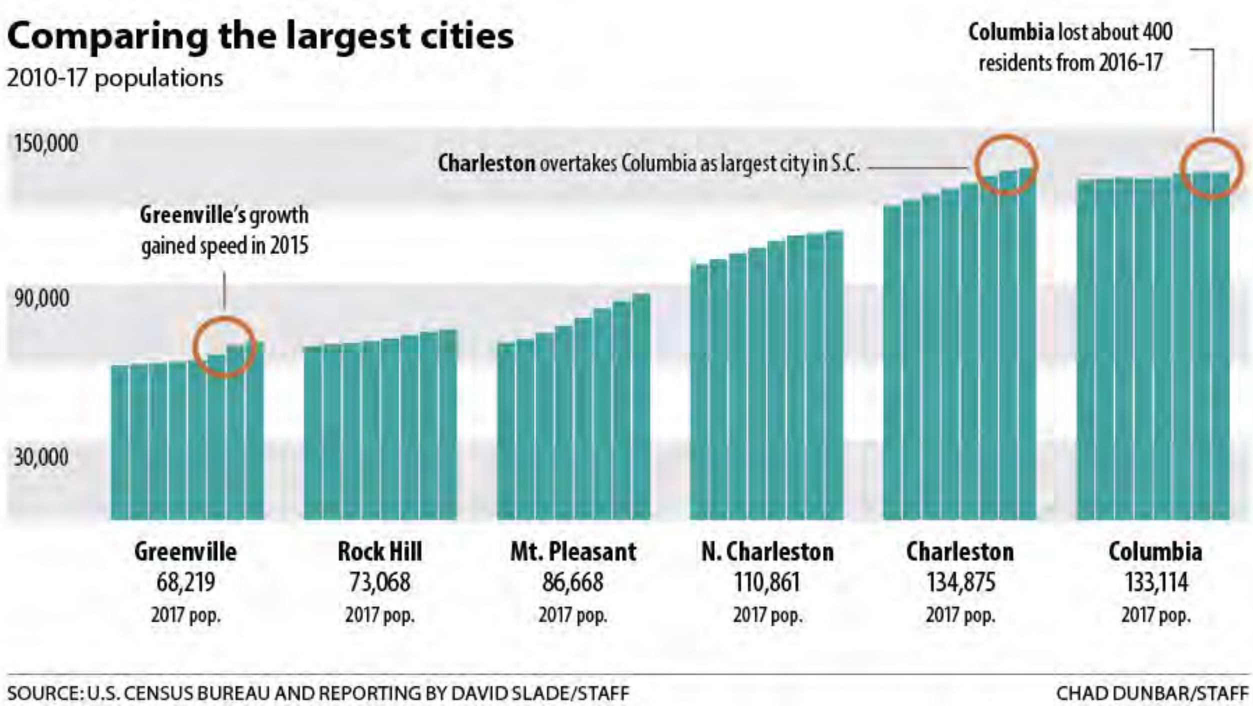

FIGURE 1: South Carolina city growth comparison.

B. Land Management Practices

Deforestation is the intentional or natural clearance of forests on a massive scale, often resulting in damage to the quality of the land and adverse environmental effects. Deforestation directly affects soil quality and the water cycle, while causing habitat loss and other environmental changes, substantial flooding, cultural displacement, and agricultural and financial losses (Faiza et al).

The forests are like a sponge, absorbing rainwater from storms while anchoring the soil and releasing water at regular intervals, which can help moderate the destructive flood and drought cycles that can occur when forests are cut. When forest cover is lost, flows quickly turn into streams, raising river levels and flooding villages, towns, and agricultural fields downstream.

The forests of South Carolina provide a number of economic and societal benefits such as manufacturing, employment, recreation, aesthetics, habitat, and environmental protection. Demands on our forest resources, as well as threats to the future status of our working forests, are as great as at any time in recent history. South Carolina is experiencing significant change in the management and use of our woodlands. Population growth, ownership changes, residential development, non-consumptive demands, and the presence or absence of markets for our forest products will determine the future of South Carolina's forests. To ensure that our forests can meet the current and future economic, ecological, cultural, and recreational demands placed on them, managers must focus their efforts on addressing changing landowner objectives, fragmentation, current and emerging markets, forest regulation, critical habitats, and cultural/recreational concerns (SCFC).

Deforestation is a major contributor to the flooding equation because trees prevent sediment runoff and forests hold and use more water than farms or grasslands. Some rainwater stays on the leaves, and it may evaporate directly to the air - the more water used in the watershed, the less remains to run off (Why Files, Flood of Evidence).

Tree roots increase soil permeability, resulting in (SCFC):

- Reduced surface runoff of water from storms;
- Reduced soil erosion and sedimentation of streams;
- Increased groundwater recharge; and
- Improved soil and water quality.

Deforestation carries another driver of flooding - the release of sediment. Vast amounts of eroded soil wind up in riverbeds, shrinking channels and the river's ability to carry water without flooding. Soil erosion, as a natural process, is accelerated by deforestation. Trees and plants offer a natural barrier to water flow through their roots that anchor the soil and prevent it from washing away. Trees help retain water and topsoil, which provide the rich nutrients to sustain healthy forest life. When deforestation takes place, it results in decreased water absorption (Faiza et al.).

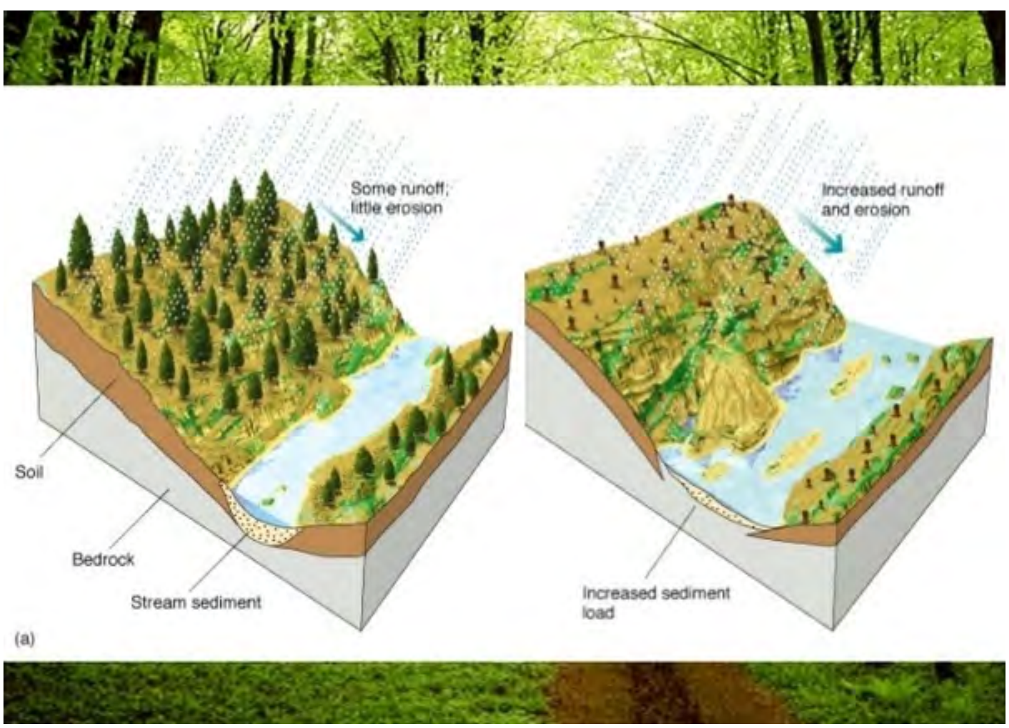

FIGURE 2

C. Wetland Vulnerability

Undeveloped floodplains, wetlands, and open space (in specific locations) naturally store floodwaters. This critical function can reduce flood risks and increase resilience for nearby human communities as well as downstream. Past and ongoing development, particularly in areas of the state that are growing, has been built on floodplains, flood-prone areas and open space that should be left undeveloped to serve as valuable floodwater storage areas. More of our state's floodplains and critical open space may be eliminated or altered as South Carolina's population grows and urban/suburban areas expand.

Loss of floodplains and floodwater storage areas puts people at risk, not only on those specific lands but also on other lands where flooding is magnified due to loss of floodwater storage capacity.

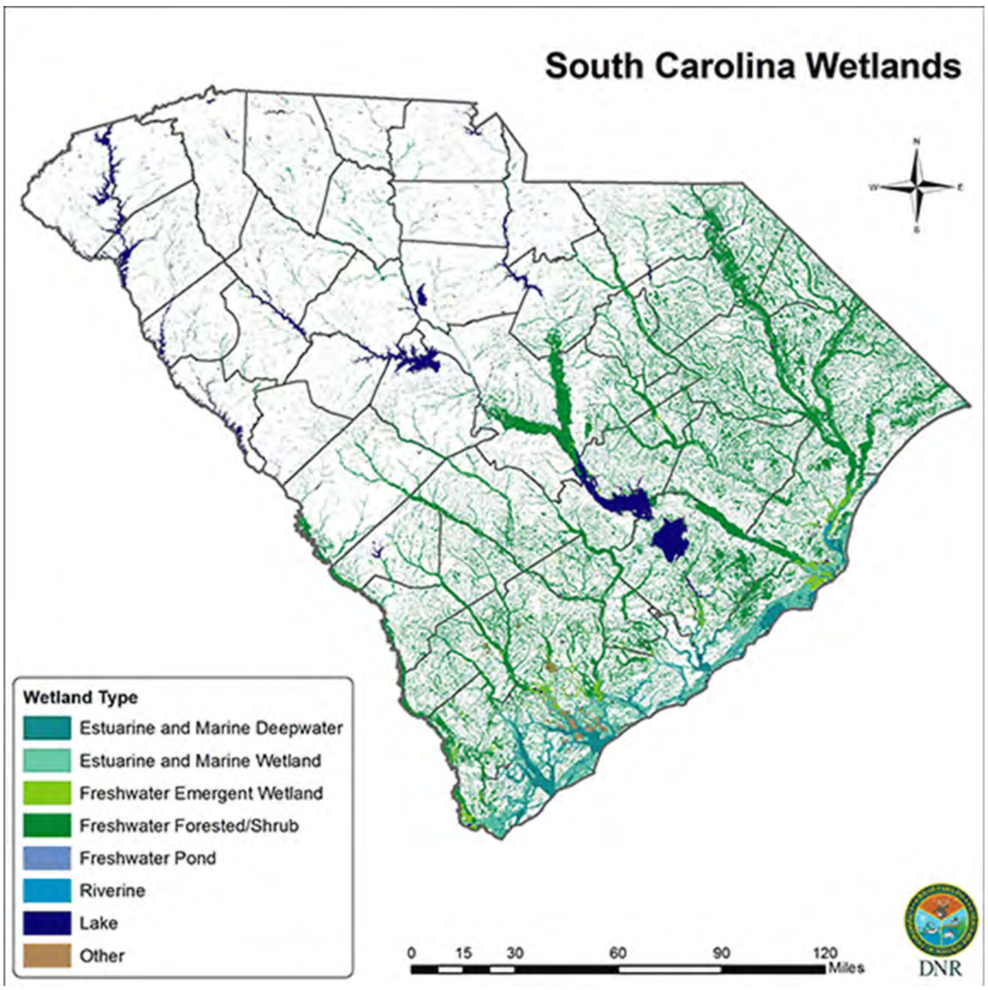

FIGURE 3: South Carolina Wetlands (http://www.dnr.sc.gov/wildlife/wetlands/wetlandsmaps.html).

The successful management of future wetlands for coastal retreat and realignment strategies will require careful consideration of the effects of floodplain structures on time periods and depth of inundation affecting below-ground storage capacity, soil surface elevation changes, discharge, and the realistic movement of the water (Rodriquez).

Identifying high priority floodplains, wetlands, and open spaces through existing maps and analyses on a county-by-county basis in order to reduce flood damage is of critical importance. This may require new hydrologic and flooding models, or better synthesis of existing models that are housed in various agencies or universities. Maintaining the flood storage capacity of floodplains, wetlands and critical open space through outright purchases, conservation easements, and tax credits that incentivize preservation will create the economic conditions for achieving this objective.

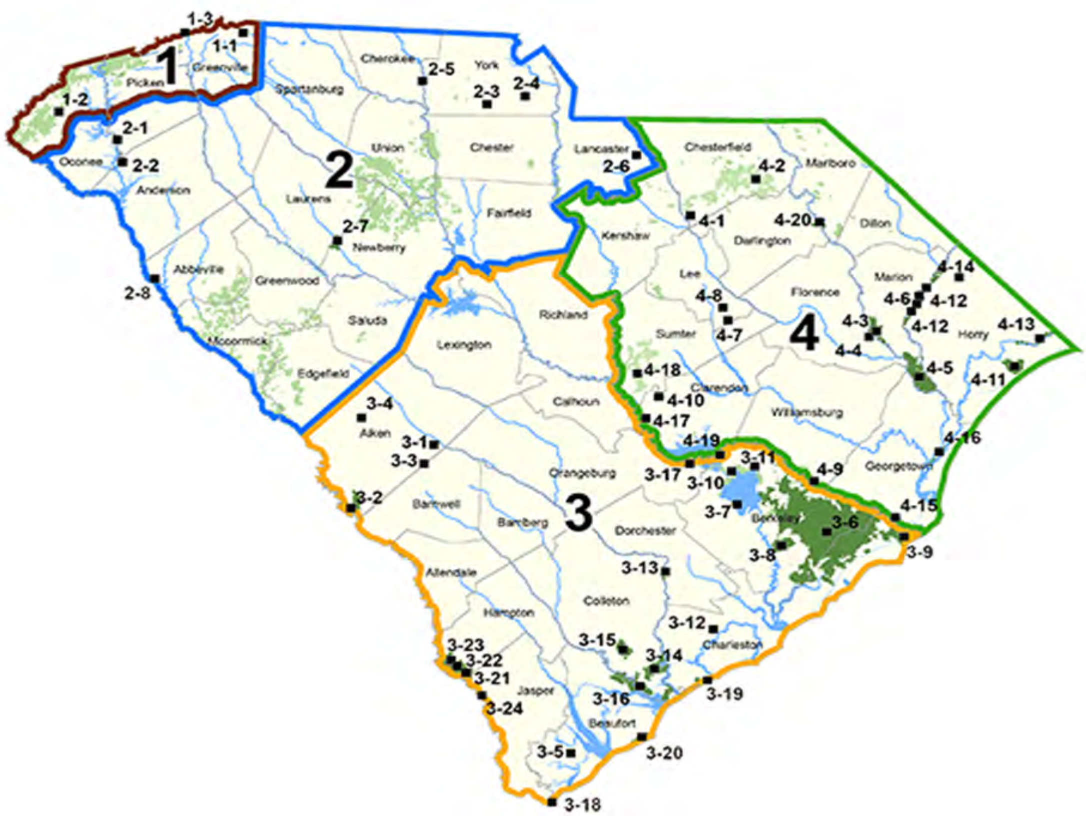

FIGURE 4: South Carolina wildlife management areas (http://www.dnr.sc.gov/wma/).

TABLE: 2012 National Resources Inventory (https://www.farmlandinfo.org/statistics/south%20carolina).

	1997-2002	2002-2007	2007-2012	1982-2012
Agricultural land converted to developed land (acres)	74,600	39,900	18,300	395,900
Agricultural land at the beginning of the reporting period (acres)	3,981,600	3,657,400	3,482,500	4,710,200
Prime agricultural land at the beginning of the reporting period (acres)	1,821,600	1,696,600	1,623,600	2,071,900
Forest land converted to developed land (acres)	230,900	134,600	83,500	922,400
Other land converted to developed land (acres)	6,200	2,400	5,400	35,000
Total surface area (acres)	19,939,300	19,939,300	19,939,300	19,939,300

D. Shoreline/Beach Erosion

Coastal erosion is the landward retreat of the shoreline in reaction to natural and human factors. Beach-dune systems act as a barrier to coastal water intrusion for inland areas, but many of these systems in South Carolina are eroding. Sand dunes, in particular, absorb the impact from high-energy storms by protecting coastal development from the forces from wind and water.

Stabilization of Dunes

The stabilization of beach dunes is critically important to ensure the prolonged integrity of the state's beaches and to protect the homes and business communities in South Carolina. From 2917-2019, state and local governments have invested over $60 million in beach renourishment and restoration activities along South Carolina's coast. In order to optimize the full potential of these activities, it is critical for sand dune stabilization to be conducted in conjunction with beach renourishment activities and maintained between renourishments.

Along the coast, the careful planning and planting of native coastal plants can help protect property from storm damage and flooding. Coastal dunes provide a buffer against coastal hazards such as wind erosion, wave overtopping, storm surges, and tidal inundation during storm events. They also provide a natural source of sand to replenish the beach during periods of erosion. For this reason, the emplacement and protection of coastal vegetation is important for the long-term security of beach-front properties. Coastal dunes have three general vegetation zones based on soil salinity that can vary in width or may even be entirely absent. Landward of the highest tides, frontal zone (or Fore Dune) sites are stabilized by the sand trapping action of various rhizomatous grasses and low growing forbs that are tolerant of salt spray

Trough areas and additional inland dunes may fall in the Fore Dune area. Landward of the frontal zone area, the Mid Dune zone (also often called the shrub or scrub zone) supports less salt tolerant grasses and forbs as well as shrubs and some trees. The forest zone (or Back Dune) is the vegetation zone farthest from the ocean, and the vegetation in this zone transition from maritime to non-maritime species. Marshland or grassy areas may occur between the Back Dune and forest zone areas.

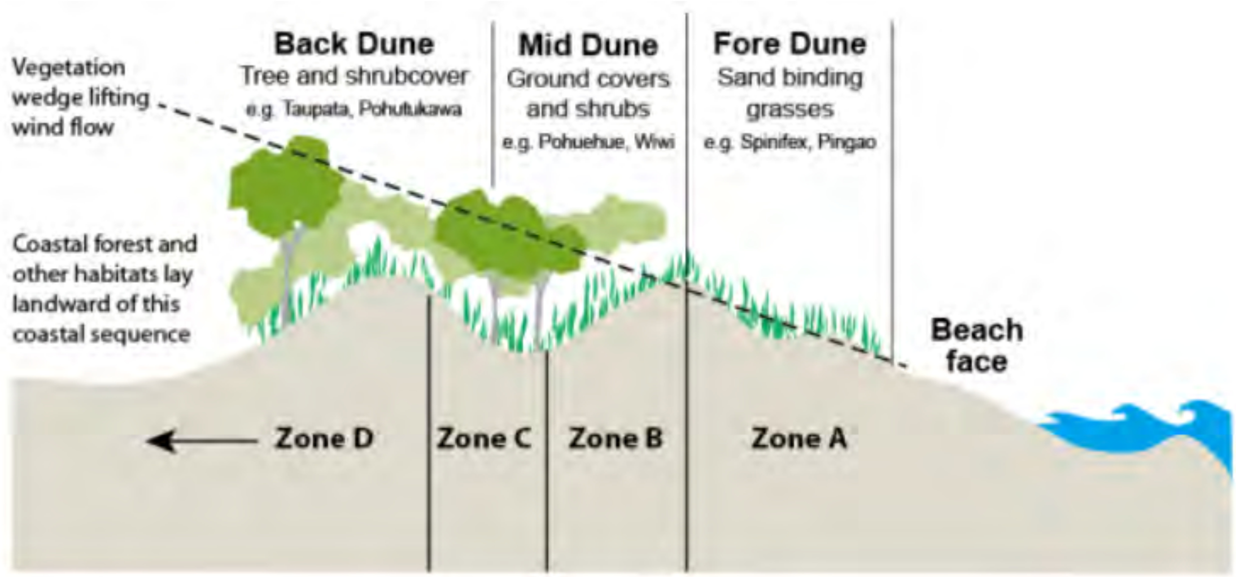

FIGURE 5 (https://www.kauriparknurseries.co.nz/secret-stabilising-saving-sand-dunes/).

Only a few plant species can tolerate the stresses of a dune environment, particularly frontal dune sites. Fore Dune plants must be able to survive being buried by blowing sand, sand blasting, salt spray, saltwater flooding, drought, heat, and low nutrient supply. Salt spray, by providing potassium, sodium, calcium, and magnesium, is a major source of plant nutrients in dune soils. In the absence of salt-bearing onshore winds, many coastal dune plants grow poorly or die. Many plant species that occur on dune areas have developed specific attributes to help them survive these harsh environments. These include high growth rates, dense root systems, low profiles, and high flower and seed production rates.

The Back Dune zone, a series of older dunes that are more stable and have higher organic matter, occur landward of the Fore Dune area. When sufficient organic matter accumulates in dune fields on the mainland or barrier islands, colonizing woody vegetation becomes established. Many of the woody species found in dune fields are low growing and shrubby due to low nutrient and drought conditions. Wind and salt spray can have a dramatic effect on the growth and appearance of vegetation adjacent to the ocean. High winds and salt spray often prune the terminal buds of the trees and shrubs growing on the dunes and result in salt-saturated, windswept canopies. Salt exposure is just one of the many environmental factors that makes coastal landscaping challenging. Selecting plants that are tolerant to salt exposure will increase the rate of success. Salt tolerant plants can range from highly to moderately tolerant. High salt tolerance plants will grow where they are subject to direct salt spray received along sand dunes and adjacent to the oceanfront. Plants with a moderate salt tolerance will grow adjacent to the beachfront, but are sheltered by higher salt tolerant plants, structures, or sand dunes.

Native dune species should require little maintenance after establishment. Sites should be monitored for establishment of invasive species and weeded as necessary. All sites should be protected as much as possible from foot and vehicular traffic.

Strategies will include:

Plant native vegetation along coastal Fore Dunes (part of the 'frontal zone').

This action is especially important following emergency orders when scraping results in a berm that is in the location of the former primary dune or following beach nourishment. Under these circumstances, the bare sand is highly susceptible to wind-blown sand transport. Vegetation anchors this sand from being transported, thus preserving the sand the taxpayers paid for and protecting the landward infrastructure from future flooding.

Standardize sand fencing regulations statewide.

In S.C. Code §48-39-10 Regulation 30-13.L.(1), there is general language about sand fence requirements. This language states sand fence installation should be according to plans established by Department staff. The Department staff language (OCRM – How to Build a Dune) is "recommended" language, not prescriptive. The requirement for this shore protection method should be prescriptive. In the absence of vegetation sand fencing is critically important for stabilizing dunes. There may be circumstances where both are indicated.

Beach Renourishment.

Beaches are a primary tourism asset for South Carolina's coastal tourism industry. South Carolina Parks, Recreation, and Tourism (SCPRT) estimates that approximately two-thirds of all domestic visitor spending – totaling $8.6 billion – occurs within South Carolina's coastal counties. In addition, the state's coastal destinations serve as primary destinations for much of the state's international visitation.

Recognizing the importance of these tourism assets and following the events of Hurricane Joaquin, the king tides and flooding in 2015, SCPRT – at the direction of Governor Haley's office – collected information from the state's coastal destinations regarding the amount of erosion that had resulted from these events and the associated costs of renourishing the impacted public beaches. Based on the information received, SCPRT estimated that the state had approximately $40 million in beach renourishment needs, including both emergency and cyclical renourishment needs.

In the FY 17 budget, SCPRT received $30 million in non-recurring appropriations for beach renourishment. SCPRT Director Parrish and select staff members met with staff from DHEC-OCRM and, utilizing background information from this meeting, developed a beach renourishment financial assistance grant program, in which the state provides a 1:1 match for local funds allocated for hard costs associated with beach renourishment projects. In the wake of Hurricane Matthew in 2016, SCPRT again polled SC's coastal destinations and estimated that this event resulted in an additional $3 million in beach renourishment needs. In FY18, SCPRT received $5 million in non-recurring funding for the beach renourishment grant program, and an additional $11 million in non-recurring funding in FY19. To date SCPRT has received a total of $46 million in non-recurring funds for the beach renourishment grant program.

Since 2016, SCPRT has provided approximately $18.4 million in grant funding to local governments and $3.1 million to SC State Parks for beach renourishment projects. SCPRT has awarded beach renourishment grant funds to the following local governments:

- Reach 1 - City of North Myrtle Beach ($890,848)
- Reach 2 - City of Myrtle Beach ($307,500)
- Reach 3 - Horry County (applying on behalf of Surfside & Garden City) ($2,400,000)
- Horry County (Arcadian Shores) ($4,291,250)
- Pawleys Island ($129,598.86)
- City of Isle of Palms ($2,982,603)
- City of Folly Beach ($1,319,739)
- Town of Edisto Beach ($6,070,842)
- Edisto Beach State Park ($3,126,037)

SCPRT currently has two beach renourishment grant funding requests that are pending award and allocation: a full renourishment project at Pawleys Island and new groin construction and full renourishment at Hunting Island State Park.

The U.S. Army Corps of Engineers (USACE) has cost-sharing beach renourishment agreements in place with the cities of Myrtle Beach, North Myrtle Beach, and Folly Beach, as well as Horry County. In the case of the Reach 3 State Grant, these funds were used to match with local funds to cover the local government cost responsibility of the agreement with USACE. The Folly Beach grant provided funding for groin rehabilitation to supplement and enhance renourishment work performed by USACE. The grant projects at North Myrtle Beach and Myrtle Beach provided funding for dune restoration at these two locations, including the installation of dune fencing and planting.

II. OPPORTUNITIES

SC Floodplain Mapping Initiative
The citizens of South Carolina face significant hazards from floods and hurricanes, and more than $7 billion in damages has occurred from flood and hurricane events in the last 25 years The Federal Emergency Management Agency (FEMA) flood hazard maps are one of the essential tools for flood hazard mitigation in the United States. Throughout the years, many of these maps have become outdated, and significant areas of the country remain unmapped. Understanding the need for current, accurate flood maps prompted the South Carolina Department of Natural Resources to become a Cooperating Technical Partner (CTP) with FEMA in 1999. South Carolina is committed to reducing flood risks within the state. Through the CTP program the SCDNR works with FEMA to update flood hazard information for all of the state's 46 counties.

In 2002, South Carolina alone had over 75 communities that had not been mapped. In recognition of the connection between flood mitigation, risk reduction, and reliable flood maps, the President and the U.S. Congress provided substantial funding for Flood Map Modernization starting in Fiscal Year 2002.

In 2009, FEMA transitioned to the Risk Mapping, Assessment, and Planning (Risk MAP) program. Risk MAP builds on the flood hazard data and maps that were produced as part of the Flood Map Modernization Program. The vision for Risk MAP is to deliver quality data that increases public awareness and leads to action that reduces risk to life and property (SCDNR).

The goals for Risk MAP are as follows:

- Goal 1: Address gaps in flood hazard data to form a solid foundation for flood risk assessments, floodplain management, and actuarial soundness of the National Flood Insurance Program (NFIP.)
- Goal 2: Ensure that a measurable increase of the public's awareness and understanding of risk management results in a measurable reduction of current and future vulnerability to flooding.
- Goal 3: Lead and support state, local, and tribal communities to effectively engage in risk-based mitigation planning resulting in sustainable actions that reduce or eliminate risks to life and property from natural hazards.
- Goal 4: Provide an enhanced digital platform that improves management of limited Risk MAP resources, stewards information produced by Risk MAP, and improves communication and sharing of risk data and related products to all levels of government and the public.
- Goal 5: Align Risk Analysis programs and develop synergies to enhance decision making capabilities through effective risk communication and management.

This program should be expanded to cover all vulnerable communities.

There are many opportunities to reduce flood potential by improving management of our landscapes, both natural and man-made. As is frequently the case, the best opportunity to manage or mitigate problems is prevention. This can be in the form of preserving natural areas or preventing problems in the built environment.

A defining principle should be to allow our natural drainage systems to function as naturally as possible. As the noted geomorphologist and hydrologist Luna D. Leopold famously said, “let the rivers teach us” (Leopold Footnote comment). He argued that effective water management required attention to geography, underlying geology, and climate, as well as economic and political factors. That idea was somewhat revolutionary when he espoused it in the middle of the last century but should not be so today.

Notwithstanding the need to consider natural factors, economic and political factors remain very important, particularly in areas already harmed by significant flooding. Therefore, prevention in areas already developed or being considered for development will be addressed first.

A. <u>Prevention in the Built Environment</u>

One of the most direct descriptions of stormwater management comes from the Sustainable Sanitation and Water Management Toolbox (SSWM):

> The overall culmination of techniques is used to reduce surface run-off from causing flooding and dispersing pollutants. Stormwater management consists in detaining, retaining, or providing a discharge point for stormwater to be reused or infiltrated into the groundwater. It should best preserve or mimic the natural hydrologic cycle and fit within the capacity of existing infrastructure.

There are numerous opportunities to influence the way we develop land and build buildings and infrastructure. With the goal of reducing vulnerability to flooding in mind, such opportunities should “best preserve or mimic the natural hydrologic cycle” to the degree possible. Individual actions are also important; homeowners, as well as developers and government entities, can and should be enlisted in efforts to prevent stormwater damage leading to water quality degradation and, in many cases, flooding.

Many stormwater management techniques are well understood and may already be in plans and codes of local governments. However, small units of government may lack the capacity to design or enforce stormwater regulations or may not have felt the need for such regulations until very recently. In larger jurisdictions, existing stormwater regulations may not be as strictly enforced as would be ideal, and those regulations may not be as strong as necessary due to compromises among stakeholders during their development. The following sections describe opportunities to influence development with flood prevention in mind.

1. Planning, Design, and Enforcement

Building codes, design standards and various ordinances and regulations can be evaluated and, as appropriate, strengthened to ensure that new construction not only does not contribute to increased flood risk, but maximizes protection from flood risk. Simply complying with minimum federal and state requirements may not be sufficient as storms become more dramatic and erratic. South Carolina law currently specifies nine required elements of a comprehensive plan. Local government flood prevention and mitigation efforts could be enhanced by adding a requirement for a resilience or natural hazard element. As an example, Florida's comprehensive planning law requires the plans to:

- *Include development and redevelopment principles, strategies, and engineering solutions that reduce the flood risk in coastal areas which results from high-tide events, storm surge, flash floods, stormwater runoff, and the related impacts of sea-level rise.*
- *Encourage the use of best practices development and redevelopment principles, strategies, and engineering solutions that will result in the removal of coastal real property from flood zone designations established by the Federal Emergency Management Agency.*
- *Identify site development techniques and best practices that may reduce losses due to flooding and claims made under flood insurance policies issued in this state.*
- *Be consistent with, or more stringent than, the flood-resistant construction requirements in the Florida Building Code and applicable flood plain management regulations set forth in 44 C.F.R. part 60.*
- *Require that any construction activities seaward of the coastal construction control lines established pursuant to s. 161.053 be consistent with chapter 161.*
- *Encourage local governments to participate in the National Flood Insurance Program Community Rating System administered by the Federal Emergency Management Agency to achieve flood insurance premium discounts for their residents.*

Most flood mitigation plans contain references to enhanced building codes, stronger subdivision regulations, new or strengthened development review procedures, and stronger stormwater management regulations. Examples in South Carolina include the Central Midlands All Hazard Mitigation Plan and the Richland County Gills Creek Watershed Mitigation Plan.

The Central Midlands plan addresses all hazards; examples of preventive activities in the plan that are relevant to flood prevention and mitigation include:

- Considering areas subject to repetitive flooding for acquisition for parks and other permanent open space.
- Revising floodplain management ordinances to include a one (1) foot freeboard in areas without other restrictions that make the requirement for an extra foot of elevation impractical (e.g. historic buildings, areas with zoning ordinances with height limitations, etc.).
- Adopting stream-dumping ordinances.
- Modernizing flood insurance rate maps.

- Encouraging development reviewers to consider provisions for "no adverse impact" when development is proposed within floodplain areas.

The Richland County Gills Creek Watershed Mitigation Plan includes the following goal:

GOAL #4 – Codes, Standards, and Regulations

Design and implement enhanced building codes, standards, regulations, and ordinances to support effective mitigation for new construction to maximize protection from flood risk.

> Examples of these types of actions include evaluating and strengthening subdivision regulations, development review, capital improvement programs, and stormwater management regulations. More specific examples include supporting efforts to update the local flood ordinance to include a freeboard requirement and evaluating the current building codes and considering the adoption of the latest model codes to ensure better protection of life and property, and designing site improvements to handle severe rain events.

Many of these recommendations rely on Best Management Practices, or BMPs, which have been developed by many organizations with attention to the particular conditions in the area. While BMPs have been understood for many years, requirements that they be used are less common, and enforcement where BMPs are required is not always strong.

The Central Midlands All Hazard Plan includes information about responsible jurisdictions for various recommendations for action. A modified version of that table is included below:

TABLE 2

Activity	Type of Organization
Floodplain Management Regulations	Local jurisdictions, SC DNR, US Army Corps of Engineers
Wetlands Protection Regulations	US Army Corps of Engineers, SC DHEC
Other Management Regulations (e.g. building code enforcement, flood mapping)	SC Dept. of Insurance, SC DNR, US Army Corps of Engineers
Preservation of Open Space	County Parks and Recreation, SC PRT, Regional wetlands bank
Stormwater Management Regulations	SC DHEC, Local jurisdictions, US Army Corps of Engineers
Water Quality Regulations	SC DHEC, US Army Corps of Engineers, SC DNR
Stream Dumping Regulations	Local jurisdictions

2. <u>Green Infrastructure</u>

According to the U.S. EPA,

> (G)reen infrastructure is a cost-effective, resilient approach to managing wet weather impacts that provides many community benefits. While single-purpose gray stormwater infrastructure—conventional piped drainage and water treatment systems—is designed to move urban stormwater away from the built environment, green infrastructure reduces and treats stormwater at its source while delivering environmental, social, and economic benefits….
>
> When rain falls in natural, undeveloped areas, the water is absorbed and filtered by soil and plants. Stormwater runoff is cleaner and less of a problem. Green infrastructure uses vegetation, soils, and other elements and practices to restore some of the natural processes required to manage water and create healthier urban environments. At the city or county scale, green infrastructure is a patchwork of natural areas that provides habitat, flood protection, cleaner air, and cleaner water. At the neighborhood or site scale, stormwater management systems that mimic nature soak up and store water.

According to the City of Portland, Oregon "(g)reen infrastructure brings nature into the city, which can improve both mental and physical health, increase property value, conserve energy, enhance wildlife habitat and save money on more costly pipe infrastructure."

Examples of green infrastructure that could be useful in reducing flooding in South Carolina are outlined below.

Tree Canopy.

Maintenance of the tree canopy is one example of green infrastructure. Trees slow and disperse precipitation, giving it more time to filter into the ground. Some jurisdictions have set goals to restore the tree canopy lost when development took place. Portland, Oregon, has programs to plant trees at both multi- and single-family dwellings and offers a "tree bate" to encourage tree planting. Other cities have more actively used trees to manage stormwater. For example, the City of Philadelphia has used Stormwater Tree Trenches to store water that falls in the city.

Stormwater Tree Trench.

A stormwater tree trench is a system of trees connected by an underground infiltration structure. Stormwater flows through a storm drain into the stone filled tree trench, generally located underneath the sidewalk. Runoff is stored in the trench where it waters trees and slowly filters into the ground.

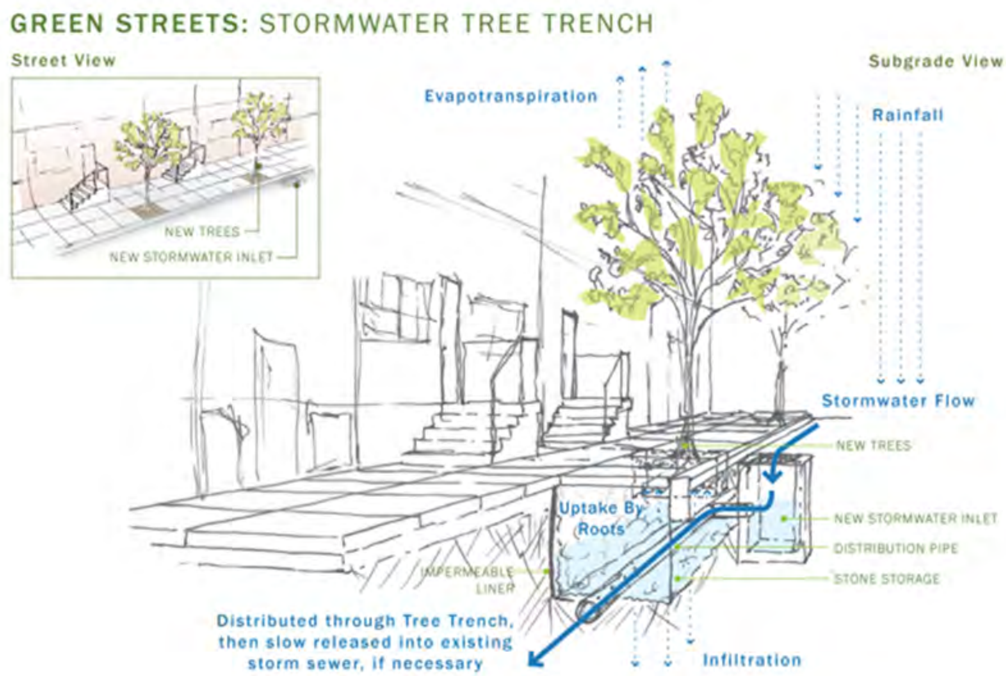

FIGURE 6: Stormwater tree trench.

Stormwater Basins and Stormwater Wetlands

Wetlands are widely acknowledged to absorb water and release it slowly. Where wetlands have been destroyed or altered by development, some of their original function can be recreated through stormwater wetlands. Although their function is similar to that of a stormwater retention basin, they are designed to mimic the natural function of a wetland, and therefore do a better job of providing habitat and an aesthetic asset for the community.

Philadelphia created this one-acre stormwater wetland in Fairmont Park, a major urban park, to protect both the public drinking water supply and the riparian ecosystem during storm events. It is both functional and an attractive addition to the park.

Philadelphia has also created stormwater basins to slow water and allow evapotranspiration to reduce the volume going into stormwater systems, thus reducing combined sewer overflows. Again, the functional structure enhances the park where it is located.

FIGURE 7: Stormwater wetlands.

FIGURE 8: Streetscaping or "Green Streets" (Phillywatersheds.org).

Runoff in developed areas can be controlled through a number of techniques ranging from stormwater planters to vegetated "bumpouts" to large raingardens and pervious pavement. These measures can all enhance the community while performing a valuable service.

STORMWATER BUMPOUT – an extension of the curb into the street, where water can be stored, infiltrated, and taken up by the plants (evapotranspiration)

FIGURE 9: Stormwater "Bumpout", Queens Lane, Philadelphia.

STORMWATER PLANTER – similar to the *bumpout*, a stormwater planter is located slightly below street grade, and is constructed so as to collect, store and allow water to infiltrate or be taken up by the plants

FIGURE 10: Stormwater Planter, Columbus Square, Philadelphia.

FIGURE 11: Raingarden in Liberty Lands, Philadelphia.

RAIN GARDEN – a garden or planted area designed to collect runoff from impervious surfaces such as roofs, walkways, and parking lots, allowing water to infiltrate the ground

POROUS (PERVIOUS) PAVEMENT – Pavement that allows water to pass through, which may be either porous concrete or asphalt, or pavers designed to let water pass through small openings. A potential change in building codes to require such applications for sidewalks, walkways, driveways, etc. would go far to reduce the impacts of new development on natural drainage patterns.

FIGURE 12: Pervious pavers, pervious asphalt and a bioretention cell in Wilmington, MA (GeoSyntech).

RAINWATER HARVESTING – Rainwater harvesting allows water to be collected for later use, and to slow entry into rivers and riparian areas. It could be particularly helpful during extended drought or excessive rainfall.

GREEN ROOFS – Adding a vegetative layer to a roof can allow the building to capture nearly all stormwater precipitation in the summer months with lesser contributions during slow growing seasons. Green roofs also help to address the heat island effect seen in cities and developed areas.

FIGURE 13: Potential green roof layout (EPA).

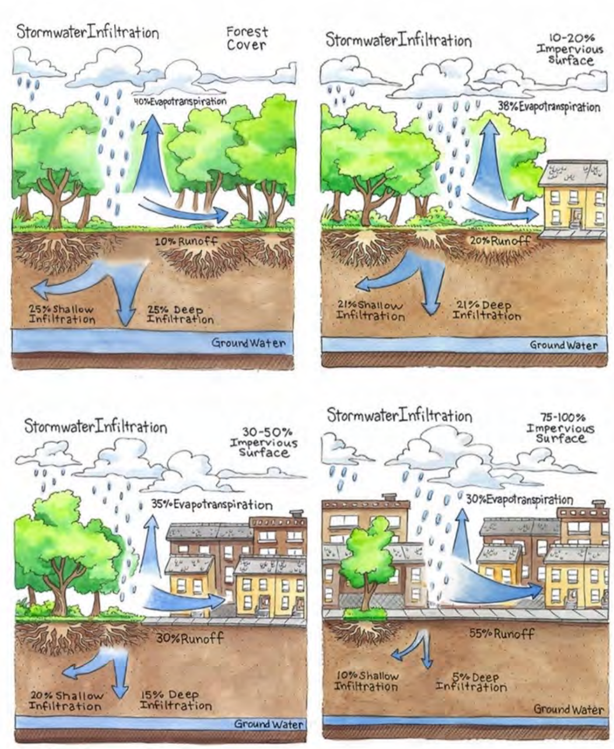

FIGURE 14: South Carolina Urban & Community Forestry Program: Charleston case study images.

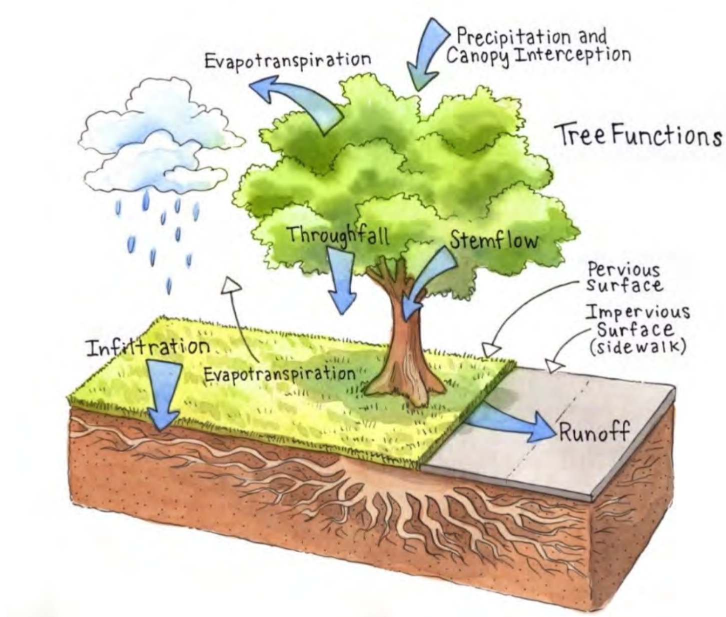

FIGURE 15: South Carolina Urban & Community Forestry Program: Charleston case study images.

3. Cost and Monitoring/Maintenance

Whether utilizing permitting, zoning, and other regulations or measures such as the installation of green infrastructure, cost will be a concern. Incentives may need to be provided, and if governments themselves install green infrastructure, they will need to consider cost. However, it is likely that in most, if not all cases, the costs of prevention will be less than those of repair and restoration. Of course, different entities may pay those costs, so finding ways to balance the needs of those paying for prevention with those paying for repair and restoration is important.

There are some tools available to assist. The Center for Neighborhood Technology (CNT) has developed a tool to compare green infrastructure with traditional stormwater management approaches. As the organization states:

> [t]he National Green Values™ Calculator is a tool for quickly comparing the performance, costs, and benefits of Green Infrastructure, or Low Impact Development (LID), to conventional stormwater practices. The GVC is designed to take you step-by-step through a process of determining the average precipitation at your site, choosing a stormwater runoff volume reduction goal, defining the impervious areas of your site under a conventional development scheme, and then choosing from a range of Green Infrastructure Best Management Practices (BMPs) to find the combination that meets the necessary runoff volume reduction goal in a cost-effective way.

More specific versions of the tool have been developed for some jurisdictions or states; South Carolina may want to consider a similar approach.

Even when preventive measures have been taken, monitoring and maintenance is crucial. This must also be budgeted, and a locus of responsibility for every aspect of long-term monitoring needs to be established before measures are undertaken.

B. Protection of the Natural Environment

Preserving or restoring natural areas such as floodplains, wetlands, and coastal areas enlists their natural functions in the reduction or even prevention of flood damage. Floodplains are not always recognized for what they are—a part of the river and its associated ecosystem. Floodplains store and slow the movement of water, holding it rather than sending it rushing downstream. By doing so, they allow groundwater aquifers to recharge, helping to ensure availability of groundwater during times of drought. At the same time, they allow pollutants to filter out of the water, and support a wide variety of plant and animal life. When we channel a river to accommodate development, we often make flooding worse. Think about holding your finger over part of a stream of water from a hose—the water rushes out with far greater strength than if there is no obstruction over the end of the hose. Perhaps worse, structures in or along a river meant to control water flow can give the illusion of safety, encouraging development where it should not be.

1. <u>Preserve or Restore Rivers, Floodplains, Wetlands and Coastal Areas to Their Natural State</u>

As noted in the introduction to *opportunities* above, the first principle should be to allow natural landscapes to stay natural, in order to provide low cost flood mitigation. Prevention is the least expensive approach to the problem. One approach is to require consideration of sea level rise before state funds can be invested in a flood prone area. In Florida, SB 78 would mandate that any coastal construction project that receives state funds get a "sea level impact projection" study before commencing. The idea is to ensure infrastructure projects are built to withstand the impacts of sea level rise (the Florida Senate). In South Carolina, such an approach would require modification to the State Infrastructure Investment Act.

Another approach to preserving the valuable flood control functions of wetlands is to create incentives to encourage federal, state and local officials to require additional mitigation for wetland impacts in watersheds containing flood-prone areas. In calculating mitigation, these officials could add an additional factor to account for impacts to communities affected by flooding, along with the more traditional impact calculations. While most wetland mitigation is governed by the Army Corps of Engineers, local jurisdictions could establish additional requirements of their own. In addition, the Corps itself has the ability to enforce requirements for increased mitigation due to (for example) few wetlands remaining in a watershed. This calculation could be extended to address flood-prone areas.

Continuing to support the lessons learned from the state's Living Shorelines Working Group (SCDHEC) would also be useful.

Yet another approach is to simply establish a land protection goal for the state, which would by its very nature protect wetlands and flood-prone areas along with other valuable properties. The state could, for example, establish a goal of 30% land protection by 2030.

Further, riverine landscapes should be restored to their natural state whenever possible to capitalize on their protective function. When rivers are restored to original contours and flood plains are allowed to spread, as needed, into natural floodplains, water enters the ground more slowly. Wetlands thrive and retain rainwater. Communities nearby benefit from a more attractive natural area, providing habitat and recreational opportunities, and communities downstream benefit by having less flood damage. Additionally, flood control is cheaper. The Minnesota Department of Natural Resources calculated that replacing the natural floodwater storage function of wetlands would cost $300 per acre foot. (Lincoln Institute)
Examples of this philosophy extend from recommendations for the Netherlands, to the Mississippi River Valley to the very small Gills Creek Watershed. In the Netherlands, a country known for its engineered solutions to flood control, a new philosophy has taken hold, spurred in

part by the recognition that engineered structures will not be sufficient to combat the flooding caused by climate change. (*Room for The River* website)

> *The goal of the Dutch Room for the River Programme is to give the river more room to be able to manage higher water levels. At more than 30 locations, measures are taken to give the river space to flood safely. Moreover, the measures are designed in such a way that they improve the quality of the immediate surroundings… Every river is different and requires a tailor-made solution.*

Another example is the Charles River Basin in Massachusetts, which opted to spend $10 million to purchase and protect 8,500 acres of wetlands as a "natural valley storage system" to control flooding, rather than accept the $100 million price tag for a system of dams and levees proposed to accomplish the same thing (Lincoln Institute).

Recent flooding in the Midwest has highlighted solutions that work. In a June 1, 2019, interview on the Weekend Edition Saturday program on National Public Radio, the option of turning flood-prone lands into parks was discussed. A huge and controversial flood control project was initiated in Tulsa, OK, after a deadly flood in 1984. The city bought and tore down 500 flood-prone houses along one creek alone. They built an expansive park that, despite weeks of torrential rain, did not flood. A local leader described the benefits of removing flood-prone structures:

Flanagan says Tulsa should take the same approach now along the Arkansas River."

FLANAGAN: "If we've got money to spend, why not spend it buying those houses out and turning that into flood plain open space, rather than putting hundreds of millions of dollars into repairing levees that are protecting things that maybe shouldn't even be there to begin with?"

Goal 5 from the Gills Creek Watershed Flood Mitigation Plan states:

> *Natural Systems Protection*
>
> *Pursue measures that increase protection of sensitive flood-prone areas like wetlands and river or stream corridors. Provide incentives to maintain green space and use existing vacant land to the highest practical flood storage use. Examples of these types of actions include sediment and erosion control, stream corridor restoration, forest management, conservation easements, and wetland restoration and preservation.*

Clearly, any change in land use will require sensitivity and most likely, public expenditures. However, in light of the amounts currently spent on more traditional flood control (average annual flood losses have increased from $6 billion to $10 billion from 2000-2010 , according to

American Rivers) and restoration, paying to recover the flood mitigating properties of natural river and coastal systems should be a bargain.

One approach to restoring river systems involves mitigation for alterations elsewhere. For example, when no nearby mitigation site for wetlands alteration at Owens Field in Columbia, SC, could be identified, mitigation was shifted to the upper end of the same watershed, where a portion of Jackson Creek and its floodplain was restored by lowering the adjacent land contours to restore a natural floodplain and allow flooding waters to spread out through a wooded area rather than rushing downstream to a heavily populated area. If more mitigation measures were directed toward flood protection, with ancillary water quality and wildlife benefits, there may be more benefits than some current mitigation involving protection of land which might not be developed in any case.

Similarly, when flood damage does occur, local jurisdictions should be mandated, or at the very least, strongly encouraged to buy out damaged structures (particularly if they are repeatedly damaged) and return the area to natural area to the degree possible.

2. <u>Increase/Integrate Green Spaces</u>

Green spaces can and should be integrated into new developments, particularly in coastal or riverine areas. Ideally, green spaces should be integrated, and designed to hold the largest rainfall expected to fall on a development *in the future* (projected catastrophic rainfalls, rather than historic rainfalls.) In areas heavily dependent on tourism, increased green spaces can only serve to enhance the experience of visitors. Green spaces also offer an opportunity to educate the public about the natural environment and the systems that can enhance or significantly disrupt our communities. Few residents, much less visitors, give stormwater any thought; green infrastructure provides opportunities to draw attention to how stormwater management can affect the community, and point out examples of techniques that can be adapted for residential or business properties. At a very basic level, green spaces can provide a showcase for the use of native plants and pollinator plants in the landscape, encouraging homeowners to plant with wildlife in mind.

According to the Lincoln Institute of Land Policy, decisions about land preservation are increasingly likely to be made at the local level, due in large part to the devolution of governmental responsibility (with accompanying fiscal responsibility) as well as the rise of conservation banks. Local governments are dependent on property taxes, and thus might be expected to favor development over green space or open land protection.

However, a policy paper by the Lincoln Institute cites a review of fiscal impact studies by Robert Burchell and David Listokin that concluded that “generally residential development does not pay its own way… that nonresidential development does pay for itself, but is a magnet for residential development, and that open space falls at the break-even point.” Further, they note that a study of 11 towns in New England found that “on a strictly financial basis, the cost of providing public services is more than twice as high for residential development as for commercial development or open space." If these arguments hold true in South Carolina, concerns over lost revenues, if any, should be alleviated. In addition, as the City of Portland, Oregon, notes, greenspace saves money in avoided costs for more traditional infrastructure and can aid in flood management.

The full value of integrated green space is hard to calculate in monetary terms, since so many "services" provided by green space are intangible. (Lincoln Institute). However, it is not hard to see that at a minimum, integrated green space increases the value of adjacent property. This increased value might serve as an incentive to developers/owners to include green space in plans. Local governments may be able to find ways to recoup the value conferred on adjacent properties as a result of foregone development next door and apply that to additional flood protection measures.

C. **Incentives**

Measures discussed above will not be inexpensive and will not come without significant political cost. The Pew Charitable Trusts has found that for every $1 invested in flood mitigation that supports safety, property protection and continuity of use, $6 is saved. Savings are important to be understood and shared. Clearly, there is a need for incentives for individuals, businesses, and possibly even local governments to encourage sound stormwater management and implementation of flood control measures. Small-scale examples of such incentives are the City of Columbia's reduction in stormwater fees in exchange for installing BMPs like bioswales or pervious pavement. Seeking funding sources to help pay for more expensive pervious pavement could be desirable.

Another local example is addressed by GOAL #7 in Richland County's Gills Creek Flood Mitigation Plan:

Local Funding and Investments

Identify local funding instruments that are dedicated sources of revenue for funding flood mitigation actions. Examples of these types of actions include establishing a stormwater utility program to provide a dedicated source of revenue to fund stormwater projects and setting up a Special Purpose Local Option Sales Tax (SPLOST) and focus SPLOST funds toward identified drainage improvement projects.

Another source of funding is the ability to use State Accommodations Tax, Local Hospitality Tax and Local Accommodations Tax revenue for the control and repair of flooding and drainage. Legislation to permit such is currently introduced in the SC state Senate as S 217. This bill is pending at the present time.

However, measures such as these will not begin to address the larger issues facing the state. Funding sources and non-financial incentives must be identified to encourage swift action. One tool that can and should be utilized by local governments is the Community Rating System, which incentivizes local governments to be more proactive through the National Flood Insurance Program, providing the potential to lower private insurance costs. DHEC already supports a "Coastal CRS Users Group" and could expand that support to non-coastal areas as needed. More information, including a list of South Carolina cities and counties eligible for varying levels of CRS discounts, is available in the National Flood Insurance Program's Flood Insurance Manual.

Community Rating System Explorer: documenting open space preservation for flood mitigation and economic savings

The Community Rating System (CRS) is a voluntary program administered by the National Flood Insurance Program (NFIP) in which communities undertake flood mitigation activities that exceed minimum NFIP standards and in turn receive discounts on flood insurance premium rates for policyholders within that community. Communities within the program can move from a Class 10 to a Class 1, with increasing discounts in each class, as they undertake more activities and receive more points. One barrier to entering the CRS program and advancing in classes is the heavy burden of documentation that comes with the program. Activity 420 within the CRS program is the Open Space Preservation category, where communities receive credit for protecting and documenting open space within their floodplain. There is a lot of opportunity within Activity 420 to gain additional credit through additional land protection.

South Carolina local governments are recognizing the importance of open space preservation for flood mitigation as well as the economic benefit associated with insurance savings within the Community Rating System (CRS). The Nature Conservancy (TNC) has developed the Community Rating System Explorer (CRS Explorer), an app that helps planners identify areas that are eligible for open space credit, supports the CRS application process, and enables communities to interactively explore their data to identify future open space which would further reduce flood risk and premiums. The CRS Explorer app eases the burden of documentation by allowing communities to submit their data and does the processing and map documentation needed for CRS review conducted by FEMA. TNC, in partnership with the South Carolina Department of Health and Environmental Control's Office of Ocean and Coastal Resource Management (DHEC-OCRM), has developed this app for 20 South Carolina coastal counties and municipalities, with more communities likely to be included in the coming years. These communities can now get credit for currently protected open space, as well as explore parcels that could be protected in the future. This allows a community to prioritize land protection and funding opportunities in a way that can mitigate flood risk while also gaining points within the CRS program and thus lower community-wide flood insurance premiums.

It would be beneficial to expand the CRS Explorer app to all CRS-participating communities across South Carolina. In addition, the CRS Explorer app could be expanded to include additional layers / data that further inform prioritization of land protection for flood mitigation. It would be helpful to migrate the CRS Explorer app to establish a centralized State data warehouse.

III. CHALLENGES

Floodplain Protection:

Undeveloped floodplains, wetlands, and open space (in specific locations) naturally store floodwaters. This critical function can reduce flood risks and increase resilience for nearby human communities as well as downstream. Past and ongoing development, particularly in areas of the state that are growing, has been built on floodplains, flood-prone areas and open space that should be left undeveloped to serve as valuable floodwater storage areas. More of our state's floodplains and critical open space may be eliminated or altered as our state's population grows and urban/suburban areas expand. This loss of floodplains and floodwater storage areas puts people at risk, not only on those specific lands but also other lands where flooding is magnified due to loss of floodwater storage capacity.

Resilience Strategy:

- Identify high-priority floodplains, wetlands and open spaces through existing maps and analyses on a county by county basis. This may require new hydrologic and flooding models, or better synthesis of existing models that are housed in various agencies or universities.
- Maintain the flood storage capacity of floodplains, wetlands and critical open space through outright purchases, conservation easements, and tax credits that incentivize preservation.
- Identify high-priority areas where past development has already reduced or eliminated their capacity to absorb floodwaters. Use buy-outs as a fair, free-market-based strategy to acquire these areas and restore them to natural functions.
- Identify local, state and federal funding sources for this strategy.

A number of challenges interfere with our ability to reduce damages from flooding. They include:

1. Lack of education about the relationship between how we manage land and flooding.

Very few people understand the role that wetlands and floodplains play in mitigating damage from floods. On a micro-landscape level, people living in urban areas rarely understand the relationship between yard waste, storm drains, and flooded streets, and complain to their governments about flooded streets even as they rake yard waste into the storm sewer. Similarly, local and state government officials may not be as knowledgeable as they would like about causes and solutions of flooding. This understanding is evolving as weather via "rain bombs" and "king tides" are creating a new normal. In rural areas as well as urban areas, the maintenance of dams and retention and detention systems are critical to retain waters as they were intended.

2. Landowner/Developer interest in maximizing use of property.

Naturally, property owners seek to recoup and grow their investment. This often can result in a short time horizon, when statewide floodplain management requires a much longer time horizon and the consideration of a much broader suite of interests. We must find a way to balance the interests of downstream communities, and the state as a whole (when called upon to) against those of individual property owners through incentives and measures to make potentially damaging development less attractive in the first place.

3. Lack of adequate local government planning tools.

While there are many tools available to local governments, smaller jurisdictions may not have the staff or funds to study and adapt them. The state, or an entity such as the Municipal Association of SC, could develop a suite of floodplain/watershed management tools and sample plans, and aid local jurisdictions in how to adapt and administer them. Such a suite of tools could include guidelines for review of comprehensive plans, master plans, land use and zoning plans, and planning activities under the NFIP's Community Rating System (CRS), as well as design and implementation of enhanced building codes, standards, regulations, and ordinances to support effective mitigation for new construction to maximize protection from flood risk. In addition, the state should advise local governments on potential incentives to make flood-mitigation efforts more attractive to developers and landowners. Creation of good, science based, reliable resources may prove valuable as more communities need to turn to new evolving information. One resource for this information may be SC Sea Grant Consortium or the Carolinas Integrated Sciences and Assessments.

4. The "Tragedy of the Commons" problem.

Activities upstream may have a more significant effect on downstream communities than in the community where the activity takes place. Because we all contribute in ways small and large to the problem of stormwater runoff and poor floodplain management, it is easy to assume that our small contribution is not significant in the grand scheme, and therefore we are blameless. We need to create a shared sense of responsibility for managing floodwaters in the state, helping upland owners see that they too bear responsibility for damage downstream. This will require both a concentrated public information effort and on-going reminders.

IV. DELIVERABLES

SHORT-TERM DELIVERABLES (up to 18 months out)

Identify high priority floodplains, wetlands and open spaces through existing maps and analyses on a county-by-county basis.

Expand the Risk MAP program with SCDNR and FEMA to cover all vulnerable communities that have not yet been mapped.

Standardize sand fencing regulations state-wide.

Plant native vegetation along coastal Fore Dunes (part of the 'frontal zone"), especially in conjunction with beach renourishment projects. This DELIVERABLE is applicable for all time periods and should be adhered to as a matter of policy applicable coast-wide.

Encourage and incentivize local governments to participate in the National Flood Insurance Community Rating System administered by FEMA to achieve flood insurance premium discounts for their residents. Make available to all interested communities The Nature Conservancy's Community Rating System Explorer, an app that helps planners identify areas eligible for open space credit, supports the CRS application process, and enables communities to identify future open space to reduce flood risk and insurance premiums for their residents. This DELIVERABLE is applicable for all time periods.

Support the passage of S 217, introduced in the state Senate in 2019 and pending for the upcoming legislative session. This legislation enables the use of revenues from the State Accommodations Tax, Local Hospitality Tax, and Local Accommodations Tax for the control and repair of flooding and drainage.

Make the National Green Values Calculator (from the Center for Neighborhood Technology) available, or adapt it for the state's needs, and make it available to counties and communities. This tool compares green infrastructure and Low Impact Development to traditional stormwater practices for performance, costs and benefits.

MID-TERM DELIVERABLES (up to 5 years out)

Provide incentives to maintain the flood storage capacity of floodplains, wetlands and critical open space with outright purchases, conservation easements, tax credits, and other economic means (See the Task Force Report on Federal Funding for information on some sources for funding for these efforts).

South Carolina law currently specifies nine required elements of a comprehensive plan requirement. Local government flood prevention and mitigation efforts could be enhanced by adding a requirement to the law for a resilience or natural hazard element, along the lines of the Florida comprehensive planning law.

Review and modify the State Infrastructure Investment Act along the lines of Florida's approach so that any coastal infrastructure project that receives state funds has a "sea level impact projection' study before starting construction. This will ensure that infrastructure projects are built to withstand the impacts of sea level rise.

Consider areas subject to repetitive flooding for acquisition for parks and permanent open space by state, county or local governments. Utilize available federal and state funds for this purpose (See the Task Force Report on Federal Funding for information on federal program funds).

Develop model building codes, standards, regulations and/or ordinances to support effective mitigation for new construction to maximize protection from flood risk.

Include Integrating green spaces into new development by designing to hold the largest rainfall *expected* to fall, as opposed to relying on historic rainfall amounts, which are inadequate considering current and expected extreme weather events going forward.

In urban areas incentivize the use of green infrastructure as a cost-effective approach for managing and reducing stormwater at its source, through such methods as tree canopies, stormwater tree trenching, stormwater basins and stormwater wetlands, stormwater "bump-outs" and planters along flood-prone roads, use of pervious pavement for sidewalks, roadways, driveways, etc., raingardens and green roofs,

LONG-TERM DELIVERABLES (Five years plus)

Restore riverine landscapes to their natural state whenever possible to utilize their protective function. Consider the Netherlands example where rivers are given more room to flood safely.

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State of South Carolina

Governor Henry McMaster

Thomas S. Mullikin, Chairman

South Carolina Floodwater Commission

National Security Task Force Report

November 8, 2019

<u>NATIONAL SECURITY TASK FORCE</u>

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SCMD

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United States Marine Corps

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MILITARY BASES AND INSTALLATIONS
Assessments, Vulnerabilities, and Recommendations 2019

PROLOGUE

ON OCT. 15, 2018, GOVERNOR MCMASTER ESTABLISHED the National Security Task Force (NSTF) as one of the 10 named task forces (subcommittees) which form the S.C. Floodwater Commission. The NSTF was charged with identifying potential risks associated with flooding events and making recommendations to prepare for and mitigate or otherwise minimize those risks.

During the first official meeting of the NSTF on Jan. 24, 2019, Col. Bill Connor was nominated and elected chair of the NSTF. Col. Steve Vitali and Col. W. Thomas Smith, Jr. were then nominated and elected to the posts of operations officer and executive secretary respectively. At that initial NSTF meeting, then-S.C. Adjutant General, Maj. Gen. Bob Livingston, recommended the task force include National Guard and Reserve installations, and Col. Connor received Commission approval for the task force to include representatives and responsibilities for all state military bases.

The NSTF has since held or been engaged in seven public meetings all of which were attended by representatives of various military installations across the state and at least one representative from the office of the Governor of South Carolina.

The strategic importance of South Carolina's military community as part of the broader United States military is critical. South Carolina's military community provides a variety of resources that the nation regularly draws from for training, combat, and support services. These include: Force generation for the long-term sustainability of the U.S. Armed Forces; active engagement in the defense of national interests; and direct support of combat operations.

As noted in our charter, the S.C. military community collectively creates an economic impact to the state of $24.1 billion. South Carolina is home to eight major military installations and numerous facilities, supporting 62,520 in Department of Defense (DoD) personnel with $2.6 billion in payroll. $2.1 billion in DoD contracts is currently being executed among 752 firms within the state.

These figures speak to the criticality of the NSTF's work and why the task force was formed with individual base representatives as well as representatives from the S.C. Emergency Management Division and the Army Corps of Engineers among others.
We want to thank all the members of the NSTF, both the commissioners and the liaisons (please see ACKNOWLEDGEMENTS).

Among the NSTF's responsibilities was developing the leadership team for the culvert-clearing operation in Nichols, S.C., slated as of this writing for June 15, 2019. We also want to thank all those from outside the task force who contributed to the work of the task force, in particular, members of the South Carolina Emergency Management Division who helped with coordination with local civilian emergency managers with responsibilities adjacent to the various military bases. That coordination and work has been critical to the success thus far of this task force.

Additional responsibilities for the NSTF going forward are to continue to hold solutions-based discussions, all of which are open to the public, and to identify and implement short-term and long-term recommendations to alleviate and mitigate flood impacts to South Carolina with a focus on the state's military installations.

EXECUTIVE SUMMARY

The purpose of the National Security Task Force Executive Report to the Governor of South Carolina and the Chairman of the S.C. Floodwater Commission (herein referred to as the NSTF Report) is to present to both the Governor and the S.C. Floodwater Commission Chairman the NSTF's findings over our past several months of meetings. These findings are based on research, assessments, and evaluations regarding vulnerabilities and other floodwater issues to respective military facilities and other national security-related infrastructure within the NSTF's area of responsibility. This report will also make determinations and offer suggestions as to what needs to be done to address all issues.

As previously noted, the NTSF responsibilities included all military bases in the state, which included National Guard and Reserve (all services) armories in the state.

Overall, we assess that flooding has and will affect the military facilities in the state, particularly in the Midlands and along the coast. Both freshwater flooding and the rising ocean will also impact coastal military facilities.

The Great Flood of 2015 (aka the "1,000-year flood event") as well as the three successive hurricanes that have hit South Carolina since have had a negative impact on our military installations, and repairs are still ongoing. Of benefit to all is that those disasters revealed to the military installations, as well as DoD, areas that needed work to improve floodwater resilience.

In January of 2019, just as the Floodwater Commission was standing up, DoD released its Report on Effects of a Changing Climate to the Department of Defense. This report notes that "The effects of a changing climate are a national security issue with potential impacts to Department of Defense missions, operational plans, and installations… Vulnerabilities to installations include coastal and riverine flooding."

To ensure that military facilities better withstand flooding and severe weather issues, DoD is making appropriate changes to installation master planning, design, and construction standards. This includes efforts to better understand rates of coastal erosion, natural and built flood protection infrastructure, and inland and littoral flood planning and mitigation. DoD is also working to apply, evaluate, and improve scenarios and other tools for projecting interactions of sea level rise, storm surge, precipitation/land-based flooding at U.S. military installations. The NSTF's efforts are complementary to that process.

For each of the bases under South Carolina Military Installations, this report includes an overview, issues and challenges, and goals/way ahead.

This NSTF report also includes an addendum of the slides prepared and regularly updated by each military base for all teleconference calls and briefings held since Jan. 24, 2019.

I. MILITARY INSTALLATIONS GENERAL CONSIDERATIONS

Representatives from all major military installations located within South Carolina participated in the NSTF review. These included:

- U.S. Army Training Center and Fort Jackson
- McEntire Joint National Guard Base
- Shaw Air Force Base
- Joint Base Charleston
- Naval Hospital Support Base Charleston
- Coast Guard Sector Charleston
- Marine Corps Air Station Beaufort
- Marine Corps Recruit Depot Parris Island
- S.C. National Guard Armories
- Reserve armories of all four uniformed services.

We also received briefings from the U.S. Army Corps of Engineers Charleston District.

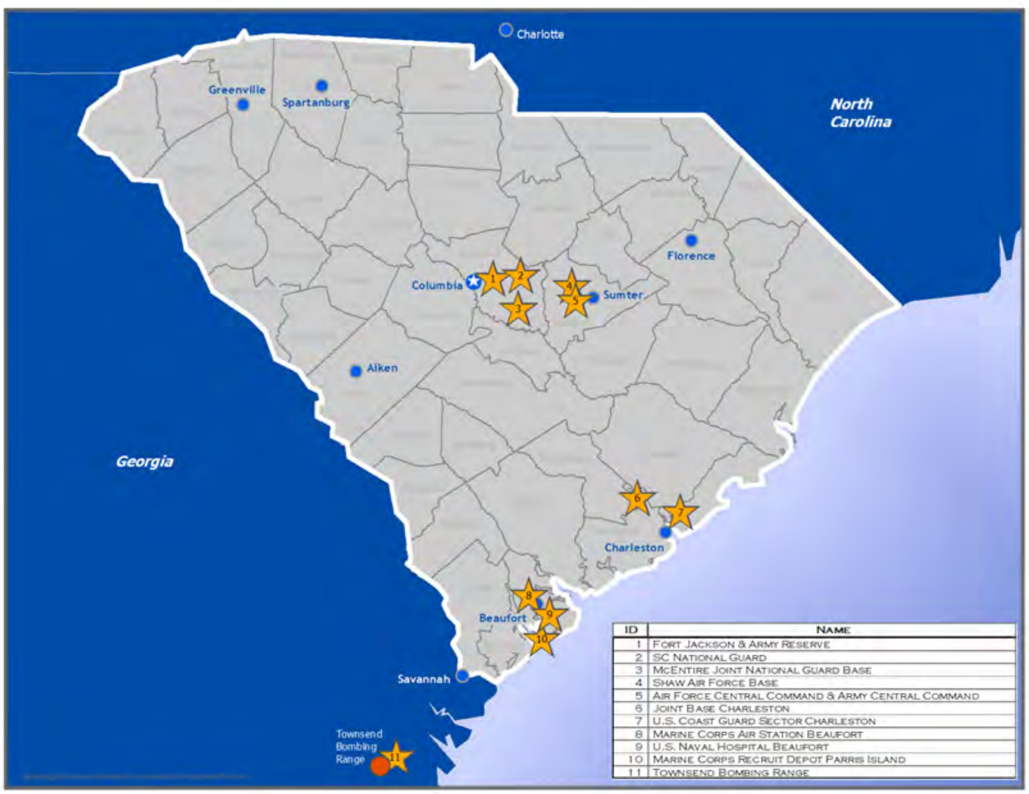


FIGURE 1: South Carolina military installations.

II. MILITARY INSTALLATION CATEGORIES

- Underground water aquifer or water contaminate, spills, and sludge.
- Storm water / culverts.
- Water distribution on installation and linked to adjacent or nearby communities.
- Wastewater treatment.
- Hazardous waste.
- Chemical storage and spills.
- Petroleum – fuel, oil, and fuel-tank vulnerabilities.
- Solar panels and storage.
- Nuclear materials stored vulnerabilities.
- Solid waste.
- Landfill.
- Medical, health, diseases.
- Environmental: vulnerabilities such as erosion, drought, wildfires, or recurring floodwater.
- Existing Floodwater Contingency Plans linked with local communities.
- Installation dams.
- Electrical grids.
- Roads.
- Bridges.
- Rail.
- Communications.

III. PRELIMINARY ASSESSMENTS AND DETERMINATIONS

- Military Installation interagency collaboration and communication with the S.C. Emergency Management Division (SCEMD) is effective and responsive to floodwater emergency events.
- Short, medium, and long-term floodwater impacts / strategies are Installation-specific, and not necessarily generic to all installations. The duration for completion of remediation projects differ and they vary between military bases.
- A general significant aspect facing installations in floodwater remediation is the ability to receive adequate and timely FEMA funding, "Act of Nature" funding from the National Guard Bureau, and/or state funding. Advocacy from legislators – state and national – should be urged to push for Federal government assistance in providing for the needs of our military installations in S.C.
- In general, remediation efforts are centered on:
    - Repairing dams from breaching.
    - Relocating the vast majority of the overhead power lines to underground.
    - Securing appropriate backup generators.
    - Upgrading or debris-clearing of drainage ditches.
    - Collaborating with local communities on shared projects to improve infrastructure; and to consider eventual movement of vulnerable/mission-critical facilities out of the hazard zones.
    - Tree removal.
    - Elevating roads and causeways leading to installation entrances that routinely flood during major floodwater events.
    - Dredging.
- The long-term goal of the NSTF is to conduct a Table Top Exercise of all major S.C.-based military installations in conjunction with SCEMD and the local military surrounding communities.
- Fort Jackson was selected for a short-term demo in FY20.

IV. MILITARY INSTALLATION – SPECIFIC CONSIDERATIONS

A. U.S. Army Training Center and Fort Jackson

- Overview: Fort Jackson is the largest basic-training center in the U.S. Army. Fifty percent of all soldiers entering the Army attend entry-level training here. The 52,000-acre base conducts numerous other training and soldier-support missions. The base hosts several key Army schools, and it has large military and civilian populations living and working on or near the post. Much of Fort Jackson is undeveloped piney woods and is interspersed with approximately 100 ranges and training sites.
- Issues and Challenges: Three major dams on Fort Jackson are under mediation from floodwater dam breaches from the great flood of 2015.
  - Legion Lake Dam: Considered to be a low-level hazard dam. Completion of maintaining embankment free of larger vegetation to be completed by 2019.
  - Semmes Dam: State-of-the-art labyrinth weir design. Meets seismic standards. Will safely pass water (without over-topping) through all flood stages. Construction complete (Sept. 2020). Mid-term deliverables: Complete the construction of Semmes Lake dam.
  - Weston Dam: Considered to be a high hazard dam. Temporary repairs underway to correct seepage through the embankment. Once permanent repair design is complete (Fall, 2019) funding will be needed based on outcome of design effort. Monitoring the dam and finish the USACE design for permanent repairs. Short term deliverables: Set up a table top exercise for Weston Lake dam. Clean existing storm water ditches. Long term deliverable: Perform final repairs.
- Perform quarterly dam inspections, keep dams mowed to facilitate inspections. Maintain storm water systems, dams and detention ponds. Perform reconstruction of low hazard dams.
- Goals/Way Ahead:

- NSTF is requesting SCEMD to help push for Federal funding of Weston Dam repair.
- Fort Jackson will be conducting a Table Top Exercise in conjunction with SCEMD. The exercise is scheduled for 2020 and has three primary focuses: Notification, Evacuation and Swift-water rescue.

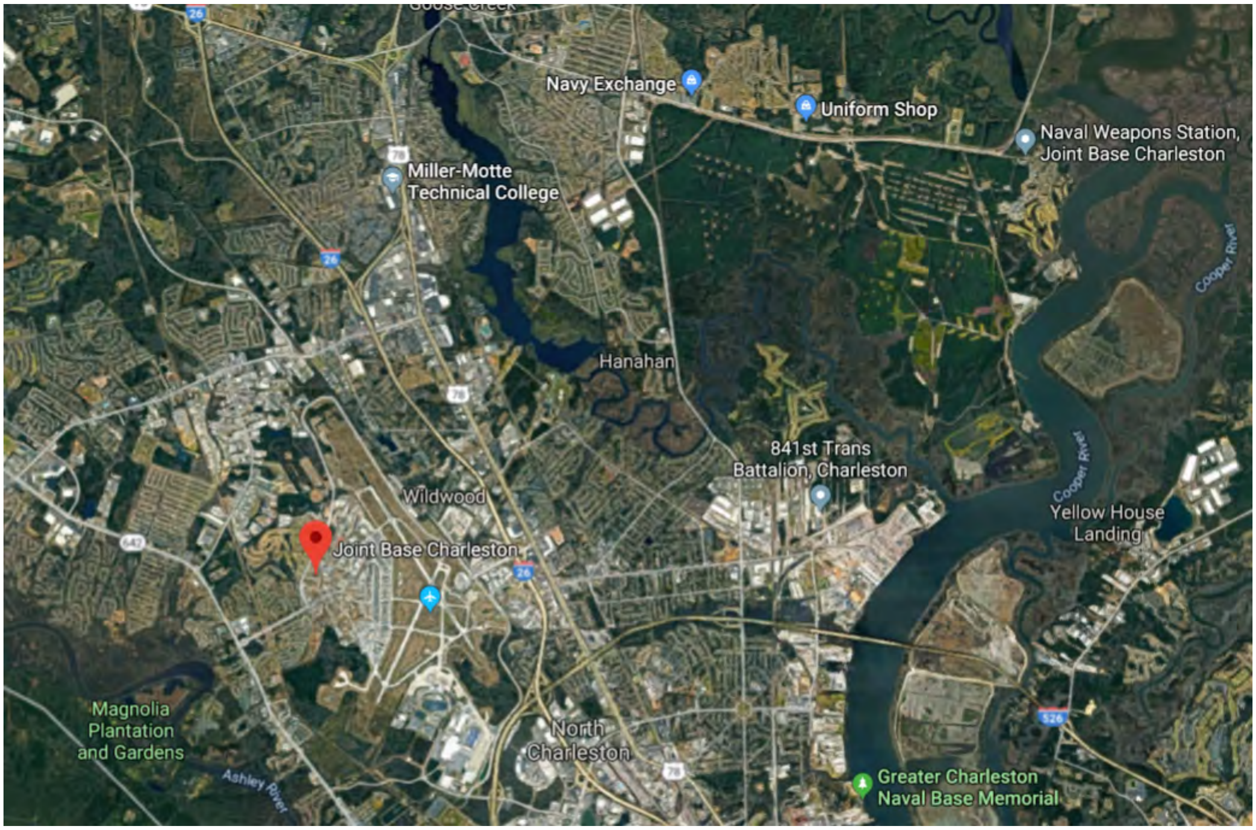
B. McEntire Joint National Guard Base

- Overview: Located 15 miles southeast of Columbia, McEntire Joint National Guard Base is home to the S.C. Air National Guard's 169th Fighter Wing (flying F-16s). There are also Army National Guard aviation elements and other functions on the base.
- Issues and Challenges:
  - During major flooding, back-gate entrance road is cut off, but main entrance into installation is passable.
- Goals/Way Ahead:
  - Upgrade fiber-optic communications capability.
  - Reduce facility flooding: Drainage study complete. Southwest drainage repair design complete. $1M contract expected to be awarded in FY 19. Until complete installation, must sandbag around certain facilities to prevent flooding during expected heavy rainfall.

C. Shaw Air Force Base

- Overview: Located in Sumter, Shaw AFB is the only base in S.C. with dual, parallel runways. The U.S. Air Force's largest F-16 combat wing, the 20th Fighter Wing, comprised of 79 jets, resides at Shaw AFB. It is also home to the Ninth Air Force and two defense headquarters: the U.S. Air Forces Central Command and U.S. Army Central.
- Issues and Challenges:
  - Floodwater impacts downstream. There is a risk of dam failure at Booth Pond downstream from Shaw AFB until funding allocated and repairs completed.
- Goals/Way Ahead:
  - Shaw Air Force Base has significantly improved its resilience of late by relocating the vast majority of the overhead power lines to underground. All mission critical facilities and infrastructure (water wells, sanitary sewage pump stations, and a wastewater treatment plant) have back-up generators that are regularly tested and maintained.
  - Support community efforts to improve existing Booth Pond Dam that is downstream of drainage from the base.
  - The City of Sumter is pursuing $1.6M in FEMA funding to improve the dam. It was inundated during hurricane Matthew and Irma and requires repair.
  - NSTF has requested SCEMD assistance in pushing for the FEMA funding.

D. Joint Base Charleston



- Overview: Joint Base Charleston is home to over 60 Department of Defense and federal agencies including the Navy's Nuclear Power training, SPAWAR's information warfare technology and the 628th Air Base Wing. Joint Base Charleston is one of three military seaports – and the Port of Charleston is one of 13 commercial seaports – designated as Strategic Seaports under the National Port Readiness Network. Joint Base Charleston currently supports major force deployments, worldwide, including rapid and surge deployments. A loss of this base and port would significantly reduce DoD's capability to support major force deployments and continuing mission support to units in various theaters overseas.
- Issues and Challenges:
    - Increased flooding upriver from the Cooper River leads to greater sedimentation, impacting fuel delivery and general port access; and it may lead to the need for more frequent dredging of the Cooper River.
    - Flooding due to heavy rain and tropical storms already impacts Joint Base Charleston. Permanent inundation due to sea-level rise is a potential long-term climatic effect over the next century, affecting primarily the Naval Weapons Station at Goose Creek, and to a lesser extent, the Air Base for Joint Base Charleston.
    - The potential exists for increased disaster/emergency response coordination requests from local communities because of more frequent/intense tropical storms – i.e. increased requests for Defense Support of Civilian Authorities (DSCA).

- The potential disruption to off-installation, river-based industry (Virginia Avenue, Bushy Park areas)
- The potential for toxic industrial chemical (TICs) relocations or unintended storage releases.

▪ Goals/Way Ahead:
  - Dredge Cooper River near the Naval Weapons Station to allow unimpeded access for vessels
  - Joint Base Charleston Civil Engineering, Port Operations, and Army Transportation Battalion recommend the following: begin infrastructure assessment; collaborate with local communities on shared projects to improve infrastructure; and consider eventual movement of vulnerable/mission-critical facilities out of the hazard zones.

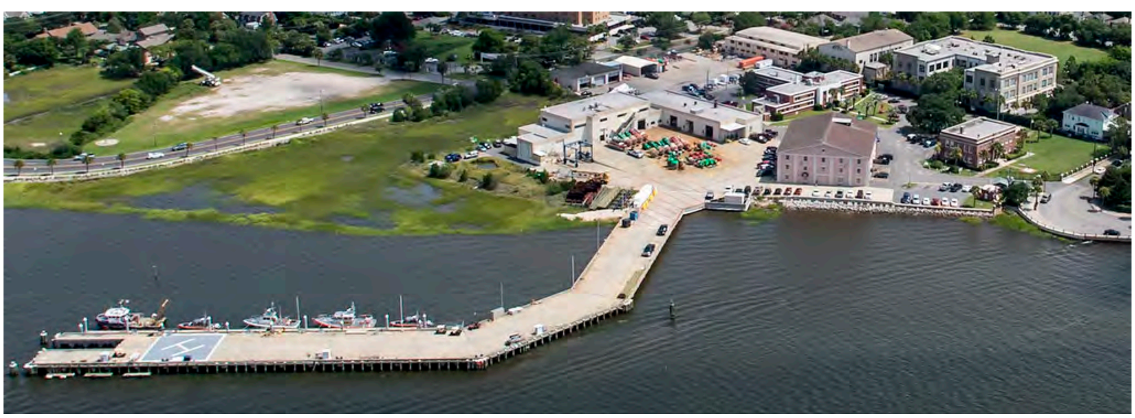
E. Naval Hospital Support Base

▪ Overview:

▪ Issues and Challenges: Flooding in-and-around facility and basement.

▪ Goals/Way Ahead
  - Yearly clearing of debris from storm drains.
  - Short-term Deliverables: (1) Relocating of critical electrical equipment from basement to higher location (complete). (2) Installation of sump pumps in the basement (in progress).
  - Moved critical electrical equipment from the facility basement to higher ground. Sump pumps in the basement should be completed this summer, but it is yet to be determined if they will be effective.

F. Coast Guard Sector Charleston



▪ Overview: Coast Guard Sector Charleston (aka "Sector Charleston") executes all Coast Guard missions in the Sector Area of Responsibility including: Search and Rescue, Ports Waterways and Coastal Security, Waterways Management, Maritime Homeland Security, Marine Science Activities, Aids to Navigation, and Command and Logistical Support.

- Issues and Challenges:
  - Flooding at Coast Guard Sector Charleston and Coast Guard Base Charleston located at the Federal Law Enforcement Training Center continues to be an issue. Both the Tradd Street and Register Street locations have significant issues from high tides and storm surge, offshore storms (hurricanes / tropical storms), and heavy rain events. There are several low-lying areas leading into the entry routes for both facilities that make traveling to-and-from almost impossible.
  - Reducing flooding on roads at entrance of Federal Law Enforcement Training Center/Sector Charleston after heavy rains and high tides.
  - Chronic flooding on the Charleston peninsula affects Sector Charleston's Tradd Street location in downtown Charleston.
  - Pump station was requested by City of Charleston to be installed in the parking lot of Sector Charleston's Tradd Street location. Coast Guard declined proposal due to the impact that construction and pump-station location would have on day-to-day ongoing operations.
- Goals/Way Ahead:
  - Vac/Jet work on storm water system outfalls at base of viaduct bridge. New ditch cut between both viaducts.
  - Palmetto Railways completed Vac/Jet work and construction of new ditch between viaducts.

- Calhoun West Drainage Improvement Project due to high tides and heavy rains.
  - Coast Guard Civil Engineering Unit – Miami offered alternate location – undeveloped marsh area adjacent to Sector.
  - Charleston Peninsula Flood Study – Joint study with U.S. Army Corps of Engineers and the City of Charleston to address tidal surge/rising sea level, and high tides above six feet. The study will identify options.
  - Proposed Resiliency Strategy: Continue working with private industry, as well as local, state, and federal agency partners to determine suitable courses of action to reduce flooding.
  - Short-term Deliverables: Continue to research / study alternatives for drainage improvement projects and pump site locations.
  - Mid-term Deliverables: Continue to research / study alternatives for drainage improvement projects and pump site location.

G. <u>Marine Corps Air Station Beaufort</u>

- Overview: Known as "Fightertown East," the 7,000-acre Marine Corps Air Station Beaufort is home to about 4,700 personnel. The installation is home to five Marine Corps F/A- 18 squadrons and one F-35B Fleet Replacement Squadron.
- Issues and Challenges:
  - Drainage systems were constructed in 1957 and need replacement. Projects are scoped, drafted and approved by Headquarters Marine Corps. Funding reallocation due to Hurricane Florence will delay project execution to 2020-21.
  - Destructive weather events have damaged or caused trees to fall on utility lines or homes. Local funding addressed immediate issues; however, tree removal is an ongoing process. The mitigation of short-term issues will occur via quarterly inspections for life safety issues. A project to eliminate all dead or dying trees is delayed until 2021 due to Hurricane Florence funding reallocation.
- Goals/Way Ahead:
  - MCAS Beaufort's projects include:
  - Airfield drainage system.
  - Industrial and billeting areas drainage system.
  - Laurel Bay Housing drainage system.
  - Tree removal – overhanging utility lines.

H. USMC Recruit Depot Parris Island – Eastern Recruiting Region

- Overview: The Marine Corps Recruit Depot Parris Island is home to two commands: The Training and Education Command and the Recruiting Command. It is an 8,000-plus-acre training installation that trains all male enlisted Marine recruits east of the Mississippi River and all female Marine recruits from across the United States. MCRD Parris Island is entry level "boot camp" training.
- Issues and Challenges:
  - Located at the confluence of the Broad and Beaufort Rivers, Parris Island is largely marshland.
  - The installation is experiencing the permanent, temporary and ongoing indications of impacts to mission from climate influenced factors. To address these impacts the installation requires a comprehensive assessment and plan to cohesively and cost-effectively address the impacts in the short, medium, and long-term.
  - Elevation of main causeway is a primary concern during tropical storm surge. There is a need to improve access road, "causeway," into the Depot's main ingress point. During previous storms, the causeway was closed until washed-up debris and wet reeds could be removed.
  - Potential future sea level rise.
- Goals/Way Ahead:
  - Elevate road base to bolster flood resilience.
  - Quantify Built Environment Vulnerability and develop resiliency strategy/projects.

- Standardizing which climate-change model should be used as the basis for planning.
- Establish DoD policy/directive (NAVFAC Climate Change Planning Handbook).
- USGS provide technical lead to understand the impact of sea level rise on water table elevation and subsequent impact on storm water drainage; conversion to wetlands, etc.
- Complete the Parris Island Climate Change Adaptation and Resilience Plan. The assessment will consider the vulnerabilities of both the built and natural environment and impacts to mission. The resilience plan will develop discrete projects to mitigate potential impacts. The contract has been awarded and the estimated completion date is May 2020.

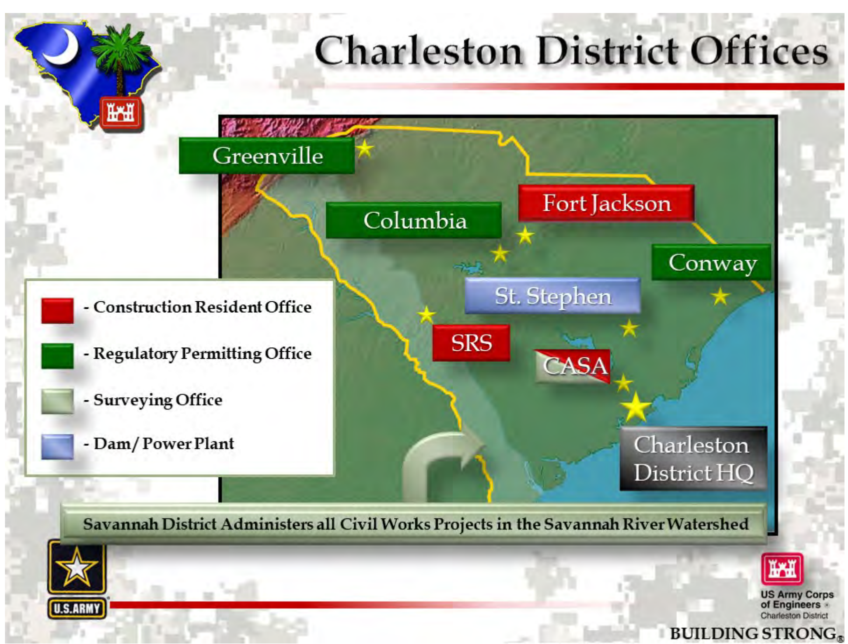
I. SOUTH CAROLINA NATIONAL GUARD ARMORIES

- Overview: Numerous S.C. National Guard armories are located throughout the Palmetto State. All serve varying important functions, and all have unique floodwater mitigation needs.
- Issues and Challenges:
  - The issues faced by the S.C. National Guard armories are the preparation of our statewide facilities and associated equipment for floodwater and storm effects in order to meet our DSCA mission. State and federal funding is another challenge in that normal annual budgets do not include contingency dollars, so when a natural disaster occurs, normal operations and maintenance funds must be used.
  - There are four facilities that are most susceptible to floodwater impacts:
    - McCrady Training Center – Utilizing backup generators.
    - Charleston Readiness Center – Requires backup generators but funding resources has been deferred to a 2020/2021 project.
    - Current Floodwater Plan is to fall Brigade HQ back to Orangeburg. This is the S.C. National Guard Brigade that supports the coast.

    - Manning, Marion, and Mullen armories have been hit hard by flooding. Requires Act of Nature Funding from National Guard Bureau in Washington.
- Goals/Way Ahead:
    - The resiliency strategy for the armories includes using state and federal funds to provide backup-power generators and to upgrade installation electrical-distribution systems, minimize facility damage through protective works, and increase storage capacity for organization equipment in key locations.
    - Funding for generators.
    - Orangeburg Motor Pool. Increase storage capacity area for organizational equip. Completion 2019.
    - Short-term deliverable is completion of backup power generation at McCrady Training Center (primary RSOI site) and increasing organization equipment capacity at our main response armory in Orangeburg.
    - Mid-term deliverable is completion of protective works at Pee Dee area armories (Mullins, Marion and Manning).
    - Long-term Deliverables:
        - Backup power generation at coastal armories and the Charleston Readiness Center.
        - Upgrade installation electrical distribution system (backup power generation)
        - Design and install backup generator and transfer switch. Expected completion date is summer 2021.

NOTE: RESERVE ARMORIES IN THE STATE (ARMY, NAVY, AIR FORCE, MARINE CORPS) FACE SIMILAR CHALLENGES TO NATIONAL GUARD ARMORIES.

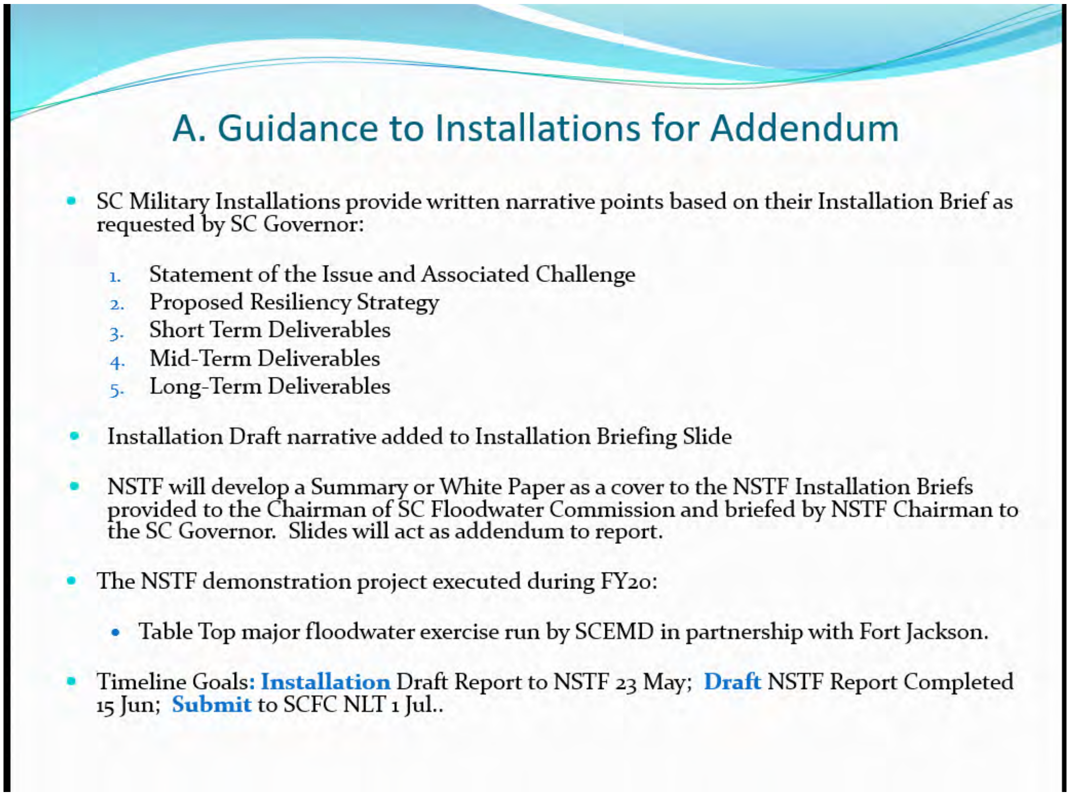
J. <u>Charleston District U.S. Army Corps of Engineers</u>

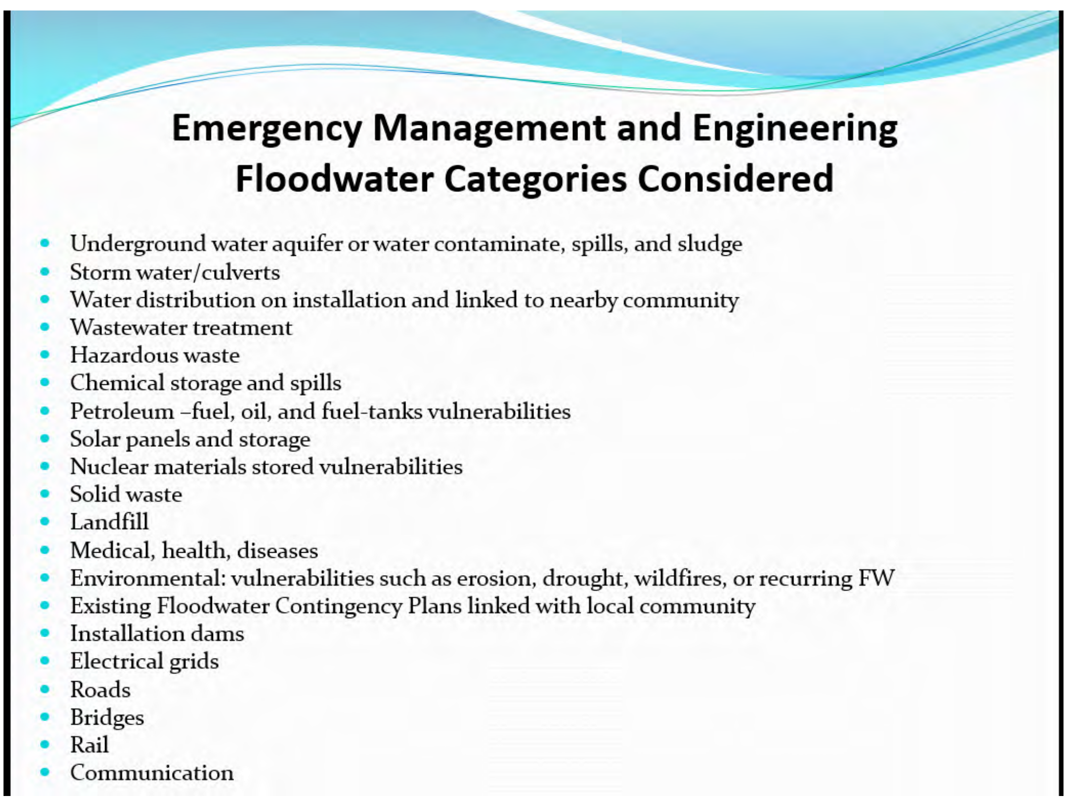


- Overview: The Charleston District protects the nation's aquatic resources, while allowing reasonable development through fair, flexible and balanced permit decisions. Charleston District is responsible for administering the regulatory program throughout the state of South Carolina. The Corps evaluates permit applications for construction activities that occur in the Nation's waters, including wetlands. Corps permits are also necessary for any work, including construction and dredging, in the Nation's navigable waters.
- Issues and Challenges:
    - In 1987 as Gills Creek Flood Control Feasibility Study was initiated to protect private property along the drainage pathway in the Midlands of S.C., the recommended plan was to convert and enlarge the upper Boyden Arbor Road Pond into a wet/dry pond for storage. However, H&H outdated mitigation, as plan was never implemented.
- Goals/Way Ahead:
    - Flood Damage Reduction Projects (DoD):
        - Reduce flood risk to onsite and adjacent structures.
        - Planning H&H environmental historic/cultural construction based on BC Ratio.
    - Flood Damage Reduction Projects (Non-DoD):
        - Planning assistance to states.
        - Cost shared – $100,000 Federal, Feasibility Studies/PAS 50/50 and Construction cost 65/35.

National Security Task Force Addendum

A. Guidance to Installations for Addendum





B. Fort Jackson Basic Training Center

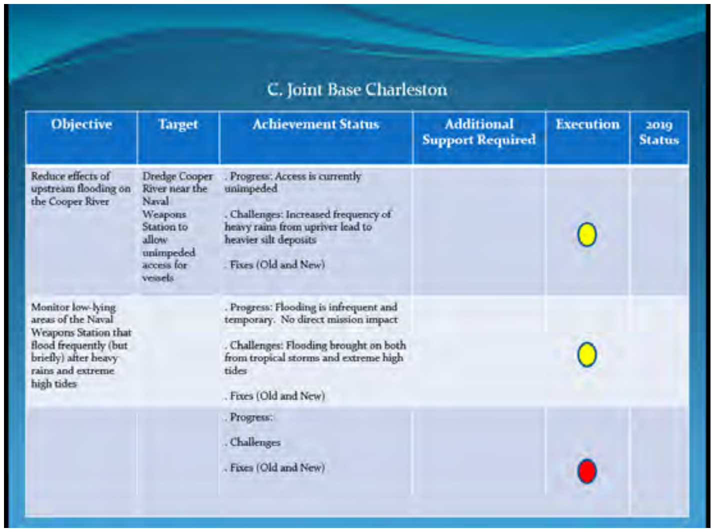
B. Fort Jackson Basic Training Center

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Semmes Dam Repair		. Progress: Construction complete ~SEP 2020 . State-of-the-art labyrinth weir design, meets seismic stds, will safely pass water (w/o overtopping) through all flood stages. . Challenges: Once constructed, exercise Emergency Action Plan (EAP) & maintain embankment (free of larger vegetation)	None at this time.	Underway, ECD 9/20	
Weston dam repairs	May 19	. Progress: Temporary repairs underway to correct seepage through embankment. . Challenges: Once permanent repair design complete (fall 19), will need funding based on outcome of design effort. .Fixes (Old and New) Continue to maintain embankment free of larger vegetation.	Suggest TTX to exercise EAP.		
Legion Lake Repair		. Progress: Complete Feb 2019 . Challenges: Maintain embankment (free of larger vegetation). .Fixes (Old and New)	None. Legion is considered a low hazard dam.		

Summary – Fort Jackson Training Center

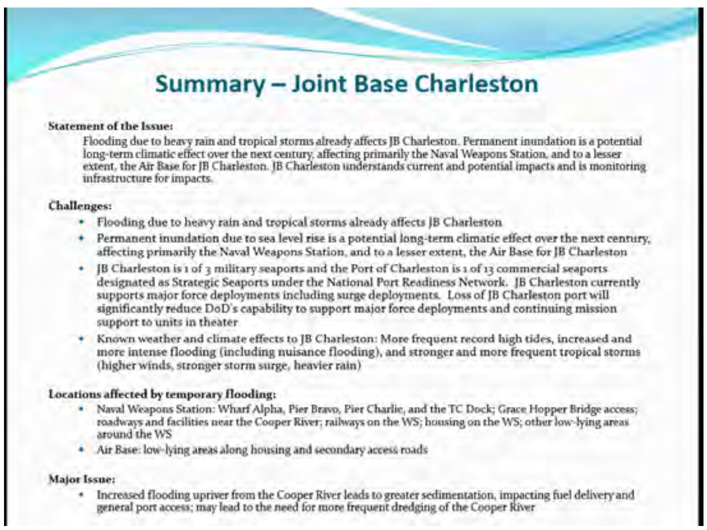
- Fort Jackson Training Center:
  - Statement of the Issue and Associated Challenge
    - Monitoring Weston Lake dam and finish the USACE design for permanent repairs.
  - Proposed Resiliency Strategy
    - Perform quarterly dam inspections, keep dams mowed to facilitate inspections. Maintain storm water systems, dams and detention ponds.
  - Short Term Deliverables
    - Set up a Table Top Exercise for Weston Lake dam. Clean existing storm water ditches.
  - Mid-Term Deliverables
    - Complete the construction of Semmes Lake dam. Perform reconstruction of low hazard dams.
  - Long-Term Deliverables
    - Perform final repairs at Weston Lake dam.

C. Joint Base Charleston



C. Joint Base Charleston

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Reduce effects of upstream flooding on the Cooper River	Dredge Cooper River near the Naval Weapons Station to allow unimpeded access for vessels	. Progress: Access is currently unimpeded . Challenges: Increased frequency of heavy rains from upriver lead to heavier silt deposits . Fixes (Old and New)			
Monitor low-lying areas of the Naval Weapons Station that flood frequently (but briefly) after heavy rains and extreme high tides		. Progress: Flooding is infrequent and temporary. No direct mission impact . Challenges: Flooding brought on both from tropical storms and extreme high tides . Fixes (Old and New)			
		. Progress: . Challenges . Fixes (Old and New)			



Summary – Joint Base Charleston

Statement of the Issue:

Flooding due to heavy rain and tropical storms already affects JB Charleston. Permanent inundation is a potential long-term climatic effect over the next century, affecting primarily the Naval Weapons Station, and to a lesser extent, the Air Base for JB Charleston. JB Charleston understands current and potential impacts and is monitoring infrastructure for impacts.

Challenges:

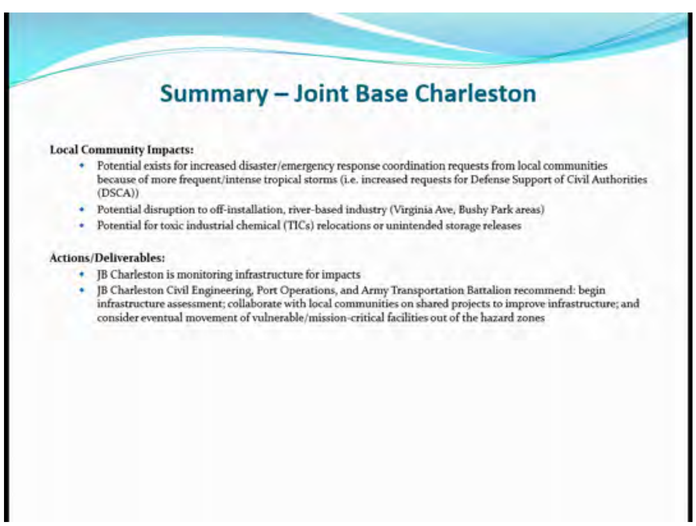
- Flooding due to heavy rain and tropical storms already affects JB Charleston
- Permanent inundation due to sea level rise is a potential long-term climatic effect over the next century, affecting primarily the Naval Weapons Station, and to a lesser extent, the Air Base for JB Charleston
- JB Charleston is 1 of 3 military seaports and the Port of Charleston is 1 of 13 commercial seaports designated as Strategic Seaports under the National Port Readiness Network. JB Charleston currently supports major force deployments including surge deployments. Loss of JB Charleston port will significantly reduce DoD's capability to support major force deployments and continuing mission support to units in theater
- Known weather and climate effects to JB Charleston: More frequent record high tides, increased and more intense flooding (including nuisance flooding), and stronger and more frequent tropical storms (higher winds, stronger storm surge, heavier rain)

Locations affected by temporary flooding:

- Naval Weapons Station: Wharf Alpha, Pier Bravo, Pier Charlie, and the TC Dock; Grace Hopper Bridge access; roadways and facilities near the Cooper River; railways on the WS; housing on the WS; other low-lying areas around the WS
- Air Base: low-lying areas along housing and secondary access roads

Major Issue:

- Increased flooding upriver from the Cooper River leads to greater sedimentation, impacting fuel delivery and general port access; may lead to the need for more frequent dredging of the Cooper River



Summary – Joint Base Charleston

Local Community Impacts:

- Potential exists for increased disaster/emergency response coordination requests from local communities because of more frequent/intense tropical storms (i.e. increased requests for Defense Support of Civil Authorities (DSCA))
- Potential disruption to off-installation, river-based industry (Virginia Ave, Bushy Park areas)
- Potential for toxic industrial chemical (TICs) relocations or unintended storage releases

Actions/Deliverables:

- JB Charleston is monitoring infrastructure for impacts
- JB Charleston Civil Engineering, Port Operations, and Army Transportation Battalion recommend: begin infrastructure assessment; collaborate with local communities on shared projects to improve infrastructure; and consider eventual movement of vulnerable/mission-critical facilities out of the hazard zones

D. Shaw Air Force Base

D. Shaw Air Force Base

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Upgrade installation electrical distribution system	Primary incoming electrical feeder (Duke and Black River)	. Progress: $5M Contract awarded to place overhead electrical lines underground. ECD: Dec 2019 . Challenges: Until complete, installation must trim trees near power lines to improve resiliency during storm events . Fixes (Old and New): Three additional projects planned to do the same with the remaining sub-distribution electrical infrastructure. Backup generators in place for mission critical facilities.			
Reduce facility flooding	Reduce building / facility damage due to floodwaters	. Progress: $1M project awarded to repair drainage at youth center. ECD: Aug 2019 . Challenges: Due to Shaw's topography, a number of buildings have entryways in low lying areas and are prone to flooding . Fixes (Old and New): Reinforce entryways with sandbags until drainage diversion projects complete.			

D. Shaw Air Force Base

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Floodwater impacts downstream of Shaw AFB	Support community efforts to improve existing dam that is downstream of drainage from installation	. Sumter city pursuing $1.6M in FEMA funding to improve damn. It was inundated during hurricane Matthew and Irma and requires repair (see pictures below) . Challenges: Until complete, increased risk of damn failure during major storm events. . Fixes (Old and New): Community pursuing FEMA funding.			

Summary – Shaw Air Force Base

- "While Shaw AFB has some issues from any major storm event, the general design and condition of the infrastructure is fairly resilient in the face of significant rain events. There are some low lying areas that require pre-positioning of sand bags at facilities and some localized flooding occurs on some roads but the water subsides fairly quickly after the rain stops.
- The base has significantly improved its resilience of late by relocating the vast majority of the overhead power lines to underground. All mission critical facilities and infrastructure (water wells, sanitary sewage pump stations, and wastewater treatment plant) have back-up generators that are regularly tested and maintained."

E. S.C. National Guard Armories

E. S.C. National Guard Armories

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Upgrade installation electrical distribution system (backup power generation)	• MTC (RTI) • CRC	. Progress: MTC – 50% complete, CRC – 0% . Challenges: MTC cost $200k, CRC cost est. $200k .Fixes (Old and New): design and install back up generator and transfer switch	• None at this time	• MTC Summer 2019 • CRC 2021	MTC CRC
Minimize damage to facility caused by flooding from Hurricane Florence	• Manning, Marion, Mullins	. Progress: in design (15%) . Challenges: cost $515k total .Fixes (Old and New): Reinforce entryways with sandbags until drainage diversion projects complete, water-proof facility (walls, roof)	• None at this time	• Fall 2019	
Increase storage capacity area for organizational equip	• Orangeburg	. Progress: design complete, starting construction . Challenges: cost $330k .Fixes (Old and New): cut/fill, regrade, compaction, geo fabric	• None at this time	• Summer 2019	

Summary – S.C. National Guard Armories

- **<u>Statement of Issue and Associated Challenges</u>**
- The issued faced by the SC National Guard Armories is the preparation of our statewide facilities and associated equipment for floodwater and storm effects in order to meet our Defense Support to Civilian Authorities (DSCA) mission. State and federal funding is another challenge in that normal annual budgets do not include contingency dollars, so when a natural disaster occurs, normal Operations and Maintenance funds must be used.

- **<u>Proposed Resiliency Strategy</u>**
- Our resiliency strategy includes using state and federal funds to provide backup power (generators) and upgrade installation electrical distribution systems, minimize facility damage through protective works, and increase storage capacity for organization equipment in key locations.

- **<u>Short-term Deliverables</u>**
- Completion of backup power generation at McCrady Training Center (primary RSOI site) and increasing organization equipment capacity at our main response armory (Orangeburg).

- **<u>Mid-term Deliverables</u>**
- Completion of protective works at our Pee Dee area armories (Mullins, Marion and Manning).

- **<u>Long-term Deliverables</u>**
- Back-up power generation at coastal armories and the Charleston Readiness Center (CRC).

F. McEntire Joint National Guard Base

F. McEntire Joint National Guard Base

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Upgrade Fiber Optic Communications Capability	Primary incoming communications feeder (AT&T)	. Progress: Completed addition of second fiber optic communications cable for installation. $50,000 project			
Reduce facility flooding	Reduce building /facility damage due to floodwaters	. Progress: Drainage Study Complete. Southwest drainage repair design complete. $1 M contract expected to be awarded in FY 19 . Challenges: Until complete installation must sandbag around certain facilities to prevent flooding during expected heavy rainfall. .Fixes: Rework drainage around facilities			
Outfall drainage ditch repair	Reduce damage due to floodwaters	. Progress: Completed outfall drainage ditch repair. $1 M project.			

Summary – McEntire JNGB, SC

- McEntire JNGB SC

  1. Reduce Building/Facility Damage Due to Floodwaters
  2. Southwest Drainage Repair Study and Repair Design Complete
  3. Contract expected to be awarded in FY 19/20 to complete rework of Southwest Drainage Ditches
  4. Upgrade Drainage around ACA Facility – Projected 5 to 10 years out
  5. No notable projects projected after 10 years

- Repairs from 2015 flooding to outfall drainage ditches completed. Addition of second fiber optic communications cable completed. Southwest drainage ditch repair study and repair design completed. Expect to award contract to complete southwest drainage ditch rework in FY 19/20. This will reduce the possibility of flooding of certain facilities due to heavier than normal rain.

G. Naval Hospital Support Base: Charleston

G. Naval Hospital Support Base: Charleston

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Reduce flooding/standing water at or around facility.	Naval Hospital Charleston immediate area.	. Progress: Storm drains are cleared yearly of debris or as needed. . Challenges: None, storm drains are in good condition.	None	Yearly	
Reduce facility flooding.	Naval Hospital basement.	. Progress: Installation of sump pumps . Challenges: None . Fixes: (New) Yet to be determined if the pumps will meet the objective.	None	Summer 2019	
Protect critical electrical equipment and infrastructure.	Naval Hospital basement.	. Progress: Electrical equipment and infrastructure in low lying areas susceptible to water have been moved to a higher elevation within the basement. . Challenges: None	None	Complete	

Summary – Naval Hospital Support Base: Charleston

- Naval Hospital Charleston
  1. Issue and Challenges: Flooding in and around facility and basement.
  2. Proposed Strategy: Yearly clearing of debris from storm drains.
  3. Short-term Deliverables: (1) Relocating of critical electrical equipment from basement to higher location (complete). (2) Installation of sump pumps in the basement (in progress).
  4. Mid-term Deliverables: None at this time.
  5. Long-term Deliverables: None at this time.

- Naval Hospital Charleston Public Works has taken a proactive approach by moving critical electrical equipment from the facility basement to higher ground. Sump pumps in the basement should be completed this Summer but it is yet to be determined if they will be effective. Clearing of debris from storm drains has proven to be very effective and is scheduled on a yearly basis or as needed.

H. Marine Corps Air Station Beaufort

H. Marine Corps Air Station: Beaufort

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Repair storm water drainage on airfield	MCAS Airfield	. Progress: Project scope drafted, submitted and approved by HQMC. . Challenges : Funding; competition for facility maintenance funds due to cost of Hurricane Florence. . Repairs storm water drains specific to the airfield. Current drainage system was construction in 1957 and is failing causing sink holes to develop.	Higher Headquarters budgetary commitment.	2020	
Repair storm water drainage on MCAS	MCAS industrial and billeting areas	. Progress: Project scope drafted, submitted and approved by HQMC. . Challenges : Funding; competition for facility maintenance funds due to cost of Hurricane Florence. . Repairs storm water drains throughout MCAS. Current drainage system was construction in 1957 and is failing causing sink holes to develop.	Higher Headquarters budgetary commitment.	2021	

H. Marine Corps Air Station: Beaufort

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Repair storm water drainage on Laurel Bay	Laurel Bay Housing	. Progress: Project scope drafted, submitted and approved by HQMC. . Challenges : Funding; competition for facility maintenance funds due to cost of Hurricane Florence. . Repairs storm water drains specific to the airfield. Current drainage system was construction in 1957 and is failing causing sink holes to develop.	Higher Headquarters budgetary commitment.	2021	
Remove trees overhanding utility lines aboard MCAS Beaufort	MCAS Beaufort and Laurel Bay inner perimeter	. Progress: Ongoing inspection and removal of trees/limbs overhanging power lines throughout MCAS Beaufort. . Challenges Funding. .Prevents/minimizes risk of power outage due to storms.	Quarterly inspection by MCAS Beaufort and Tri command personnel	Ongoing	

Summary – Marine Corps Air Station Beaufort

- Projects
  1. Airfield drainage system
  2. Industrial and Billeting Areas drainage system
  3. Laurel Bay Housing drainage system
  4. Tree removal overhanging utility lines

- Drainage systems were constructed in 1957 and need replacement. Projects are scoped, drafted and approved by HQMC. Funding reallocation due to Hurricane Florence will delay project execution to 2020-21.

- Destructive weather events have damaged or caused trees to fall on utility lines or homes. Local funding addressed immediate issues; however, tree removal is an on-going process. The mitigation of short term issues will occur via quarterly inspections for life safety issues. A project to eliminate all dead or dying trees is delayed until 2021 due to Hurricane Florence funding reallocation.

I. Coast Guard Sector Charleston

I. Coast Guard Sector: Charleston

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Monitor low-lying areas near/on roadways. Reduce flooding on roads at entrance of FLETC/Sector Charleston after heavy rains and high tides.		. Progress: Vac/Jet work on storm water system outfalls at base of Viaduct Bridge. New ditch cut between both viaducts. . Challenges: Monitor to determine if new ditch will eliminate future flooding. .Fixes (Old and New): Palmetto Railways completed Vac/Jet work and construction of new ditch between viaducts.			
Calhoun West Drainage Improvement Project due to high tides and heavy rains.		. Progress: Coast Guard Civil Engineering Unit – Miami offered alternate location – undeveloped marsh area adjacent to Sector . Challenges: Chronic flooding on Charleston peninsula affects Sector Charleston's Tradd Street location in Downtown Charleston. .Fixes (Old and New): Pump station was requested by City of Charleston to be installed in the parking lot of Sector Charleston's Tradd Street location.	Coast Guard declined proposal due to the impact construction and pump station location would have to ongoing day-to-day operations.		
Charleston Peninsula Flood Study - Joint study with USACE and the City of Charleston to address tidal surge/rising sea level, and high tides above 6ft.		. Progress: Study commenced with CG participation . Challenges : Tradd Street approaches (corner of Lockwood and Broad Street) is first to flood during high tides or storm surge. .Fixes (Old and New): Study will identify options.			

Summary– Coast Guard Sector: Charleston

- **Statement of the Issue and Associated Challenge:** Flooding at Coast Guard Sector Charleston and Coast Guard Base Charleston located onboard the Federal Law Enforcement Training Center, 1050 Register Street and at 196 Tradd Street continues to be an issue. Both the Tradd Street and Register Street locations have significant issues from high tides/storm surge, offshore storms (hurricanes/tropical storms), and heavy rain events. There are several low lying areas leading into the entry routes for both facilities that make traveling to and from almost impossible.
- **Proposed Resiliency Strategy:** Continue working with private industry, local, state, and federal agency partners to determine suitable courses of action to reduce flooding.
- **Short Term Deliverables:** Continue to research/study alternatives for drainage improvement projects and pump site location.
- **Mid-Term Deliverables:** Continue to research/study alternatives for drainage improvement projects and pump site location.
- **Long-Term Deliverables:** None at this time, TBD.

J. USMC Recruit Depot Eastern Recruiting Region

J. USMC Recruit Depot: Eastern Recruiting Region

Objective	Target	Achievement Status	Additional Support Required	Execution	2019 Status
Improve access road into Depot's main ingress point	Commercial and POV vehicular traffic	. Progress: None . Challenges: elevation of main causeway is a concern during Tropical Cyclone storm surge. .Fixes (Old and New): During past storms, the causeway was closed until washed-up debris & wet reeds could be removed	Elevate road base to bolster flood resilience	Not implemented	
Quantify Built Environment Vulnerability	Quantify vulnerability and develop resiliency strategy/projects	. Progress: Contract awarded . Challenges: Standardizing which climate change model should be used as the basis for planning .Fixes (Old and New): Establish DoD policy/directive	- NAVFAC Climate Change Planning Handbook	2019-2020	
Quantify Vulnerability of training areas/ vegetative cover	Quantify vulnerability and develop resiliency strategy/projects	. Progress: Project validated . Challenges: Complex system that will require long-term study in order to reasonably predict impacts .Fixes (Old and New)	USGS provide technical lead to understand the impact of sea level rise on water table elevation and subsequent impact on storm water drainage; conversion to wetlands, etc.	2020-2025	

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Summary – USMC Recruit Depot: Eastern Recruiting Region

- USMC Recruit Depot / Eastern Recruiting Region
- Parris Island Climate Change Adaptation and Resilience Plan
  - The installation is experiencing the permanent, temporary and ongoing indications of impacts to mission from climate influenced factors. To address these impacts the installation requires a comprehensive assessment and plan to cohesively and cost-effectively address the impacts in the short, medium, and long-term.
  - Contract awarded
  - The assessment will consider the vulnerabilities of both the built and natural environment and impacts to mission
  - The resilience plan will develop discrete projects to mitigate potential impacts
  - Estimated completion date: May 2020

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K. <u>Corps of Engineers</u>

K. Corps of Engineers

Project	Objective	Recommended Plan	Additional Support Required	Execution	2019 Status
Gills Creek Flood Control Feasibility Study (1987)	Protect Private Property along Drainage Pathway	Convert and Enlarge the Upper Boyden Arbor Road Pond into a Wet/Dry Pond for Storage.		Never Implemented	H&H Outdated Mitigation
Flood Damage Reduction Projects (DOD)	Reduce Flood Risk to Onsite and Adjacent Structures	Planning H&H Environmental Historic/Cultural Construction Based on BC Ratio	Facility Responsible for Maintenance		
Flood Damage Reduction Projects (Non-DOD)	Reduce Flood Risk to Onsite and Adjacent Structures General Investigations Continuing Authorities 205 Planning Assistance to States	Planning H&H Environmental Historic/Cultural Based on BC Ratio Construction	Cost Shared $100,000 Federal Feasibility Studies/PAS 50/50 Construction 65/35		

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Stakeholder Engagement Task Force Report

November 8, 2019

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I. INTRODUCTION

Hurricane Matthew, in 2016, set record high-water levels along the Waccamaw and Pee Dee rivers and left hundreds of millions of dollars worth of damage in its wake. Following on the heels of major flooding events in 2015, Hurricane Matthew brought damage to South Carolina's coastal communities that would require years of recovery. These communities, however, did not have years. The 2018 hurricane season brought with it Florence, a slow-moving hurricane that subjected the state to heavy rains that exceeded the records set by Matthew two years earlier. Recovery efforts were set back as more homes and businesses flooded, and disaster recovery efforts began anew. As of May 2019, many residents are still displaced, without the resources to repair and return to the places they call home.

As tropical cyclone and other major storm events increase in frequency, South Carolina faces a future full of uncertainty. Nuisance flooding is already becoming commonplace in coastal communities, such as Charleston, where tidal fluctuations can interfere with transportation. Addressing future flooding events will require the collaboration of many different stakeholders in order to create a coordinated effort for better cooperation between communities, businesses, and government agencies to support current flooding relief efforts and preparation for increased community resiliency for future flooding events.

II. STATEMENT OF THE ISSUE AND ASSOCIATED CHALLENGES

Increased coastal development over the past century has led to an increase in economic losses from the landfall of tropical storms and hurricanes (Klotzbach et al., 2018). A 2018 examination of tropical cyclone landfall in the continental United States since 1900 shows a significant increase in inflation-adjusted losses as a result (Klotzbach et al.).

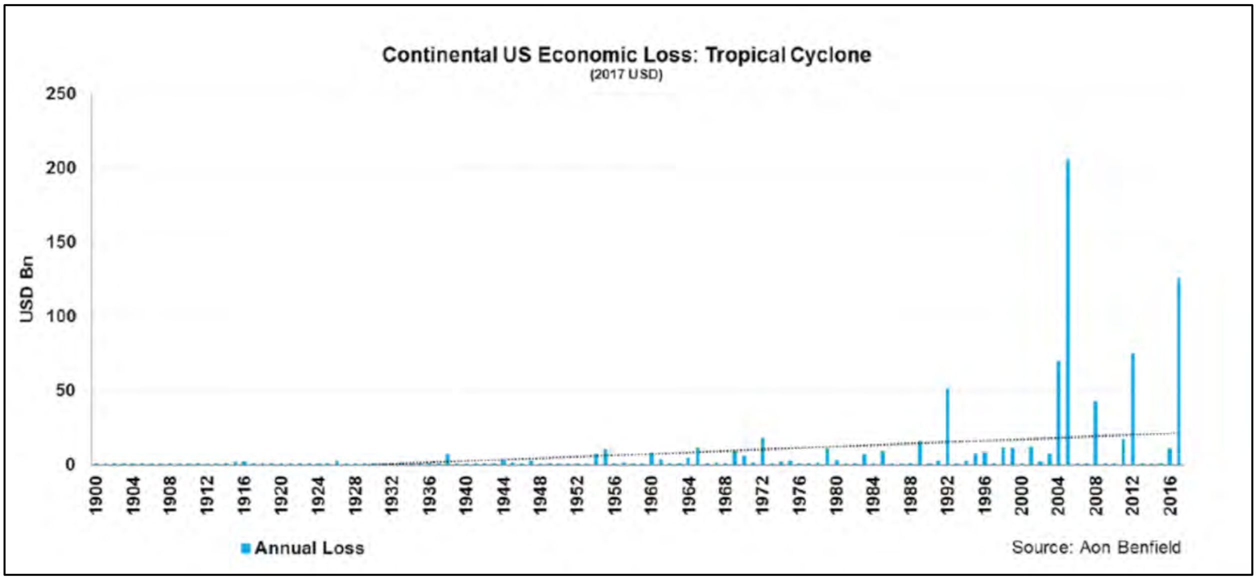


FIGURE 1: Economic losses resulting from tropical cyclone landfall between 1900 and 2017, adjusted for inflation. The linear trend shows a significant increase. (Klotzbach et al., 2018)

Klotzbach et al. predict greater economic losses in the future, even without an increase in the frequency of storm events, due to the increasing coastal population and development (2018). On top of that, the frequency of Atlantic hurricane formation has been increasing since the 1970s (Saunders and Lea, 2008). A strong correlation between sea surface temperature and hurricane formation in the North Atlantic suggests that the increase in sea surface temperature will lead to even greater hurricane frequency in the future (Saunders and Lea, 2008; Zhao and Held, 2012).

With more tourism and development along state waterways and more storm and flooding events that will create statewide impacts, South Carolina faces a future full of uncertainty. A state-wide effort is needed to respond to past flooding and prepare for future events. This collaborative effort will require the involvement of many different stakeholders. The following is a recap of literature and guidelines currently available for disaster preparation and response, and recommendations for planning and coordinating efforts between stakeholders to help achieve the goal of engaging stakeholders.

A. The Importance of Stakeholder Engagement

Natural disasters such as flooding affect the entire community, not just those who suffer direct damage. Because emergency preparation and management require coordination of all groups involved in order to effectively respond to community needs, stakeholder engagement is a vital portion of any disaster relief project (WHO). A 2014 publication by Baroudi and Rapp cites a definition of stakeholders as “any person or organization that is either actively involved in, affected by, or can influence a project (184). Whole communities face the challenges of preparation and recovery and therefore have a strong need for education on flooding and disaster preparation. A state-wide effort is needed to respond to past flooding and prepare for future events. Naturally, elected leaders need to be involved in any such efforts. However, Documet et al. point out that involvement by those with the least power in their communities promotes the greatest success in implementing innovative and sustainable outcomes (2018). Involvement by a wide variety of stakeholders helps to reveal gaps in knowledge and resources that need to be addressed in both preparation and recovery efforts.

Kartez and Lindell (1987) list two major obstacles to the adoption of effective disaster preparation: lack of experience and lack of effective planning processes. Lack of experience is an unavoidable result of the changing environmental processes that are leading to more frequent flooding events within our state. However, the findings of Kartez and Lindell’s study suggest that effective planning processes that involve multidisciplinary approaches can compensate for this lack of experience and lead to better disaster recovery outcomes.

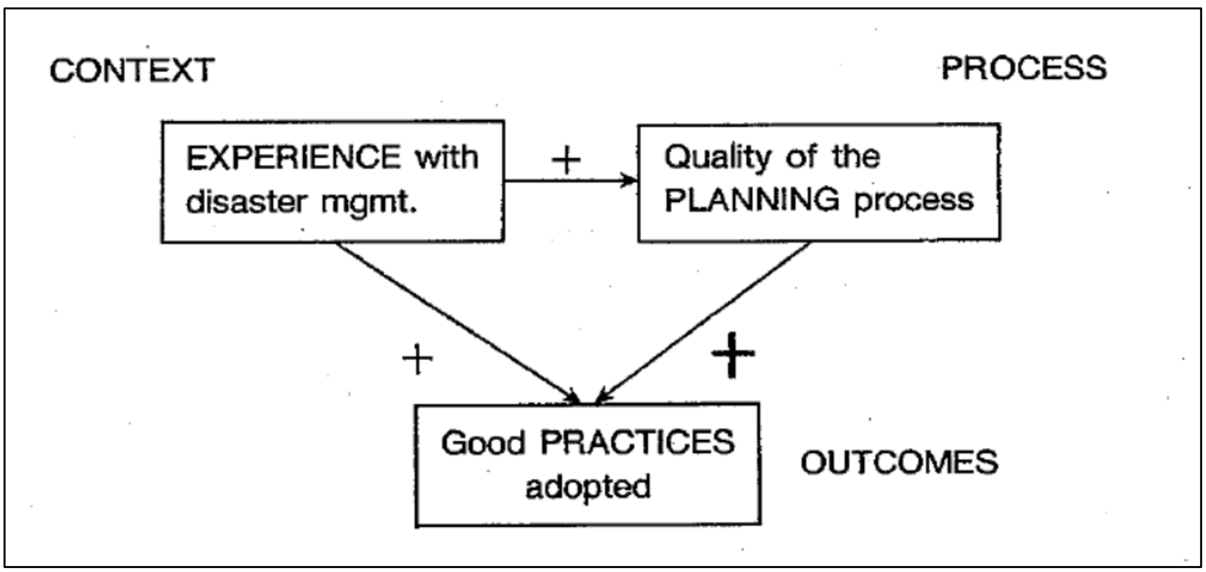


FIGURE 2: A model of local disaster planning. The quality of the planning process is the most important factor in the adoption of good preparedness practices. (Kartez and Lindell, 1987)

The movement of resources after any disaster is vital to reconstruction efforts. Baroudi and Rapp report on the importance of supply systems that are often disrupted during such events and cite stakeholder involvement as an important requirement in creating a more holistic view of disaster recovery (2014). Effective planning efforts by stakeholders can help to preemptively alter the movement of supplies in the case of an emergency that cuts off transportation routes, leading to faster and more effective distribution of resources when needed. Stakeholder engagement is also important for revealing the differences between the interests of local stakeholders and agencies involved in recovery efforts. In a 2016 case study by Lin et al., the restoration of a beach following the 2011 earthquake and tsunami in Japan saw conflict between the local community’s desire to restore the beach and the government's plans to erect a seawall. A community leader stated that "without such collective discussion, we would have never realized that there were so many issues to consider" (Lin et al., 2016: 19). Meeting with the local residents also allowed the government officials to express their own responsibilities and challenges, helping the local stakeholders to understand the work required in reconciling the two differing viewpoints (Lin et al., 2016).

The involvement of multiple groups and agencies in disaster recovery can become a challenge when those groups "assume that they can operate with the same degree of management control that they use in smaller emergencies" (Kartez and Lindell, 1987: 488). Effective stakeholder engagement during planning stages can help "eliminate duplication of effort among Federal, State, and regional entities" (FEMA, 2015: 16). Research shows that it is important for communities to work with stakeholders in order to drive recovery efforts from a community point of view (Baroudi and Rapp, 2014; Lin et.al, 2016). The ability for communities to manage successful recovery efforts and "build back better" is "dependent on stakeholder co-operation" (Mannakkara and Wilkinson, 2013: 2).

III. PROPOSED RESILIENCY STRATEGY

A. The Proactive Approach

"Resiliency" refers to the ability of a community to face challenges, such as those of natural disasters, and develop more effective methods to face future challenges (Kulig et al., 2011). Those preparing for a disaster situation need to understand the vulnerabilities in their system and what capabilities they have to deal with the range of scenarios that might be presented to them in the event of an emergency (Bharosa, 2010).

In order to fully prepare for a disaster situation, a community needs to be able to assess the risks involved and how to approach these risks. Price and Vojinovic (2008) recommend involving a variety of data to help assess flood risks, including measurements of land use and elevation, rainfall forecasts, and atmospheric models, and combining those with information about local water and energy consumption, inspection of infrastructure, and stakeholder opinions and concerns.

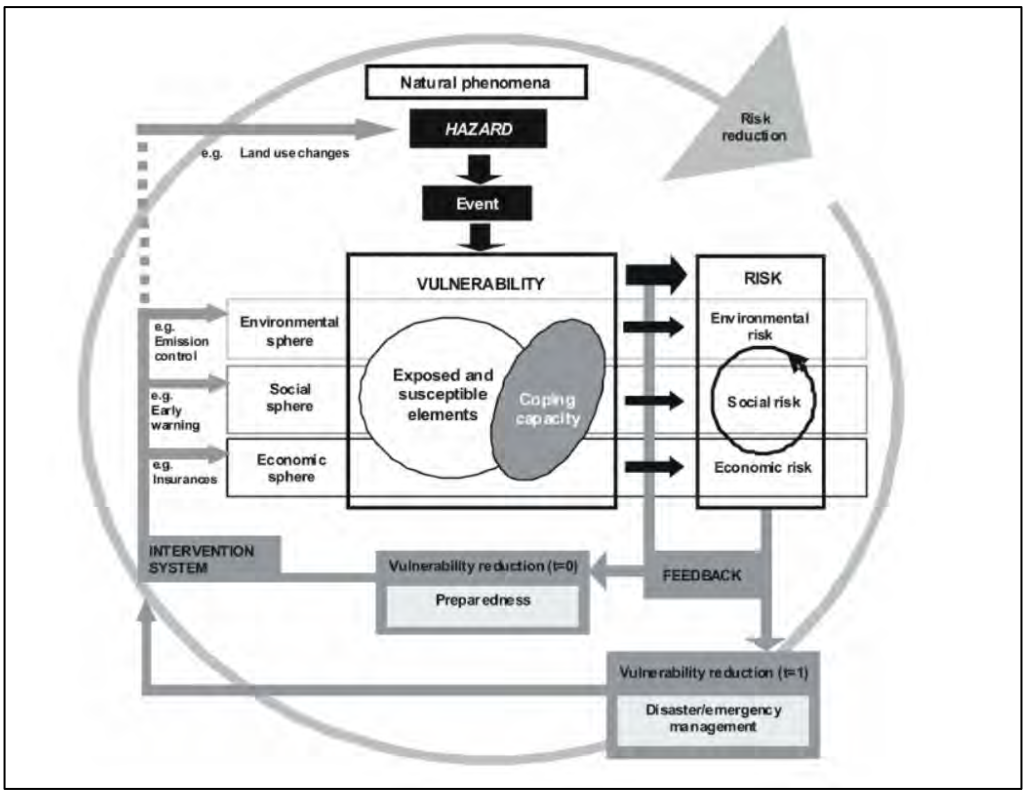


FIGURE 3: BBB Framework for Risk Assessment. (Taubenbock et al., 2009)

Bharosa et al. recommends the use of dashboards- "digitalized representations of performance indicators over a certain time interval"- to prepare for multi-agency responses to future disasters (2010; p.2). Bharosa states that the lack of standardized performance indicators among relief agencies complicates the ability of these agencies to work together in the case of a disaster (2010).

When creating dashboards to represent performance indicators, Bharosa et al. (2010) states that the challenge lies not in the application of technology, but in maintaining stakeholder engagement and understanding. Price and Vojinovic (2008) offer recommendations for the creation of a "digital city," which uses geographic information systems (GIS) maps overlain with hydrological information to show floodplains and areas of highest risk during flooding events. It is not just important for government and relief agencies to work together, but also for the general population to function as a community as well. Kulig et al. (2011) describes the importance of community leadership and proactive planning in dealing with local effects of disasters. Despite the limited resources of many small communities, "proactive behavior" such as flood mitigation techniques and evacuations of people and belongings can improve outcomes and boost community resiliency (Kulig et al., 2011; p.7). Understanding the vulnerabilities of varied socioeconomic groups involved in such communities can be an important part of a proactive approach.

The following are recommendations for disaster preparedness within small local communities:

- Develop memorandums of understanding with relevant agencies to ensure that during and after the disaster, arising issues are addressed and that lines of communication and authority are in place.
- Develop public education and disaster awareness that is appropriate for the community (e.g., having a livestock evacuation plan).
- Create an updated community disaster plan which identifies a backup community that could assist and transportation plans for evacuations (e.g., use of school busses).
- Maintain up-to-date maps to locate all individuals that may need evacuation.
- Establish policies to determine if large gatherings planned for the time period of an evacuation or evacuation alert should be canceled.

(from Kulig et al., 2011; p.2)

In developing early warning systems for tsunamis, Taubenbock et al. (2009) mentions the importance of understanding socioeconomic vulnerabilities, such as social patterns surrounding access and compliance with warnings and evacuation orders. This study develops some important questions for risk-assessment that can apply broadly to flooding situations as well:

- What kind of inundation dynamics and what time frames are expected?
- How many structures and people and which groups of people are exposed for particular hazard scenarios?
- What factors influence different responses/behaviour to the [flood] early warning and coping capacity of various social groups in emergency situation?
- Which bottlenecks arise during the process of evacuation?
- Which scenario-specific decisions and recommendations have to be met to minimize disaster risk?

(from Taubenbock et al., 2009; p.1512)

Assessing flooding risks is an important part of preparing for such events. However, effective preparation also requires community stakeholders to understand the roles that they will play in the event of a major flood. If stakeholders understand what their responsibilities are and what they are capable of, they will be able to respond more quickly and effectively in disaster situations.

B. Federal Emergency Management Roles

The Federal Emergency Management Agency (FEMA) provides assistance in preparing for and responding to disaster situations. A FEMA presentation on the role of stakeholders during recovery lists the following local government departments and their roles:

- The City Manager is in charge of hiring contractors, reporting the status of the recovery efforts, and making the necessary policy changes.
- Finance departments must document damage expenditures, keep track of reimbursable costs, and track grant applications.
- Public works departments are in charge of post-disaster assessments and the restoration of public water services, sewer systems, and any other damaged infrastructure.
- Planning committees develop disaster recovery plans, develop grant applications, distribute disaster assistance information, and identify suitable sites for reconstruction following the disaster.
- Police departments assist individuals and protect both public and private property, while fire departments perform initial search and rescue, suppress fires, and assist with damage assessments.
- Building inspectors perform damage assessments and determine the habitability of damaged structures.
- The local floodplain administrator assesses the type of flood damages sustained and uses this information to assess the accuracy of Flood Insurance Rate Maps and notify homeowners of options.
- Locally elected officials, such as mayors, city council members, and county judges, represent and advocate for their constituents. They help distribute assistance while publicizing community needs and approving or denying any proposed policy changes.

(adapted from FEMA)

In addition to these local stakeholders, FEMA's "Stakeholders and their Roles in Recovery" presentation lists the responsibilities of state-level stakeholders. State Emergency Management Assistance is in charge of the direction, control, and dispersal of resources. It also provides public information, such as warnings, training, and technical assistance. State Emergency Management oversees shelter, evacuations, law enforcement, and hazardous materials.

The governor and state legislature also play important roles, according to FEMA. The governor has the emergency powers provision and post-disaster power. He or she is responsible for requesting federal disaster declarations, mobilizing the National Guard, requiring evacuations and establishing their routes, establishing curfews, temporarily possessing private property for state use, authorizing the use of public funds for recovery, suspending state statues, entering into mutual aid agreements, and reassuring disaster victims. The governor also delegates authority to the State Director of Emergency Management. The state legislature, on the other hand, has the responsibility to order a state-wide hazards assessment, create a disaster trust fund, participate in the Emergency Management Assistance Compact, assess the state level of preparedness and the recovery and mitigation programs, establish a State Emergency Response team and inventive programs, encourage teaching of disaster awareness in schools, pass state budgets that include emergency management duties, establish a post-disaster recovery commission, and adopt or amend state enabling legislation.

With the many responsibilities shouldered by local and state officials, it is important that the citizens themselves aid in disaster recovery as well. Kartez and Lindell (1987) point out that citizens are often seen as potential obstacles to recovery, and that law enforcement is erroneously emphasized over collaboration that can lead to cooperative solutions. Studies cited by Lin et.al espouse the effectiveness of Japanese-style "Machi-zukuri" (community-based planning) that involves civic activism different from more conventional top-down government models (2016). Disaster victims, which can include both local residents and vacationers, play an important role in assisting others, participating in disaster preparedness groups, volunteering with relief organizations, providing information to other victims and to recovery agencies, and applying for disaster recovery assistance (FEMA). Media outlets, also, have important responsibilities within disaster relief. These are key for informing large groups of the population, uncovering issues and weaknesses in preparation or recovery efforts, and eliciting a strong emotional response in stakeholders (FEMA). The establishment of a central media information center is one practice recommended by Kartez and Lindell as part of a comprehensive disaster response (1987). There is a danger, however, of media outlets reporting inaccurate or misleading information. It is important for media to recognize that "disaster recovery is a complex, relatively slow process" (FEMA).

Businesses, corporations, universities, and research institutions play valuable roles in the community, and have important responsibilities in disaster response. Businesses create contingency plans in order to prepare for a disaster. The interruption of business due to a disaster can result in loss of revenue for the business, loss of work for the employees, and economic impacts that span the community. Once a business can become operational again following a disaster, it can stand as an example of recovery and reach out to provide disaster assistance to others (FEMA). Despite the macro-economic perspective of many studies, local business continuity and community recovery following disasters are intertwined with one another, as small businesses form the "backbone of the economy" and the recovery of small businesses can be an essential part of "individual, family/household, and community recovery" (Lin et.al, 2016: 4). Business leaders can advocate for their communities and persuade others to join in preparation and recovery efforts (FEMA). Universities and research institutions have a unique role in their ability to address complex research questions. However there is often a lack of applied research, and findings are not always publicized in a way that is accessible to the general public. Research should be used to provide policy advice, filling in problems or gaps in the literature and training future emergency management professionals. Post-disaster data collection and analysis is also an important role of research institutions. FEMA emphasizes the importance of updated information in flooding situations, such as high-quality topographic maps that can be used to update flood risk maps and inform flood mitigation needs in certain areas (FEMA, 2015).

Other groups that are engaged in disaster recovery include non-profit agencies that provide assistance to those affected by the disaster, environmental groups that can seek positive change in policy and regulations, and contractors who implement post-disaster recovery grant programs.

C. The Engagement Process

Local level engagement, according to the World Health Organization, requires connections with stakeholders in any decision-making process that affects them or the communities that they represent (WHO). Kartez and Lindell (1987) cite an earlier study in which the standard procedures created by local governments were often found to be inadequate in their response to real-life events. However, the assumption that only repeated experience with disaster situations can lead to better management is erroneous.

The World Health Organization, however, emphasizes that identification and consultation with stakeholders should take place early in any disaster relief effort (WHO).

The World Health Organization outlines "critical components" of stakeholder coordination:

- Identification of key stakeholders, and the lead agency or person
- Agree on Terms of Reference for the coordination team with clear objectives
- Division of roles, tasks, and responsibilities within the coordination mechanism
- Agree on working terms in relation to information sharing, tasks, responsibilities, organization of meetings
- Everyone must perceive a benefit from the investment that they [work] to coordinate

(from WHO)

Further techniques on how to coordinate stakeholder efforts come from FEMA, with conference calls, webinars, social media outreach, newsletters, websites, and regional conferences all listed as suggestions for stakeholder outreach (FEMA, 2015). Conference calls and newsletters are effective methods of distributing information in either audio or visual formats, and webinars are an effective way to combine the two formats for distribution both in real time and archived for later access. Social media and regional websites are effective outlets for communicating information to the public as well as soliciting community input, and regional conferences can gather stakeholders who might not otherwise meet face to face and offer them an opportunity to communicate and collaborate.

The time constraints created by disaster situations naturally complicate response efforts, making it difficult to apply effective project management strategies to them (Lin et.al, 2016). "Active Leadership," a project management concept focused on uniting stakeholders in a coordinated effort, is one way to approach disaster preparation and recovery. The following are key points of "Active Leadership":

1. effective identification of project objectives and relevant stakeholders
2. efficient management of stakeholder engagement
3. robust understanding of the socio-cultural context in which the [project takes] place

(from Lin et.al, 2016)

An effective disaster response requires the use of both technical skills relevant to the environmental and structural damages, and 'soft skills' involving management of involved individuals and organizations. Technical skills come into play when identifying relevant project stakeholders, and the management of those stakeholders with soft skills ensures that the project is carried out efficiently (Lin et.al, 2016).

IV. DELIVERABLES

A. **Short-Term**

1. Marion County Survey Project

The purpose of the Marion County Survey Project is to connect with stakeholders in one of the communities hardest-hit by recent flooding events. Understanding the experiences of residents whose homes and livelihoods have been affected by flooding will help inform decisions and guide plans to address recovery efforts and prepare for future flooding events.

a) *Introduction*

Situated between the Greater Pee Dee and Little Pee Dee Rivers, Marion County is a rural, low-lying county along South Carolina's coastal plain and is prone to flooding during heavy rain events. Communities, particularly in the southern portion of the county where the two rivers meet, suffered major flooding during the events in 2015, 2016, and 2018. Many residents are still displaced, and recovery efforts are still continuing into 2019. The Marion County stormwater drainage system has been identified as requiring immediate attention and plans to clean and restore some of the culverts that have not been maintained are underway. However, the Marion County Survey Project also seeks the input of the communities in Marion County to better understand the changes they want to see in flood recovery efforts by providing a method of soliciting opinions and comments from local residents. The survey seeks to gauge flooding impacts on individuals and how those individuals view recovery efforts within their communities.

b) *Development of Survey Items*

The items on the survey were chosen to address the experiences of Marion County residents after the catastrophic flooding events during recent years. An effective survey would need to be kept short, requiring no more than about 5 minutes to complete, but need to address both the physical and economic effects of flooding and the opinions of the respondents regarding recovery efforts. A series of questions were suggested by a panel of coastal policy students at Coastal Carolina University led by Floodwater Commission Chairman Thomas Mullikin. The questions were then revised with the guidance of Dr. Robert Sheehan, professor of statistics at Coastal Carolina University.

Four distinct sections of survey questions were developed. The first, "Flood Knowledge and Experience," gauges respondents' knowledge about local flooding, including South Carolina flood zones and property-level flood mitigation techniques, and the impact that flooding has had on their lives, including physical, mental, and economic effects of recent flooding. Because many of the respondents may have lived in Marion County for decades, the questions also ask respondents to answer regarding *just* flooding that has occurred during the past ten years, keeping the focus of the responses on recent flooding events. Under guidance from Dr. Sheehan, scale questions are written with four answer choices, preventing respondents from selecting a "middle" choice.

The second section of questions, “Property and Community Resources,” asks respondents about their own property; whether they rent or own, whether they have flood insurance or not, and whether they have the resources to repair flood damage. This section also asks about opinions regarding building codes and zoning, and the use of state resources in flood mitigation efforts. This section contains primarily yes/no questions and does *not* contain third “maybe” or “unsure” options.

The third section of questions is titled “Responsibility and Your Community.” These questions ask for respondent opinions about the cause of flooding events and the responsibilities involved in flood recovery efforts, providing answers and asking respondents to “check all that apply.” This section also contains an item for validity measurement, as well as several demographic questions (age, gender, and level of education).

The fourth section, optional for respondents, contains three open-ended questions that ask for further information regarding existing flood prevention measures, opinions about the use of state resources, and opinions about future flood prevention measures. While making these questions optional prompted concerns about lack of responses, the initial pilot study suggested that many respondents were eager to give their opinions.

c) *Implementation of Surveys*

Before implementing the survey in Marion County, a pilot study was performed in North Myrtle Beach to test the statistical analyses being used. After this, the first step in implementing the surveys in Marion County began with Marion County Schools. Surveys were distributed to schools to be sent home with students for completion by their parents or guardians. This provided a fast and easy method of reaching a large amount of respondents. However, because only 33% of households in Marion County have children under the age of 18, there was a need for further survey distribution in order to minimize bias (U.S. Census Bureau).

An online version of the survey was created and hosted via Google Forms, in order to more effectively distribute the survey. Evans and Mathur (2005) describe the advantages of online surveys, such as the flexibility of construction and the ease of distribution. Online surveys also offer speed in distribution and receiving responses, as responses are logged and compiled immediately, not requiring the transport of physical surveys. Online surveys are also convenient for respondents, and the distribution of online surveys has the potential to fill gaps left by physical distribution methods.

d) *Statistical Methods*

In order to establish the reliability and validity of the survey, two different statistical tests have been employed. Cronbach’s Alpha is a test of internal consistency that is commonly used to establish the reliability of a survey. Survey items with responses that should logically correlate can be examined and scored in order to provide an estimate of the survey reliability on a scale from 0 to 1, with scores closer to 1 indicating high reliability of survey responses.

This survey contains two groups of questions used for reliability analysis as determined by analysis of a pilot study (n=27). Item 1 includes the responses to question 5 (property damage, income, traffic, physical illness, and mental illness), and Item 2 includes questions 9, 10, and 12-14 (opinions on property zoning and building codes, willingness to work with other communities, and interest in further education).

The survey includes an item in section 3 for validity testing. This question asks respondents to report how relevant they feel the survey is to their opinions and experiences. Because the question uses a four point scale, a validity score of 2.5 or higher will indicate a survey relevant to the interests of the respondents.

d) *Results*

Preliminary results of the survey (n=303) showed promising reliability and validity scores. Responses to Item 1 returned a Cronbach's Alpha score of 0.736, and Item 2 a score of 0.802, suggesting high reliability of survey responses. Question 19, which asked respondents to rate the face validity of the survey, had an average response of 3.09 on a scale of 1 to 4, indicating that respondents found the questions relevant to their experiences and opinions.

Respondents spanned a wide range of ages and education levels. 49% of respondents were male, 51% female.

FIGURE 4: Demographic information from preliminary survey results: education level and age of respondents.

The preliminary results reveal some important information about residents' flood education. Only 12% of respondents knew what flood zone they lived in, and while 43% reported being aware of flood mitigation measures, they could perform on their personal property (such as flood gardens and levees), only 8% had invested in such measures. Despite this, 67% reported an interest in further education about flood prevention in their community, and 70% reported a willingness to work with other communities to address flooding.

While 55% of respondents reported sustaining some form of property damage from flooding over the past ten years, only 11% of respondents had flood insurance. Of those who had sustained flooding damage but did not have insurance, the most common explanation was that they didn't think they needed it (37%). Others reported that it was too expensive (17%) or that they did not know about it (4%). 42% of those who had sustained flooding damage and did not have flood insurance either did not give a reason or selected "other," suggesting that there may be further barriers limiting the community's access to insurance that should be investigated.

Some important relationships stood out among the respondents. Older respondents were significantly more likely to know what flood zone they lived in than younger respondents, with the majority of those who knew their flood zone being over the age of 40. Homeowners were also significantly more likely to know their flood zone than those who rented their home (0.011). Another significant difference between homeowners and renters appeared in their responses to hurricane and flooding warnings. The respondents reported how seriously they took warnings on a 4-point scale from “not seriously at all” to “very seriously,” and while there was no relationship between demographics, a significant difference in response to hurricane and flood warnings was observed between homeowners and renters. Those who owned their home reported taking warnings more seriously than those who rented.

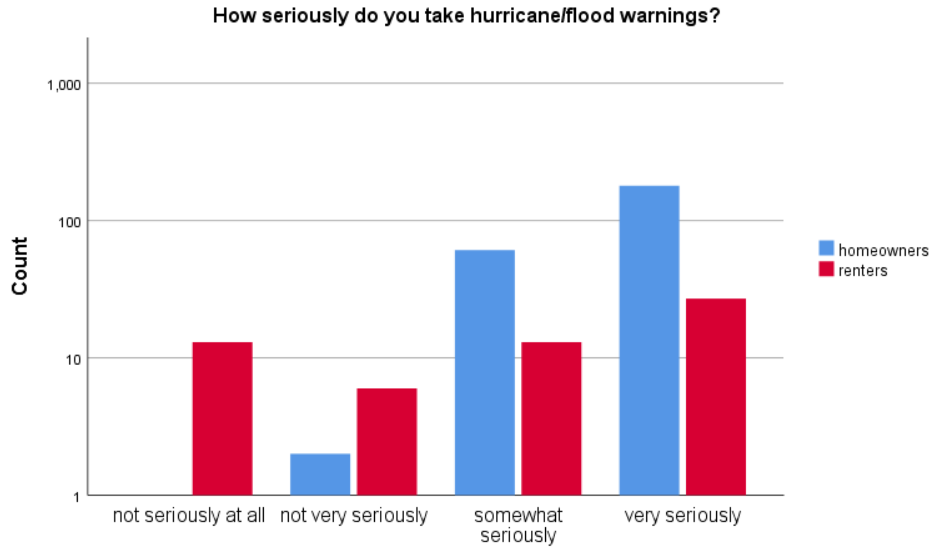


FIGURE 5: Reports of how seriously respondents take hurricane and flood warnings, separated by home ownership.

Open-ended questions at the end of the survey asked respondents for their opinions as to how best to use resources in order to prevent and mitigate future flooding. Of those who gave their opinions, almost all mentioned the poor state of drainage ditches and local streams such as Catfish Creek. Respondents suggested dredging rivers and streams, cleaning and maintaining ditches, and even digging more drainage ditches to further divert floodwaters. For all who wrote in responses, the focus was not on how to respond to past events, but how to prepare for the future. “Prevention and preparation is KEY to flooding issues,” wrote one respondent, “homeowners are limited to only so much prep[aration].” Another suggested “[d]eploy government resources before the flooding starts to help with prevention rather than deploying after the damage.” These suggestions are in line with current plans to address the ditches and culverts in Marion County, and the intention to have preparation measures in place to prevent such significant damage in future flooding events.

For the full survey results, see Appendix 1-2. As the survey is expanded in Marion County, further responses will be added and the results refined and updated to better represent the population of Marion County as a whole. These results will be analyzed by a student at Coastal Carolina University. A full report will be made accessible online for the general public.

B. <u>Mid-Term Deliverables</u>

Further plans to educate communities around the state and support preparation efforts for future flooding events will require the work of many stakeholders capable of performing research and outreach. As suggested by literature and initial reports from community surveys, our communities have a strong need for education on flooding and disaster preparation. Educational programs and resources that are both accessible and engaging will be required to reach out to vulnerable populations. In addition, research on the best practices for community preparation and resilience will rely on studying data about past flooding events and projecting into the future to learn where flooding is likely to happen next and how communities can best address those risks if and when they occur.

Making emergency management information easily accessible is an important start in connecting communities with the education they need to make informed plans for future flood responses. The creation of a statewide database of emergency information, such as contact information for state agencies and a call list for emergency management based on resident location would help to localize the information for residents and communities to make their own preparations. The South Carolina Emergency Management Division already has resources on its website for residents, such as hurricane evacuation zone maps, family planning toolkits, and listings of emergency shelters. Building upon resources like this and making sure that local communities are aware of how to access the information should be an important goal of stakeholder outreach.

Other outreach programs and studies such as the Marion County Survey Project offer opportunities to understand the experiences and opinions of flood-affected communities. There are also projects underway to connect individual residents to a wider audience using online tools. Dr. Jaime McCauley, of Coastal Carolina University, is working on the development of an interactive flooding map, where residents can pinpoint their location and upload images and firsthand accounts of flooding. This kind of project both promotes community solidarity as it allows residents a platform through which to share their stories and offers valuable spatial information for researchers seeking data on the height and extent of past flooding. Building upon such a system could lead to the creation of a statewide flood database, allowing for the combination of personal anecdotes and historic records such as water levels and rainfall to create an interactive map. Expanding it to include mapping of the state's road system; primary, secondary and tertiary, including unpaved roads, would help inform residents when planning their travel during flooding events. Such a map, if available online, would provide information to both local residents and researchers interested in both the mechanics and the social impacts of South Carolina's recent flooding history. Future projects of this kind will be important steps to connecting with communities and reaching out to those communities for the purpose of flood recovery and future flood preparation.

Flood preparation efforts will rely on efforts to study past events and project the extent of future events. Studies similar to Taubenbock et al.'s (2009) modeling of tsunami evacuation patterns could be used to help inform residents of the most effective methods and routes for evacuation prior to a major hurricane or flood. In addition, there is a need for projects similar to current research being performed by Dr. Jinkun Lee of East Carolina University, who is using data of road closures during past flooding events to model where and when roads may face closures in future flooding scenarios. The ability to identify how and when roads become impassable during a flood event will allow communities and relief agencies to make preparations for alternate routes, and even preemptively reroute traffic in order to most effectively deliver resources to the affected area.

Another important facet of stakeholder engagement is involving local residents in rescue efforts and data collection during flooding conditions. The winning team of IBM's 2018 Call for Code, inspired by stories of blackouts following hurricane-related flooding, presented Project OWL. This includes a fleet of rubber duck-like flotation devices that can be deployed during flooding conditions and provide a wireless network to facilitate communication between residents and first responders using existing devices such as smartphones. These would be particularly useful in remote areas. Team lead Bryan Knouse is quoted by IBM Developer Staff explaining the importance of the project, that "with better information and better analytics, you can get the resources you need to the places that need it most" (2018). Innovations such as Project OWL are providing opportunities for communities to remain connected even during disasters, and it will be important for communities here in South Carolina to find methods that will connect residents and authorities not only before and after flooding events, but also during events when the need for rescue and relief efforts is greatest. Being able to receive reports about flooding as it happens will also enable researchers to better recognize patterns in the process and extent of flooding, and better refine predictive models in order to issue more accurate flood warnings and evacuation orders. The more that the state of South Carolina understands about the experiences and needs of flood victims, the better we can prepare for and respond to flooding events in the future.

C. Long-Term Deliverables

1. Promoting Cooperation and Collaboration

The wide reach of the South Carolina Floodwater Commission means that many important stakeholders are already involved in work with the Commission's task forces. Part of the goal of the Stakeholder Engagement Task Force is to provide recommendations for collaborative work between ongoing projects. Moving forward, it is important to recognize ways that the Floodwater Commission's Task Forces can work together to achieve their respective goals.

The Artificial Reef Systems Task Force aims to construct artificial reef systems along the state's coastline and promote the construction of organic breakwaters through programs like the Oyster Recycling and Restoration Initiative (CORRI). Artificial reefs are a form of "soft stabilization," or protection of vulnerable coastlines using natural methods of erosion control. The Living Shoreline Task Force is also investigating and implementing soft stabilization measures such as the installation of vegetation cover and oyster reefs. This work falls in line with efforts by the Infrastructure and Shoreline Armoring Task Force in assessing the need for "hard stabilization" such as seawalls in developed areas along the South Carolina coastline. Evaluation of locations for either soft stabilization such as artificial reefs or hard stabilization could be performed as a collaborative effort to reduce redundancy and promote better understanding of the factors that influence the decision of how to stabilize eroding coastline and protect beaches.

The Landscape and Beautification Task Force already has intentions to work with the Living Shorelines Task Force in coordinating efforts to both protect and beautify coastlines with the help of native vegetation. The Landscape and Beautification Task Force aims also to reduce the effects of flooding through landscaping, as well as maximizing the value of such properties through promotion of public use. The Economic Development Task Force is also interested in promoting use of natural resources along South Carolina's waterways, and could benefit from collaboration with landscaping efforts that use native plants to stabilize shorelines and create green spaces that attract both local residents and tourists. The Local Economic Development Strategy outlined by the Economic Development Task Force in their report is a process that could benefit the Landscape and Beautification Task Force in their efforts to design, establish, and maintain green spaces.

Projects underway by the Smart River and Dam Security Task Force could benefit flood mitigation efforts statewide. Access to the geographic information system (GIS) detailing the state's river systems would offer the groundwork for further projects that rely on elevation and mapping data. These data, if shared, could inform decisions made by the National Security Task Force in their efforts to assess risks to South Carolina's federal installations, projects undertaken by the Infrastructure and Shoreline Armoring Task Force in their efforts to identify and attend to maintenance needs within existing drainage systems, and research by the Grid Security Task Force to identify risks to the state's critical infrastructure assets.

Along with promoting Cooperation and Collaboration the Stakeholder Engagement Taskforce should explore additional education and outreach options. These would include a possible central media information center established for each region that follows floodplains or watersheds and not necessarily political boundaries. Use of websites and NIXLE alerts at a more local level. Using trusted community partners such as the Chamber of Commerce, Houses of Worship, School Districts and Tax Bills to disseminate important and/or timely information. More creative platforms to disseminate information might include Gas Station TV, Enmark Radio, Convenience Stores and town landfills where employees could help to disseminate important information.

Further cooperation of the task forces will likely continue as their efforts are refined and put into motion. The Stakeholder Engagement Task Force will continue to encourage collaboration that will benefit both the efforts of the Floodwater Commission and the communities involved.
See Appendix 3 for Synopsis/Priorities/Implementation Suggestions.

APPENDIX 1: FULL FLOODWATER SURVEY

I. Flood Knowledge and Experience

1. Do you know what flood zone you live in?

○Yes ○No

- **If yes, what flood zone do you live in?**

○AE ○A ○X

2. Are you aware of things you can do on your property to reduce the effects of flooding?

○Yes ○No

3. Have you invested in flood protection on your own property (rain garden, levee, etc.)?

○Yes (*see question 23*) **○No**

- **If you have not invested in personal flood protection, would you be interested if provided with education and resources?**

○Yes ○No

4. How often have you experienced flooding on your property over the past ten years?

○ never
○ occasionally
○ often
○ very often

5. How seriously has flooding affected your life in the following ways over the past ten years?

- **Property damage or destruction:**

○ not at all affected
○ somewhat affected
○ seriously affected
○ very seriously affected

- **Loss of work or income:**

○ not at all affected
○ somewhat affected
○ seriously affected
○ very seriously affected

- **Obstruction of traffic and travel:**

○ not at all affected
○ somewhat affected
○ seriously affected
○ very seriously affected

- **More frequent physical illness or infection:**

○ not at all affected
○ somewhat affected
○ seriously affected
○ very seriously affected

- **More severe mental health problems or illness:**

○ not at all affected
○ somewhat affected
○ seriously affected
○ very seriously affected

APPENDIX 1: FULL FLOODWATER SURVEY (cont.)

<table>
<tr><th colspan="2">II. Property and Community Resources</th></tr>
<tr><td rowspan="2">6. Do you own or rent your home?

○Own ○Rent

▪ If you own property, how many acres of land do you own?
________________</td><td>10. Should building codes be updated because of flooding?

○Yes ○No</td></tr>
<tr><td>11. Have you used resources provided by local businesses after flooding?

○Yes ○No</td></tr>
<tr><td rowspan="2">7. Do you have flood insurance?

○Yes ○No

▪ If you do <u>not</u> have flood insurance, why not?

○ too expensive
○ didn't think I needed it
○ didn't know about it
○ other</td><td>12. Would you be willing to work with other communities to address flooding?

○Yes ○No</td></tr>
<tr><td>13. Would you be interested in further education about flood prevention?

○Yes ○No</td></tr>
<tr><td>8. If your house has been damaged or destroyed, do you or your landlord have the means to repair it?

○Yes ○No
○ My house has not been damaged.</td><td>14. Do you believe it is a worthwhile use of resources to address local flooding?
○ Yes
○ No, resources should be used in other ways (see question 24)</td></tr>
<tr><td>9. Should property zoning be revised because of flooding?

○Yes ○No</td><td>15. Do you have suggestions to help prevent flooding or reduce impacts?

○Yes (see question 25) ○No</td></tr>
</table>

APPENDIX 1: FULL FLOODWATER SURVEY (cont.)

<table>
<tr><th colspan="2">III. Responsibility and Your Community</th></tr>
<tr><td>16. How seriously do you take hurricane/flood warnings?

○ not seriously at all
○ not very seriously
○ somewhat seriously
○ very seriously</td><td>20. What is your age?

○ younger than 20 ○ 20-29
○ 30-39 ○ 40-49
○ 50-59 ○ 60-69
○ 70-79 ○ older than 80</td></tr>
<tr><td>17. What is the cause of recent flooding? (mark all that apply)

□ storms/heavy rain events
□ poor drainage
□ development of natural areas
□ climate change
□ other</td><td>21. What is your gender?

○Male ○Female</td></tr>
<tr><td>18. Who is responsible for recovery after flooding? (mark all that apply)

□ individual residents
□ local government
□ non-profit organizations
□ state government
□ federal programs (such as FEMA)</td><td>22. What is the highest level of education you have completed?

○ some K-12 schooling
○ high school diploma or GED
○ some college
○ 2-year (associate’s) degree
○ 4-year (bachelor’s) degree
○ postgraduate degree</td></tr>
<tr><td>19. How relevant are the questions in this survey to your experiences and opinions?

○ not relevant at all
○ not very relevant
○ somewhat relevant
○ very relevant</td><td></td></tr>
</table>

APPENDIX 1: FULL FLOODWATER SURVEY (cont.)

IV. Open Response Questions
23. If you have taken flood prevention measures on your property, please briefly describe them here.
24. If you have suggestions for other ways to use local and state resources, please share them here.
25. If you have suggestions for ways to help prevent flooding and reduce impacts, please share them here.

APPENDIX 2: FULL SURVEY RESULTS

Do you know what flood zone you live in?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	37	12.2	12.2
	no	266	87.8	100.0
	Total	303	100.0	

If yes, what flood zone do you live in?

		Frequency	Valid Percent	Cumulative Percent
Valid	no response	266	87.8	87.8
	A	17	5.6	93.4
	AE	3	1.0	94.4
	X	17	5.6	100.0
	Total	303	100.0	

Are you aware of things you can do on your property to reduce the effects of flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	129	42.7	42.7
	no	173	57.3	100.0
	Total	302	100.0	
Missing		1		
Total		303		

Have you invested in flood protection on your own property?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	24	8.0	8.0
	no	277	92.0	100.0
	Total	301	100.0	
Missing		2		
Total		303		

APPENDIX 2: FULL SURVEY RESULTS (cont.)

If you have not invested in personal flood protection, would you be interested if provided with education and resources?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	158	60.1	60.1
	no	105	39.9	100.0
	Total	263	100.0	

How often have you experienced flooding on your property over the past ten years?

		Frequency	Valid Percent	Cumulative Percent
Valid	never	177	65.6	65.6
	occasionally	52	19.3	84.8
	often	34	12.6	97.4
	very often	7	2.6	100.0
	Total	270	100.0	
Missing		33		
Total		303		

How seriously have you been affected by the following: Property damage or destruction

		Frequency	Valid Percent	Cumulative Percent
Valid	not at all affected	138	45.5	45.5
	somewhat affected	95	31.4	76.9
	seriously affected	21	6.9	83.8
	very seriously affected	49	16.2	100.0
	Total	303	100.0	

APPENDIX 2: FULL SURVEY RESULTS (cont.)

Loss of work or income

		Frequency	Valid Percent	Cumulative Percent
Valid	not at all affected	186	61.4	61.4
	somewhat affected	82	27.1	88.4
	seriously affected	19	6.3	94.7
	very seriously affected	16	5.3	100.0
	Total	303	100.0	

Obstruction of traffic and travel

		Frequency	Valid Percent	Cumulative Percent
Valid	not at all affected	108	35.6	35.6
	somewhat affected	105	34.7	70.3
	seriously affected	32	10.6	80.9
	very seriously affected	58	19.1	100.0
	Total	303	100.0	

More frequent physical illness or infection

		Frequency	Valid Percent	Cumulative Percent
Valid	not at all affected	227	74.9	74.9
	somewhat affected	58	19.1	94.1
	seriously affected	8	2.6	96.7
	very seriously affected	10	3.3	100.0
	Total	303	100.0	

More severe mental health problems or illness

		Frequency	Valid Percent	Cumulative Percent
Valid	not at all affected	231	76.2	76.2
	somewhat affected	55	18.2	94.4
	seriously affected	11	3.6	98.0
	very seriously affected	6	2.0	100.0
	Total	303	100.0	

APPENDIX 2: FULL SURVEY RESULTS (cont.)

Do you own or rent your home?

		Frequency	Valid Percent	Cumulative Percent
Valid	own	243	80.5	80.5
	rent	59	19.5	100.0
	Total	302	100.0	
Missing		1		
Total		303		

If you own property, how many acres of land do you own?

		Frequency	Valid Percent	Cumulative Percent
Valid	.25	3	1.6	1.6
	.33	2	1.1	2.7
	.50	5	2.7	5.4
	.75	2	1.1	6.5
	1.00	87	47.3	53.8
	1.50	3	1.6	55.4
	2.00	57	31.0	86.4
	2.50	2	1.1	87.5
	3.00	3	1.6	89.1
	4.00	4	2.2	91.3
	5.00	1	.5	91.8
	6.00	1	.5	92.4
	8.00	3	1.6	94.0
	11.00	1	.5	94.6
	20.00	1	.5	95.1
	22.00	1	.5	95.7
	40.00	1	.5	96.2
	50.00	2	1.1	97.3
	55.00	2	1.1	98.4
	60.00	2	1.1	99.5
	70.00	1	.5	100.0
	Total	184	100.0	
Total		303		

APPENDIX 2: FULL SURVEY RESULTS (cont.)

Do you have flood insurance?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	32	10.6	10.6
	no	269	89.4	100.0
	Total	301	100.0	
Missing		2		
Total		303		

If you do not have flood insurance, why not?

		Frequency	Valid Percent	Cumulative Percent
Valid	too expensive	25	9.4	9.4
	didn't think I needed it	117	44.2	53.6
	didn't know about it	39	14.7	68.3
	other / no response	84	31.7	100.0
	Total	265	100.0	

If your house has been damaged or destroyed, do you or your landlord have the means to repair it?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	55	18.5	18.5
	no	38	12.8	31.2
	my house has not been damaged	205	68.8	100.0
	Total	298	100.0	
Missing		5		
Total		303		

APPENDIX 2: FULL SURVEY RESULTS (cont.)

Should property zoning be revised because of flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	152	50.5	50.5
	no	149	49.5	100.0
	Total	301	100.0	
Missing		2		
Total		303		

Should building codes be updated because of flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	230	76.2	76.2
	no	72	23.8	100.0
	Total	302	100.0	
Missing		1		
Total		303		

Have you used resources provided by local businesses after flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	68	22.5	22.5
	no	234	77.5	100.0
	Total	302	100.0	
Missing		1		
Total		303		

APPENDIX 2: FULL SURVEY RESULTS (cont.)

Would you be willing to work with other communities to address flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	213	70.5	70.5
	no	89	29.5	100.0
	Total	302	100.0	
Missing		1		
Total		303		

Would you be interested in further education about flood prevention?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	201	66.6	66.6
	no	101	33.4	100.0
	Total	302	100.0	
Missing		1		
Total		303		

Do you believe it is a worthwhile use of resources to address local flooding?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	249	82.5	82.5
	no, resources should be used in other ways	53	17.5	100.0
	Total	302	100.0	
Missing		1		
Total		303		

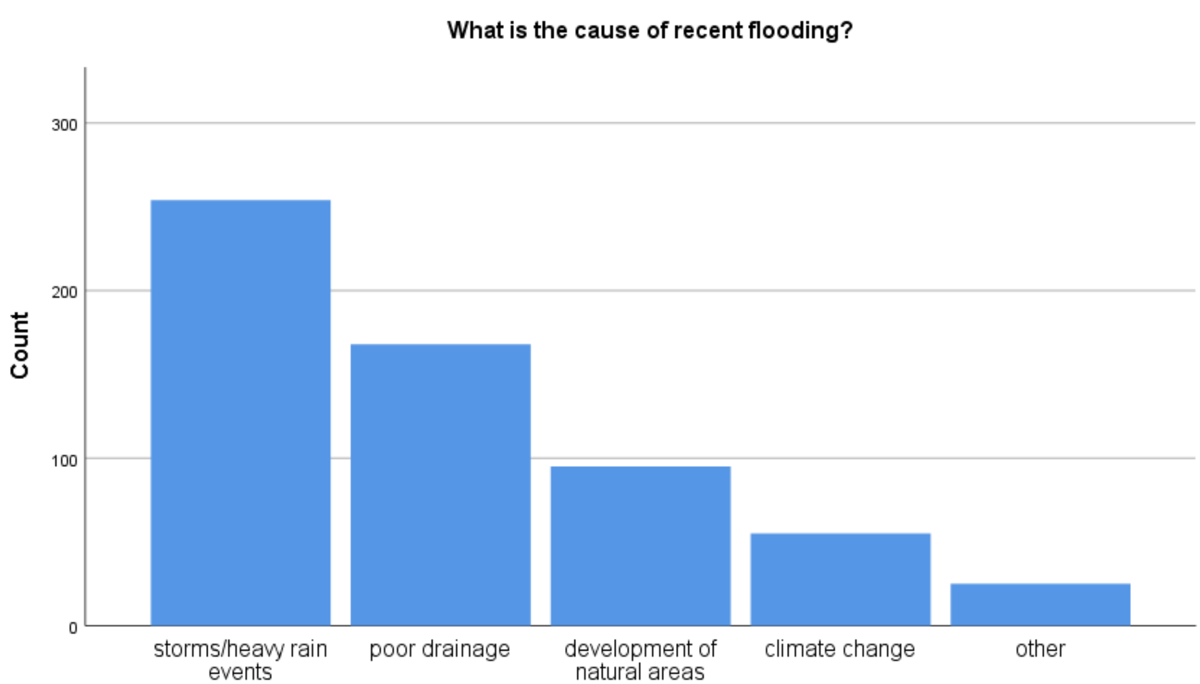
APPENDIX 2: FULL SURVEY RESULTS (cont.)

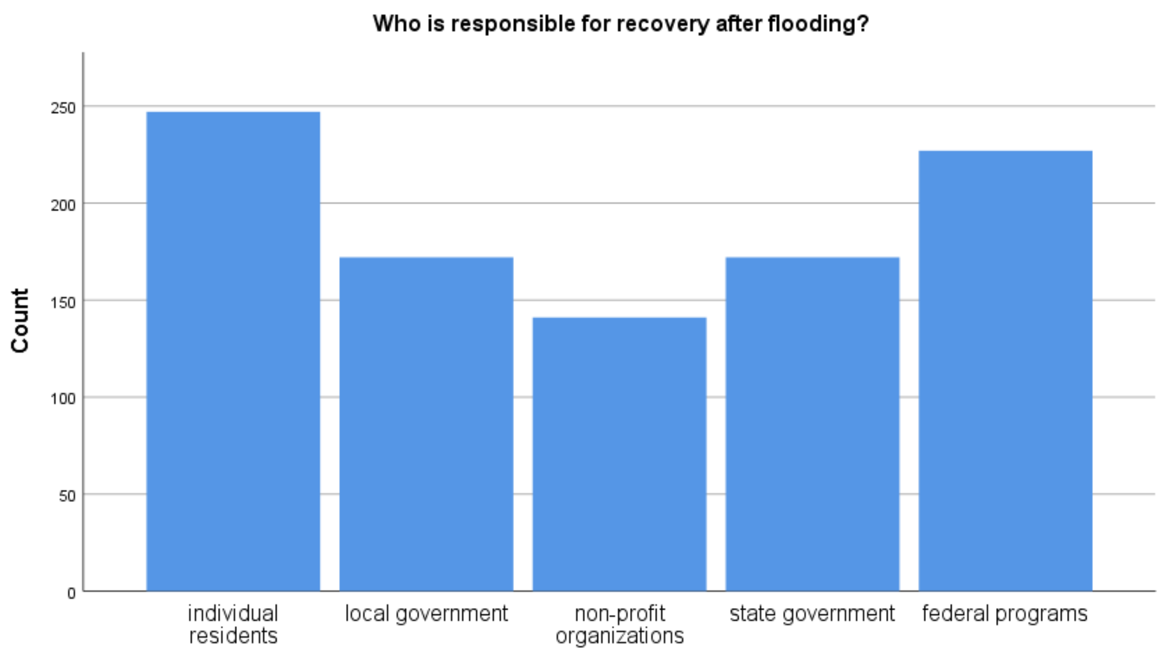
Do you have suggestions to help prevent flooding or reduce impacts?

		Frequency	Valid Percent	Cumulative Percent
Valid	yes	64	21.2	21.2
	no	238	78.8	100.0
	Total	302	100.0	
Missing		1		
Total		303		

How seriously do you take hurricane/flood warnings?

		Frequency	Valid Percent	Cumulative Percent
Valid	not seriously at all	14	4.6	4.6
	not very seriously	8	2.6	7.3
	somewhat seriously	75	24.8	32.0
	very seriously	206	68.0	100.0
	Total	303	100.0	





How relevant are the questions in this survey to your experiences and opinions?

		Frequency	Valid Percent	Cumulative Percent
Valid	not relevant at all	19	6.3	6.3
	not very relevant	28	9.3	15.6
	somewhat relevant	163	54.0	69.5
	very relevant	92	30.5	100.0
	Total	302	100.0	
Missing		1		
Total		303		

APPENDIX 2: FULL SURVEY RESULTS (cont.)

What is your age?

		Frequency	Valid Percent	Cumulative Percent
Valid	younger than 20	30	9.9	9.9
	20-29	16	5.3	15.2
	30-39	61	20.2	35.4
	40-49	48	15.9	51.3
	50-59	82	27.2	78.5
	60-69	55	18.2	96.7
	70-79	9	3.0	99.7
	older than 80	1	.3	100.0
	Total	302	100.0	
Missing		1		
Total		303		

What is your gender?

		Frequency	Valid Percent	Cumulative Percent
Valid	male	146	48.7	48.7
	female	154	51.3	100.0
	Total	300	100.0	
Missing		3		
Total		303		

What is the highest level of education you have completed?

		Frequency	Valid Percent	Cumulative Percent
Valid	some K-12 schooling	24	8.0	8.0
	high school diploma or GED	86	28.6	36.5
	some college	47	15.6	52.2
	2-year (associate's) degree	59	19.6	71.8
	4-year (bachelor's) degree	59	19.6	91.4
	postgraduate degree	26	8.6	100.0
	Total	301	100.0	
Missing		2		
Total		303		

APPENDIX 3
Synopsis/Priorities/Implementation Suggestions

T—Technical Factors
AS—Area Specific
C—Critical Issue
G—General

Technical (T)

PROJECTS NEEDEED BUT NOT YET BEGUN

Methods need to be developed involving a variety of data to help assess flood risks, including measurements of land use and elevation, rainfall forecasts and atmospheric models as well as geographic information system (GIS) data detailing the state's river systems as well as elevations and mapping data.

Create a "digital city" which uses geographic information systems (GIS) for high quality topographic maps overlain with hydrological information to show flood plains and areas of highest risks during flooding events to inform flood mitigation needs in specific areas. Studying data about past flooding events and projecting communities can best address those risks when they occur.

Develop dashboards as digitized representations of performance indicators over a certain time interval to prepare for multi-agency responses to future disasters. This would help overcome the lack of standardized performance indicators among relief agencies which has historically complicated the ability of these agencies to work together in cases of disaster. Measurement dashboards with data should evaluate and prioritize risks as well as proactive efforts for damage prevention/minimization, information dissemination and recovery efforts. Dashboards should incorporate all available digital information including GIS, flood zones, flood plains, tide charts (useful for areas prone to coastal flooding as well as inland river flooding), zones ranked according to flood threat (i.e. first area to flood, remains flooded the longest, most difficult due to drainage issues) as well as current topographical maps showing flood risk areas and flood mitigation needs.

PROJECTS BEGUN THAT CAN BE BUILT UPON

The South Carolina Emergency Management Division (SCEMD) already has resources on its website such as hurricane evacuation zone maps, family planning toolkits and listings of emergency shelters. This could be expanded to include contact information for state agencies and a call list for emergency management based on resident location.

Dr. Jaime McCauley of Coastal Carolina University is developing an interactive flooding map where residents can pinpoint their location and upload images and firsthand accounts of flooding. This will promote community solidarity and allow residents a platform through which to share their stories. Building on this system could lead to the creation of a statewide flood database with historical data, topographical maps, timelines, changes due to development/woodland and marsh destruction and allow for personal anecdotes and historic records such as water levels and rainfall to create a truly interactive map. This project can connect communities and reach out to those communities for flood preparation and recovery. It could also provide full mapping of the state's road systems: primary, secondary, tertiary and dirt roads.

IBM's 2018 Call for Code produced "Project OWL" which uses rubber-duck like flotation devices with antennas that can be deployed during flooding to provide a wireless network to facilitate communication between residents and first responders using existing devices such as smart phones. These mobile transceivers can work in remote areas.

General (G)

All communities have a strong need for education on flooding and disaster preparation. A state-wide effort is needed to respond to past flooding and prepare for future events. This will require the collaboration of many different stakeholders. Involvement by those with the least power in their communities promotes the greatest success in implementing innovative and sustainable outcomes. Involvement by a wide variety of stakeholders helps to reveal gaps in knowledge and resources that need to be addressed in both preparation and recovery efforts. Two major obstacles to effective disaster planning are (1) lack of experience and (2) lack of an effective planning process. An effective planning process that involves multidisciplinary approaches can compensate for lack of experience and lead to better disaster recovery outcomes. Effective stakeholder engagement during planning stages can help eliminate duplication of effort among Federal, State and regional entities.

All education and disaster awareness programs need to be community appropriate (e.g. having a livestock evacuation plan).

Update flood zone maps and building codes to reflect current information.

Provide increased information on flood insurance (i.e. what it is, the importance of, cost, etc.).

Create targeted information for renters whose interests and priorities may differ from homeowners.

Make plans to deploy government resources before the flooding starts to help with prevention rather than deploying after the damage.

The Marion County Survey

While this survey was administered in a limited geographical area, its results are invaluable and it should be replicated in other selected areas. Among its most remarkable findings:

1. The majority surveyed don't know what flood zone they live in.
2. The majority have not invested in any flood protection on their property.

3. The majority do not have flood insurance.
4. The majority are willing to work with each other to address flooding issues.
5. The majority are interested in further education about flood prevention.
6. The majority believe it's a worthwhile use of resources to address local flooding.
7. The majority take flood/hurricane warnings seriously.

Area Specific (AS)

Education includes what residents can do to reduce effects of flooding on their property.

Determine how often residents' property has flooded over the past 10 years (can be incorporated into the GIS mapping/topographical flood maps to help determine zones, prevention methods).

Determine the extent of property damage or destruction (also to be incorporated into the GIS mapping/topographical flood maps).

Local EMD's need to determine the most effective method(s) of communication and partner with SCEMD and follow FEMA/JIC protocols.

Critical Issue (C)

Stormwater drainage issues. Immediate maintenance is needed, continued clearing, upgrading, improvements need to be prioritized. Expansion may also need to be incorporated into municipal budgets.

Dredging of drainage ditches, culverts and flood-prone waterways.
This addresses current flooding issues and acts as a preventive measure for the inevitable future flooding events

Collaboration Opportunities

Artificial Reef Systems impact the **Living Shoreline** which in turn impacts **Infrastructure and Shoreline Armoring.**

Landscape and Beautification impacts **The Living Shoreline**

Landscape and Beautifucation impacts **Economic Development**

Drainage on waterways in the Upstate could impact waterways through the Midlands down into the Lowcountry. Coordination, timing, and communication across the state is priority.

Proactive projects—maintenance, implementation of flood mitigation processes helps not to drain limited personal and municipal budgets and resources.

Public education and outreach to as many areas of the state as possible.

Education/Outreach Options:

1. A central media information center should be created for each region, following flood plains and not necessarily following political boundaries.
2. Municipal/County/State Emergency Management Departments
3. Sheriffs' Offices—NIXLE Alerts
4. County and Municipal Websites
5. SC EMD Website
6. Social Media (Facebook, Twitter, Instagram, etc.)
7. TV/Radio
8. Chambers of Commerce
9. Houses of Worship (many citizens rely on clergy for information and advice)
10. Tax Bills (such things as flood zones, elevations, etc. can be incorporated into tax notices)
11. School Districts (children can educate parents)
12. Gas Station TV (everybody buys gas, especially during a weather event. While not all gas stations have TV in their pumps, many do and many more are coming on stream)
13. Enmark Radio (what better way to communicate with citizens than while they are captive standing in line at a convenience store)
14. Convenience Centers/Town Dumps (convenience center attendants can hand out flyers of evacuation/emergency information)
15. Make presentations to county and municipal councils and employ their resources and creativity.

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State of South Carolina

GOVERNOR HENRY MCMASTER

THOMAS S. MULLIKIN, CHAIRMAN

South Carolina Floodwater Commission

Federal Funding Task Force Report

November 8, 2019

FEDERAL FUNDING TASK FORCE

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Senator Chip Campsen
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I. NATURAL DISASTERS & SOUTH CAROLINA

A. <u>Severity of the Storms & Years of Repetitive Flooding</u>

South Carolina is no stranger to natural disasters and has been devastated by five major storm or flood events in the last four years.

In October 2015, the state experienced what many thought would be a once in a generation event with Hurricane Joaquin. Many communities across the state suffered one-thousand-year flood levels. More than 20 inches of rain devastated the state, causing loss of life and extensive damages to roads, bridges, dams, homes and businesses. Over 600 dams and roads were impacted, while some completely failed. Many businesses remained shuttered for four to six weeks, while some never reopened. More than 33,000 homes were inundated with over a foot of water, and many remain uninhabitable to this day. The damage estimate was $2 billion, a formidable level of harm for our small state.

One year later, Mother Nature devastated the state once again. In October 2016, Hurricane Matthew made landfall near McClellanville, South Carolina. The storm ravaged the interior of South Carolina, submerging entire communities under feet of water. More than 32,000 homeowners suffered property and personal losses. To make matters worse, underserved communities where poverty and unemployment rates are above state and national averages were hit the hardest.

In September 2017, Hurricane Irma came ashore in Florida and came up through Georgia and South Carolina. Irma's large wind field pushed water ashore along the coast, causing extensive flooding, downed trees, power outages, and damage to homes and businesses. The effects were felt from the coast and through the interior of the state to the mountains. Yet another federal disaster had to be declared.

In September 2018, Hurricane Florence made landfall and stalled over the Northeastern border of South Carolina. Across the entire watershed, rivers rose above historic levels and into businesses and homes. A major federal disaster was declared across 19 counties in the state. The most severe federal disaster designation was declared in eight counties in the northeastern corner of the state where 16,000 homes were impacted.

Florence was followed by Hurricane Michael in October 2018. Although it had been reduced to a tropical storm by the time it reached South Carolina, it nonetheless was a significant flood event causing extensive flooding along the southeastern coast up to and including Charleston, downed trees, power outages, and heavy rainfall.

1. <u>Hurricane Florence</u>

Hurricane Florence was initially predicted to be a Category 4 storm. However, the storm weakened to a Category 1 hurricane as it made landfall on September 14, 2018. The eye of the storm hit Wrightsville Beach, North Carolina in the early morning and lingered over South Carolina for two days before it traveled up to the northeast as a tropical depression.

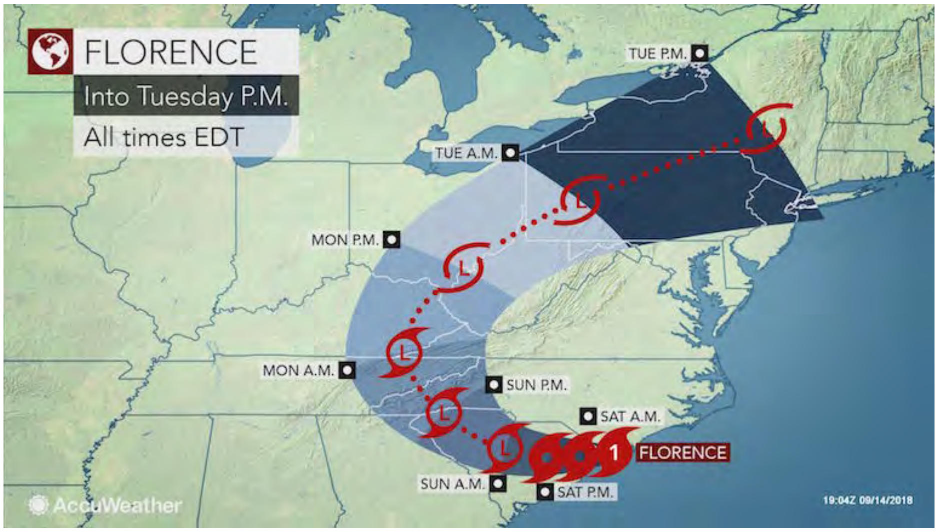


FIGURE 1: AccuWeather, Sep. 14, 2018

After Hurricane Florence made landfall the storm slowed drastically down and there was record-breaking rainfall across eastern North Carolina and northeastern portion of South Carolina. According to the National Weather Service at NOAA, over 30 inches of rain were measured in North Carolina locations, exceeding the highest single-storm rainfall amounts in the state. A station in Loris, South Carolina recording 23.63 inches of rain setting a new state tropical cyclone rainfall record for the state of South Carolina.

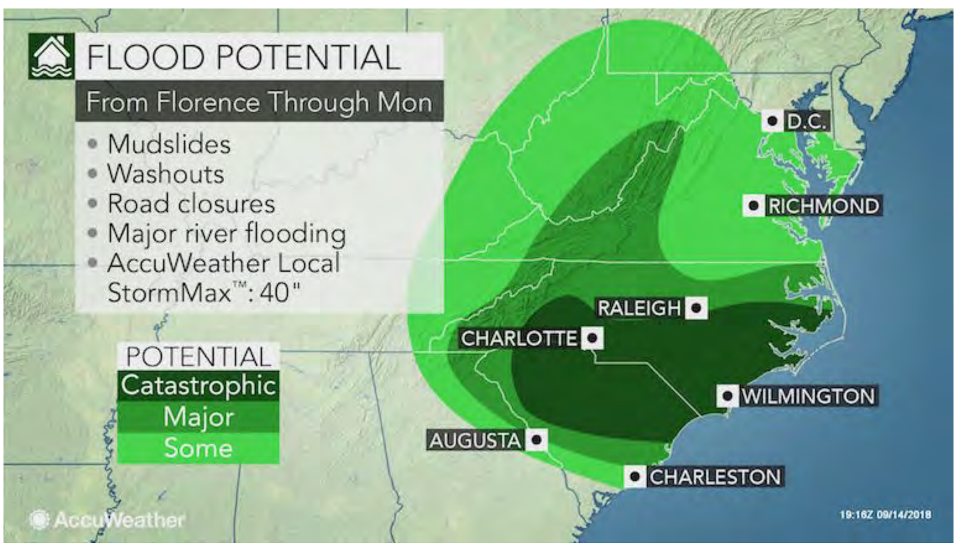


FIGURE 2: AccuWeather, Sep. 14, 2018

One of the major issues during Hurricane Florence was the drastic amount of rainfall. USGS reported nine river gauges had floods exceeding their 1 in 500 year expected return intervals. There was record flooding for all major rivers in the Pee Dee River Basin: Waccamaw River, Little Pee Dee River, Great Pee Dee River, and Lumber River. These rivers all flow into Winyah Bay near Georgetown. As record-breaking amounts of water slowly traveled downstream, extensive flooding and damage occurred throughout the Pee Dee and Grand Strand.

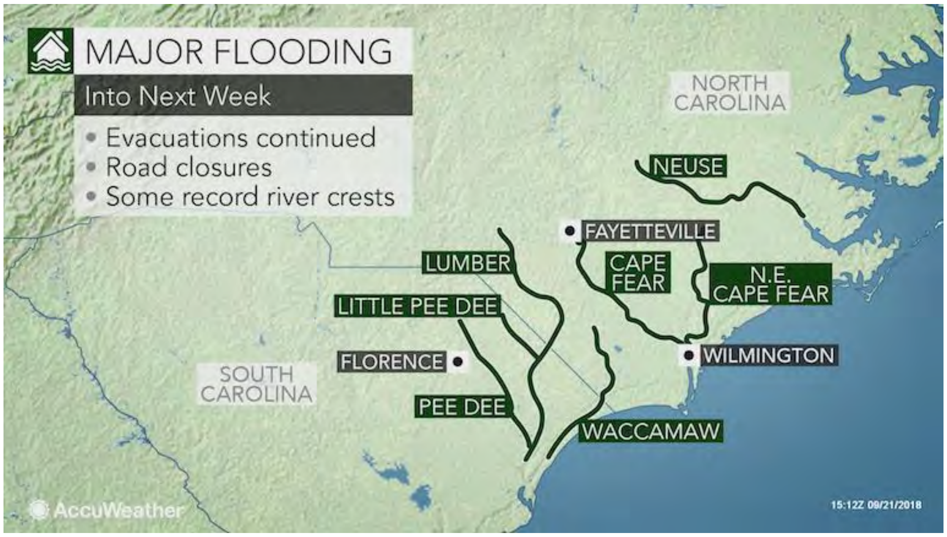


FIGURE 3: AccuWeather Sep. 21, 2018

For example, two weeks after Hurricane Florence made landfall, on Wednesday, September 26, 2018 the Waccamaw River crested at around 21.2 feet. The previous record for the river was only 17.9 feet.

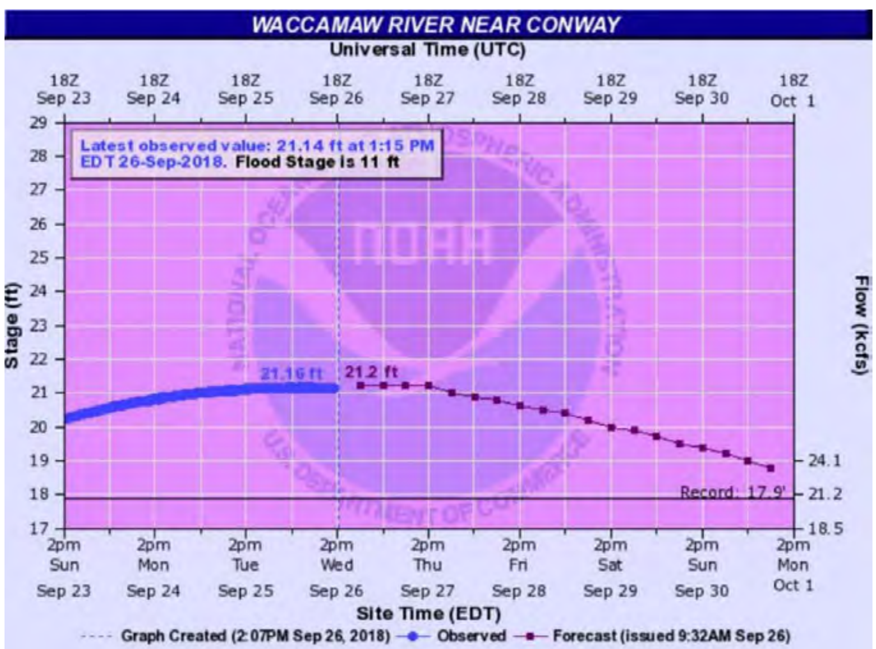


FIGURE 4: NOAA, Sep. 26, 2018

This flooding eventually destroyed roads, bridges and damaged thousands of homes. In total, Hurricane Florence caused more than 1,200 road closures in South Carolina including parts of Interstate 95.

Hurricane Florence took 53 lives. Hundreds of thousands of people were left without power and thousands took refuge in emergency shelters over the course of the storm as well as the flooding that caused severe conditions weeks later. In South Carolina, over 16,000 houses were damaged.

These homes were primarily in the same area that was hit the worst during 2015 Severe Storm and Floods and Hurricane Matthew.

II. FEDERAL RESPONSE

A. FEDERAL FUNDING SOURCES

The Robert T. Stafford Disaster Relief and Emergency Assistance Act was enacted in the late 1980s to help support citizens in disaster recovery efforts. This Act establishes the process and implementation of a presidential disaster declaration and determines the type of projects and aid that may be distributed to an area. The Federal Emergency Management Agency (FEMA) is the agency that has boots on the ground and coordinates emergency response efforts.

Following a natural disaster, a variety of federal funding sources exist to provide assistance to individuals, businesses, non-profits, farmers and many others affected by the disaster. This process begins through a disaster declaration.

Pursuant to Robert T. Stafford Disaster Relief and Emergency Assistance Act (Stafford Act) Section 401, "All requests for a declaration by the President that a major disaster exists shall be made by the Governor of the affected State." The Governor makes the request to a FEMA Regional Office. State officials and federal personnel begin estimating the extent of the disaster and conduct a preliminary damage assessment (PDA). The information gathered is used to support the Governor's request to FEMA for a presidential disaster declaration. (If the extent of the disaster is severe, the Governor's request may be submitted prior to the completion of a PDA.) The Governor's request must include the amount of state and local resources available for recovery, the severity of the damage and the type of assistance needed. FEMA then makes a recommendation to the President. Based on the Governor's request, the President may declare an emergency or major disaster and this declaration triggers federal assistance programs.

1. FEMA Public Assistance

Public Assistance (PA) is a FEMA grant program that is available to help communities recover following a major disaster or emergency declared by the president. PA provides emergency assistance to save lives and protect property and assists with permanently restoring community infrastructure affected by a federally declared disaster.

States, federally recognized tribes, US territories, local governments and private non-profits may be eligible applicants. PA provides funding to cover costs associated with eligible work activity. Eligible work includes projects that were affected by the declared disaster and are located in the designated disaster area.

PA emergency work covers the costs for safety measures, such as debris removal, shelters, evacuations, and protective barriers. Public assistance for permanent work consists of projects that repair and replace public infrastructure and facilities that were damaged from the disaster.

The President in the emergency or major disaster declaration will announce which category of public assistance is available to the distressed areas. Public Assistance may include the following categories:

Emergency Work:

- Category A- Debris Removal
- Category B - Emergency protective measures

Permanent Work:

- Category C – Roads and bridges
- Category D – Water control facilities
- Category E – Buildings and equipment
- Category F – Utilities
- Category G – Parks, recreational and other facilities

Public assistance funding generally has a cost-share split with 75% of the costs covered at the federal level and the remaining 25% of the costs covered by the grantee. The President has the ability to increase the amount of the federal cost-share to above 75% in certain circumstances.

2. FEMA Individual Assistance

Section 408 of the Stafford Act provides financial and direct services to eligible individuals and households, following a presidential disaster declaration, which have uninsured or underinsured necessary expenses and serious needs. The main program that offers assistance to individuals and families is the Individuals and Households Program (IHP). This program provides Housing Assistance and Other Needs Assistance.

There are certain requirements and limitations for receiving individual assistance (IA). IHP is the only form of IA that may be authorized by an emergency declaration. The cap for individual assistance is $34,000 per household, but this is an annually adjusted amount based on Department of Labor Consumer Price Index. This assistance is also limited to 18 months following the disaster declaration, unless there is an extension.

a) *Housing Assistance*

FEMA provides funding paid directly to individuals or households for the housing repairs following a natural disaster. Housing Assistance under IHP is provided at 100% federal share.

Financial housing assistance is available to eligible applicants in the form of rental assistance, lodging expense reimbursement, home repair assistance and home replacement assistance. FEMA will cover costs for temporary housing while repairs are being made to an applicant's primary residence. Additionally, FEMA will reimburse an applicant for lodging expenses incurred while the applicant is displaced during or following the natural disaster. FEMA will also provide assistance for replacing an applicant's primary residence that was destroyed. FEMA will provide financial assistance for costs to repair an applicant's primary residence, utilities and privately-owned access routes.

If there are no available housing resources in an area where a natural disaster occurs, then the state may request Direct Temporary Housing Assistance. In these cases, FEMA may provide manufactured homes to be used as temporary housing. Additionally, FEMA may enter into lease agreements with owners of multifamily rental properties to provide temporary housing. And in very rare cases, if there are no housing resources available at all, home repair or construction services may be provided.

b) *IHP Other Needs Assistance*

There is an opportunity for individuals and households to receive financial assistance for expenses and needs caused by the disaster called IHP Other Needs Assistance. Other Needs Assistance requires 25% of the costs be covered by the grantee.

IHP Other Needs Assistance includes: funeral assistance, medical and dental assistance, child care assistance and other assistance. Funeral assistance is available to individuals who have or will incur funeral expenses directly or indirectly related to the disaster. Medical and dental funding is available to cover expenses associated with injury, illness, loss of medication and equipment, and insurance co-payments caused by the disaster. Funding for child care is available to cover up to eight weeks of child care expenses for a household's increased financial burden to care for their children who are 13 years and younger or 14 to 18 years old if the child has a disability. Additionally, other items that the state determines may be purchased or rented after a disaster to help recover and later be reimbursed may be covered, such as those associated with cleaning efforts.

According to FEMA, some additional IHP Other Needs Assistance is available to individuals who do not qualify for an SBA loan. This includes but is not limited to repairing or replacing furniture, appliances, ADA accessibility items, tools, protective clothing required by an employer, and educational materials. Repairing damaged vehicles or transportation costs may also be covered by this assistance. Also funds may be available to cover moving costs or to store personal property when repairing a damaged primary residence.

i. Crisis Counseling Program

Section 416 of the Stafford Emergency Act provides funding under FEMA for mental health assistance and training activities in areas that have received a Presidential major declaration with Individual Assistance. This program assists with recovering from the psychological effects of natural disasters. There are two grant service programs provided to disaster areas: 1) Immediate Service Program; and, 2) Regular Services Program. The Immediate Service Program provides funds for 60 days of services following an IA declaration, while the Regular Services Program provides funds for up to 9 months from the date of the notice of an award.

ii. Disaster Case Management

Pursuant to Section 426 of the Stafford Act, "the President may provide case management services, including financial assistance, to State or Local government agencies or qualified private organizations to provide such services to victims of major disasters to identify and address unmet needs." This disaster case management provides a partnership between a case manager and victim to help assist them in their disaster recovery plan.

iii. Disaster Unemployment Assistance

Disaster Unemployment Assistance Program provides unemployment benefits and reemployment services to individuals who have become unemployed as a direct result of a natural disaster for a maximum of 26 weeks. This program is funded through FEMA and administered by the Department of Labor and the state employment office.

One or more the following criteria must be met to qualify for this program:

- Individuals who are unemployed due to the disaster, and do not qualify for regular unemployment insurance benefits.
- Self-employed individuals and small business owners who lost income due to the disaster.
- Individuals who were prevented from working due to an injury caused by the disaster.
- Individuals who have become the major supplier of household income due to the disaster-related death or injury of the previous major supplier of household income.
- Individuals who are unable to reach their job or self-employment location because they must travel through the affected area and are prevented from doing so by the disaster.
- Individuals who were to commence employment or self-employment but were prevented by the disaster.

iv. Disaster Legal Services

Disaster legal services are available to disaster victims following a declared disaster. FEMA partners with the American Bar Association, Young Lawyers Division to provide free legal assistance. The legal assistance typically provided includes insurance claims, landlord/tenant issues, consumer protection matters, replacement of wills and other documents that may have been destroyed in the natural disasters. These services are provided to low-income individuals who are unable to receive adequate legal services due to the natural disaster.

v. Disaster Supplemental Nutrition Assistance Program

Following a natural disaster, USDA offers short-term food assistance to affected families. Eligible households receive one month of the maximum amount of SNAP benefits according to their household size. Benefits are issued through an EBT card. Households not normally eligible for SNAP benefits may qualify for D-SNAP if they have been impacted by the disaster. Additionally, ongoing SNAP beneficiaries whose benefits are less than the monthly maximum can request a supplement in order to bring their benefits up to the maximum level.

Following a request from the State, USDA operates D-SNAP benefits in areas that have received a FEMA IA declaration. Residents in any IA designated county who have experienced damage to or destruction of their homes, loss or inaccessibility of income, or non-reimbursable disaster-related expenses are encouraged to apply. Additionally, in order to be eligible for D-SNAP, individuals must also be below certain income thresholds. This is referred to as the disaster gross income limit.

The primary responsibility for providing D-SNAP assistance rests with the State. The State must design a D-SNAP plan, evaluate the need for D-SNAP benefits after a disaster, and submit a detail request to USDA to operate D-SNAP. Once approved, the State is responsible for effectively carrying out the program, i.e. processing applications, conduction public outreach and education, and administering EBT cards. Once the program closes, the State must perform post-disaster reviews and report their findings to USDA.

USDA provides approval for D-SNAP plans and also supports the State's efforts through policy guidance, training, and technical assistance. Additionally, USDA provides funding for 100 percent of D-SNAP benefits and 50 percent of the State administrative costs.

3. <u>Other Federal Assistance to Individuals and Families</u>

Other than FEMA IA, there are other forms of federal funding available to victims of a natural disaster including: SBA Disaster Loan Program, National Flood Insurance Program and Community Development Block Grant – Disaster Relief program.

a) *Small Business Administration Disaster Loan*

According to the Small Business Administration, SBA provides, "low-interest disaster loans to businesses of all sizes, private non-profit organizations, homeowners, and renters to repair or replace uninsured/underinsured disaster damaged property." This is an affordable loan to allow individuals and businesses to recover from declared disasters.

The following are the maximum amounts a small business, homeowner or renter may borrow:

- A homeowner may borrow up to $200,000 to repair / replace his or her disaster damaged primary residence.
- A homeowner or renter may borrow up to $40,000 to repair / replace damaged personal property.
- A small business, small agriculture cooperative, small business engaged in aquaculture or a non-profit organization may borrow up to $2 million for economic injury.
- A small business may apply for maximum business loan (physical and economic injury of $2 million.

SBA disaster loans could become available in a couple different ways. If the President declares a major disaster declaration or an emergency declaration and authorizes both IA and PA, SBA loans become available for those located within a disaster area. Additionally, if the President declares a major disaster declaration, and provides only PA to the state, SBA disaster loans may be available for private non-profits. Additionally, SBA could issue disaster declarations as well; however, only under certain circumstance. SBA could issue a physical disaster declaration if the governor has requested assistance. SBA could issue an economic injury disaster loan declaration when at least 5 small businesses suffered economic injury because of a disaster and eligible applicants would include small agricultural cooperative or private nonprofits. SBA could also issue a declaration for economic injury disaster loans if the Secretary of Agriculture has made a determination of a natural disaster or the Secretary of Commerce issues a determination that a fishery resource failed.

SBA will review the applicant's credit and then will estimate the total physical loss to the damaged property. The loan officer will make a determination within 2-3 weeks of the application being filed and then disburse funds.

i. Eligibility for SBA Disaster Loan Program

The SBA Disaster Loan Program assesses three criteria in making credit decisions: 1) eligibility based on disaster losses; 2) satisfactory credit; and 3) repayment ability.

b) *National Flood Insurance Program (NFIP)*

The NFIP serves as the primary source of federal assistance following a severe flood event. Originally established in 1968, the program has undergone a series of short-term reauthorizations. The general purpose of the NFIP is to provide flood insurance to properties with significant flood risk. The program also encourages the adoption of floodplain management and safety standards.

The NFIP is managed by FEMA, which coordinates with local communities in order to develop Flood Insurance Rate Maps (FIRMs). These maps depict the amount of flood risk on a geographic basis. While there are many different amounts, or zones, of flood risk, Special Flood Hazard Areas (SFHAs) are particularly significant. SFHAs are estimated to flood during a "1 in 100 year flood," which means properties within these areas have a flood risk of 1% or greater in a given year. SFHAs are significant because properties within these areas are required to purchase flood insurance in order to receive a federally backed mortgages. Additionally, homeowners within SFHAs who do not purchase flood insurance can be denied other forms of federal assistance following a natural disaster.

NFIP carries multiple policies for both residential and commercial buildings. Maximum coverage limits are set by federal law and are dependent on occupancy type. For example, single-family homes have a coverage limit of $250,000 for the structure. Additional insurance options exist in the private market for homeowners seeking to insure homes with values above $250,000.

Generally, premium rates in the NFIP are intended to reflect the full flood risk of a structure. The costs of a flood insurance policy are determined by factors such as elevation and location with respect to flood zones. However, Congress has taken steps to insulate certain properties from the full costs of flood insurance. These properties include structures built before December 31, 1974 or homes designated into a new flood zone as result of an updated FIRM.

c) *Community Development Block Grant-Disaster Recovery (CDBG-DR)*

CDBG-DR is a highly flexible source of federal funding that can be utilized to fill the unmet needs of local communities following natural disasters. CDBG-DR funds must be used for "…necessary expenses related to disaster relief, long-term recovery, and restoration of infrastructure, housing, and economic revitalization in the most impacted and distressed areas resulting from a major disaster."

Following a major natural disaster, Congress will typically pass legislation containing a broad appropriation of CDBG-DR funding. In order to comply with earmark rules, the legislative text will only reference a certain dollar amount to be spent in relation to certain natural disasters.

Immediately following the passage of this legislation containing CDBG-DR funding. The Department of Housing and Urban Development (HUD) will examine data collected by FEMA and SBA in order to break down the total appropriation into smaller allocations for specific grantees. Eligible grantees are determined in the legislative text, but frequently includes states, and sometimes local units of government. HUD will publish this allocation, along with other guidance relating to the use of funds, in the federal register. Within the federal register notice, HUD will typically require at least 80 percent of the total combined funds provided within each State to address unmet needs within “most impacted and distressed (MID) communities.”

Once this federal register notice is published, grantees can submit an action plan to HUD in order to draw down the funding. The plan must be approved by HUD before funding can be accessed by the grantee.

4. Assistance for Agriculture

The United State Department of Agriculture (USDA) administers several programs to assist the agriculture industry in the wake of a natural disaster. The federal crop insurance program often serves as the primary source of federal assistance following a natural disaster. While types of coverage vary, crop insurance is available to most major and many specialty crops. Farmers must purchase a policy before planting, and payments are triggered by deductibles specified in the policy. USDA also administers the Noninsured Disaster Assistance Program (NAP), which provides assistance to crops that are ineligible for federal crop insurance.

Federal assistance in the forms of grants and loans are also available through USDA. The agency provides compensation for eligible livestock producers following a natural disaster. Low-interest financing and deferral options are also available to farmers who have suffered losses due to natural disasters.

In early 2018, Congress passed the Bipartisan Budget Act of 2018, which established the Wildfire and Hurricane Indemnity Program (WHIP). This program provides payments to eligible producers for crop, tree, bush, and vine losses from a hurricane or wildfire in 2017. Payments are based on expected value of the lost crop, the value of the actual crop harvested, insurance coverage, and insurance indemnity. In addition to maximum payment limitations, all producers who receive WHIP payments are required to purchase coverage for the next two crop years. The Bipartisan Budget Act provided $2.68 billion in funding for this program.

5. Federal Highways

The U.S. Department of Transportation (DOT) provides federal assistance for roads damaged by natural disasters. The Emergency Relief (ER) Program, administered by the Federal Highway Administration, provides funding for repairs undertaken on federal-aid highways in response to a natural disaster. Similar to other transportation programs, funding is distributed through state DOTs; local communities are unable to apply.

Funding for the Emergency Relief program is provided through separate revenue streams. On December 4, 2015 the ER program was reauthorized in the Fixing America's Surface Transportation Act. This act provided the ER program with an annual authorization of $100 million in contract authority from the Highway Trust Fund. However, the nationwide cost of repairing disaster-damaged roads typically exceeds $100 million annually. In response, Congress has frequently acted to provide the ER program with additional funding through either annual or supplemental appropriations legislation.

Emergency repairs to restore essential travel, minimize the extent of the damage, or protect remaining infrastructure are completely reimbursed by the federal government, as long as the repairs are accomplished within 180 days of the disaster. Permanent repairs are reimbursed at the same federal share as would normally apply to a federal-aid highway facility. Typically, repairs to interstate system highways are reimbursed 90 percent of the cost, and most other highways at 80 percent.

6. U.S. Army Corps of Engineers

The U.S. Army Corps of Engineers, overseen by the Department of Defense, is responsible for various civil works projects in relation to natural disasters. The agency carries out activities to plan, construct, and maintain the operation of important water resource and shore protection projects. The Corps primarily provides federal assistance in the wake of a natural disaster through four accounts - construction, operation and maintenance, investigations, and flood control and coastal emergencies (FCCE). While these four accounts receive federal funding during the annual appropriations process, Congress typically acts to provide increased supplemental funding in response to significant natural disasters.

Typical Corps projects in response to natural disasters include beach renourishment, river and channel deepening and dredging, and dam operations. Similar to FEMA public assistance, projects require a non-federal sponsor which typically face cost-sharing requirements.

Recent post-disaster appropriations have also funded the Army Corps, at full federal expense, to complete a detailed analysis and maps of the vulnerability of coastal populations from North Carolina to Alabama, plus Puerto Rico and the US Virgin Islands. A similar analysis was conducted after Superstorm Sandy for the states impacted by that storm. It has proven to be a useful science-based product for federal, state and local agencies in emergency planning and longer-term mitigation strategies.

7. National Oceanic and Atmospheric Administration (Department of Commerce)

The National Oceanic and Atmospheric Administration may provide funding to disaster areas for operations, research, facility repairs, construction and fishery disaster assistance. Some funds may be available following a disaster for repairing equipment and property or for marine debris removal. Funds for mapping or hurricane intensity forecasting may be available following a natural disaster. Additionally, funds may available for disaster relief associated with fishery disaster assistance projects for mitigating effects of commercial fishery failures directly related to a storm.

NOAA administers the "Title IX" National Coastal Resilience Fund. This program makes grants to restore or enhance natural features that provide flood protection for coastal communities (e.g., salt marshes, sand dunes, oyster reefs and river floodplains). The grant program is administered by the National Fish & Wildlife Foundation (NFWF). The 2019 disaster appropriations bill includes $50 Million for this program.

8. <u>Other Federal Assistance</u>

The significant disaster recovery programs are listed above, but there may be other federal assistance programs that are available for disaster relief. Other forms of assistance may be available through United States Geological Survey, Department of Education, Economic Development Administration and others.

The input of other federal programs into disaster recovery funding usually occurs through the agencies listed above.

It is important not to decouple disaster recovery funding from disaster response. Disaster recovery should be a seamless process that flows from disaster response.

III. DISASTER RECOVERY FUNDING

The National Disaster Recovery Framework (NDRF) utilizes federal agencies to provide assistance to the FEMA Federal Disaster Recovery Coordinator (FDRC) in the form of Field Coordinators (FCs). These FCs provide the FDRC with staff subject matter expertise in two ways: they give the FDRC expert advice on resource impacts and identify sources of funding for recovery projects as well as additional agency resources that can be brought in to assist with disaster recovery issues/projects. The State must request that the NDRF or portions of the NDRF be requested during a federally declared emergency.

Typically, projects are developed in the Recovery Support Strategy document where the scope of the project, the resource recovery outcome, the estimated project costs and the sources of the project funding are identified. These project descriptions are developed by the FCs in conjunction with the stakeholders (State resource /regulatory agencies, Non-governmental organizations, and other concerned governmental entities and organizations) for review by the FDRC.

Some federal agencies/programs that have funding and/or provide assistance during disaster recovery are described below.

A. U.S. Department of Agriculture (USDA)

1. Emergency Watershed Protection Program

The Emergency Watershed Protection Program (EWPP) was created by Congress to respond to emergencies caused by natural disasters. EWPP is designed to help people reduce imminent hazards to life and property threatened by excessive erosion and flooding caused by heavy rains, drought, earthquakes, windstorms and other natural disasters. The purpose of EWPP is to help communities with a common problem. All projects undertaken must be sponsored by a political subdivision of the State such as a city, county, or a flood control district. The projects can remove debris from wetlands and floodplains.

2. Environmental Quality Incentives Program (EQIP)

EQIP addresses livestock mortality (disposal of dead livestock), destroyed fences, broken windmills, loss of vegetation, and excessive erosion.

The USDA Natural Resources Conservation Service (NRCS) is responsible for administering the EWPP and EQIP programs, working through local units of government, usually through the county extension agents.

3. Emergency Conservation Program (ECP)

ECP provides funding to rehabilitate farmland damaged by flooding.

4. Emergency Forest Restoration Program (EFRP)

EFRP provides payments to eligible owners of rural nonindustrial private forest land to carryout emergency measures to restore forest health on land damaged by natural disaster.

5. Emergency Assistance for Livestock, Honeybees and Farm-raised Fish Program (ELAP)

ELAP provides money to producers of livestock, honeybees and farm-raised fish to help compensate for losses due to disease, drought, and adverse weather.

6. Livestock Indemnity Program (LIP)

LIP provides benefits to livestock producers for livestock deaths in excess of normal mortality caused by adverse weather.

7. Noninsured Crop Disaster Assistance Program (NAP)

NAP provides financial assistance for uninsurable crop losses due to drought, flood, hurricane, or other natural disasters.

8. Tree Assistance Program (TAP)

TAP provides financial assistance to qualifying orchardists and nursery tree growers to replant or where applicable, rehabilitate eligible trees, bushes and vines lost by natural disasters.

B. U.S. Army Corps of Engineers Continuing Authorities Program (CAP)

The Continuing Authorities Program establishes a process by which the Corps of Engineers can respond to a variety of water resource problems without the need to obtain specific Congressional authorization for each project.

•Decreases the amount of time required to budget, develop, and approve a potential project for construction.
•Federal funding limits range from $500,000 to $10 million. The total cost of a project is shared between the federal government and a non-federal sponsor and various percentages.

Projects:

- Need to be requested by the Sponsor
- Do not need Congressional authorization
- Are implemented quickly
- Have limited scope and complexity
- Have established federal costs limits
- Do not compete with government infrastructure for prioritization

The CAP can be used to remove debris, protect shorelines, government facilities, and infrastructure.

NOTE: Two FEMA Fact Sheets have been included below that address the funding limitations and possible policy inconsistencies of the USDA EWPP, USCOE CAP, and FEMA Emergency Response debris removal program funding guidelines.

C. U.S. Environmental Protection Agency (EPA) Urban Waters Program

This EPA program has the goal to improve federal agencies' abilities to offer support to local efforts, and to promote the economic, environmental and social benefits of urban waters revitalization projects. The EPA launched the Urban Waters Federal Partnership in 2011. Today, 14 federal agencies work together in 19 "Partnership Locations" with the support of 28 Non-governmental organizations and in collaboration with local partners on the ground. Partnership locations include the watersheds related to an urban water project and the communities within them. Detailed information on the 19 locations, as well as the Vision, Mission and Principles for the Urban Waters Federal Partnership can be found at urbanwaters.gov.

D. U.S. Department of the Interior (USDOI)

1. The National Park Service's (NPS) Rivers, Trails, and Conservation Assistance Program

(RTCA) helps carry out the National Park Service's conservation and outdoor recreation mission. As one of the agency's leading community assistance programs, RTCA is uniquely positioned to increase the value and benefits of the NPS by helping communities across the country conserve and restore waterways, preserve open spaces and parks, develop trails and greenways, and provide opportunities for outdoor recreation. The RTCA provides park planning assistance and related services but does not provide funding for construction.

The RTCA in Louisiana following the 2016-17 floods was brought in to assist recovering communities with park planning to utilize FEMA mitigation funding rebuilding lost and damaged community parks. After Hurricane Harvey, RTCA and USEPA Urban Waters were recruited to assist in a large proposed mitigation project for Houston stormwater management that involved the creation of a "super park complex" south of the city to store stormwater.

2. National Conservation Preservation Technical Training Center

Through the National Park Service, the National Conservation Preservation Technical Training Center provides expertise in cultural and historical, and archeological resources and access to National Historic Preservation Grants for restoration and recovery of these resources.

3. United States Geological Survey (USGS)

U.S. Geological Survey provides streamflow measurements, flood inundation maps, coastal hazard areas and geomorphology.

In the Louisiana 2016-17 floods and Hurricane Harvey mitigation programs, USGS teamed with FEMA Mitigation personnel using HMPG funds and the state water resource agencies to define, map and describe the watersheds of developed urban areas to attempt to estimate stormwater capacity and future economic losses from storm induced flooding.

4. USDOI Coordinating Organizations that offer Recovery Grants & Assistance

a) *Institute for Museum and Library Services (IMLS)*

The IMLS offers technical assistance grants for planning, staff training and protection of collections and building environments.

Applicable Institutions: public school libraries, college & university libraries,
State library institutions and agencies, and library associations. Grants Available: Library Services & Technology Grants = $150,000,000/year.https://www.imls.gov/grants/grants-state/five-year-plans. These are state-by-state grants provided to state library administrative agencies.

b) *Museum Assessment Program*

Museum Assessment Program helps small and mid-sized museums that are administered by the American Alliance of Museums: www.aam-us.org.

c) *Heritage Emergency National Task Force* (HENTF)

The HENTF provides emergency grants to stabilize museum collections, support disaster preparedness in museums and risk management assessment. Grants= $6,000/year through the National Endowment for the Humanities (NEH).

NEH also offers larger grants through their Sustaining Cultural Heritage Program of up to $350,000 for training, education and collection preservation.

FEMA DEBRIS FACT SHEETS:

FEMA Fact Sheet

PUBLIC ASSISTANCE: Flood Control Facilities

The Federal Emergency Management Agency (FEMA) Public Assistance (PA) Program provides supplemental assistance to states, tribes, and local governmental entities, as well as certain private non-profit organizations (hereinafter referred to as applicants). FEMA's *Public Assistance Program and Policy Guide* (http://www.fema.gov/public-assistance-policy-and-guidance) provides comprehensive information regarding assistance that FEMA can provide and the requirements that applicants must follow in order to receive the assistance. The purpose of this Fact Sheet is to provide applicants with an understanding of the various Federal agency authorities for flood control facilities.

Flood control facilities are those structures such as levees, flood walls, flood control channels, and water control structures designed and constructed to have appreciable effects in preventing damage by irregular and unusual rises in water levels. Flood control facilities are eligible public facilities; however, FEMA cannot provide PA funding when another Federal agency has specific authority to provide assistance. Applicants need to apply to the respective agency for assistance with a facility under that agency's authority.

Flood Fighting Activities

FEMA provides PA funding for flood-fighting activities necessary to reduce an immediate threat to life, public health and safety, or improved property, which may include, but are not limited to, sandbagging, dewatering behind a levee by breaching or pumping, or temporarily increasing the height of a levee.

The U.S. Army Corps of Engineers (USACE) can conduct flood fighting activities; however, they cannot reimburse flood fighting activities; therefore, it is eligible for PA funding. However, flood fighting activities related to flood control works under the specific authority of the Natural Resource Conservation Service (NRCS), which are those that are part of the NRCS Watershed and Flood Prevention Operations (WFPO) Program under Public Law (PL) 83-566, are not eligible for PA funding.

Debris Removal

When disaster-related debris is causing an obstruction in a flood control facility and posing an immediate threat to life, public health and safety, or improved property, the removal of the obstruction is eligible for PA funding, this includes debris removal from flood control facilities that are also eligible for USACE's RIP. The Applicant is responsible for identifying debris deposited by the incident that poses an immediate threat.

Debris removal from flood control facilities that are part of the NRCS WFPO Program under PL 83-566 is not eligible for PA funding, even if NRCS does not have sufficient funding or does not provide assistance. Additionally, debris removal from Federally Maintained Navigable Waterways is not eligible for PA funding.

FEMA provides PA funding for removal of debris from waterways that is necessary to eliminate the immediate threat to life, public health and safety, or improved property, such as when the debris:

- Obstructs, or could obstruct, intake structures;
- Could cause damage to structures, such as bridges and culverts; or

"FEMA's mission is to support our citizens and first responders to ensure that as a nation we work together to build, sustain, and improve our capability to prepare for, protect against, respond to, recover from, and mitigate all hazards."

October 13, 2017

- Is causing, or could cause, flooding to improved public or private property during the occurrence of a 5-year flood.

For FEMA to determine that debris removal from waterways is eligible, the Applicant must provide documentation that:

- Establishes legal responsibility;
- Includes the basis of the immediate threat determination;
- Identifies locations, types, and quantities of debris; and
- Demonstrates the debris claimed was deposited by the incident and was not pre-existing.

Removal of debris in a waterway that does not meet this criterion is not eligible for FEMA PA funding, even if the debris was deposited by the incident, unless the facility is an engineered facility and the Applicant can substantiate the pre-disaster capacity and maintenance of the facility.

Emergency Repairs and Permanent Restoration

Temporary emergency repairs or permanent restoration of a flood control facility under the authority of USACE or NRCS are not eligible for PA funding. Secondary levees riverward of a primary levee are ineligible, unless the secondary levee protects human life.

USACE: The Applicant may apply to USACE for emergency repairs and permanent restoration to Flood Controls Works that are eligible for the USACE RIP. USACE has authority under PL 84-99 to supplement local efforts in the repair of both Federal (USACE-constructed, locally operated and maintained) and non-Federal (constructed by non-Federal interests) flood control projects damaged by flood.

- For a non-Federal flood control project to be eligible for Rehabilitation Assistance, it must have been inspected, evaluated, and accepted into RIP (i.e., granted Active status) prior to the onset of the flood, and still be Active (based on the latest Continuing Eligibility Inspection) at the time of the flood.
- For a Federal flood control project to be eligible for Rehabilitation Assistance, it must be in Active status by having passed its last inspection of Completed Works inspection.
- Rehabilitation Assistance will be provided only when the work is economically justifiable, the damage was sustained during the recent flood event, and the cost of repairs is more than $15,000.
- Rehabilitation Assistance for the non-Federal project is cost shared between the Public Sponsor and USACE. The Public Sponsor must provide 20 percent of the cost of the Rehabilitation Assistance.

NRCS: The Applicant may apply for assistance under the NRCS Emergency Watershed Protection Program (EWPP) to reshape and protect eroded banks, correct damaged drainage facilities, establish cover on critically eroding lands, repair levees and structures, and repair conservation practices. The sponsor's application should be in the form of a letter signed by a qualified representative of the sponsoring organization. The letter should include information on the nature, location, and scope of the problem for which assistance is requested.

All projects must be related to a sudden watershed impairment and erosion control that reduces threats to life and property. All EWP work must:

- Be economically, socially, and environmentally defensible

Federal Emergency Management Agency

- Be sound from an engineering standpoint
- Yield benefits to more than one person
- Represent the least expensive, environmentally sound alternative

Assistance under the EWPP is provided based on priority. Therefore, the Applicant will need to identify the areas of priority in its application to NRCS.

FEMA: The Applicant may apply to FEMA for temporary emergency repairs and permanent restoration of its facilities that are improved and maintained provided that the:

- Facility is not an engineered channel that was Federally constructed;
- Facility was never Active in RIP; and
- Applicant applied to NRCS EWPP and NRCS determined the facility ineligible for reasons other than funding.

For Additional Information:

- FEMA's Public Assistance Program and Policy Guide: https://www.fema.gov/media-library/assets/documents/111781
- USACE RIP: http://www.nws.usace.army.mil/Portals/27/docs/Levees/Levee%20Safety/6.%20Rehabilitation%20and%20Inspection%20Program.pdf
- NRCS EWPP: http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/landscape/ewpp

IV. HURRICANE FLORENCE AND FEDERAL RESPONSE

A. Emergency Declaration

On September 9, 2018, South Carolina Governor Henry McMaster requested that President Trump issue an Emergency Declaration to the state of South Carolina.

Prior to Hurricane Florence making landfall on September 10, 2018, President Trump declared a Federal Emergency Declaration for all 46 counties in South Carolina. This authorizes the Department of Homeland Security, FEMA to provide appropriate assistance for emergency measures and is intended to begin coordination efforts such as evacuations prior to the disaster's occurrence, at the local and state level.

The September 10th Emergency Declaration specifically relates to FEMA providing Category B – Emergency Protective Measures under the Public Assistance program. The Emergency Protective Measures program covers costs associated with implementing safety measures, such as search and rescue and evacuations. Funding for public assistance is split – the federal government covers 75% of the costs but the state or local government must cover 25%. The storm made landfall on September 14, 2018.

B. Major Disaster Declaration

Following the devastation of Hurricane Florence, on September 16, 2018 President Trump granted a Major Disaster Declaration for the State of South Carolina. The Presidential Declaration of a Major Disaster triggered the release of federal funding assistance programs for the incident period of September 8, 2018 to October 8, 2018.

On September 16, 2018 Public Assistance – Category B (Emergency Protective Measures) was designated to the following counties: Berkeley, Charleston, Dorchester, Georgetown, Horry, Marion, Orangeburg, and Williamsburg Counties. Five days later on September 21, 2018, FEMA amended the Federal Disaster Declaration to include FEMA Public Assistance – Category B (Emergency Protective Measures) for Dillon and Marlboro Counties. Additionally, this Declaration provided FEMA Individual Assistance for Dillon, Horry, Marion and Marlboro Counties. On September 25, 2018, Chesterfield County was designated for Individual Assistance and other counties such as Chesterfield, Darlington, Florence and Sumter were granted Public Assistance – Category B (Emergency Protective Measures). The next day, FEMA amended the Federal Disaster Declaration again to include Individual Assistance for Georgetown County. On October 2, 2018, FEMA designated the final two counties, Darlington and Florence, with Individual Assistance.

On October 16, 2018 additional amendments were made to the major disaster declaration and Berkeley, Williamsburg, Chesterfield, Darlington, Dillon, Florence, Georgetown, Horry, Marion and Marlboro Counties were all designated Category A and Categories C, D, E, F and G. Also, Calhoun, Clarendon, Colleton, and Lancaster Counties received Public Assistance.

All of the Counties that received IA or PA under the major disaster declaration were eligible for FEMA Hazard Mitigation funding.

C. Disaster Funding for Hurricane Florence

Shortly after Hurricane Florence made landfall on September 26, 2018, Congress appropriated $1.68 billion in Community Development Block Grants – Disaster Relief (CDBG-DR) to address long-term recovery needs of 2018 disasters in the FAA Reauthorization Act. On October 5, 2018 President Trump signed this bill into law as Public Law 115-254. Since that time, Hurricane Michael, California wildfires, and many other natural disasters have unfortunately devastated the nation. The language in the law provides $1.68 billion in CDBG-DR funding for "disaster relief and long-term recovery, restoration of infrastructure and housing, and economic revitalization in the most impacted and distressed areas resulting from a major disaster declared in 2018."

On May 14, 2019, the US Department of Housing and Urban Development (HUD), announced the following breakdown of the $1.68 billion CDBG-DR funding. This funding will be allocated by HUD to the grantees with the Supplemental Disaster funding that was appropriated by Congress at the beginning of June 2019.

TABLE 1: CDBG-DR Funding (2019)

State	Natural Disaster	CDBG-DR Allocation (May 14, 2019)
California	Wildfires	$ 491,816,000
Florida	Hurricane Michael	$ 448,023,000
Georgia	Hurricane Michael	$ 34,884,000
Hawaii	Flooding and Volcano	$ 66,890,000
North Carolina	Hurricane Florence	$ 336,521,000
South Carolina	Hurricane Florence	$ 47,775,000
Texas	Flooding	$ 46,400,000
American Samoa & North Mariana Islands	Typhoon	$ 205,000,000

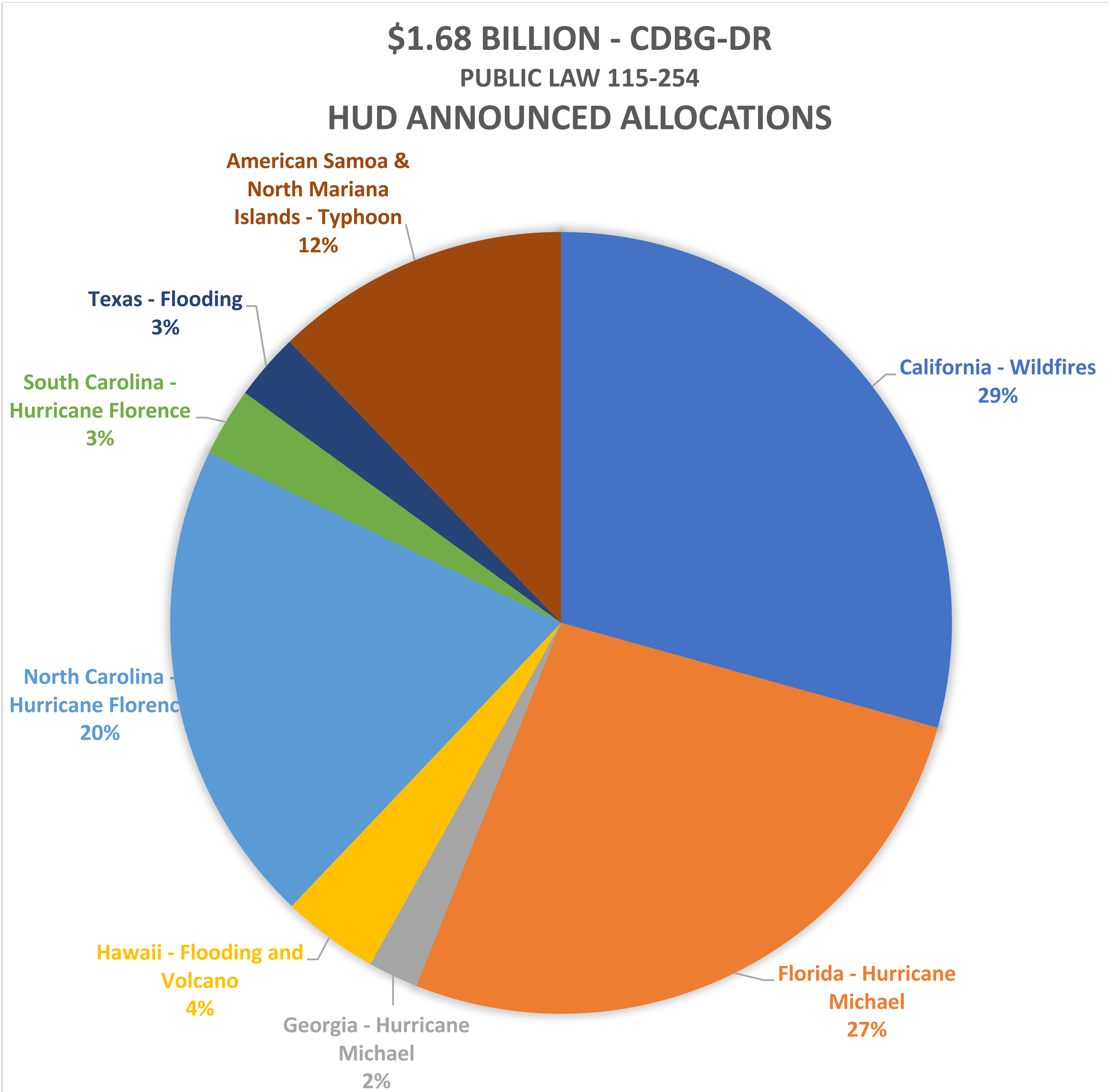


FIGURE 5: CDBG-DR Funding (2019)

D. Supplemental Disaster Funding

Many natural disasters devastated different parts of the country at the end of 2018 and beginning of 2019. Congress has been working to pass a disaster supplemental appropriations bill. Typical disaster supplemental bills appropriate funding to HUD (CDBG-DR), FEMA, USDA, SBA, Army Corps of Engineers, Federal Highway Administration-ER and other agencies to be issued to disaster areas to provide relief.

On June 3, 2019, Congress passed a Supplemental Disaster Relief Appropriation bill for $19.1 billion. The Act includes, but is not limited to, the appropriations to the following agencies:

CDBG-DR: $2.43 billion

- FEMA declared major disaster that occurred in 2018 and 2019

USDA-WHIP: $3 billion

- Losses of crops, milk, wine grapes, trees, bushes, and vines impacted by hurricanes (including Florence), floods, tornadoes, typhoons, volcanic activities, snowstorms in 2018 and 2019. Also, peaches lost in 2017 frost.

USACE – Investigations: $35 million

- States and insular areas that were impacted by Hurricanes Florence and Michael, Typhoon Mangkhut, Super Typhoon Yutu, and Tropical Storm Gita

USACE – Construction: $740 million

- States and insular areas that were impacted by Hurricanes Florence and Michael, Typhoon Mangkhut, Super Typhoon Yutu, and Tropical Storm Gita
- Projects that received funding in the 2018 disaster supplemental are ineligible

USACE – FCCE: $1 billion

- To prepare for flood, hurricane and other natural disasters and support emergency operations, repairs, and other activities

Federal Highway Administration - Emergency Relief: $1.65 billion

- Federal Highways damaged due to natural disasters

This funding will be allocated by the agencies and divided amongst different states or grantees that qualify for the funding.

E. <u>Mitigation for 2015 Floods and Hurricane Matthew</u>

Congress passed the Bipartisan Budget Act of 2018 and it was signed into law on February 9, 2019 (Public Law 115-123). This law provides a set-aside of CDBG-DR funding for “mitigation activities”. In April, HUD announced $16 billion in proposed mitigation allocations for specific grantees. This included the following awards for the 2015 Floods: 1) $90,026,000 to South Carolina; 2) $18,585,000 to Columbia; 3) $15,185,000 to Lexington County; and, 4) $21,864,000 to Richland County. Another $67,564,000 was also directed to South Carolina for Hurricane Matthew to carry out mitigation activities. Additionally, this announcement included $12 billion of CDBG-DR to be allocated amongst 2017 disasters. Currently, HUD and Office of Management and Budget (OMB) are reviewing the allocation and preparing the federal register notice.

V. IDENTIFYING GAPS

South Carolina has faced five recent natural disasters, four of which merited a disaster declaration. There are several obstacles and issues that the state faces and perhaps should be reviewed to better prepare for future disasters and recovery.

A. Natural Disasters and Flooding

South Carolina has been victim to four presidentially declared natural disasters over the past four years:

- FEMA 4241-DR: South Carolina Severe Storm and Flooding, 2015
- FEMA 4286-DR: Hurricane Matthew, 2016
- FEMA 4346-DR: Hurricane Irma, 2017
- FEMA 4394-DR: Hurricane Florence, 2018

The following maps outline the counties affected during each natural disaster and the counties that were designated both public assistance and individual assistance. These maps show the areas in South Carolina that are repeatedly receiving the brunt of these storms and affected by the aftermath of the flooding.

1. <u>South Carolina Severe Storms and Flooding</u>

Major Disaster Declaration declared on October 5, 2015
Incident Period: October 1, 2015 – October 23, 2015

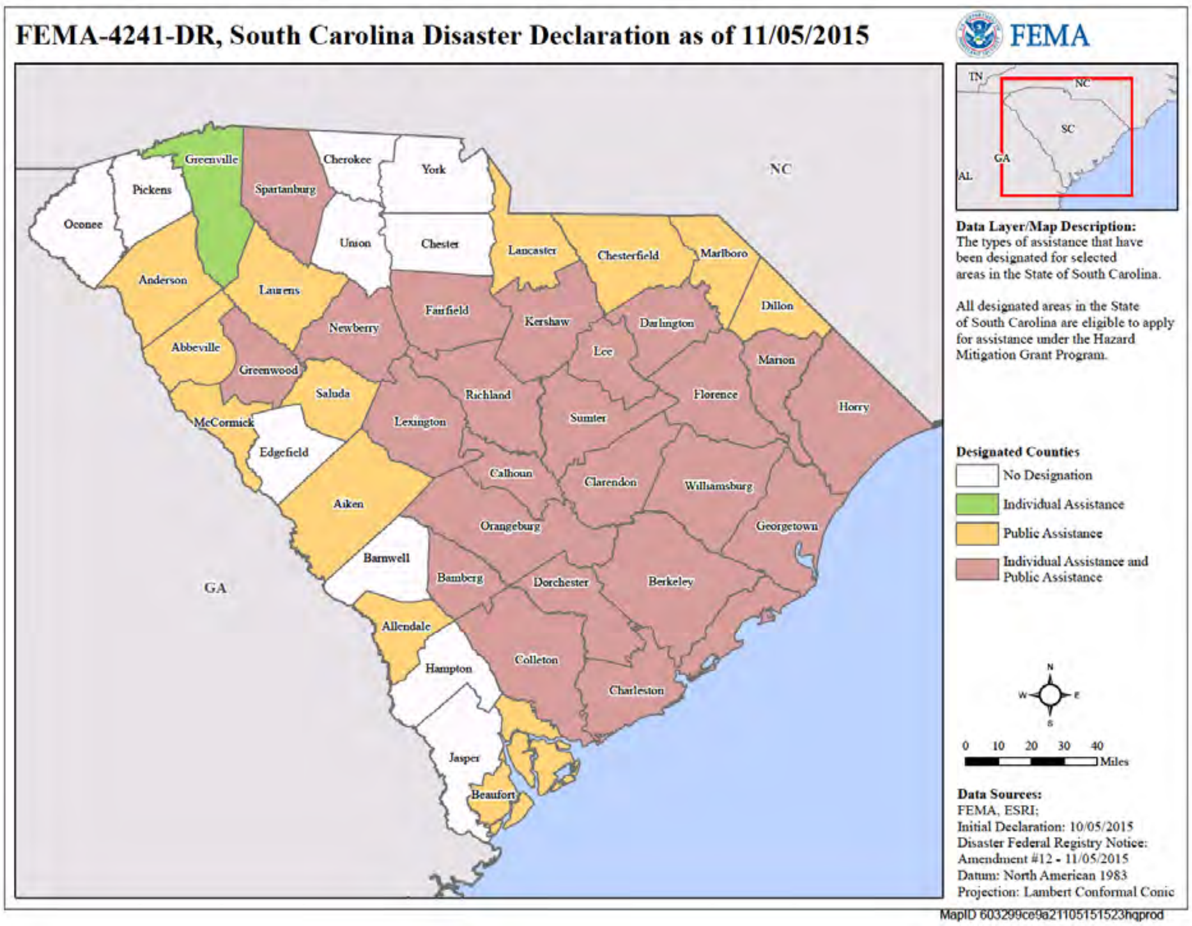


FIGURE 6: SC Disaster Declaration – Historic Flood (Federal Emergency Management Agency, 2015)

2. Hurricane Matthew

Major Disaster Declaration declared on October 11, 2016
Incident Period: October 4, 2016 – October 30, 2016

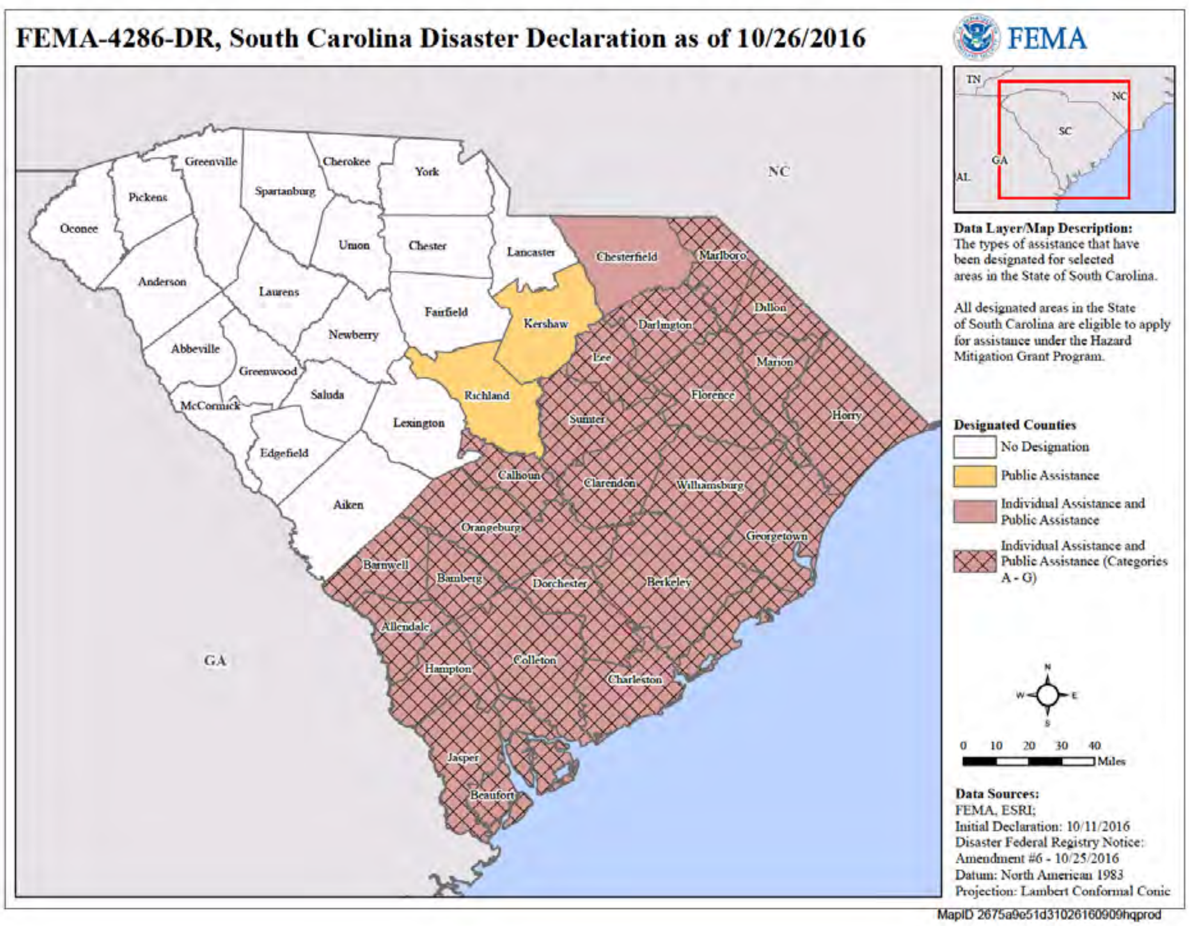


FIGURE 7: SC Disaster Declaration – Hurricane Matthew (Federal Emergency Management Agency, 2016)

3. Hurricane Irma

Major Disaster Declaration declared on October 16, 2017
Incident Period: September 6, 2017 – September 13, 2017

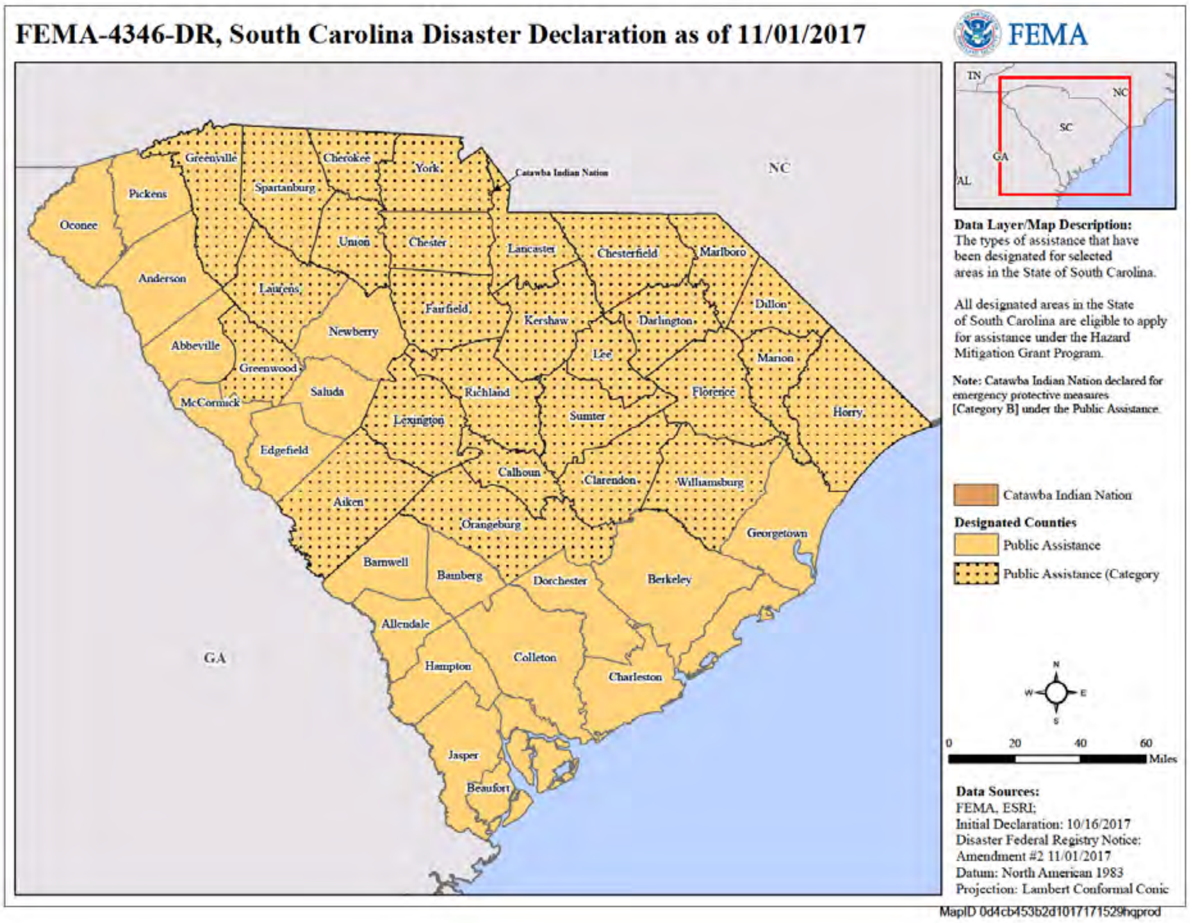


FIGURE 8: SC Disaster Declaration – Hurricane/Tropical Storm Irma (Federal Emergency Management Agency, 2017)

4. Hurricane Florence

Major Disaster Declaration declared on September 16, 2018
Incident Period: September 8, 2018 – October 8, 2018

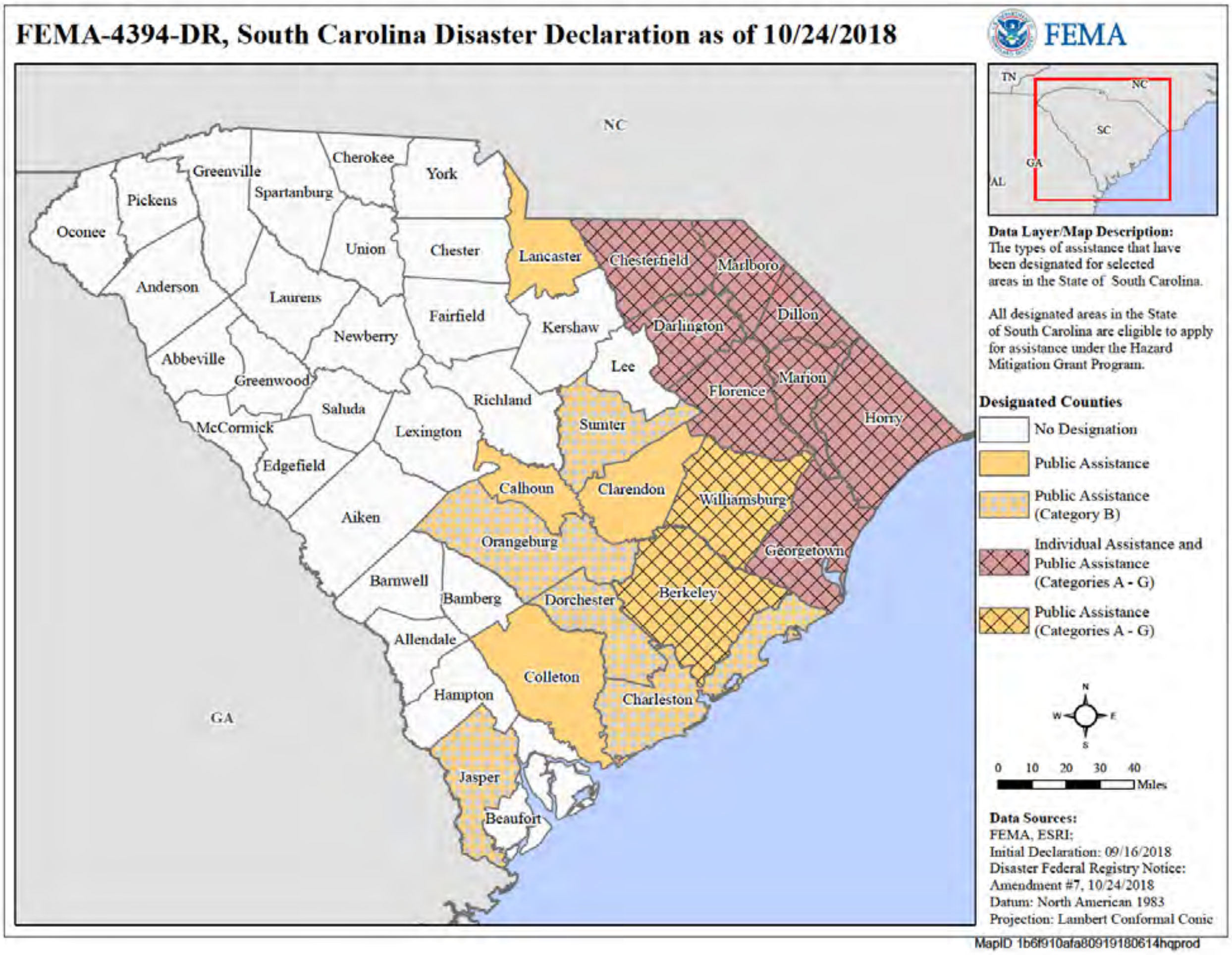


FIGURE 9: SC Disaster Declaration – Hurricane Florence (Federal Emergency Management Agency, 2018)

The outstanding unmet needs assessment in the state from storms before Hurricane Florence includes:

Unmet Needs	**2015 Severe Storm & Flooding**	**Hurricane Matthew**
Housing	$349,992,658	$286,412,420
Economy	$59,129,380	$91,504,747
Infrastructure	$21,655,403	$54,846,172
Total Unmet Need		$782,755,997

Official state requests for federal funding may utilize unmet needs calculations. With the frequency of natural disasters, the state's ability to quantify unmet needs is essential when developing estimations of severe damage. If these unmet needs are not addressed and incorporated by the state in disaster estimations, then South Carolina may not fully recover and be left behind.

B. Efficiency of Rebuilding/Recovery Efforts

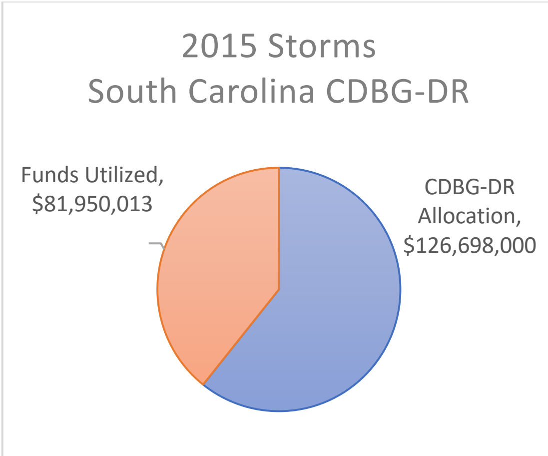
Following the 2015 storms and Hurricane Matthew, the South Carolina Congressional delegation was able to secure CDBG-DR funding to assist in disaster recovery efforts.

1. Efficiently Rebuilding

South Carolina has a limited scope disaster recovery strategy, and this has affected the efficiency of the rebuilding efforts.

For 2015 Severe Storm and Floods, HUD allocated to the state of South Carolina $126,698,000. As of the April 30, 2019 CDBG-DR Grant Financial Report the state of South Carolina has utilized $81,950,013 of the grant funding. This is approximately 65% of the disaster funding made available.

Additionally, South Carolina has used only $32,015,186 of the $95,086,000 grant funding received to recover from the Hurricane Matthew storm. This amounts to approximately 34% of the total funding received.



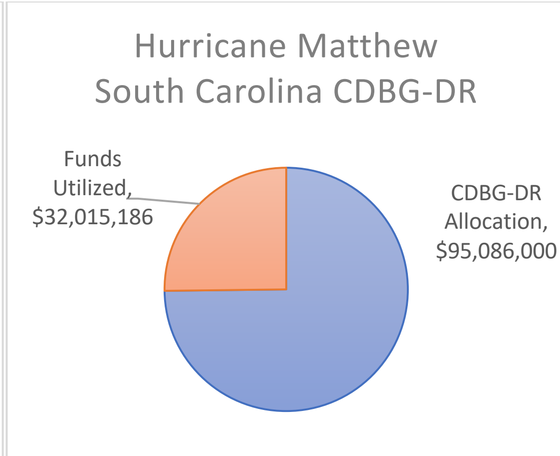


FIGURE 10: CDBG-DR Fund Utilization

The state estimated that they would repair or replace 1,350 homes with the CDBG-DR funding following Hurricane Matthew. As of May 30, 2019, 634 homes have been repaired. This equates to over 53% or 700 victims that are still left without a home or are living in substandard housing two and half years after the storm has hit.

Due to the fact that South Carolina has been devastated by four natural disasters in the last four years, it is necessary for the state to develop a way to quickly and efficiently repair and rebuild homes for victims following a natural disaster. Timeliness is of great importance because residents need to recover from the last storm before the next one hits.

To put this into context, our state's citizens were still rebuilding after the 2015 Severe Storms and Hurricane Matthew and not yet back in their homes before Hurricane Florence made landfall in 2019.

TABLE 2: September 12, 2018 – Two days before Hurricane Florence made landfall

	Number of homes completed, and keys turned over to resident
2015 Severe Storms and Floods	1,210
Hurricane Matthew	281

2. <u>Broaden Scope of Federal Funding</u>

Under federal law, CDBG-DR funding may be used for "necessary expenses related to disaster relief, long term recovery, and restoration of infrastructure, housing, and economic revitalization in the most impacted and distressed areas resulting from a major disaster."

The state's initial approach to disaster recovery following 2015 severe floods was narrowly tailored to address only unmet housing needs. However, CDBG-DR funding is expansive and may encompass housing as well as infrastructure and economic revitalization.

C. Lack of Utilizing Federal Funding Resources

1. “FEMA Fatigue” – Failure to Register

Due to the frequency of natural disasters that has harmed South Carolina communities, victims of these storms are suffering from “FEMA fatigue”. During Hurricane Florence recovery efforts, it became apparent that residents of counties that were eligible for FEMA assistance who had been victims to severe storms in the past were choosing not to file a FEMA application. Most residents that failed to apply for FEMA assistance decided not to because they believed the extensive process was not worth the outcome.

This is an issue that needs to be addressed across the state. Not only do these residents deserve to receive aid where they qualify and should seek this assistance, but severity of the storm and impact on the state is calculated from this FEMA intake process.

The FEMA intake process is an essential measuring tool that helps determine the impact of a storm and the needs of further funding assistance at the federal level. Impacted residents need to be identified and encouraged to report their losses via the FEMA application process in order to adequately evaluate the loss.

2. Hazard Mitigation Grant Funding Opportunities

Pursuant to Section 404 Stafford Act, a main source of federal disaster mitigation assistance is the Hazard Mitigation Grant Program.

The Federal Emergency Management Agency (FEMA) defines mitigation as follows:

> *Mitigation* is defined as any sustained action taken to reduce or eliminate long-term risk to life and property from a hazard event. Mitigation, also known as prevention (when done before a disaster), encourages long-term reduction of hazard vulnerability. The goal of mitigation is to decrease the need for response as opposed to simply increasing the response capability. Mitigation can save lives and reduce property damage and should be cost-effective and environmentally sound. This, in turn, can reduce the enormous cost of disasters to property owners and all levels of government. In addition, mitigation can protect critical community facilities, reduce exposure to liability, and minimize community disruption.

The FEMA Hazard Mitigation Grant Program (HMGP) is available to all counties named in disaster declaration and provides an opportunity “to implement long-term mitigation measures that reduce, minimize, or eliminate potential damages to public private infrastructure form natural hazards.”

Eligible applicants for this source of funding include local governments, state agencies, tribal governments and private non-profits. Projects that would be eligible for consideration for this grant would be mitigation activities that reduce the effects of future disasters including: acquisition and structure demolition, structure elevation, dry floodproofing of non-residential structures or historic structures, localized flood reduction projects, nature-based and natural infrastructure projects, safe room construction, wind and infrastructure retrofitting, generators, hazard mitigation planning, management costs and other activities. This grant funding has a cost share requirement of 75% covered by federal funding and 25% of non-federal funding.

This funding is available yet many fail to apply, due to not knowing of the existence of the grant, the parameters of the grant requirements, and projects that would be eligible, or they do not have the financial means to make the match. If the non-federal cost-share requirement of 25% of the costs is a deterrent, the state could consider utilizing other disaster relief funds, such as CDBG-DR funding, to cover these costs. Overall this funding needs to be highly considered and encouraged by all.

Counties, municipalities, school districts, rural water companies, hospitals, assisted living facilities, fire and police stations, zoos and many others may be eligible for this grant funding. Of the eight counties that were hardest hit by Hurricane Florence, only six of them submitted the required pre-application for the HMGP along with some municipalities across those counties. But only one hospital, school district and local utility submitted the pre-application for the HMGP associated with Hurricane Florence.

The purpose of HMGP is not only to help those that were devastated by the storm, but also to reduce the "loss of life and damage to property in future disasters". Every community has mitigation projects that could help better prepare them for future disasters and local governments, especially in under-resourced areas, would benefit greatly from education to better understand the funding available to them to reduce flood risk and benefit their communities. This should also include capacity-building programs developed at the state level because some local governments do not have the expertise or staff capacity to plan projects, apply for the grants, and oversee implementation. Educating local leaders on these grant opportunities is essential to maximizing the state's efforts in creating a sustainable, achievable solution to preparing and preventing future natural disasters.

3. <u>Guidance on Utilizing Resources Achieved</u>

Municipalities have an opportunity to conduct projects that would mitigate floodwater issues with grant funding that they have received. However, utilizing grant funding and successfully implementing a plan and course of action with the funding can be a challenge. Making available technical and science-based information, along with the tools and assistance to understand how to use it to develop on-the-ground projects, can be a game changer and lead to valuable projects that might not otherwise be identified and implemented.

Grant funding may have a termination date where the funds are returned if no action is taken. Ensuring that all funding received in the state is utilized and spent to improve communities needs to be a priority. The ability to have access to resources to assist in developing a strategy would be advantageous in a larger mitigation plan or strategy.

D. Lack of Information Sharing and Coordination

Currently municipalities, counties and the state are all highly concerned about ways to prevent future disasters and prepare their communities in the best possible way. There are many ways to engineer strategies that would be beneficial and help prepare residents for repetitive flooding and storms.

Highly localized solutions and projects could have unintended negative consequences, and ultimately inefficiently manage resources. When dealing with an issue, such as region or watershed flooding, it is important to share information and coordinate. At this time of developing a variety of natural and engineered mechanisms, it could be beneficial to coordinate efforts and information sharing across all areas.

One approach would be to develop integrated watershed-based plans with state leadership. This approach reflects the reality of how water flows, and can help ensure that local flood mitigation plans developed within a given watershed do not cause problems in nearby or downstream communities that may happen to be in a different county or city – and ideally that local projects actually enhance each other's benefits for flood-risk reduction. High quality watershed models of water flow and risk factors (such as undersized stream crossing for roads or railroads, altered floodplains, inadequate drainage systems, etc.) that are available to all governments in a watershed can be the foundation of mitigation and risk-reduction projects. Collaboration among state and local agencies within a given watershed should be encouraged and incentivized to maximize the effectiveness of projects.

E. Unpredictability of Federal Funding and Need for Expertise

Federal funding that is appropriated through the different congressionally determined streams is very unpredictable in both the quantity as well as the timing and delivery of the funds. It is impossible to predict the scale of the resources received.

Administering federal funding requires expertise. Since the disaster funding has developed and more programs and sources to help communities and states have become available, it is a challenge to adequately maneuver this process. The state and all impacted communities would benefit from a central state tracking system of federal disaster funds allocated to South Carolina from all four years of disaster declarations. Our ability to comprehensively track and administer federal resources will better assist our citizens in responding, rebuilding, preparing for future events. It can also help make a stronger case for federal assistance and investments should future flooding and storm events bring about further damage down the road.

States play a significant role in natural disasters and the recovery process. In this capacity, the state can quantify damages and through expertise understand the rules of federal funding mechanisms in order to request and utilize the adequate amount of federal assistance.

VI. EXAMINE SOLUTIONS

A. <u>Educate the Public and Devise Public Awareness Campaign</u>

South Carolina has been hit by multiple natural disasters in the last decade. Citizens and community leaders need to be aware of the disaster relief funding sources that are available in order to adequately prepare and recover in the future.

1. <u>Flood Insurance</u>

First, all residents on the coast as well as any that reside in a flood plain or near any major river system need to be aware of flood insurance options and need to be encouraged to buy coverage. With multiple heavy rain events and rivers cresting, residents need to protect themselves and their property with flood insurance. Too many residents thought that flooding from Hurricane Matthew would not happen again and sadly were victims once again during Hurricane Florence. South Carolina Department of Insurance has held hurricane preparedness events to help address this issue. The Department has held hurricane days and expos to help educate the public on how to protect their homes and property during hurricane season. Continuing to hold these educational forums is essential to inform, prepare and protect the citizens for future hurricanes and floods.

2. <u>South Carolina Days</u>

Governor McMaster led a successful public awareness campaign by conducting the South Carolina Days in different designated disaster counties following Hurricane Florence. By coordinating events that brought together all agencies that provide relief and guidance was a great resource to all those that were victims of the storm.

These South Carolina Days could possibly be expanded to help educate at-risk residents as well as community leaders about financial opportunities associated with mitigating and rebuilding areas. Hosting a wide-variety of these South Carolina Days or public education forums for residents and community leaders would assist in a number of ways. If residents understood that the number of FEMA individual assistance applicants is a measuring tool for other federal funding sources, possibly the FEMA fatigue that exists across the state would be diminished. Residents would also learn more about financial assistance available to them following a storm as well as better ways to prepare or protect themselves in a future disaster.

Additionally, following a disaster, community leaders become the lifeline and advocate for their area. Community leaders need to have all the essential tools to be able to effectively help their town or county recover. Educational summits could be organized to educate key leaders that could achieve a better understanding of all the federal funding sources that exist, the type of projects that qualify for funding, the ability for the non-federal cost share to be covered through other sources, and the ability to be reimbursed for mitigation costs. Additionally, they could be educated on the different types of assistance available to homeowners.

This type of education is necessary because the more community leaders and residents understand about funding and assistance the better the state will be in the future.

B. <u>Comprehensive CDBG-DR Strategy</u>

Severe storms and flooding will continue to be an issue and as a result large sums of federal funds will be allocated for disaster recovery programs in the state. Former Governor Haley initially developed a disaster recovery strategy in order to administer less than $100 million in CDBG-DR funds. The current CDBG-DR strategy must be expanded and improved, and a comprehensive strategy must be developed to account for the more substantial federal allocation. South Carolina is not alone in facing the challenge of developing an effective and comprehensive CDBG-DR strategy, and we can benefit from the experience of other states. The Louisiana Watershed Initiative was launched in 2018 to stand up a comprehensive and integrated plan to administer and spend $1.2 Billion of CDBG-DR funds appropriated after extensive flooding in 2016. North Carolina recently appointed a Chief Resilience Officer to head its program administering $236 Million in CDBG-DR funding from Hurricane Matthew (2016), and the state anticipates greater funding from the 2019 disaster appropriation that covered Hurricane Florence.

It is essential to capitalize on the CDBG-DR program. CDBG-DR is a highly flexible source of federal funding that can be utilized to fill the unmet needs of local communities following natural disasters. CDBG-DR funds can be used for both built and natural or nature-based infrastructure, economic revitalization, mitigation projects such as floodplain restoration, in addition to housing repairs. This source of funding will play a critical role in planning and implementing innovative risk-reduction and mitigation projects to address repetitive flooding.

The following is a proposed comprehensive CDBG-DR strategy, which includes housing, infrastructure, and economic revitalization programs that could be implemented by the state with CDBG-DR funds to help residents and businesses recover from a natural disaster.

1. <u>Housing</u>

a) *Intake Process*

Reaching the entire population of eligible victims is an obstacle. Thus in order to increase the number of applications submitted by victims to receive CDBG-DR funding, the state could act proactively by mailing a simple, standard application (i.e. a post card) to zip codes where damage had occurred. Other states have found that conducting simple surveys is useful in reaching potential applicants and encouraging them to apply.

b) *Environmental Assessments*

During the intake process, initial environmental assessments could take place on a large scale, such as by county. While some funding may be spent on areas where homes are not ultimately rebuilt or replaced, this could speed up the process for applicants once they are deemed initially eligible.

c) *Expanding Homeowner Options*

After an applicant is deemed initially eligible, homeowner inspections could take place in order to assess both damages and repairs already undertaken. Standardized damage estimates could be determined by square foot in order to develop a grant amount. Additional considerations could take place to determine whether home elevations are needed. During this process, home inspectors also could determine repairs already made to homes in order to award a reimbursement grant. In order to account for duplication of benefits, any federal funding already obtained by the homeowner is subtracted out from the grant amount.

To increase efficiency of the rebuilding of homes damaged by the storms, there could be three pathways a homeowner could conduct repairs: 1) to have the state control the repairs or replacement of their homes; 2) the homeowner manages the project themselves; or 3) homeowner agrees to voluntary buyout. Homeowners who are eligible for a direct grant could be awarded the grant immediately.

Pathway One – State Managed
The State Managed Option continues the current CDBG-DR program South Carolina operates. The state selects the contractors to conduct repairs or replacement of the homes. The contractors are paid once the work is complete, final inspections are passed, and the keys are turned over.

Pathway Two – Homeowner Managed
The other option could be to allow homeowners to manage their own repairs of their own home. Homeowners in this circumstance select their own contractors with a built-in preference for local construction firms and certified contractors. The state could then structure payments on construction milestones, with the bulk of the grant being awarded when the work is complete and final inspection is passed. Under this pathway, certain contractual requirements are mandated – such as the homeowner completing the scope of work assessed, maintaining ownership for a period of time after the work has concluded, and purchasing flood insurance.

The state could decide that they would not repair any damaged manufactured homes, but instead if they are damaged in any way they would be completely replaced. In this case, if there was a manufactured home that was damaged, the owner could be awarded a grant (with a state-imposed cap for single-wide and double-wide) and the owner could then select and purchase a new manufactured home directly from the dealer. This could speed up the process and allow owners to return to a safe and habitable home in an efficient manner.

Pathway Three – Voluntary Buyouts
A voluntary buyout option could be considered by the state when creating a comprehensive strategy. Based on the number of storms that have hit areas in South Carolina and number of homes that currently reside in floodplains voluntary buyouts could be an option to residents.

Under this option, homeowners could forgo repairs or reconstruction and instead turn homes over to the state. Homes could be assessed for the pre-storm fair-market value and then owners could be awarded this grant award. The state could also assist homeowners with relocation costs.

d) *Homeowner Displacement*

CDBG-DR funding could be spent on paying for homeowner displacement needs. Homeowners that are forced to leave their flood damaged home due to the extent of the damage and also owners forced to vacate while their home is under construction could be financially assisted with CDBG-DR funds. Costs of displacement and temporary lodging awards could be made to homeowners on a reimbursement basis.

e) *Streamlining Inspections*

To speed up the time between final construction and applicants being able to move back into their homes, the state could consult with local communities in order to determine a program-wide inspection standard. Once this standard is set, the state could contract inspectors to carry out identical and final inspections across the entire program area that satisfy all local codes and regulations.

2. <u>Infrastructure</u>

a) *Local Match Funding*

Local communities who chose to utilize federal programs to recover from natural disasters face local matching requirements. The FEMA Public Assistance Program functions on a 75/25 funding split, with the grantee responsible for 25 percent of the costs. Low-income communities struggle with matching federal dollars. The state could utilize CDBG-DR funding to grant awards to local communities to cover the non-federal matching requirement.

b) *Sub-grants to Local Communities for Infrastructure*

Counties and cities possess unique and firsthand knowledge of the infrastructure needs following a natural disaster. To allow these municipalities to capitalize on this knowledge, CDBG-DR funding could be allocated directly to them in order to carry out projects. The state could develop a funding methodology to award these grants based on need. This methodology could take into account FEMA and SBA data along with Social Vulnerability Index and poverty levels. Grants could be awarded to local areas of government in order to carry out eligible projects, which are determined by the state. Local communities then could submit a plan, outlining the projects they wish to undertake, which the state could have final approval over.

3. <u>Economic Revitalization</u>

a) *Small Business Loan and Grant Program*

Local establishments not only face the loss of business when natural disasters occur, but also damages. To assist with the recovery process, businesses that have been impacted by a natural disaster could be part of a loan forgiveness program. These businesses could be required to show direct physical and financial losses due to a natural disaster. These loans could be structured in order to provide initial working capital to businesses, while holding them accountable for carrying out actual recovery activities. After a certain amount of the loan was paid off and the proper activities have taken place, interest and the remaining principle could be forgiven. Under this program, local banks could carry out the financing.

b) *Business Resiliency*

To mitigate against future natural disasters, a program could also be established to provide assistance for businesses to enhance their storefronts. Eligible activities could include actual construction to raise elevation levels, to moveable flood barriers, flood pumps, and generators. Additional grants could be considered to relocate businesses that have suffered repetitive losses.

c) *Workforce Development*

In areas where businesses have not been able to reopen following a natural disaster, formerly employed individuals are often forced to retool in order to find new employment. To assist with this process, a two-pronged program could be created. One program could focus on the development of soft skills, such as resume building and interview training. While a second program could provide vouchers to local businesses to operate apprenticeship and training programs. An additional program could also be considered to provide grants to local business which employ individuals displaced by a natural disaster. *How about getting our great technical training schools engaged in this so that they not only provide a benefit but receive one?*

4. Other Proposals

a) *Capacity-Building*

While a host of federal programs are available to local communities to assist with long-term recovery efforts, communities often lack the resources or ability to take advantage of these opportunities. For example, FEMA's Hazard Mitigation program includes three grant opportunities to carry out mitigation and resiliency measures. However, the complex application process deters communities with limited resources from applying. It is in the state's interest to create a program to build the capacity and knowledge of both local governments and state agencies to design projects that can be eligible for disaster funding, write grant applications, and be able to manage project implementation. This could include making available high-quality hydrologic and flooding models and data and the tools to use them, as well as training and assistance to navigate the rules and requirements of federal funding. This could be done through contractors, possibly paid for with CDBG-DR fund, and overseen by the SC Disaster Recovery Office or the SCEMD.

b) *Waivers*

Federal guidelines require 70 percent of total CDBG-DR funding to be allocated towards low-and-moderate income persons. The state could apply for a waiver, similar to other states, in order to reduce this requirement to 50 percent. While it is important the state prioritizes assistance to those who need it the most, natural disasters do not distinguish between income levels when they wreak havoc on South Carolina.

5. Examples of CDBG-DR Programs in Other States

Since CDBG-DR funding limited parameters on types of projects or programs that are eligible for funding, states have been creative and utilize these funds in a variety of ways in order to provide aid that is best suited for the communities harmed by the disaster. The following are examples of CDBG-DR plans that have been implemented in Louisiana and Texas.

a) *CDBG-DR Plan in Louisiana*

Louisiana was allocated CDBG-DR funding by HUD for recovery from severe flooding that occurred throughout the state in March and August of 2016. The following is a timeline of CDBG-DR allocations to the State of Louisiana for these disasters:

- September 29, 2016 – Continuing Resolution: HUD allocated $437.8 million
- December 10, 2016 – FY 2017 Continuing Resolution: HUD allocated $1,219,172,000
- May 5, 2017 – Consolidated Appropriations Act of 2017 – HUD allocated $51,435,000

The following outlines different programs that Louisiana established to utilize CDBG-DR funds in their rebuilding efforts after the March and August 2016 disasters.

i. Housing Assistance

The Restore Louisiana Homeowner Assistance Program (RLHP) is a program that rebuilds homes that are of high priority to Louisiana. Any repair estimate less than 80% of the reconstruction estimate warrants only repairs or rehabilitation of a home. A homeowner may be eligible for complete reconstruction if the flood-damaged home was demolished or unsafe to enter; homeowner received a condemnation letter; or, the relative percentage of the program repair estimate was greater than or equal to 80% of the reconstruction estimate.

If a homeowner is eligible for rehabilitation or reconstruction, then the homeowner may choose from the following approaches: 1) Program Managed Construction; 2) Homeowner Managed Construction; 3) Reimbursement, or 4) Voluntary Buyouts.

Solution 1: Program Managed
Repairs: The Program is managed by the state and provides repairs for a damaged home and utilizes pre-determined options and materials.

Reconstruction: The Program provides a reconstruction option for homeowners to demolish their flood-damaged home and construct a new residential structure based on a construction design determined by the Program.

It is estimated 20% of people choose the Program Managed approach.

Reconstruction Award Amount:

Single-wide: $45,000 plus eligible elevation costs of CDBG-DR funds is used to pay the manufactured housing unit dealer. Double-wide: $65,000 plus eligible elevation costs of CDBG-DR funds is used to pay the manufactured housing unit dealer. (Louisiana does not repair Manufactured Housing Units (MHUs), but only replaces them for the above stated amount.) Stick-built: Rebuild home based on square footage of old home through certain pre-determined floor plans.

Solution 2: Homeowner Managed Construction
It is estimated that 80% or more of people choose the Homeowner Managed Construction approach.

Repairs: This approach allows for the homeowner to manage their own rehabilitation through hiring their own contractor.

Reconstruction: This approach allows the homeowner to construct a new residential structure based on a construction design determined by the homeowner. The homeowner must hire a Louisiana licensed and insured homebuilding contractor, and the homeowner is responsible for any costs over and above the program award.

Reconstruction Award Amount: The Reconstruction Award is based on the total square footage of eligible rooms in the home excluding carports, garages, and porches. The eligible square footage is then multiplied by $108 per square foot and includes demolition and cost for elevation. A separate 20% for contractor overhead and profit will be included in award.

Solution 3: Reimbursement
Applicants who have completed partial or full repairs on their home before applying to the Program may be eligible for reimbursement of a percentage of eligible expenses incurred prior to the application process.

Reimbursement Award Amount: Reimbursement is limited to only those expenses determined eligible by the Program. Only eligible expenses at the Program standard price will be considered for reimbursement.

Solution 4: Voluntary Buyouts
Louisiana offers a buyout for homeowners with damaged properties inside floodways in the future if the state deems necessary.

ii. Small Business Assistance

Restore Louisiana Small Business Program - $43 million in loans
The program provides assistance to small businesses located in areas adversely affected by the 2016 Severe Storms and Flooding Events. The program will make loans between $10,000 and $150,000 to eligible businesses. If borrowers comply with program requirements, provide

required documentation and make payments as agreed, the loan will be interest free and 40% of the loan will be forgiven when 60% of the principal is repaid.

iii. Economic Development

First Responders Public Service Program – Maximum of $3 million per organization
First Responder agencies and local governmental entities that were negatively impacted by the reduction in ad valorem tax revenue may be eligible for this grant program. This grant program covers up to one year in eligible salaries and benefits, purchasing or leasing of movable equipment, staff training and operational costs.

iv. Non-Federal Cost Share Match Program

Non-Federal Cost Share Match Program - $105 million
This program provides Governor-allocated funding to assist local entities with the Non-Federal Cost Share associated with eligible projects under the FEMA Public Assistance and Transitional Sheltering Assistance.

v. Rental/Developer Assistance

Multifamily Gap Program - $38.25 million
This program provides loans and grants for developers with multi-family structures of 20 or more units.

Restore Louisiana Neighborhood Landlord Rental Program - $36 million for loans
Under this Initiative, applicants will construct new residential rental housing units or will renovate residential rental housing units in a Qualified Project located in one of the parishes declared a disaster area.

Multifamily Piggyback Program - Preliminary commitment of $33,850,000.00
This program provides funding for the new construction development or acquisition/rehabilitation of multifamily affordable housing developments that provide affordable housing. Successful applicants will be able to utilize CDBG-DR funds with 4% Low Income Housing Tax Credits (LIHTC) and LHC Multifamily Revenue Bonds.

Rapid Rehousing Program LHA - $16 million
This program assists households which are displaced and earning less than 80% AMI. The program includes:

- Rental Assistance – participants pay a portion of their monthly adjusted income towards rent and utilities
- Case Management – includes developing a budget plan that indicates how the family will meet their monthly rental obligation for each of the 12 months on the program, assistance with education and employment, financial planning and permanent housing.

The program started with the use of Emergency Solution Grant funding from the Louisiana Housing Corporation and will expand with CDBG-DR funds.

Permanent Supportive Housing
The Louisiana Permanent Supportive Housing program provides permanent, subsidized rental housing with flexible, individualized housing supports for people with disabilities.

Louisiana Farm Recovery Grant Program - $10 million
Producers with at least a pre-storm annual gross farm revenue of $25,000 in years 2014, 2015, 2016 and crop loss of at least $10,000 are eligible for a 100% grant for working capital expenses for 2017 planting year expenses (capped at $100,000).

vi. Other Louisiana CDBG-DR Recovery Programs

Isle De Jean Charles Resettlement Project - $48.3 million
This community lost more than 98% of their land over the past 60 years and decided to resettle the residents to a new community in an entirely new inland location

Louisiana Watershed Initiative (Mitigation Recovery)
The Louisiana Watershed Initiative will support statewide and local jurisdictions in providing guidance on the most effective approaches to minimize flood risk reduction within Louisiana communities, guided by best practices, data, and science.

LA SAFE (Louisiana's Strategic Adaptations for Future Environments)
This program is composed of leasers and organizations committed to enabling community members to take proactive steps towards mitigating and avoiding risk as well as increasing resilience to address coastal challenges.

b) *CDBG-DR Plan in Texas*

The State of Texas was awarded a total of $2.7 billion in CDBG-DR funding following Hurricane Harvey in 2017.

The City of Houston and Harris County received an additional amount of $2.27 billion combined.

While the state directly administers many aspects of the housing program, the buyout and infrastructure programs are directly administered by the local jurisdictions, with the funding amount for these programs determined by the state's Method of Distribution (MOD).

The state of Texas partnered with the University of Texas at Austin to develop the regional MOD. The MOD for these allocations used census data, FEMA Individual Assistance data, FEMA Public Assistance data, the Social Vulnerability Index, and impact of Hurricane Harvey to distribute funds.

i. Housing Assistance

Homeowner Assistance - $1.09 billion

Direct, state-run housing program rehabilitates and reconstructs owner-occupied single-family homes.

Local buyout and Acquisition Program - $275 million
Local governments may buyout or acquire eligible homes at a pre-storm or post-storm fair market value to move homeowners out of harm's way outside of a floodplain to a lower-risk area.
The state awards local regions funding to carry out their own buyout program with award amounts based on MOD.

Homeowner Reimbursement - $100 million
Homeowner reimbursement allows homeowners to be reimbursed for certain out-of-pocket expenses incurred for repairs to their home including reconstruction, rehabilitation or mitigation up to $50,000.

Affordable Rental - $250 million
This program provides funding for rehabilitation, reconstruction and new construction of affordable multi-family housing units in areas impacted by Hurricane Harvey. This is administered directly by the state.

ii. Infrastructure

Local Infrastructure Program - $413 million
This program repairs, enhances and restores infrastructure for local communities impacted by Hurricane Harvey as part of a comprehensive long-term recovery program. Match for FEMA Public Assistance and Hazard Mitigation Grant Programs is also eligible. This program is administered by local regions, with funding distributed by state via MOD.

iii. Economic Revitalization

Economic Revitalization Program - $100 million
This program allows for interim assistance to small businesses (up to $250,000) impacted by Hurricane Harvey through deferred forgivable loans and loans in exchange for job creation or retention for low-to-moderate income employees. The funding is also available to cover elevation costs.

Local, Regional and State Planning - $137 million
In collaboration with local communities, the state will work with Texas public universities and/or vendors to conduct planning studies in the impacted areas with the purpose of promoting sound long term recovery.

C. Benefits of Mitigation

CDBG-DR funding for "mitigation activities" has been announced for the state of South Carolina, counties and a municipality associated with the 2015 Floods and Hurricane Matthew.

This funding has yet to be printed in the federal register. (More information regarding mitigation funding is stated above.)

Any specific guidance associated with this CDBG-DR mitigation funding will be included with the allocations to the grantees in the federal register. However, similar to the CDBG-DR funding, CDBG-DR mitigation funding will most likely be a flexible program where states will determine a plan and subsequent programs that would assist in resiliency efforts.

Since the state has been hit by repetitive storms, a mitigation strategy that incorporates and develops sustainable and effective solutions will be essential to protecting the well-being of the state. The state could study the watersheds and prioritize projects that would have the greatest impact on the areas that continue to be named "most-impacted and distressed" areas by HUD.

Proposing a state-wide initiative to phase in different prioritized resiliency and mitigation projects will allow South Carolina to adequately protect its citizens from future natural disasters. A integrated and comprehensive state plan should be based on a watershed approach to reflect how waters actually flow; emphasize and encourage collaboration among state agencies and local governments in the same watersheds to promote efficient and effective use of funds and to avoid creating projects in one locality that could actually increase flood risk in another community; develop and share science-based models and tools, and provide capacity-building for local governments so they can plan and implement effective projects. The overall goals should be to reduce flood-risk and increase community resilience.

D. <u>Evacuation Route</u>

Following Hurricane Florence, the rivers in the Pee Dee and Waccamaw watersheds continued to rise for two weeks. This led to emergency efforts by the South Carolina Department of Transportation to set up barricades along main state highways because most roads around the area were washed out. The only major state highway that remained open with one lane was Highway 501 and this single lane kept the entire Grand Strand area with 250,000 citizens from being cut off from the rest of the state.

FIGURE 11

There is a clear need for a better evacuation route for visitors and residents. While South Carolina has made improvements to hurricane evacuation planning, the inadequate and outdated road system could prove deadly during a hurricane evacuation. During peak tourist season, the population of the Grand Strand swells to nearly 1 million people.

The Southern I-73 has been proposed to run between the Grand Strand and I-95 and is projected to reduce evacuation times by 11 to 15 hours. If built, this interstate could allow hundreds of thousands of people to safely leave the area during an emergency even during peak tourist season. This or other options should receive serious consideration to respond to this need.

E. State Revolving Fund for Loans and Grants

A state revolving fund for loans and grants that is dedicated to flood-related projects would be a very useful and necessary resource for the efforts of the state. Such a state fund could provide low interest loans or grants to recipients in order to assist in performing flood-related restoration projects, buyouts, or even mitigation grants' non-federal cost share.

Such a fund could assist state and local governments or agencies to be able to handle the financial burden that they may face from receiving federal funding cost shares and allow them to conduct independent projects like buyouts that otherwise these areas would not be able to afford.

The South Carolina State Legislature has a bill (S. 259) entitled the South Carolina Resilience Revolving Fund Act introduced by Senators Campsen, Goldfinch, Kimpson, Senn and Campbell. This bill has passed the Senate and has been referred to the Ways and Means Committee in the House.

This proposal could be expanded to allow for a state revolving fund that could assist in funding the non-federal cost share associated with much of the disaster relief funding.

VII. DELIVERABLES

There are several short-term, mid-term and long-term goals that could be achieved to help assist with recovery from previous disasters and preparation for future.

A. Short-Term Deliverables

1. Timeliness of Release of Funds

Timeliness of the release of disaster funds is important to the recovery of South Carolina from the devastation of these storms. There is funding to be allocated to the state from the two disaster relief bills that have passed Congress – one in September 2018 and one in June 2019. Additionally, there is funding for mitigation activities associated with Hurricane Matthew and the 2015 Floods that was passed by Congress in February 2018 and as of June 24, 2019 the funding has yet to be released to grantees as of the writing of this report.

2. Increase Coordination

Due to the number of disasters that have devastated the state in the past four years, many citizens, municipalities, counties and the state are working on initiatives to help recovery and preparation for the future. However, with such a focus on recovery efforts it is essential that efforts be coordinated, and data collection be shared at all levels.

For example, many different communities have determined that a watershed study is necessary to adequately prepare for future storms and prioritizing projects. The state is also coordinating a watershed study for the Pee Dee and Waccamaw watersheds. Since ground water flow is an interconnected system, it is important to develop a coordinated plan. Additionally, the cost of conducting such a study could be expensive for a local community. A cohesive study that includes the interconnectivity of the water systems may be best to be coordinated by the state in order to ensure no overlapping in data collection and lower costs.

B. Mid-Term Deliverables

1. Creation of Comprehensive Mitigation Strategy

Developing a sustainable mitigation strategy could assist in helping the state adequately prevent future damage from natural disasters. With a comprehensive mitigation strategy, the state can begin focusing their efforts on projects that will reduce damages in the future and begin adopting strategies that will help South Carolina when they are faced with a natural disaster.

With developing a mitigation strategy, the state must focus funding on expertise in this area that will ensure they have prioritized the correct projects and utilized the funding sources to the best of their ability. As a plan is developed at the state level, South Carolina should set standards for state and local actions and establish outcomes and criteria that will be used to evaluate proposed uses of mitigation funds. Goals should be focused on reducing flood risk on a large scale and improved community resiliency with specific measurable outcomes supporting these goals should be developed.

2. Identify and Utilize Readily Available Funding

Congress has been appropriating funds to agencies to implement disaster relief programs. Over the years different agencies have developed new and creative programs to help assist victims of disaster relief. As the state of South Carolina and communities identify their needs and develop projects these needs could be communicated and shared among leaders at the local, state and federal level. If leaders are aware of the needs across the state, then each may be able to assist in identifying funding sources. South Carolina could develop a capacity building program to assist local governments that are under-resourced identify solutions, develop a plan and apply for funding.

Federal funding that is allocated to the state of South Carolina needs to be utilized in the most efficient way possible. For example, in the past CDBG-DR funding has only been spent on housing, when the intent from HUD included opportunities to use those funds for infrastructure, economic revitalization and mitigation. South Carolina could develop programs and projects that are eligible for CDBG-DR funding that would address specific needs of the state and begin to build and restore South Carolina communities.

C. Long-Term Deliverables

1. Develop Forward Leaning Prevention Strategy

As South Carolina prepares for the future, it will be necessary to continue developing a long-term prevention strategy against natural disasters. Researching and developing innovative resiliency projects that have been utilized around the globe will allow South Carolina to be a leader in this sector.

2. Improve Understanding of Process, Roles and Available Resources when Next Storm Occurs

For an effective team and recovery efforts, all leaders at the federal, state and community must be educated on disaster relief process and resources available. The only way to combat against natural disasters that may devastate the state is to be fully armed with all the tools necessary – understanding the capacity of each personnel's role in a disaster and how the process works so that each of us can be an advocate for our community. When everyone is educated on all, that is when South Carolina can recover to the best extent possible.

State of South Carolina

Governor Henry McMaster

Thomas S. Mullikin, Chairman

South Carolina Floodwater Commission

Economic Development Task Force Report

November 8, 2019

ECONOMIC DEVELOPMENT TASK FORCE

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I. INTRODUCTION

The South Carolina Floodwater Commission's Economic Development Task Force (the EDTF) has met twice since formation in December 2018, and this report details progress so far. However, actions flowing from any EDTF recommendations are dependent upon expert estimates of the floodwater risks facing South Carolina, and a general statement of the mitigation steps to be taken to deal with them. Mitigation steps might be described in three categories: those that do not offer potential for economic gain and require public funds to execute (hereafter 'public mitigation investments'), those which on their own merits offer the potential for economic gain and might attract private capital to execute (hereafter 'commercial mitigation investments'), and those where a combination of public and private capital might be deployed in their execution (hereafter 'public/private mitigation investments').

The EDTF considers its primary scope the investigation of commercial mitigation investments. Both public mitigation investments and public/private mitigation investments require assignment of public funds, and these should ideally be proposed by state or Federal authorities based on recommendations from the Commission Task Forces.

Moreover, profit-seeking investors making commercial mitigation investments will likely require sound scientific analysis of the floodwater risks faced before considering any commercial mitigation investment, and the EDTF acknowledges the need for the South Carolina Floodwater Commission Task Forces to provide a foundation for these risk estimates in the course of their work on the Commission. A best case, worst case, and most likely case are ideal for investors as they consider making commercial mitigation investment that arise as a result of floodwater and the changing geography South Carolina faces.

Only armed with these risk assessments will profit-seeking investors be likely to invest capital. In addition, should any public or public/private mitigation investment be required to stabilize a location before commercial mitigation investments are feasible, clarity on when such investment is to be executed would also likely be required by profit-seeking investors.

This report identifies five potential areas for commercial mitigation investment and indicates all need further study and analysis, to be conducted in the next phase of the EDTF's work.

II. REPORT FOUNDATIONAL ASSUMPTIONS

The EDTF work rests upon the assumption that there will always be flooding, even in years when there are no catastrophic events such as hurricanes. Rising sea levels and more significant storm/precipitation events mean the ‘new normal’ is likely to frequently reflect record levels of water and precipitation over the foreseeable future. Identified mitigation investments include the following:

- Building of artificial lakes/reservoirs
- Wetlands expansion
- Off-shore barrier protection
- Flood water channelization
- Re-cycling of stormwater

The EDTF is unable to advise on the likelihood of many of these mitigation investments given they will not easily produce revenue streams for ongoing profit seeking enterprises and may accordingly require public mitigation investment to execute. Under such circumstances public funds will likely be required to complete the remediation, and organizations able to execute such public infrastructure investments do exist. However, the EDTF sees these investments beyond the scope of its investigation given they will not provide an opportunity for profit-seeking investment by private sector investors in commercial mitigation investment.

Regardless, an assessment of the risks and options available for public mitigation investment to mitigate floodwater risk will likely also be required before proposals for remediation can be sought from organizations able to execute public mitigation investments. Only from such assessment of the risks and options can the best method and pricing for public mitigation investments be rationally determined.

III. ECONOMIC DEVELOPMENT

Economic growth is primarily focused on the goods and services provided and produced in an area, but there is more to economic development than that. The general welfare of the public is a large concern for development, taking into consideration the health and social well-being of the people. Economic development is essential to the growth of any community, the scope of it concerning both the improvement and growth of the area. To have economic development, communities must make decisions that will positively affect the revenue and the health of the public.

As flooding is reduced throughout South Carolina due to multiple efforts in the Hazard Mitigation Plan and other methods, opportunities are created to generate significant increases to businesses and promote connectivity between communities, as well as reduce traffic and facilitate economic development through both residents and tourists.

As much of a goal as it is to stop flooding entirely, flooding is inevitable in South Carolina due to the vicinity of towns and cities to rivers and the ocean as well as the low topography across much of the state. However, multiple prospects to make flooding a benefit to our economy should be harnessed. These opportunities include ecotourism, aquatic recreation, and construction efforts. Ecotourism benefits the economy by bringing in revenue specifically for conservation and the local community.

Out of the 46 counties in the state, Charleston County is the most prone to hazards. Combined with the four next most hazard-prone counties, half of the state's entire hazard event losses have been incurred since 1960. Not only have the damage dollars accumulated, but the amount of loss in the economy has also grown, amounting to the state losing a grand total of $169,285,615 from hurricanes and tropical storms since 1960 to 2015. These losses do not include the damage from Tropical Storm Hermine (2016), Hurricane Matthew (2016), or Hurricane Irma (2017), all of which added another $67,825,000 to property damage (South Carolina Emergency, 2018).

Tourism

With beautiful beaches, famous seafood and restaurants, rich history, and vibrant attractions for the whole family, South Carolina has an incredible tourism market. In one year, the tourism industry increased by 5.5%, producing an impressive $19.1 billion in 2014. Hotel prices are rising, along with the amount of people flocking to South Carolina, increasing the hotel room occupancy. Not only do the beaches and historical downtown Charleston attract people, but the state parks are a huge appeal, generating a top revenue of $26.9 million in 2014-2015 (Dawson-House, 2016).

Areas that have plentiful types of scenery generate more people due to the variety of interests and activities. Second only to Florida in the tourist industry, South Carolina's coast attracts people who wish to be at the beach and soak in the sun. South Carolina has significantly less coastline than Florida, showing a need for preservation of the coastline available, as well as the need to maintain and raise the number of out-of-towners who flock to the beautiful state. In addition, South Carolina boasts national parks, historic museums and battlefields, and highly praised universities and hospitals.

IV. WETLAND VALUE

Wetlands are extremely important to society, having a value that is unbeatable with its natural functions of water retention of floodwaters, protection from waves and storms, filtration of water that has the potential to become drinking water, and the ability to provide a fertile environment for both flora and fauna which support fishing industries. The value of wetlands worldwide and their range of functions and services was projected to be $14.9 trillion (Economic Benefits, 2006).

Presently, South Carolina does not have any state program that assists in regulating wetlands, relying heavily on the Clean Water Act (Economic Benefits, 2006). Carolina Wetlands Association also assists in promoting the importance and worth of wetlands in North Carolina and South Carolina by leading tours through the wetlands and encouraging a $10 tax-deductible donation from each attendee. Between the two states, 8.1 million acres of wetlands are present, with 3.8 million in South Carolina, accounting for nearly 20% of the state (State of the Wetlands, n.d.). The Wetlands Reserve Program (the WRP) offers landowners financial support for their wetland restoration and protection projects. The federal government is authorized by the WRP to acquire conservation easements from the landowners and cost-share payments for rehabilitation procedures (Wetlands Reserve Program, 2013).

A. Water storage

Due to their amazing ability to store water, wetlands offer one of the best and natural flood damage reductions available. These natural buffers can reduce flooding peaks by 60% with only 15% of the watershed being maintained. One acre of land, about three-quarters of a football field, storing 3 feet of water is equivalent to nearly one million gallons (Economic Benefits, 2006). One inch of water in a home or business can cost $27,000 or more (Estimated Flood Loss, 2017). An acre is 43,560 square feet. Tables 1 -3 summarize estimate structural and personal property losses associated with varying levels of flooding in a representative 2,500 square foot house (Table 1), a 1,000 square foot house (Table 2), and a 5,000 square foot house (Table 3). A common 1,000 square foot South Carolina house with 12" of water has a loss potential of $29,360. This house would cover just 2.3% of an acre, of which that small portion of a wetland could easily store a little less than the 7,500 gallons of water that would otherwise cause the flood damage to the house.

This ability to hold water also makes wetlands an effective mitigating factor during major storms, not just during the flood stage afterward. Waves and storm surges that would otherwise flood coastal properties can be caught in wetland systems. Much of the energy associated with the wind and waves of a major storm can be dissipated by the surface and vegetation of wetlands, lessening the impact of these storm forces on the human environment. It is estimated that across the U.S., wetlands offer over $23 billion annually in these storm protection services (Costanza et al., 2008).

TABLE 1: 2,500 sq ft, one-story home with possessions worth $50,000 (Estimated Flood Loss, 2017).

Interior Water Depth (Inches)	Cost to Home	Cost to Personal Property	Combined Loss Potential
1"	$23,635	$3,172	$26,807
2"	$23,720	$3,172	$26,892
3"	$24,370	$4,917	$29,287
4"	$31,345	$7,207	$38,552
5"	$31,425	$13,914	$45,339
6"	$37,260	$14,777	$52,037
7"	$37,691	$17,700	$55,391
8"	$38,122	$20,624	$58,746
9"	$38,553	$23,547	$62,100
10"	$38,983	$26,470	$65,453
11"	$39,414	$29,394	$68,808
12"	$39,845	$32,317	$72,162
24"	$44,325	$43,001	$87,326
36"	$47,905	$46,633	$94,538
48"	$53,355	$50,000	$103,355

TABLE 2: 1,000 sq ft, one-story home with possessions worth $20,000 (Estimated Flood Loss, 2017).

Interior Water Depth (Inches)	Cost to Home	Cost to Personal Property	Combined Loss Potential
1"	$9,550	$1,269	$10,819
2"	$9,620	$1,269	$10,889
3"	$9,820	$1,970	$11,790
4"	$12,730	$2,924	$15,654
5"	$12,780	$5,474	$18,254
6"	$15,300	$5,861	$21,161
7"	$15,508	$7,019	$22,527
8"	$15,717	$8,177	$23,894
9"	$15,925	$9,335	$25,260
10"	$16,133	$10,493	$26,626
11"	$16,342	$11,652	$27,994
12"	$16,550	$12,810	$29,360
24"	$19,500	$17,160	$36,660
36"	$21,100	$18,731	$39,831
48"	$23,400	$20,000	$43,400

TABLE 3: 5,000 sq ft, multi-story home with possessions worth $100,000 (Estimated Flood Loss, 2017).

Interior Water Depth (Inches)	Cost to Home	Cost to Personal Property	Combined Loss Potential
1"	$47,110	$6,344	$53,454
2"	$47,220	$6,344	$53,564
3"	$48,620	$9,828	$58,448
4"	$62,370	$14,337	$76,707
5"	$62,500	$27,996	$90,496
6"	$73,860	$29,645	$103,505
7"	$74,662	$35,512	$110,174
8"	$75,463	$41,380	$116,843
9"	$76,265	$47,247	$123,512
10"	$77,067	$53,114	$130,181
11"	$77,868	$58,982	$136,850
12"	$78,670	$64,849	$143,519
24"	$85,700	$86,075	$171,775
36"	$92,580	$93,124	$185,704
48"	$103,280	$100,000	$203,280

A wetland can provide an efficient and effective filtration of stream or river water. With the ecosystem present in the wetlands and the plants that can absorb the excess minerals and nutrients from the water to prevent algae growth, a wetland can remove pollutants from water while minimizing filtration processes and costs. The Congaree Bottomland Hardwood Swamp, now called the Congaree National Park, is 22,000 acres and can proficiently filter out such great amounts of pollutants that it would take a $5 million treatment plant to match its productivity (Economic Benefits, 2006). In fact, the process of water filtration is so efficient that municipalities have begun to reconstruct wetlands to meet new state water quality standards and save significantly on city funds. One example of this is the Tres Rios Demonstration Project, which only cost $3.5 million to build, as opposed to the $625 million estimated to upgrade the existent water treatment plant (Gelt, 1997). This project has thrived, restoring populations of animals to the area, as well as attracting visitors who enjoy running the trail around the constructed wetlands, bird-spotting, and fishing (Tres Rios Wetlands, n.d.).

Preserving and constructing wetlands is very valuable to the economy by eliminating the need to build water treatment plants and attracting people and families who wish to hike, kayak, or camp in the wilderness. Ecotourism aims to support the conservation of wildlife by integrating tourism into natural and endangered environments. This type of tourism has shown to be successful in many places, such as Florida, Colorado, California, and Alaska.

The Everglades is a short ride away from the major city of Miami and spans 1.5 million acres of Florida (Everglades National Park, n.d.). In 2012, the Glades had 1,141,906 visitors (Tourism to Everglades, 2015). In 2014, the National Park Service estimated that the Everglades brought forth $104.5 million due to the number of visitors and money spent in communities around the park. The Clean Water Fund found data supporting the result of a $46.5 billion jump in the Florida economy with the investment of $11.5 billion. This boost would inspire real estate development and support an improved habitat (McCarney, 2019).

The value of wetlands is extraordinarily high due to the interests in hiking, bird watching, hunting, and fishing. In 2001, the fishing industry catered to over 34 million people. With this many people involved in fishing and having the need to purchase equipment, tags, permits for land, membership dues, and supplies needed for fishing trips, recreational fishing has been valued at $116 billion. Because wetlands play a vital role in the lifecycle of nearly 90% of the fish caught, this industry could not survive without them. Hunting brings in enormous amounts of money each year, with nearly $200 million being distributed out to states and their programs for wildlife management programs. Hunters spent more than $2.2 billion dollars in 2001 on equipment and private property leases with wetlands. The types of animals that are hunted either live in or migrate to a wetland habitat (Economic Benefits, 2006). With a reduction in wetlands, these industries would diminish greatly.

Some of the large corporations that retail hunting and fishing supplies are Ducks Unlimited, Cabela's, and Bass Pro Shops. Corporations that are outdoor equipment suppliers need the wetlands to be protected, conserved, and restored. Not only do they recognize their value, but many businesses are also huge advocates for the wetland habitat. Ducks Unlimited in America has partnered up with their sister corporations in Mexico and Canada, as well as Wetlands America Trust to conserve 2,236,435 acres by raising $2.34 billion in 7 years (Ammoland, 2019). The Green Bay Packers purchased land to have a Cabela's built, specifically to generate more business in the Green Bay area due to Cabela's high statistics of attracting customers with their special merchandise. In addition, the Packers needed a business that would be the sole attraction of people to visit more businesses around the area, as well as spark interest for further development. The economy would get a boost with the new jobs, along with the 4 acres of wetlands that would be constructed elsewhere, regardless of only losing 1.65 acres with the store's construction (Bergquist, 2012). As of now, the wetlands are unnamed, allowing for the naming of them to come from a large donor to their conservation or an opportunity to adopt a section of the land.

Wetlands do more than provide critical habitat for waterfowl and fish. Some plants are used in medicines and cosmetics, some are used to make roofs. Other parts of the wetland are used to grow crops. Sections of the land are leased out to home species of animals before their fur is harvested. All wetlands require surveyors and supervisors, opening numerous employment positions.

B. <u>Conservation of the Wetlands</u>

The Dogwood Alliance is an environmental organization that works to protect Southern forests and environments that are present across 14 states, including South Carolina. Their research yielded results that found the remaining 35 million acres of wetland we have left in the United States is worth $503.8 billion (Figure 1). With conservation efforts, the data reveal that their worth would increase by $45.3 billion, totaling in $549.1 billion (Figure 2). The switching of the wetlands from a timber supply to an ecotourism and conservation service would multiply the wetland worth by 15 (Davis, 2018).

In South Carolina specifically, wetland forests are worth $39.6 billion, but with conservation, their worth would increase by an estimated $5.1 billion. The protection from severe weather events and the regulation of water flow is estimated to provide $11.9 billion, but this value is projected to rise another $1.5 billion with conservation investments. Water treatment could be worth $10.2 billion with wetland conservation, as opposed to the $9 billion it is now. Erosion control and soil formation worth could increase by $210 million and food and pollination values could increase by $760 million. In 2011, approximately half of the state's residents spent $2 billion on wildlife-related recreational activities (Davis, 2018).

FIGURE 1: Breakdown of wetland forest worth, by category (Davis, 2018).

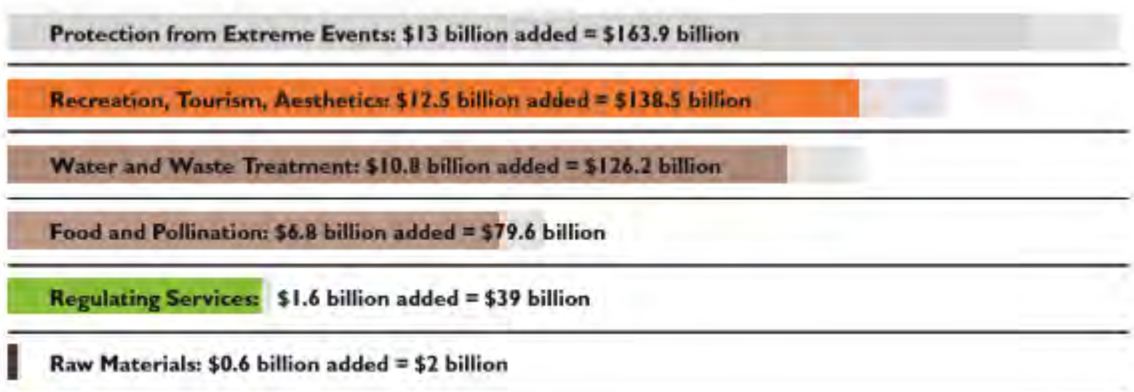

FIGURE 2: Breakdown of wetland forest worth, by category, with conservation investments (Davis, 2018).

C. Findings and Recommendations

The conservation of wetlands has shown the amount of money that can be saved in a multitude of ways, such as protection from extreme weather events to tourism and recreation. The investments made in the natural buffers that can save the state $25.5 billion in only two categories could open a plethora of opportunities for employment and savings, as well as enrich tax bases around the state. Natural disasters will not stop but we can counteract the effects with the start of wetland conservation investments from both private and public origins. In order to mobilize private money, the naming of currently protected wetlands is an honor to those who donated to their conservation efforts. In addition, wetland experts and wetland entrepreneurs can be sought out, along with their advice for the next steps.

V. OYSTER REEFS

Artificial oyster reefs, such as oyster castles, can provide a great boost to the economy in coastal communities. Farmed oysters, clams, and mussels produce nearly 66% of the cultivated populations. Oysters provide many benefits, such as seafood, water quality, and storm protection. The structures of oyster reefs also allow species of other fish to be protected from predators. These species feed other harvested fish that hide out in the reefs, such as crabs, fish, perch, trout, and shrimp. Commercial guided fishing expeditions, additional recreational fishing licenses, more tourism (SCUBA and snorkeling), and the creation of more commercial fish hatcheries could result from artificial oyster reefs being added to our shore (Office of Habitat, 2019).

Oyster production value went from $164 million in 2012 to being worth $234 million in 2015. With the ability to filter up to 50 gallons per day, oysters help improve water quality, making the most preferred habitat for ocean species, such as crabs and fish. When storms come in and make our beaches polluted and overloaded in nutrients, oysters naturally improve the waters by filtering the water (Office of Habitat, 2019). This cuts down on costs for water treatments.

The storm protection services that the oysters are able to provide naturally are valuable with their erosion resilience and protection for wetlands. Wave energy is absorbed by oyster reefs, keeping the shoreline stable and protecting the beneficial wetlands (Fu, 2018). Enhanced oyster reef development therefore may also have the added benefit of reducing the state's burden on beach nourishment costs.

Oyster castles are made from cement and recycled oyster shells, which many restaurants pay places to get their shells picked up, adding to the funds of making the castles at low cost. Shellfish farming has become more common with many programs that educate and teach people how to raise oysters before placing them back in the water (Fu, 2019). South Carolina generated $2.29 million in revenue in 2015 from oyster harvesting.

Findings and Recommendations

The offshore protection of artificial oyster reefs provides both a way to prevent damage from hazards and a way to boost our economy. Consultations with commercial oyster farmers could be beneficial in gathering ideas to make the South Carolina coast more attractive to their industry.

VI. CHANNELIZATION OF STREAMS AND RIVERS

Channelization is the process of reconstructing a stream or river into smaller paths, also called hydromodification. The alteration of different bodies of water is done to assist aspects of agricultural irrigation, navigation, and flooding. This process also includes altering the depth, width, and velocity of the stream (Environmental Protection Agency, 2007). The widening of a river helps with additional water being able to be collected into a larger area and join the flow of the river. However, channelization does often include straightening the river channel, which can lead to a faster stream, adding to the risk of flooding.

There are two scales of channelization; large and small. Large scale channelization is carried out to control flooding. The primary concept is to provide additional accommodation space for floodwaters within the main channel rather than allow these waters to overtop the banks and spill into the flood plain. Small scale channelization is done usually for industrial use and bridge and roadway construction (Gillum & Stafford, 2006).

The channelization process is composed of the planning and evaluation of the area for any possible environmental changes and pollution, plus any programs from which pollution could originate. The planning and evaluation step is imperative to understanding any consequences to the environment, such as the increased speed of the stream, which increases the amount of soil erosion or reduced the depth of the channel. The operation and maintenance programs, like floodwalls, vegetation, and grade control structures, are employed to reduce or avoid these negative effects (Environmental Protection Agency, 2007).

FIGURE 3: The channelization of the Upper Drau River in Austria (Drava – River Widening, 2013).

There are many benefits to river and stream channelization, such as the straightening of a winding channel to make it more navigable. The stronger current that results from a straighter channel can cause the land to be eroded, but this effect can be counteracted by lining the new channel with erosion-control surfaces. One type of lining, called riprap, is the use of heavy stones (sometimes grouted) to prevent erosion, as well as storm drain stabilization and structural support (Hydromodification, 2008). Another benefit in hydromodification is increasing the amount of water passage that normally would not be permitted. A large-scale modification has proven to be economically beneficial in the creation of a once abandoned and now booming city, Bricktown, Oklahoma, with the creation of the canal.

Oklahoma City's vibrant downtown area was not always that way. Investors in the area assisted in the revitalization, but the residents of Oklahoma City voted in 1993 on a self-imposing tax that would be used to revive their downtown area. The one-cent sales tax was used to build projects without incurring any debt. This $350 million tax-funded enterprise went towards many projects to rebrand Oklahoma City's image and build sports and entertainment facilities (MAPS History, n.d.). The famous canal in Bricktown, Oklahoma was a $23 million project that became the heart of downtown. The project was completed in 1999 with some improvements in 2003 and 2004. The riverfront attraction that sliced down the middle of the city was unlike anything the town has ever seen before. The Bricktown Canal is maintained by several organizations that drain and clean the entire canal every four years (Warner & Long, 2009).

The valuable properties on the river were quickly bought up by restaurants and retail stores, bringing business and visitors to the area. The canal brought in so many people and the thriving downtown area made Bricktown such a desired spot that the first major apartment complex was built since the 1980s. In the study area of multiple tracts that contain 20-30 blocks, the population increased by 725 people in 10 years (1990 to 2000). By 2008, the population had grown by more than 1,500 with the share of the population grown being in new apartment buildings and condominium complexes. The first new major apartment complex had rates that were considered high for Oklahoma City standards, but the occupancy rate was high and frequent (Warner & Long, 2009).

The increase in rental housing lead to construction of permanent homes for residents and new investment projects around Oklahoma City, such as the Oklahoma City National Memorial and Memorial Center Museum. A study found from a sample size of 250,000 paid admissions to the museum that a party of 4 spent an average of $96. The market value for Oklahoma County in 2008 was $1.373 million. The people from Bricktown constantly bring in people from all over Oklahoma City, increasing the amount of people in higher socioeconomic statuses with higher degrees, resulting in more employment. It is only 1.3 miles from the farthest corner of thriving Bricktown to the Oklahoma Health Center, which employs a multitude of younger people (Warner & Long, 2009). The Bricktown Canal was a catalyst to a huge industrial and residential boom that reduced unemployment and greatly increased economic revenue in Bricktown and the downtown area, which fed out to Oklahoma City and County.

Another canal project in progress is the Columbia Canal in South Carolina. The canal supplies drinking water to Columbia and hydroelectric power. The 60-foot-wide breach in the dam in October 2015 caused water contamination and boiling advisories (Columbia Canal, n.d.). The hydroelectric plant is no longer in operation due to only one of the gates at the head of the canal being operational. Nearly four years later, the canal still needs repair and money. The city estimates the repairs, resilience, and current standard requirements will cost a total of $169 million, which is the entire 3.5-mile-long levee being reinforced. FEMA has committed $11 million for the breach repair, which is the only thing that needs to be fixed. The city also wants to add new features, such as a trash rack which would keep the waterway clean. Another facility along the river to act as a back-up source for water in the event anything else happens to the canal is in the early stages of planning (Trainor, 2019).

The channelization of rivers presents the opportunity to expand the economic base by giving more prospects for building restaurants and businesses. Building around water has always been an attractive option for both recreational open spaces and commercial use. In the late 1960s, different organizations in Greenville purchased 26 acres and began cleaning up the polluted area. The Reedy River used to be polluted due to the textile mill buildings. The clean-up was a slow process, taking decades to reclaim and beautify the area (The Haro Group, 2014).

However, the investment of $13 million proved to be a brilliant one, with the return on investment amounting to $100 million by 2006 due to the boom in businesses, restaurants, and attractions. An old view-obstructing bridge in Greenville was demolished in 2002, the unique pedestrian-only bridge constructed shortly thereafter (The Haro Group, 2014). The suspension bridge cost $4.5 million and is named Liberty Bridge. It was funded by the City of Greenville's Hospitality Tax, which must be spent on tourism-related structures and facilities (The Liberty Bridge, n.d.).

Findings and Recommendations

City and town planners should be conscious of what floods might do to their waterways, and channelization is a response that should be considered. If such modification of flow paths is considered, care should be taken that they do not bypass flow through wetlands and marshes. Ideally such modifications would ultimately transport water into newly created wetlands.

VII. BUILDING OF AN ARTIFICIAL LAKE

Lakes are incredibly abundant around the globe, ranging in depth, size, and location. Reaching from deserts to mountains, lakes can be more than a mile deep and huge. The Caspian Sea is the world's largest lake and the Dead Sea is the world's lowest lake. Lakes can also be very small, referred to as ponds, and be as shallow as a couple feet deep (National Geographic, n.d.).

There are many ways to classify lakes: by the amount of nutrients, how the water in the lake mixes over the seasons, by the type of fish they have, if it is fed by another body of water, if it is for public use or not, and by its size (National Geographic, n.d.).

Lakes can be created naturally or artificially, creating reservoirs, used to store water for a plethora of reasons (such as recreational uses, providing electricity, industrial uses) or used to control unpredictable rivers, such as the Hoover Dam controls the Colorado River. The water in lakes have different origins, such as snow, rain, streams, and melting ice snow and ice. The majority of lakes are freshwater (National Geographic, n.d.).

People use lakes for water supply, travel, trade, irrigation, dams to provide hydroelectricity, deciding where to buy a house, and recreational activities. Artificial lakes assist in the storage of water during droughts, as well as storage of excess water from streams and rivers that flow into a lake. Part of the recreational appeal of lakes are the amount of wildlife that flock to, breed, and live in lakes (National Geographic, n.d.).

Freshwater fish that reside in lakes and rivers are a huge lure to people, attracting more than 49 million Americans annually. While the Northeast is facing issues with the salmon and the trout populations due to waters becoming warmer, the Southeast is able to sustain their populations of smallmouth and largemouth bass due to their ability to thrive in water temperatures above 70 degrees Fahrenheit. This could provide opportunities of stocking a newly-created lake with fish native to the area, increasing the chance of success with a freshly-begun ecosystem (Climate Central, 2018). Anglers in South Carolina spend an average of 15 days on fishing in the state, only two less than South Carolinians spend hunting, contributing significantly to the 31, 958 jobs and $1.6 billion in value added to the state through fishing, hunting, and wildlife-watching (away from home) according to a study published by DNR (Willis and Straka, 2016).

The option of building reservoirs has often been utilized to assist with both flooding and droughts. Artificial lakes have been made from the dams built, providing regions with lakefront property, recreational activities, ideal spots for businesses and vacations, and vast amounts of energy. Lake Murray in South Carolina originated from the need for electricity. Starting construction in 1927, the lake was finished in 1930 and stretched to Lexington County, Richland County, Newberry County, and Saluda County. Lake Murray has over 600 miles of shoreline, is 41 miles long, and encompasses 50,000 acres. Built specifically to provide electricity, the lake provided employment and power to the Midlands of South Carolina and continues to do so (Top Ten, n.d.).

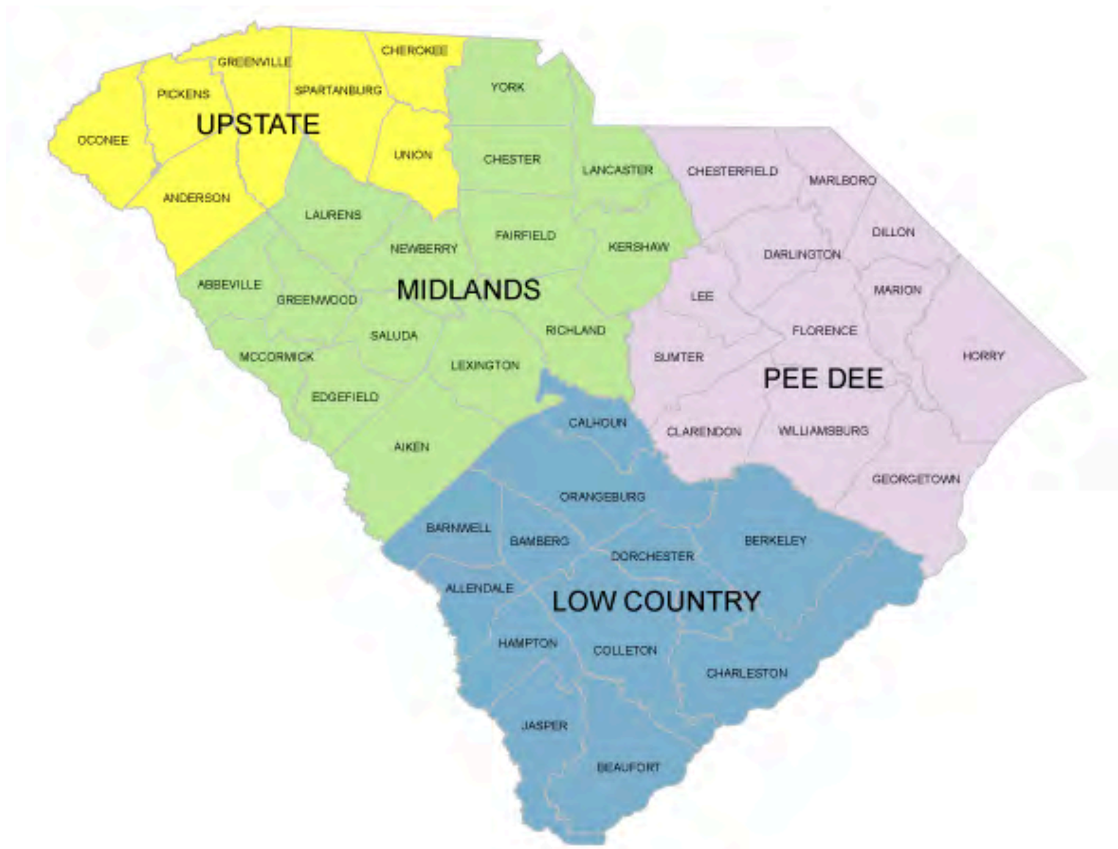

FIGURE 4: Map of South Carolina's regions (South Carolina, n.d.).

The Saluda River feeds into Lake Murray, as well as another lake and reservoir, before joining other rivers and ending at the Atlantic Ocean. Although the lake stretches to 4 counties, some counties still are not suffering from the same levels of traffic. This closer proximity to places that do not have as much congestion makes the lake ideal for new development (Cueto, 2019).

FIGURE 5: Lake Murray (About Lake Murray, n.d.).

The dam is over 200 feet tall and provides desirable views for people to run or walk along the top of it, 1.7 miles one way, and is only a short drive from Columbia, making the process of towing a boat or other water equipment more compelling (Lake Murray Dam, n.d.). With areas around Lake Murray still undeveloped, the potential for growth is great. In Saluda County, a new subdivision will be added to the land with lakefront and interior lots that range from 0.5 to 3 acres. Being one of the largest waterfront developments built along the lake in a decade, this new residential development will plan for people having boats and a plethora of people with its planned boat ramp, boat storage, parks, and playgrounds. It is projected to increase property and sales taxes, as well as bring in more restaurants, marinas, and gas stations. The new residential development is quoted as having “a ‘significant’ economic impact in the area” (Cueto, 2019).

Lake Broadway near Anderson, South Carolina is 300 acres large and has a maximum depth of 22 feet. The lake is popular for water-based recreational activities, such as boating, swimming, and fishing. The 9 listed properties around this lake have a total value of $1,375,700. The lots being sold range in size from 0.47 acres to 3.04 acres (Broadway Lake Homes, 2019). Lake Hartwell typically has over 500 lake homes for sale at any given time. The average listing price of a home for sale on Lake Hartwell is $342,000. There are 801 listings for Lake Hartwell real estate with a total value of $107,024,335 (Lake Hartwell Homes, 2019). Lake Murray homes sell for an average of $495,000 and there are currently 565 listings with a total value of $211,585,018 (Lake Murray Homes, 2019).

TABLE 4: Lake and reservoirs in South Carolina (South Carolina Lakes, n.d.).

Body of Water Name	Acres of Surface Water	Miles of Shoreline	Maximum Depth (feet)	Average Depth (feet)
Lake Marion	90,000	511	76.77	13.12
Fishing Creek Reservoir	3,431	85.1	100	N/A
Lake Greenwood	11,400	212	69.3	21.8
Lake Hartwell	56,000	962	185	45
Lake Jocassee	7,500	75	351	157
Lake Keowee	18,500	387	297	53
Lake Moultrie	60,400	210.24	75.46	18.7
Lake Murray	48,579	620	200	41.5
Lake Russell	9,899	193.56	167.3	38.7
Lake Secession	1,425	52.28	N/A	N/A
Lake Thurmond	71,100	1200	139.4	37
Lake Wateree	13,025	620	225	6.9
Lake Wylie	7,316 (SC) / 13,433 (total)	227.86 (SC) / 325 (total)	94	N/A

Lake Constance in Germany fulfills the need of drinking water for nearly 5 million people, a hot tourist spot in Central Europe, and provides a warmer climate than the surrounding area that allows sensitive plants to grow around the lake. With a surface area of 207 square miles, this lake is the third largest in Central Europe, drawing people in from all over the world. According to a study done of the lake, 90% of Germans have knowledge of the lake and about 88% of them have already visited it. The neighboring areas of Lake Constance have high population density and a high concentration of employment (Megerle, 2013).

A district in Germany that borders the northern shore of the lake found in 2010 that the lake drew a crowd of 807,187 German tourists who booked 3,610,400 overnight stays in the Lake

Constance area. International tourists totaled 1,315,700 and 507,400 overnight stays were booked by these out-of-towners. Additional studies were done by other regions in Germany and compared, finding that the income generated by tourists on a daytrip to the lake could be in the range of nearly $1,120,180,000 annually. Without day trippers, the annual recreational value of Lake Constance is estimated to be $413,410,995 per year (Megerle, 2013).

Like other lakes, Lake Constance boasts both commercial and recreational fishing. Although commercial fishing has decreased in value over the last few years, the value of fishing for the lake still sits at more than $4.48 million every year. The draw of the lake comes from the desire to live or work near the water. Populations are higher in regions close to bodies of water and the values of land closer to lakes only tend to increase. Economic development studies done on Lake Constance have shown that locations near it have been a large factor in determining locations for businesses and residential areas, as seen by the ground value and population density results (Megerle, 2013).

The fresh water supply that Lake Constance provides covers an area of 320 towns and municipalities of the federal state. The market price for drinking water to surrounding areas has increased due to a change in fixed and operational costs of distribution (Megerle, 2013).

A. **Relocation**

The ability to build Lake Murray required the acquisition of nearly 100,000 acres of land, 65,000 of it for the reservoir and its protective margins. Land was purchased from families and many structures had to be either removed or relocated, including graveyards, schools, and churches. Hundreds of workers were hired to clear out the land and produce timber, adding to the generated revenue. The land was bought from the landowners between $15 and $45 per acre, which if purchased in 1927 would be $221 to $662 in 2019 dollars (Lake Facts, n.d.).

1. Case Studies

a. *Kinston, NC*

The city of Kinston, North Carolina was hit by 3 different hurricanes in a span of 4 years that caused more than 75% of the county's homes to be flooded or damaged. Entire neighborhoods and properties, amounting to 1,600 homes in flood-prone areas were purchased and relocated to higher-elevation areas still within the city's tax district. The residents who moved were usually relocated to superior housing, contributing to the willingness of people to move. This removal of structures from areas where flooding was prevalent saved approximately $6 million in losses when the next large storm hit the area. The Neuse River formed a floodplain and the goal to restore the floodplain by means of relocating residences was accomplished. The floodplain is now 73% open space, reverting back to its natural state. FEMA's Hazard Mitigation Grant Program, HUD's Disaster Recovery Initiative, NC's State Acquisition and Relocation Fund, and other programs assisted in making the relocation goal possible (Short, 2018).

Although the city of Kinston still gets flooding in areas, the superior homes that people were relocated to have been able to withstand flooding due to the higher base levels of the homes and ability of the floodplain and open space to keep the flood waters from reaching areas farther away (Short, 2018).

Kinston, NC had an extraordinarily high rate of participation in the community relocation process (97%). To prevent any drop in this willingness to relocate, the city acted quickly and kept residents informed and prepared. With FEMA's Hazard Mitigation Grand Program funding 75% of the acquisition of properties, the State only had to pay for 25% of it, amounting to $10 million (Innovative Floodplain Management, 2013).

The utilization of inmate labor to manufacture component for replacement houses kept the costs as low as possible, with the combination of the $1.5 million contribution from the Governor's relief fund. The new region where people were moved to had some abandoned buildings that were able to be used. A Green Infrastructure was implemented for tourism and recreation (Innovative Floodplain Management, 2013). The new open space near the Neuse River has biking and hiking trails, as well as campgrounds and a nature center (Neuseway Nature Park, n.d.).

Depth of Flooding	#	Building*	Contents	Displacement	Total
Less than 2 feet	15	$184,000	$65,000	$59,000	$308,000
Between 2 and 5 feet	12	$596,000	$127,000	$183,000	$906,000
Greater than 5 feet	74	$3,117,000	$931,000	$1,125,000	$5,173,000
Total	101	$3,897,000	$1,123,000	$1,367,000	**$6,387,000**

FIGURE 6: Losses avoided, calculated with formulas developed by FEMA to estimate the average construction costs to the region. Kinston was estimated to be $45 per square foot.

Although the high amount of voluntary relocation participation yielded great results, many people still did not want to move. However, a Clean Water Management Trust Fund was granted to the city of Kinston, allowing any properties not bought during the acquisition program to be purchased. The buyout program of Kinston, NC was so successful and stands out amongst other acquisition programs due to the combined efforts to move people out of the floodplain and revitalizing downtown. Because of the strategic planning carried out by the city, the economic development increased with the influx of businesses and conservation efforts. The area was made to be more aesthetically pleasing with the removal of junkyards and the addition of green spaces (McCann, 2006).

b. *Darlington, WI*

Darlington, Wisconsin is a community consisting of 2,200 residents that were affected by the flooding of the nearby river for 43 years, the last flood covering a span of 20-30% of the town. This flood left infrastructure damaged, crops ruined, businesses forced to close, and properties devalued. A collaboration with Southwestern Wisconsin Reginal Planning Commission (SWWRPC), EDA, FEMA, multiple state officials, and other agencies was carried out to determine the necessary aspects for an effective flood mitigation plan. FEMA approved the state's first Flood Hazard Mitigation Plan and a couple years later, the next floods that occurred were met with funding and preparedness. SWWRPC assisted with acquiring the funds through different federal programs and grants, such as HUD and FEMA's Hazard Mitigation Grant Program (Resilient Regions, 2011).

Rather than relocate, the city decided to floodproof. Basements were filled with sand, the windows on the first floor were sealed, and the utilities of nearly 40 buildings were raised to be above base flood elevation level. Drain holes were installed in interior areas of buildings to allow for draining and cleaning after floods, as well as equalizing pressure in buildings during floods and preventing damage. Wheelchair ramps were used as additional floodwalls. The property values for the buildings on Main Street in Darlington were doubled due to the flood mitigation and area revitalization (Resilient Regions, 2011).

Some properties were recognized as being polluters, leading to their relocation. The properties included fuel companies and agricultural suppliers, due to their chemical contamination. Other businesses that were moved were car dealerships and farm implement dealerships, due to their lack of historical character of the downtown area. A wastewater treatment facility was also relocated from the flood zone. The newly acquired land was made into a fairground for a farmer's market, campgrounds, a multi-use trail, a park, and a campground. The construction of baseball fields also brought in people from out of town, adding to the flux of people visiting and walking around Main Street in the downtown area (Resilient Regions, 2011).

A 33-acre area was built south of Darlington to be a business park using EDA funding. This area included water mains, a gravity sewer, and drainage improvements. The properties relocated were given first pick to this business park. The trails near the campgrounds are popular with off-road vehicles; running over the main bridge of the city, allowing for highly visible downtown area and what it has to offer (Resilient Regions, 2011).

These areas would not have been made possible without the funds provided by the EDA, which were eventually repaid. The EDA also assisted in the start-up of a business development fund, which focused on the expansion of projects and businesses to create jobs (Resilient Regions, 2011).

B. <u>Findings and Recommendations</u>

Because Lake Murray was projected to increase value to the area and add a plethora of jobs, there was a great turnout of cooperation from property owners and officials in the area. Many of the people relocated opted to move right alongside the lake. This type of behavior can encourage others to move along the lake as well. Areas may even see immediate property value increases at a fraction of the price due to the new development in an area. Marion County has large swaths of land that can easily accommodate a lake with significant amounts of water from storms to replenish it, as well as create jobs, and reduce flooding by channeling the water to the lake. Businesses for outdoor recreational activities are easily able to be manufactured with the simple start-up of a shack for kayaks or canoes.

Waterfront properties have always been known to have a higher value in real estate. Even during bad economic conditions, waterfront properties always are listed higher when being sold. Location is vital in real estate and a lakefront property is always coveted. With the creation of a lake and a lakefront housing development that will only expand, this investment is one that should be exploited.

An artificial lake that is the size of 400 acres (4,710 feet across, if a perfect circle) could be easily placed in a handful of areas throughout South Carolina. With just under 3 miles of shoreline made available (2.8 miles), this lake could have a multitude of houses built around it (assuming standard 1 acre lots, this shoreline could accommodate 22 water-front lots). By taking the known average depth of the 13 lakes listed in TABLE 4, the average depth is calculated to be 33.4 feet. The volume of earth to be moved from a lake that is 400 acres of surface area, with 33.4 feet as the maximum depth, would equal 581,939,937 cubic feet. This earth can be distributed to low lying parts in the state to raise the elevation in flood-prone areas. Marion County might be an ideal place due to the rural area and the connection of the Little Pee Dee River and the Lumber River.

We recommend consulting with experts to determine if there are areas similar to Kinston NC that exist in SC, and if so, what resources would be required to execute a similar relocation program. Further, we recommend experts identify potential areas for artificial lakes and prepare an assessment of the costs and flood reduction benefits to accomplish such a step. This would also require environmental impact and feasibility studies.

VIII. FEDERAL APPROACHES TO FLOODING

A. Insurance Participation

Building in floodplains is subject to a coverage program to provide a claim payment to assist in the compliance of community floodplain management. This program is called Increased Cost of Compliance (ICC) coverage and assists in the cost of elevating, floodproofing, demolishing, or relocating a building. Floodproofing is nonresidential building specific. The maximum amount of $30,000 is available for these services (FEMA, 2017).

A building must be insured by the Standard Flood Insurance Policy (SFIP) under the National Flood Insurance Program to have ICC coverage. In addition, the community must declare the building to be substantially or repetitively damaged by flooding to be considered, and it must be rebuilt to the set standards to reduce future flood damages. This program will only pay for flood-related damages, which must equate to 50% or more of the market value of the home prior to the flood damage. ICC can also provide coverage for a mixture of these services (FEMA, 2017).

FEMA designated areas of flood risks and Special Flood Hazard Areas (SFHAs). Another of the qualifications for ICC coverage is for the building to be in a SFHA. It must also be insured by a National Flood Insurance Program and have a Standard Flood Insurance Policy while in the SFHA (FEMA, 2017).

ICC can help a building be rebuilt to meet local flood standards or be moved to a higher ground away from the flooding. The floodproofing aspect of ICC assists nonresidential buildings and includes the options of watertight shields, reinforced walls for floodwater pressures, and drainage collection system installations (FEMA, 2017).

FEMA supplies a multitude of options for reducing the flood risk in homes that cannot be elevated above the Base Flood Elevation (BFE), such as filling in the basement, abandoning the bottom floor, elevating the lowest interior floor, and installing flood openings. The BFE is the base height that floodwaters are expected to reach. These plans are used to reduce flooding damage, save money over time due to the flood damage prevention, and have the potential to reduce flood insurance premiums.

Flood openings are openings in the foundation walls or can be placed in the enclosure walls of houses that are below the BFE floodwaters to enter and exit. A case study was done in 2015 on a house located in an AE Zone with the first flood elevation above the crawl space was 4 feet above the BFE. AE Zones are "[a]reas in FEMA's mapped 1% annual chance floodplain where base flood elevations are provided." The estimated cost range for the flood openings on the one-story home without a basement was $6,500 to $9,500 including annual maintenance. The current annual flood premium for a $250,000 building with $100,000 contents is $1,147 for maximum coverage. After the flood mitigation, the annual flood insurance premium for maximum coverage drops to $610, amounting to a $537 drop. The estimated time of mitigation cost recovery ranges from 12 to 18 years. The life of this option is 15 to 20 years with occasional yearly maintenance costs.

A case study on a basement infill was done on a $250,000 single-family two-story house with $100,000 contents. The house was located in an AE Zone, with the first floor's elevation above the basement was right at the BFE. A second floor was added to compensate for the lost space due to the infill. The estimated cost range for the basement infill was $72,000 to $108,000, including yearly maintenance. After this process is carried out, the annual flood insurance premium for maximum coverage drops from $6,537 to $1,631, a total savings in $4,906. The estimated time of mitigation cost recovery ranges from 15 to 22 years. The life of this option is 30 to 50 years with minimal or zero additional maintenance of flood openings (FEMA, 2015).

An elevated home can reduce annual flood insurance premiums. An elevated home with the first floor placed 3 feet above the BFE is expected to save 60% or more on annual flood insurance premiums. Even one foot above the BFE has the potential to lower annual flood insurance premiums by 30% (FEMA, 2007).

Coverage Type	Flood Coverage Limit
One to four-family structure	$250,000
One to four-family home contents	$100,000
Other residential structures	$500,000
Other residential contents	$100,000
Business structure	$500,000
Business contents	$500,000
Renter contents	$100,000

FIGURE 7: The flood coverage limits for a standard flood policy (FEMA, n.d.).

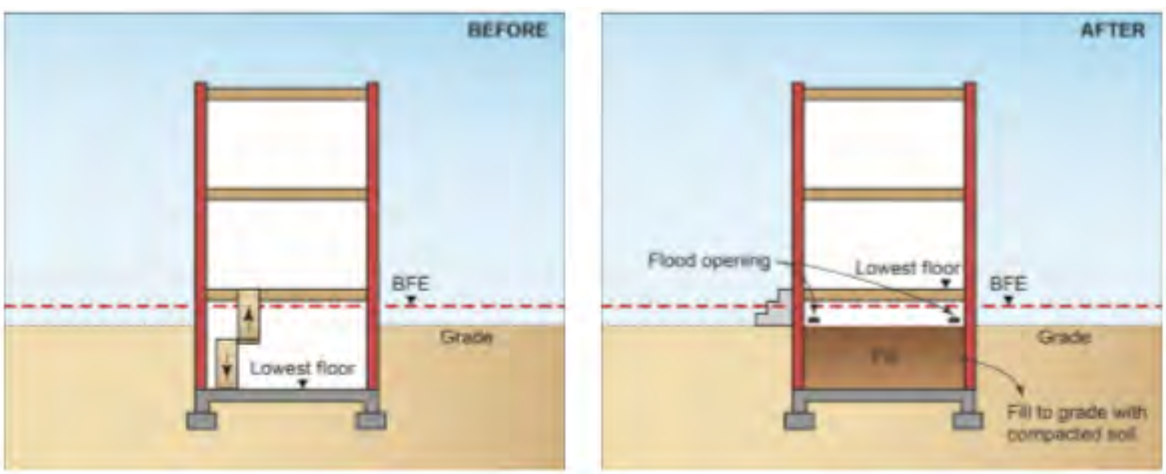

FIGURE 8: Basement infill (FEMA, 2015).

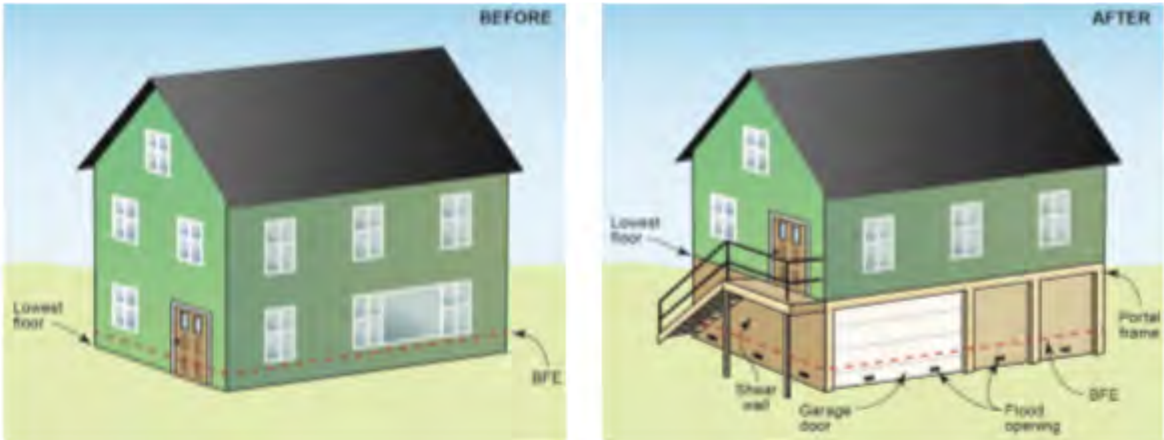

FIGURE 9: The abandonment of the lower floor (FEMA, 2015).

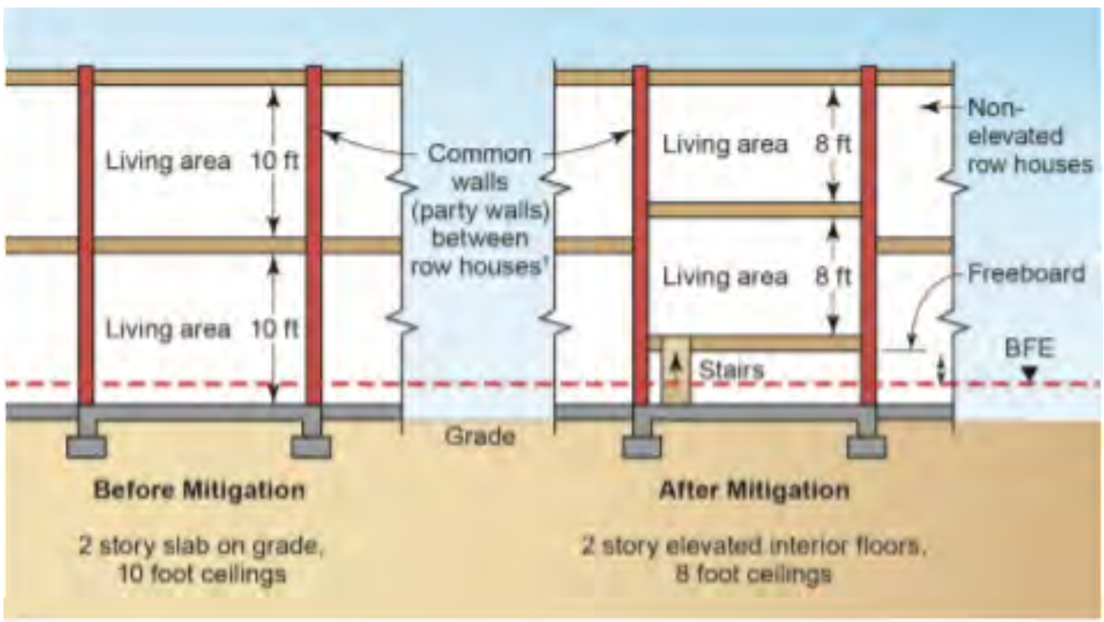

FIGURE 10: The elevation of the lowest floor (FEMA, 2015).

FIGURE 11: Placement of flood openings (FEMA, 2015).

Mitigation Measure	Life Cycle Cost	Expected Useful Life	Design Complexity	Potential for Reducing Flood Damage
Wet Floodproofing Measures				
Flood Openings	Low	15–20 years	Low	High
Elevate building utilities	Low to Moderate	15–20 years	Low	Moderate
Floodproof building utilities	Low to Moderate	15–20 years	Moderate	Limited
Flood damage-resistant materials	Moderate	10–20 years	Moderate	Limited
Dry Floodproofing Measures				
Dry floodproofing system	High	15–30 years	High	Moderate
Barrier Measures				
Floodwall with or without gates	High	50 years	High	Moderate
Levee with and without gates	High	50–100 years	High	Moderate
Interior Modification/Retrofit Measures				
Basement infill	Moderate to High	30–50 years	High	High
Abandon lowest floor	Moderate to High	30–50 years	High	High
Elevate lowest interior floor	Moderate to High	30–50 years	High	High

FIGURE 12: Mitigation options, excluding building elevations (FEMA, 2015).

B. <u>Case Study</u>

In Southern Mississippi, a community called Pass Christian implemented a new zoning map in 2008 called SmartCode. SmartCode is a customizable plan that intersects areas that range from open space to a denser urbanized area (See Figure 12). SmartCode is used in Pass Christian to combine hazard mitigation with the building design, making the downtown vibrant and integrated with various businesses. This encourages visitors to walk around the area and make the downtown area more vibrant. This flood mitigation addresses flood-prone areas and keeps them at lower population densities. The lower density flood zones have transferable development rights (TDDR), which are development rights that property owners can transfer to an area with a lesser flood hazard (Resilient Regions, 2011).

In 2009, Christian Pass began construction on an $8 million improvement project in the downtown area. The funding comes from the Hurricane Katrina Recovery Package and is being used to improve drainage in the downtown area, as well as make the area more walkable and livable for more economic development (Resilient Regions, 2011).

FIGURE 13: SmartCode zoning system and scales of division (Resilient Regions, 2011).

FINDINGS / RECOMMENDATIONS

The integration of several types of buildings, both commercial and residential, could enhance the area and make it more vibrant. Downtown Charleston has hotels and apartments for rent in the mixture of retail store, restaurants, and business offices, showing that more walkable areas make places more accessible and desirable. Although the SmartCode system would not be able to be executed in Charleston, the system can be employed in other areas in South Carolina that experience flooding issues.

IX. RECYCLING WATER

A. Economic Growth Impacts of Investments on Water Reuse

Recycled water is interchangeable with reclaimed water that can be reused. With 94% of the water withdrawn from groundwater and surface water in the United States going towards energy production, food production, and water supply, a model of energy-water-food is recognized as having such a relationship between them that any change in one area affects the others (Tricas & Liner, 2017).

In 2014, a study by the Water Research Foundation and the Water Environment Research Foundation assessed the economic benefits of 30 water utilities' actual and planned expenditures. The report analyzed the economic impact of the water utilities by following how a dollar is spent in one area of the energy-water-food paradigm and re-spent in another. By looking at the direct, indirect, and induced economic activities, the study reported 289,000 jobs and $52 billion per year were created, with only 36,500 employees amongst the utilities (Tricas & Liner, 2017).

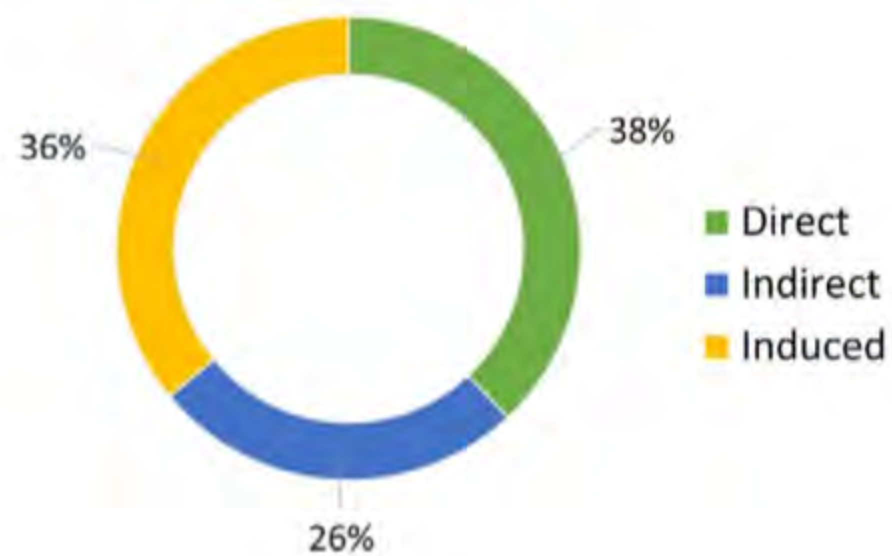

FIGURE 14: Allocation of US jobs created by water investment (16.5 jobs created per million dollars invested) (Tricas & Liner, 2017).

The Clean Water and Drinking Water State Revolving Fund programs have been regarded as the most effective infrastructure funding programs the federal government and states have administered. These programs have provided low-interest loans for thousands of projects across the country. They were analyzed in 2016 by the Water Environment Federation and the Water Reuse Association and found that every federal dollar spent in these programs has a 21.4% return to the federal government as taxes, making the programs a federal investment. The analysis estimated if $34.7 billion was distributed on a federal level, the state was projected to spend $116.2 billion, which together would result in $32.3 billion in federal taxes. Another benefit would be increased employment and labor, adding to the generated revenue (Tricas & Liner, 2017).

TABLE 5: "Jobs created per million dollars capital invested" (Tricas & Liner, 2017).

Sector	*Study*	*Year*	*Jobs created/$million*
Transportation	APTA	2014	15.9
Transportation	Heintz et al.	2009	13–20
Water	Gordon et al.	2011	10
Water	Heintz et al.	2009	15
Water	WEF and WateReuse	2016	16
Water	PA Consulting Group	2009	19–25

According to the Utah Transportation Coalition in a 2014 report, the investment of an additional $11.3 billion to their prearranged $54.7 billion to their new transportation funding would create nearly 183,000 jobs by 2040, in turn resulting in $130.5 billion in more household income, $183.6 billion in gross domestic product, and $22.2 billion in tax revenue from the economic growth (Tricas & Liner, 2017).

B. Types of Water

Before water can be used for eating, drinking, or bathing, it must be treated and meet specific standards. Water is separated into different categories, primarily potable, gray water, and groundwater. Potable water is safe water and has been treated and filtered, meeting drinking water standards. Gray water is wastewater from houses or office buildings, excluding toilets and kitchen sinks. Groundwater is water being held in soil and rock formations.

Potable water is wastewater that has been treated for reuse. Potable water reuse is split into two categories: direct and indirect. Direct potable water reuse is water that has been treated and distributed without a natural environmental buffer, like a lake or groundwater aquifer. It is water that has been deemed safe for consumption. Indirect potable reuse (IPR) does have an environmental buffer where the water is present before being treated at a water treatment plant (EPA, n.d.).

The cost of treatment equipment for a potable water reuse facility varies depending on the location, capacity, and supplementary facilities. The direct potable reuse (DPR) facility in Texas holds 1.8 million gallons per day ($7.00/1,000 gal) and the DPR facility in Orange County, California holds 70 million gallons per day ($6.50/1,000 gal). These costs do not reflect the costs of engineering, permitting, or additional costs, but are estimated to be around one-quarter of the total costs. Another approximate 50% of the costs are the microfiltration and reverse osmosis equipment. However, costs are lower for a facility that is in close proximity to an ocean (EPA, 2017).

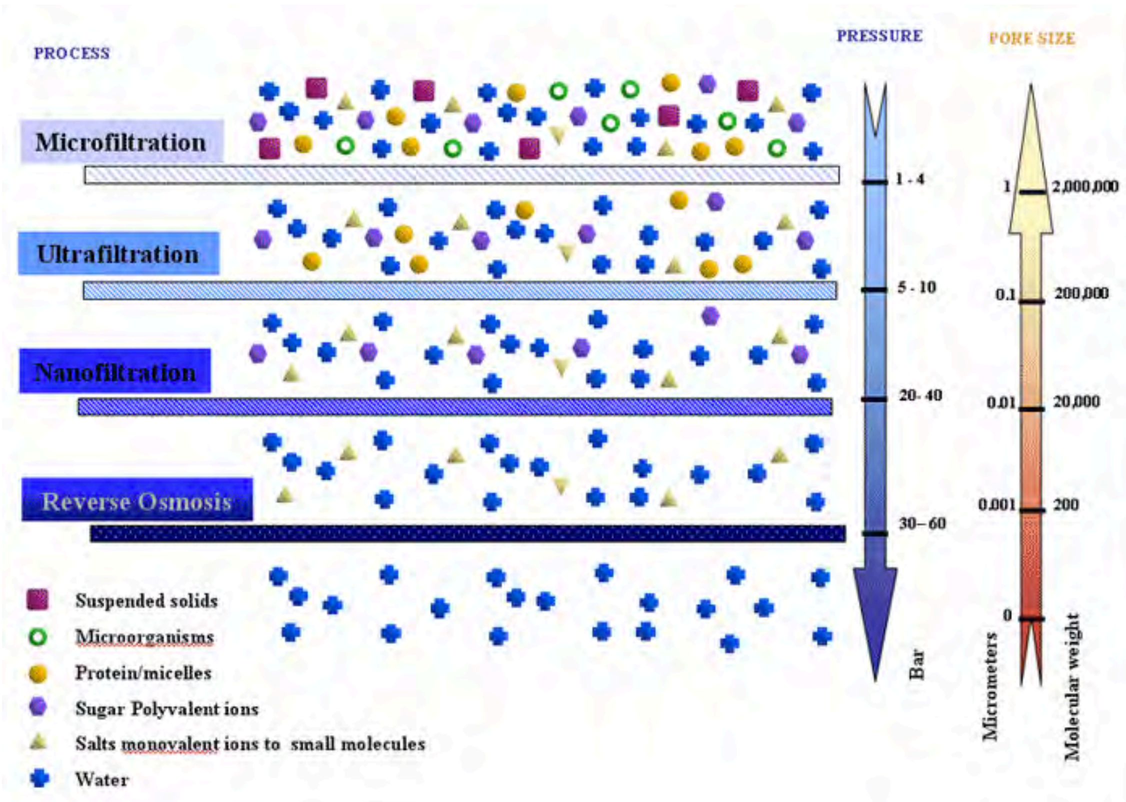

FIGURE 15: Membrane filtration (Membrane filtration, n.d.).

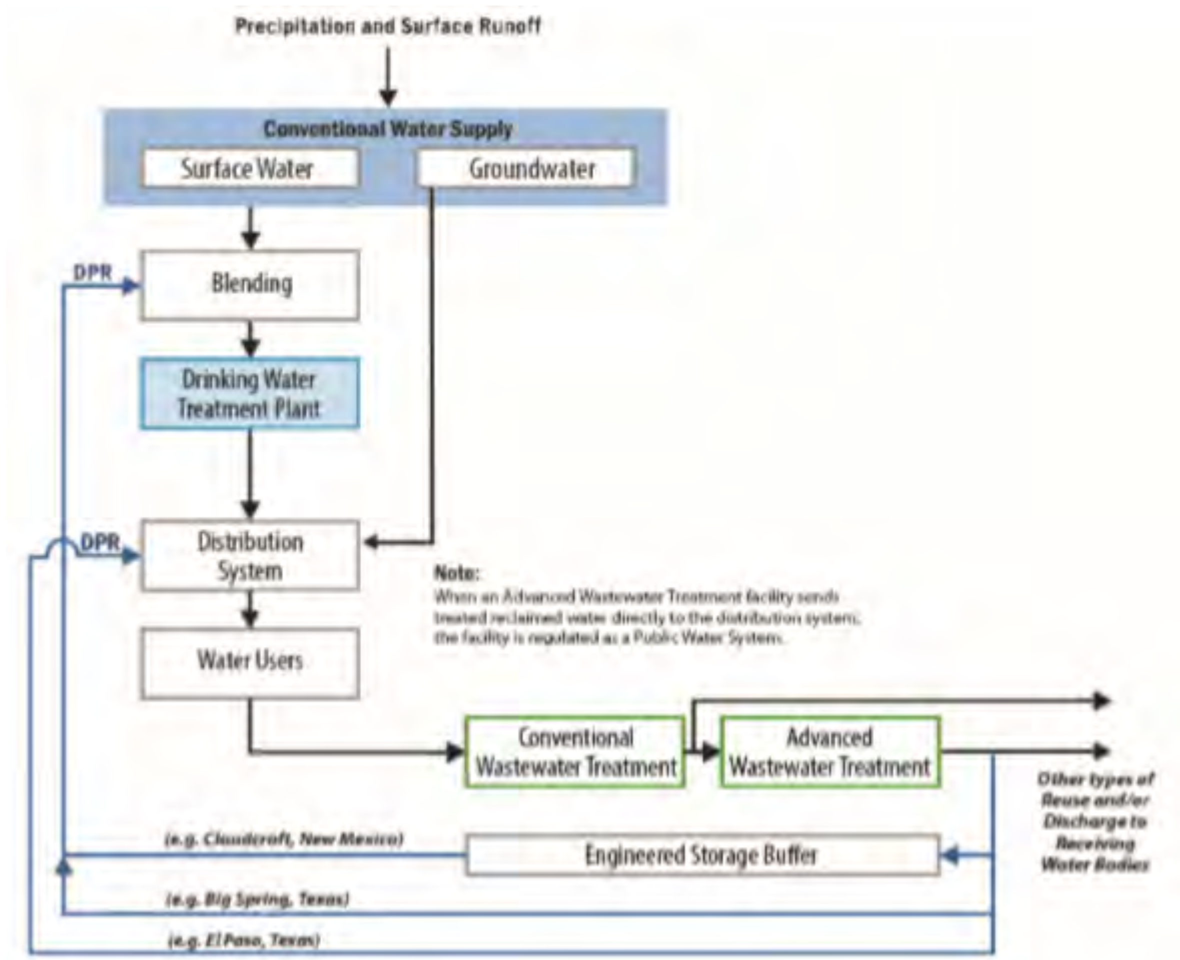

FIGURE 16: Planned DPR scenarios and examples (EPA, 2017).

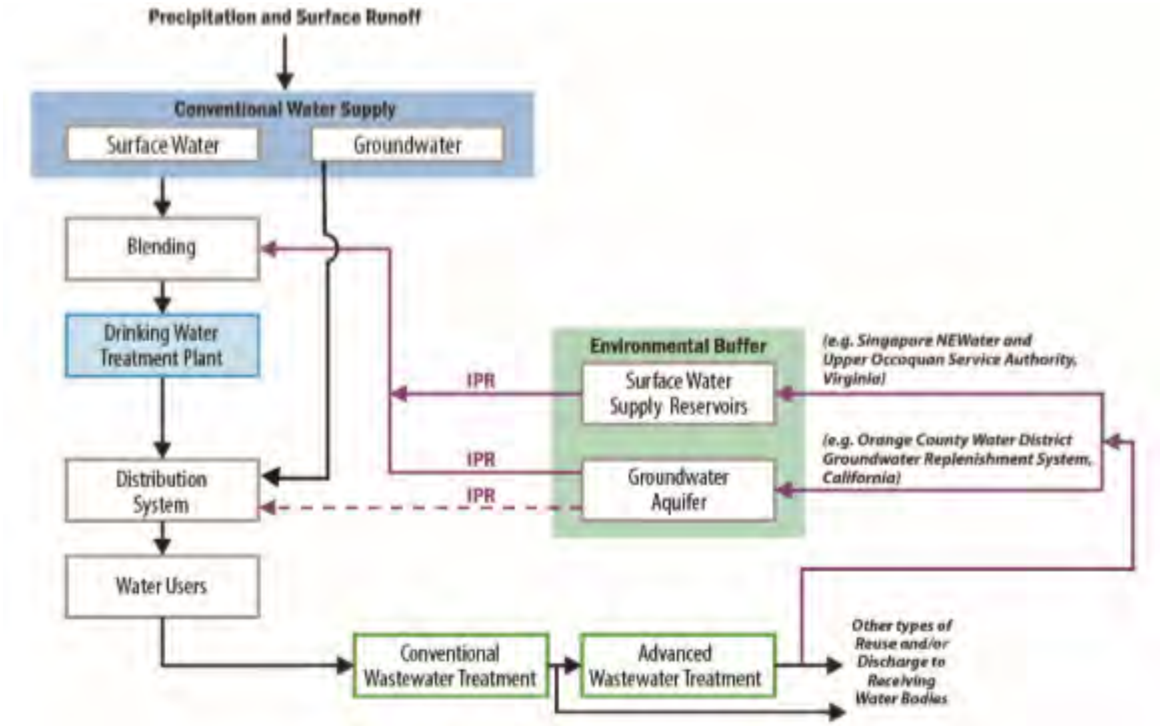

FIGURE 17: Planned IPR scenarios and examples (Source: EPA, 2017).

Gray water is water from households and businesses that do not come into contact with human waste. By avoiding the collection of water that has come into contact with solid human waste, there is a significant reduction of risk in the contamination of bacteria and disease-causing agents in the water. Examples of gray water are water after showers, washing machines, and dishwashers. Because gray water comes from cooking, cleaning, and washing, gray water contains food, soap, oil, and more. Despite there being materials in the water, gray water can be used in irrigation due to the lack of pathogens present in the water or drinking water once it has been treated (About Greywater Reuse, n.d.).

Groundwater is stormwater and rainwater that infiltrates into the ground and penetrates deep within the soil. Some of the bedrock absorbs the water, becoming the aquifer while some of the rock layers in the Earth's surface are not permeable enough for water to seep down any farther. The aquifer becomes saturated and extra water unable to be absorbed turns into surface water, such as a river or lake. The top of the saturated aquifer is called the water table. Many wells are drilled directly into the aquifer to directly access the groundwater (USGS, n.d.).

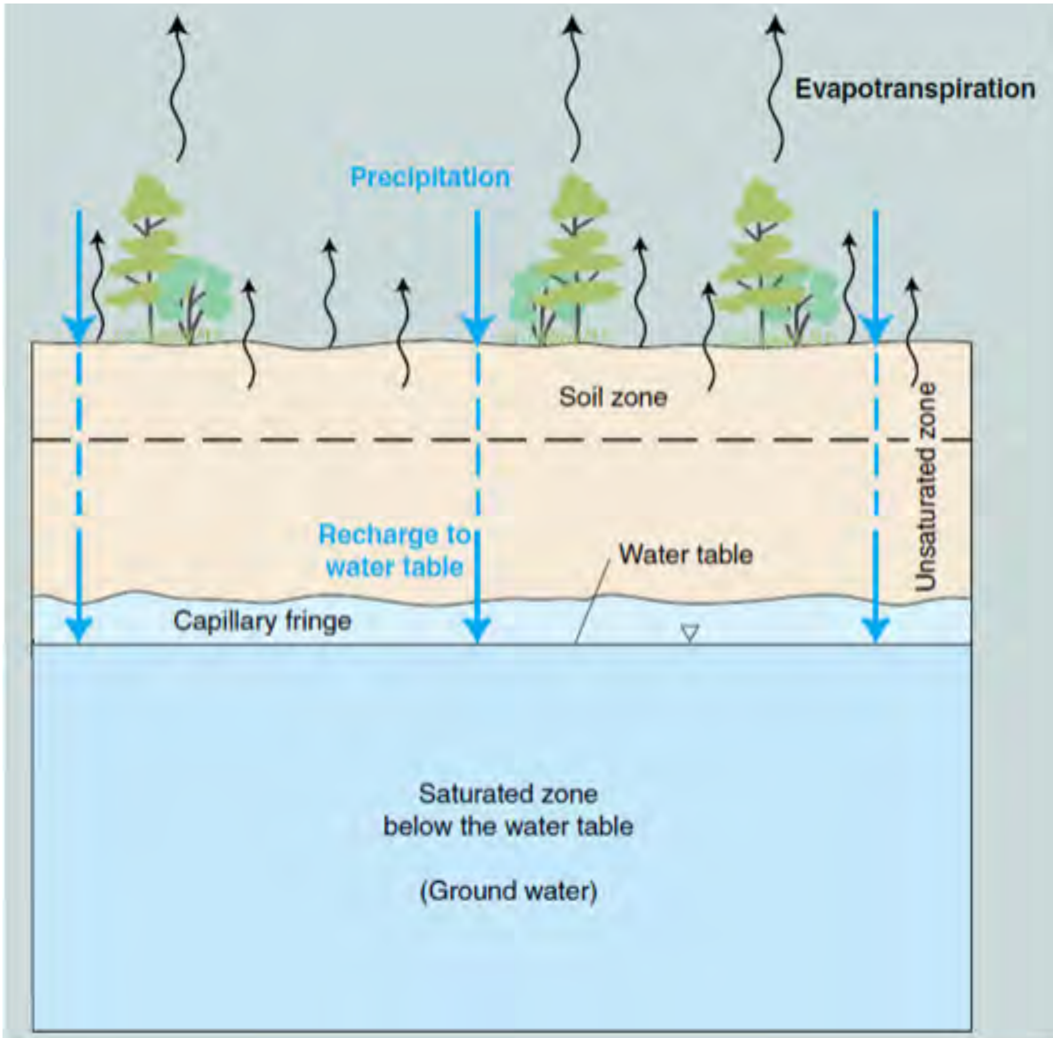

FIGURE 18: Diagram of groundwater (USGS, n.d.).

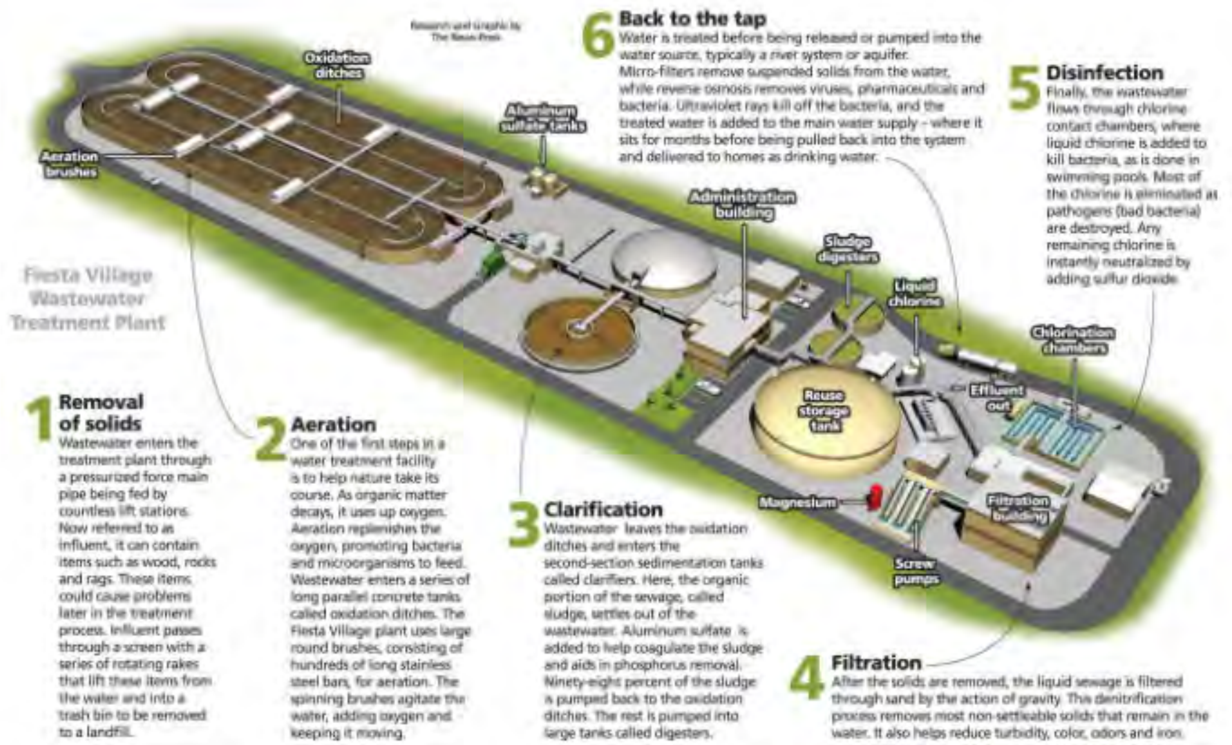

FIGURE 19: An illustration of a wastewater treatment plant in Florida (Wastewater Recycling, 2018).

Rainwater is not considered to be gray water because it is precipitation directly from the sky, therefore being free of chemicals, minerals, and salts. Rainwater harvesting occurs when the precipitation is collected before it permeates the soil. Floodwater harvesting can be dammed and the forced inundation of an area can result in saturated land which is needed for some agriculture. Floodwater can also be diverted to another area, which can be used for irrigation or to reduce flooding.

C. <u>Examples of Water Recycling</u>

Rain Water Solutions has had much success in their program of rainwater barrel distribution programs in a multitude of areas, such as Texas, California, South Carolina, Tennessee, and Pennsylvania. In South Carolina, over 2,000 barrels were purchased by residents of the Ashley Cooper River basin, contributing to the reduction of flooding and stormwater pollution. In addition, this effort has reduced erosion in our stream banks. Each barrel holds 50 gallons of water and the prices of the gallons have been reduced to nearly 50%, making them affordable to many homeowners. Due to this availability, over 100,000 gallons of rainwater have been collected in Charleston County and will continue to collect with each rain (Rain Water Solutions, 2016).

Some breweries have started using recycled water to create a special type of beer to help cut down on the use of water. Pure Water Brew makes beer using 100% recycled water with different brewers from all over the country to show that technology can refine wastewater that at the very least meets drinking water standards, sometimes exceeding them. With resources that promote water sustainability and educate the public on water treatment, this alliance of engineers, technology companies, brewers, and utilities can show an option of recyclable water that can be done several places around the state and with the same facilities already in place (Water Environment Federation, n.d.).

California has a proposed bill that would help make wineries and breweries more efficient in their desire to reuse onsite recycled water. By doing so, one business said they could save hundreds of gallons a day (Chinn, 2019).

Alberta, Canada proudly has an ice-skating rink that uses the melted snow and ice that collects in the snow melt pit. The floodwater recycling system cut down on the need to use 300,000 gallons of potable water annually. With the cost of the system amounting to a little less than CAN $400,000 (around US$298,232), the return of investment on this project is about 7 years (O'Shea, 2018).

Pakistan has a major water shortage crisis, deeming it one of the country's biggest issues. The group of engineers that are working on this challenge have found that the rainy season brings so much water that not reserving this abundant source would irresponsible. There are three rivers that the engineers want to strategically place these structures around that get so much water in them, they can store nearly 50,000 acres feet of floodwater (about 16.3 trillion gallons). The proposed small reservoirs would assist in the summer with crop irrigation and provide drinking water in addition to recharging groundwater (Hasan, 2019).

Using modern technology, the silt in the reservoirs can be minimized and removed. The underground aquifers can also have water reach them faster with holes drilled into them. This direct injection of the water with specially designed wells can help with the recharging of the groundwater, which is depleting quickly (Hasan, 2019). This process is called Aquifer Storage and Recovery (EPA, 2018) and serves as a strategic plan to store water during times of excess for eventual use during times of need.

These reservoirs can help with the economy in Pakistan by working towards solving the water shortages, lack of potable drinking water, the sewage system, water in health facilities, water in villages, and with the agricultural industry in the country. With the ability to have the crops in the summer irrigated, farmers can produce higher yields of their crops and be able to get the best market price for them (Hasan, 2019).

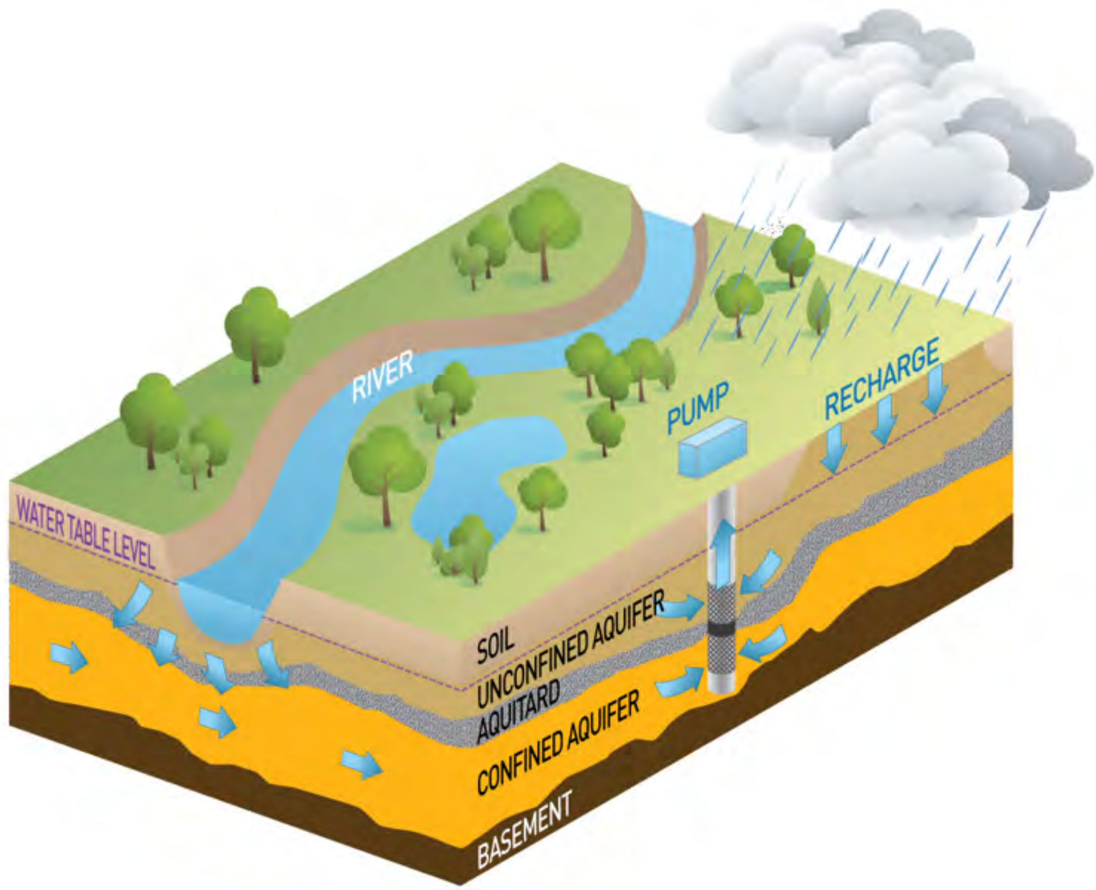

FIGURE 20: How groundwater recharges and a well drilled directly into an aquifer (Discover groundwater, n.d.).

Arizona ended its longest drought in the state's history on June 4, 2019, after 10 years (National Integrated Drought, 2019). During this time, Arizona wisely planned out its water conservation. Despite geographically being a desert, the capital of Arizona, Phoenix, has been able to store one hundred years' worth of water due to the numerous water sources and the city's implementation of water reuse. Using snow prevents the city from having to use groundwater. Highly treated wastewater becomes reclaimed water, used for nuclear powerplant cooling, irrigation throughout the city in parks and the vegetation along rivers and streams, and recharging groundwater. These methods save on using potable water (City of Phoenix, n.d.).

The infrastructures and supplies are built in Phoenix by using developer's fees to cover the cost of construction. Growth in Phoenix does not need to be curtailed due to the water facilities and water reuse efficiency. Phoenix's economy relies on growth in the area. With the steady growth in the population in Phoenix, the economy has been able to steadily rise with residential construction and employment and commerce bases. Without the growth of Phoenix, the city would not be able to afford more projected water resources (City of Phoenix, n.d.). Although the drought in Arizona is no longer in effect, the city will continue to use and improve their water usage and facilities.

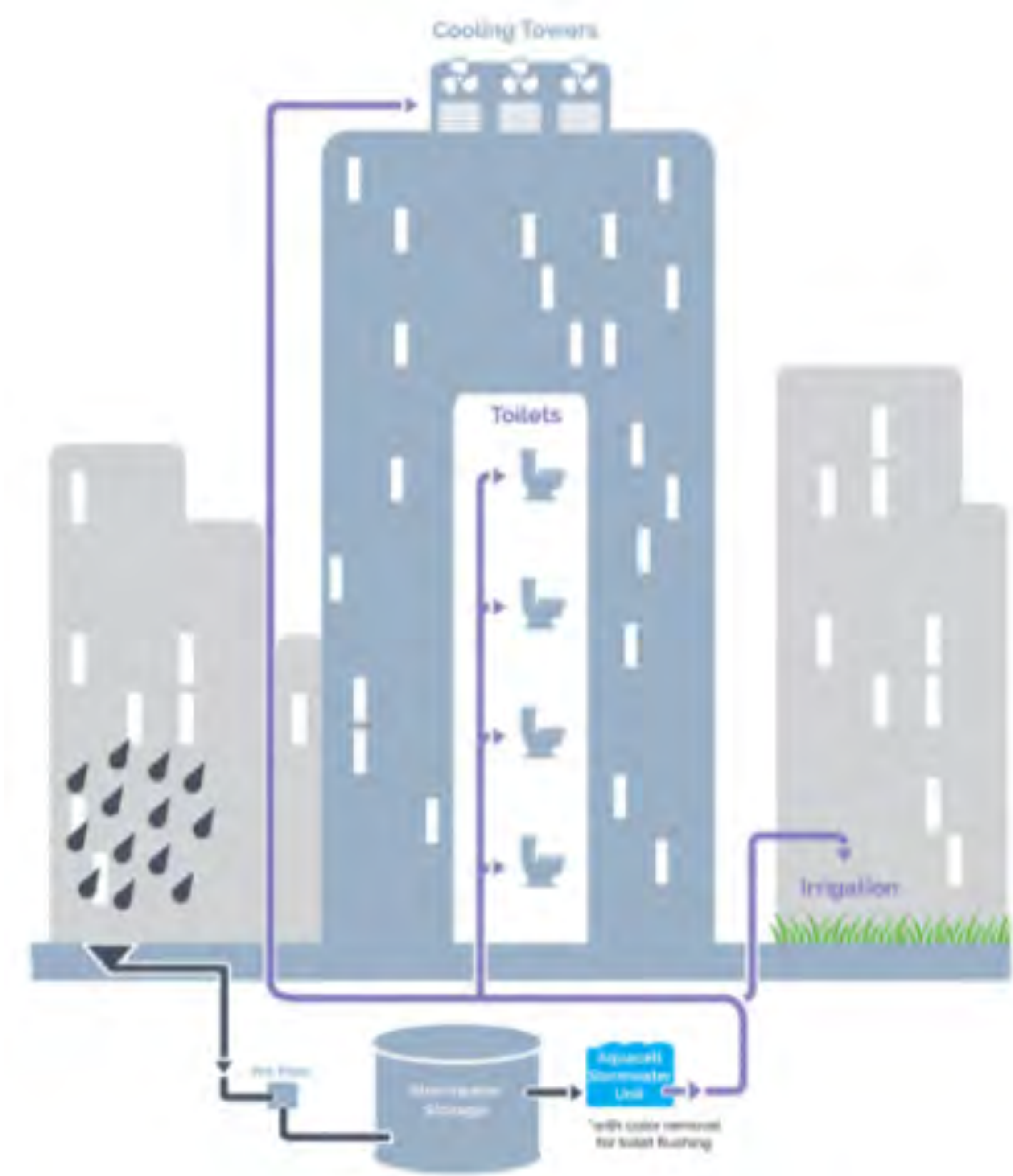

FIGURE 21: Typical flow of stormwater collection and recycling system used in Phoenix, AZ (Rainwater, n.d.).

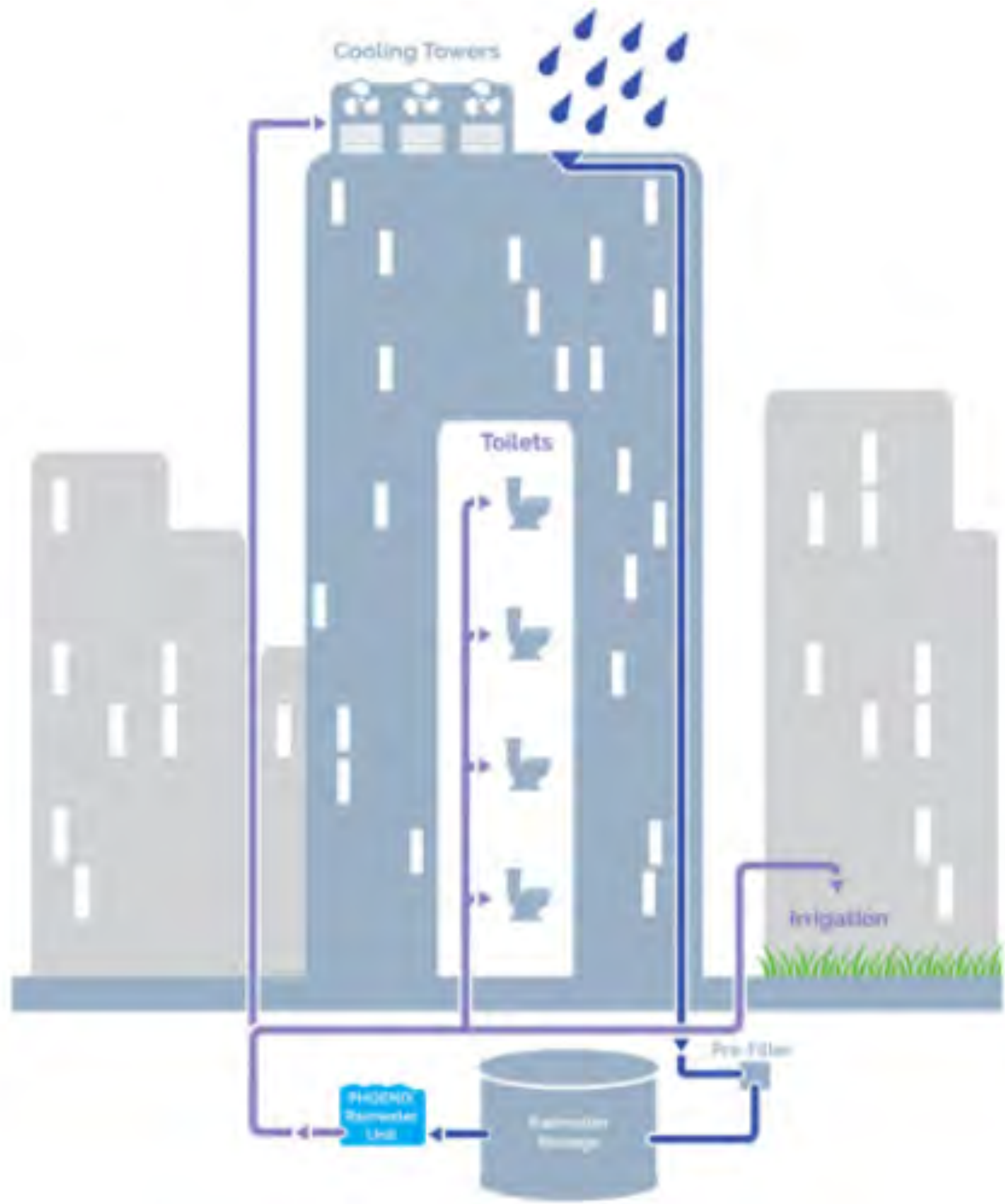

FIGURE 22: Typical flow of rainwater collection and recycling system used in Phoenix, AZ (Rainwater, n.d.).

FIGURE 23: Breakdown of recycled wastewater uses in Phoenix Arizona (Arizona, 2014).

FIGURE 24: Sign showing use and importance of recycled water (Water Reuse, 2016).

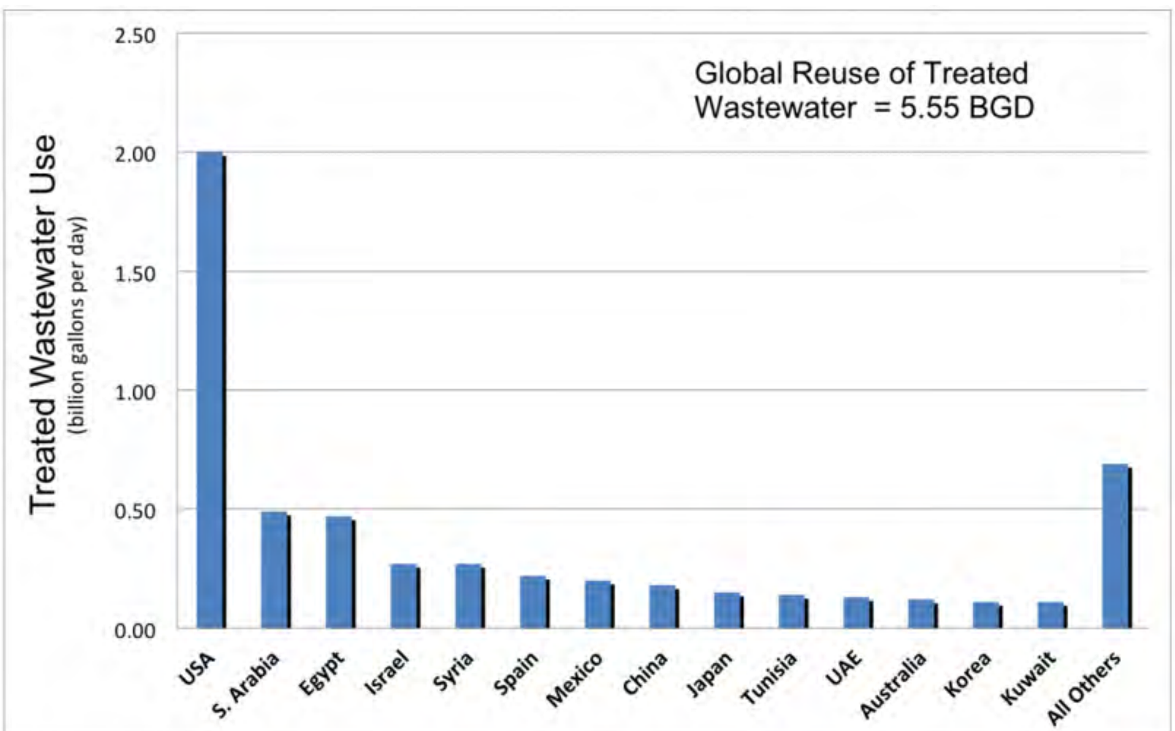

FIGURE 25: According to 2008 estimates, the United States reuses a greater volume of water than any other country (shown here in billions of gallons per day, BGD), and it is ranked thirteenth among countries by per capita water reuse. Qatar and Israel have the highest water reuse per capita. Data from Jiménez and Asano (2008) (Types of Water Reuse, n.d.).

A study carried out in 2013 by the Australia Academy of Technological Science and Engineering compared multiple proposed options for DPR and IPR systems for one of the coastal cities. Overall figures found that DPR is more cost effective than IPR, comparing the systems with "indicative capital costs" of DPR at $616 million to the $1.287 billion for the IPR system. Annual costs for the systems again put the DPR system at less than the IPR system with operating costs at $53 million and $72 million, respectively (Drinking Water, 2013).

D. Findings and Recommendations

With 48 breweries currently in operation in South Carolina coupled with different engineering schools and business to help with the process, the concept of recycling water offers businesses to make beer cheaper, in turn incentivizing them. This concept could later be used for soup or soda. With cheaper options to produce the same amount of product, businesses can create a larger profit, leading to larger taxes returned to the federal, state, and municipal levels of governments.

By replicating the types of structures and reservoirs as seen in Pakistan, South Carolina can add to the removal of excess water from the rivers, stormwaters and floodwaters.

Technology used in Phoenix can be used in South Carolina to aid in storing the water, as well as refreshing it and putting it in a reservoir that can be used to further boost the economy. With the amount of water that can be saved and reused, extra water can be put towards filling in lakes around the state, or filling and maintaining a newly created lake.

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APPENDIX

South Carolina Floodwater Commission

Local Floodwater and Drainage Mitigation Projects

As of October 14, 2019

Compiled by:
SOUTH CAROLINA
EMERGENCY MANAGEMENT DIVISION
OFFICE OF THE
ADJUTANT GENERAL

Appendix – South Carolina Emergency Management Division
Local Floodwater and Drainage Mitigation Projects

The State of South Carolina
Military Department

OFFICE OF THE ADJUTANT GENERAL

R. Van McCarty
MAJOR GENERAL
THE ADJUTANT GENERAL

October 14, 2019

To South Carolina Floodwater Commission:

The following report is a collection of floodwater and drainage mitigation project proposals identified by the counties and local governments and compiled by SC Emergency Management Division personnel. Projects are organized by county and contain estimated costs, priority, point of contact, a description, and in some cases, photographs or maps.

Please direct any inquiries or comments to the undersigned.

Sincerely,

Kim Stenson
Director

KS/djc

Emergency Management Division
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Executive Summary

In 2018, Governor Henry McMaster formed a Floodwater Commission in response to frequent flooding from rain, storms, hurricanes, and tides that have affected South Carolina the past five years. This Commission was formed to identify and implement short and long-term recommendations to alleviate and mitigate flood impacts to the State. The Infrastructure and Shoreline Armoring Task Force within the Floodwater Commission asked the South Carolina Emergency Management Division (SCEMD) to assist with developing a comprehensive and prioritized list of local floodwater and drainage projects.

Starting in March of 2019, the State Regional Emergency Managers (REMS) were tasked to meet with each of their supported Counties and to assist in the development of prioritized project lists. Planning information and guidance included:

- Specific funding sources are currently not in place, but project lists would justify procuring funds through various sources.
- Counties should review current mitigation plans for floodwater and drainage projects.
- Counties should coordinate with local municipalities to identify their project needs.
- Counties should prioritize projects (High, Medium, Low) and provide best-guess cost estimates.
- Counties should provide any local flood vulnerability studies, photos or other related backup documentation.
- A point of contact should be provided for each project.

From March through September of this year, REMS met with all 46 Counties. Through the Counties, local municipalities, the University of South Carolina, Clemson University and the Catawba Indian Nation were invited to submit potential projects. Sixteen Counties, the University of South Carolina and the Catawba Indian Nation declined to submit projects. Three other entities, Clemson University, Dorchester County and the City of Columbia expressed interest in participating but have yet to provide any additional information. If identified, their projects and information will be incorporated into this document.

The remaining Counties and Municipalities identified a total of 227 projects with an estimated cost of $275,325,905. The inclusion of a 10% estimate for management costs results in an overall cost estimate for all projects of $302,858,495. In those cases where a cost estimate range was provided, the higher estimate was used. The State Disaster Recovery Office (SDRO) under a different initiative identified a number of floodwater mitigation projects. The two lists have been reconciled and 16 projects for an estimated $43,628,000 million were identified to be common to both lists. While the intent of this initiative was to identify infrastructure projects, a few counties identified residential housing acquisitions, which have been included.

Projects identified include:

- Flood Studies
- Updates to Mitigation Plans
- Bridge repairs
- Culvert cleaning, upgrades, and repairs
- Clearing of drainage ditches
- Raising of roads that repeatedly flood
- Relocation of critical facilities such as County Emergency Operations Centers
- Repetitive loss property buyouts
- Flood related search and rescue equipment
- Public information campaigns

Local Floodwater and Drainage Mitigation Projects

County	Number of Projects	Project Summary	Estimated Cost
Abbeville	0	No project requests for commission	No project requests for commission
Aiken	0	No project requests for commission	No project requests for commission
Allendale	0	No project requests for commission	No project requests for commission
Anderson	0	No project requests for commission	No project requests for commission
Bamberg	0	No project requests for commission	No project requests for commission
Barnwell	0	No project requests for commission	No project requests for commission
Beaufort	0	No project requests for commission	No project requests for commission
Berkeley*	4	4 County Projects: Water system upgrades, buyouts or diversion options, soil and hydrological study, and a dredging feasibility study	$3,700,000-$33,300,000
Calhoun	2	1 County Project: Improve/regrade 2 roads, and repair or replace culverts	$350,000
Catawba Indian Nation	0	No project requests for commission	No project requests for commission
Charleston	8	8 County Projects (some costs still TBD): Demolition and rebuilding 2 county buildings, reference stations, stream gauges installation, high water marks, dredging, vulnerability assessment, and a watershed assessment	$4,000,000+
Cherokee	3	1 County Project: 6 road culverts 1 City of Gaffney Project: 12 road culverts 1 City of Blacksburg Project: 1 bridge improvement and 1 catch basin Improvement	$3,005,000
Chester	2	2 City of Chester Projects: Storm drainage improvements and maintenance equipment	$662,137.20
Chesterfield	2	2 Town of Patrick Projects: Clean ditches and install headwalls and modify the drainage system	$727,445
City of Columbia		No data submitted	No data submitted
Clarendon*	2	2 County Projects: River channelization/ clean up and floodwater diversion	TBD
Clemson University		No data submitted	No data submitted
Colleton	6	6 City of Edisto Beach Projects: Beach nourishment, Arc Street/Billow drainage project, lagoon system dredging, Fort Street drainage project, groin maintenance and repair, and sea level rise study	$23,375,000
Darlington*	92	24 County Projects 18 City of Darlington Projects 18 City of Hartsville Projects 18 Town of Lamar Projects 14 Town of Society Hill Projects	$14,598,600

County	Number of Projects	Project Summary	Estimated Cost
Dillon*	11	4 County Projects: Canals cleanup and a hydrology study 3 Town of Latta Projects: Clean ditches 4 Town of Lake View Projects: Enlarge culverts and replace drain tiles	$1,267,000-$1,402,000
Dorchester		No data submitted	No data submitted
Edgefield	0	No project requests for commission	No project requests for commission
Fairfield	3	3 County Projects: Dredge a road, purchase mobile generator and construct a dam	$27,700,000
Florence	2	2 County Projects: Countywide hydrology study and buyout 14 homes	$3,500,000
Georgetown	20	8 County Projects: Drainage and repetitive flooding 12 City of Georgetown Projects: Drainage system upgrades	$30,352,000
Greenville	3	3 County Projects: Install a culvert and two bridges	$858,000
Greenwood	0	No project requests for commission	No project requests for commission
Hampton	0	No project requests for commission	No project requests for commission
Horry*	7	7 County Projects: Study raising 10 roads/ highways, clear river of snags, new dam to protect a road, diversion canal study, and 3 studies to improve 3 creek watersheds	$4,500,000
Jasper	0	No project requests for commission	No project requests for commission
Kershaw	0	No project requests for commission	No project requests for commission
Lancaster	7	7 County Projects: Maintain and/or upgrade dams, replace or retrofit culverts, install stream gauges, FEMA Floodplain study update, and property acquisition	$68,107,400
Laurens	2	2 County Projects: New EOC/911 Center and generator for Wastewater Treatment Center	$4,140,000
Lee*	3	3 County Projects: Hydrological/drainage studies and drainage ditch	$275,000
Lexington	10	10 County Projects: Improve water rescue capability with equipment purchases, 2 bridge retrofits, and 3 culvert modifications	$1,942,864
Marion*	14	8 County Projects: Cleaning river and culverts, hydrology study 4 Town of Mullins Projects: Cleaning culverts and ditches, 1 Town of Nichols Project: Clean ditches	$7,810,000
Marlboro*	4	4 County Projects: 3 projects to clean 4 creeks and 1 project to clean numerous roadsides	$10,500,000
McCormick	0	No project requests for commission	No project requests for commission
Newberry	1	1 City of Newberry Project: Create a drainage basin to protect major water treatment facility and numerous neighborhoods	$4,000,000
Oconee	0	No project requests for commission	No project requests for commission

County	Number of Projects	Project Summary	Estimated Cost
Orangeburg	0	No project requests for commission	No project requests for commission
Pickens	0	No project requests for commission	No project requests for commission
Richland	1	1 County Project: Improve rural firefighting capabilities	$812,000
Saluda	7	7 County Projects: Hydrologic study, replace bridges, and redesign pond relief pipes	$2,235,000
Spartanburg	1	1 County Project: 9 bridge replacements and a culvert replacement	$10,261,000
Sumter	1	1 County Project: Revise and implement FEMA Floodplain mapping	TBD
Union	1	1 County Project: Update Mitigation Plan for FEMA approval	$5,000
University of South Carolina	0	No project requests for commission	No project requests for commission
Williamsburg	0	No project requests for commission	No project requests for commission
York	8	1 York County Project: Creek stabilization 3 City of Rock Hill Projects: Stream restoration, culvert and drainage pipe replacement, bridge repair 1 Rock Hill School District Projects: Storm drain repair 1 Town of Clover Project: Property buyout 2 City of Fort Mill Projects: Bank stabilization and generators	$16,907,459

Note: In cases where there is range in the estimated costs, the higher dollar amount is used.
*: Indicates County has a common project(s) identified on State Disaster Recovery Office (SDRO) list

Summary:
- Number of Projects: 227
- 30 Counties currently participating
- $275,325,905 Total Estimated Costs
- $27,532,590 Estimated Management Costs (10%)
- $302,858,495 Total Cost

Abbeville County

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No Project Requests for Commission

No Project Requests for Commission

Allendale County

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No Project Requests for Commission

Anderson County

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No Project Requests for Commission

Bamberg County

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No Project Requests for Commission

Barnwell County

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No Project Requests for Commission

Beaufort County

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No Project Requests for Commission

Berkeley County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Dennis Drive	Complete water system upgrade	City of Goose Creek	$400,000	High	Benjamin Almquist 843-826-7628 benjamin.almquist@berkeleycountysc.gov
California Branch[1]	Home Buyout or Diversion and cross pipe improvements or Implement an easement diversion option	Town of Moncks Corner	$1,300,000-$30,900,000	High	Benjamin Almquist 843-826-7628 benjamin.almquist@berkeleycountysc.gov
Wagon Trail Crossing	Soil and hydrological study	Berkeley County	$300,000	High	Benjamin Almquist 843-826-7628 benjamin.almquist@berkeleycountysc.gov
Bushy Park Boat Landing	Dredging feasibility study	Berkeley County	$1,700,000	High	Benjamin Almquist 843-826-7628 benjamin.almquist@berkeleycountysc.gov

[1] SDRO Project ID 2: California Branch Drainage Study

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Project Name: Dennis Drive

Project Priority: High

Entity Proposing Project: City of Goose Creek
Estimated Costs: $400,000
Point of Contact: Benjamin Almquist, 843-826-7628, benjamin.almquist@berkeleycountysc.gov

Details: Complete water system upgrade in Goose Creek, South Carolina

Project Name: California Branch

Project Priority: High

Entity Proposing Project: Town of Moncks Corner
Estimated Costs: $1,300,000 (Option 1); $3,940,000 (Option 2); $30,900,000 (Option 3)
Point of Contact: Benjamin Almquist, 843-826-7628, benjamin.almquist@berkeleycountysc.gov

Details: To handle flooding along California Branch in Moncks Corner, there are multiple options. Option 1: Home Buyout of previously impacted homes; Option 2: Diversion and cross pipe improvements; Option 3: Implement an easement diversion option

Project Name: Wagon Trail Crossing

Project Priority: High

Entity Proposing Project: Berkeley County
Estimated Costs: $300,000
Point of Contact: Benjamin Almquist, 843-826-7628, benjamin.almquist@berkeleycountysc.gov

Details: Soil and hydrological study in Summerville, SC

Project Name: Bushy Park Boat Landing

Project Priority: High

Entity Proposing Project: Berkeley County
Estimated Costs: $1,700,000
Point of Contact: Benjamin Almquist, 843-826-7628, benjamin.almquist@berkeleycountysc.gov

Details: Dredging feasibility study on 1500 block of Bushy Park Road

Calhoun County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Road Culvert Upgrades	Raising and regrading two roads and replacing or repairing culverts	Calhoun County Roads and Bridges	$350,000	High	David Chojnacki 803-456-0860

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Project Name: Road Culvert Upgrades
Project Priority: High
Entity Proposing Project: Calhoun County Roads and Bridges
Estimated Costs: $350,000
Point of Contact: David Chojnacki, 803-456-0860

Details: There are two roads (Garden Lane and Good Hope Road) in the county that need to be raised and regraded so they are above flooding. The culverts and drainage pipes will need to be replaced or repaired. It is estimated that the cost for Garden Lane is approximately $150,000 and the cost for Good Hope Road is approximately $200,000.

Catawba Indian Nation

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No Project Requests for Commission

Charleston County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Charleston County Juvenile Detention Center 700-17A	Demolition and rebuilding of Juvenile Detention Center	Charleston County	TBD	High	Ed Lee Charleston County Capital Projects elee@charlestoncounty.org
Charleston County South Windermere Library	Demolition and rebuilding of library	Charleston County	TBD	High	Janette Alexander Charleston County Capital Projects jalexander@charlestoncounty.org
County Risk and Vulnerability Assessment	Procure a regional vulnerability assessment	Charleston County	TBD	Med/High	Niki Grimball Charleston County Planning ngrimball@charlestoncounty.org
County Watershed Assessment	Provide an updated assessment	Charleston County	1,000,000	Med/High	Niki Grimball Charleston County Planning ngrimball@charlestoncounty.org
West Ashley Outfall Dredging	Dredge 2 sandbars	Charleston County	$3,000,000+	Med/High	Chris Wannamaker Charleston County Storm Water cwannamaker@charlestoncounty.org
CORS-CRS	Incorporate Continuously Operating Reference Station (CORS) from NOAA	Charleston County	TBD	Low	William Horne Charleston County Building Inspections whorne@charlestoncounty.org
High Water Marks	Additional High water marks	Charleston County	TBD	Low	William Horne Charleston County Building Inspections whorne@charlestoncounty.org
Stream Gauges	Install Stream Gauges	Charleston County	TBD	Low	William Horne Charleston County Building Inspections whorne@charlestoncounty.org

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Project Name: Charleston County Juvenile Detention Center 700-17A

Project Priority: High
Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: Ed Lee, Charleston County Capital Projects, elee@charlestoncounty.org

Details: Demolition of the existing facility to mitigation repetitive flooding and rebuilding in a new area.

Project Name: Charleston County South Windermere Library

Project Priority: High
Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: Janette Alexander, Charleston County Capital Projects, alexander@charlestoncounty.org

Details: Demolition of the existing facility to mitigation repetitive flooding and rebuilding in a new area.

Project Name: County Risk and Vulnerability Assessment

Project Priority: Med-High
Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: Niki Grimball, Charleston County Planning, ngrimball@charlestoncounty.org

Details: Procure a regional vulnerability assessment that incorporates all County and surrounding jurisdictions to understand flooding on a regional level and provide recommendations; and to provide a foundation for making policy changes.

Project Name: County Watershed Assessment

Project Priority: Med-High
Entity Proposing Project: Charleston County
Estimated Costs: $1,000,000
Point of Contact: Niki Grimball, Charleston County Planning, ngrimball@charlestoncounty.org

Details: Provide an updated assessment to understand the impacts of watersheds throughout the county.

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Project Name: West Ashley Outfall Dredging

Project Priority: Med-High
Entity Proposing Project: Charleston County
Estimated Costs: $3,000,000+
Point of Contact: Chris Wannamaker, Charleston County Storm Water, cwannamaker@charlestoncounty.org

Details: Dredge two sand bars in the middle of the creek that are significantly reducing flow for 2000+ homes; cannot utilize HMGP because it is a maintenance project.

Project Name: CORS-CRS

Project Priority: Low
Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: William Horne, Charleston County Building Inspections, whorne@charlestoncounty.org

Details: Incorporate Continuously Operating Reference Station (CORS) from NOAA. CORS provide GPS data to support very accurate 3D positioning, meteorology, space weather, and geophysical applications. None are located in Charleston, and overall SC has very few. To get CRS credit on this, CORS must be located within a 30-mile radius of each other.

Project Name: High Water Marks

Project Priority: Low
Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: William Horne, Charleston County Building Inspections, whorne@charlestoncounty.org

Details: To assist in planning for future flood conditions, Charleston needs additional high-water marks throughout the county to help estimate flood inundation at different locations.

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Project Name: Stream Gauges

Project Priority: Low

Entity Proposing Project: Charleston County
Estimated Costs: $TBD
Point of Contact: William Horne, Charleston County Building Inspections, whorne@charlestoncounty.org

Details: Located throughout Charleston County. Help with analyzing streamflow conditions and recording data/conditions.

Cherokee County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
County Road Improvements	6 County Roads: installing box culverts and building up roads	Cherokee County	$525,000	High	Steve Bratton 864-761-6072 steve.bratton@cherokeecountysc.com
City of Gaffney Road Improvements	12 sections of city roads: installing box culverts and building the roads up	City of Gaffney	$920,000	High	James Taylor City of Gaffney Administrator 864-486-6059 james@cityofgaffney-sc.gov
City of Blacksburg Road Improvements	2 sections of city roads: installing box culverts and building the road up	City of Blacksburg	$1,560,000	High	Laura Foster Town of Blacksburg 864-839-2332 laura@townofblacksburg.com

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Project Name: County Roads Upgrades

Project Priority: High

Entity Proposing Project: Cherokee County
Estimated Costs: $525,000
Point of Contact: Steve Bratton, 864-761-6072, steve.bratton@cherokeecountysc.com

Details: All projects are open creek crossings on County roads where we would propose installing precast box culverts in the crossing and building the road up to go across the culvert. These projects do not consider the amount of traffic on each of these roads.

-Junies Rd - creek crossing $75,000 - There are 6 property owners on this road. 100 Block to 300 Block
-Carolina Ridge Rd - creek crossing $75,000 - There are 32 property owners on this road. 300 Block
-Cherokee Ford Rd - creek crossing $75,000 - There are 26 property owners on this road. 300 Block
-Woods Cross Rd - creek crossing $75,000 - There are 7 property owners on this road. 400 Block
-Little Hope Rd - creek crossing $150,000 - There are 23 property owners on this road.
-Chestnut Ridge Rd - creek crossing $75,000 - There are 46 property owners on this road. 500 Block

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Project Name: City of Gaffney Road Improvements

Project Priority: High

Entity Proposing Project: City of Gaffney
Estimated Costs: $920,000
Point of Contact: James Taylor, City of Gaffney Administrator, 864-486-6059, james@cityofgaffney-sc.gov

Details: The below roads need mitigation due to flooding, to include installing box culverts and raising the roads.

Street Names	Structure ID	Size	Pipe Material	Latitude & Longitude	Cost	Persons Impacted
Annette St.	CB2010	60"	Corrugated Metal	35.062172,-81.630244	$50,000.00	33
Robinhood Dr.	CB1521	80"	Corrugated Metal	35.058163,-81.655080	$65,000.00	31
Pleasant Meadows Dr.	CB307	48"	Corrugated Metal	35.092933,-81.668918	$60,000.00	36
Lincoln Dr.		48"	Galvanized	35.090517,-81.678021	$70,000.00	13
Peeler St.	CB2909	50"	Concrete	35.081900,-81.651073	$120,000.00	15
Littlejohn St.	CB2912	72"	Concrete	35.084011,-81.649881	$40,000.00	88
W. Carlisle St.	CB3282	60"	Concrete	35.082910,-81.650462	$150,000.00	33
W. Carlisle St.	CB3160	36"	Plastic	35.086149,-81.654607	$25,000.00	33
Calton Dr.	CB294	48"	Concrete	35.084965,-81.664514	$80,000.00	31
Calton Dr.	CB310	48"	Concrete	35.082932,-81.667512	$80,000.00	31
Saxon St.	CB180	48"	Concrete	35.079279,-81.685635	$30,000.00	14
Briarwood Drive	Creek Pipe	60"	Galvanized	35.060876,-81.664460	$150,000.00	57
				Total	$920,000.00	
Calton Dr. both pipes need to be up-sized to 60"						

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Project Name: City of Blacksburg Road Improvements

Project Priority: High

Entity Proposing Project: City of Blacksburg
Estimated Costs: $1,560,000
Point of Contact: Laura Foster, Town of Blacksburg, 864-839-2332, laura@townofblacksburg.com

Details: Brugg Street Bridge - The Brugg Street Bridge over Doolittle Creek floods with excessive rain. Due to hurricanes in the past few years, residents from a South Carolina Regional Housing Authority Apartment complex and a single-family dwelling have had to be evacuated. The evacuation displaces seven housing units with 42 total residents. The cost to replace the SCDOT Bridge is approximately $1,500,000.

Pictures available upon request.

Lime Street - The existing pipe and catch basin on Lime Street is too small. This results in flooding of Lime Street and the house across the street. The public works department estimates the cost of replacing the pipe and catch basin to be $60,000.

Pictures available upon request.

Chester County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
East Chester Neighborhood Storm Drainage Improvements	Replace/ upsize road crossings and establish roadside ditches	City of Chester	$296,928	High	Stephanie Jackson Chester City Administrator 803-581-2123 x241 sjackson@chester.sc.gov
Maintenance Equipment	Equipment to maintain roadside ditches	City of Chester	$365,209.20	High	Stephanie Jackson Chester City Administrator 803-581-2123 x241 sjackson@chester.sc.gov

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Project Name: East Chester Neighborhood Storm Drainage Improvements
Project Priority: High
Entity Proposing Project: City of Chester
Estimated Costs: $296,928
Point of Contact: Stephanie Jackson, Chester City Administrator, 803-581-2123 x241, sjackson@chester.sc.gov

Details: There are existing storm drainage pipes under Bailey Street, Loomis Street, Collis Street, Caldwell Street, Lincoln Street and Walnut Street where the major storm drainage features intersect them. These pipes were likely put in many years ago and are probably not up to current SCDOT design specifications. By ensuring that these crossings have adequate capacity, the City of Chester can decrease the chance of water backing up on adjacent property owners. The cost to replace/upsize the road crossings and to establish roadside ditches, where needed, is estimated at $296,928. It is anticipated that the bulk of this work will be done inside existing SCDOT rights-of-way.
Detailed cost estimate and background floodplain study available upon request.

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Project Name: Maintenance Equipment

Project Priority: High

Entity Proposing Project: City of Chester
Estimated Costs: $365,209.20
Point of Contact: Stephanie Jackson, Chester City Administrator, 803-581-2123 x241, sjackson@chester.sc.gov

Details: This project is to purchase equipment to maintain the mitigation in the East Chester Neighborhood Storm Drainage Improvements Project.

Equipment Purchase Under State Contract	Cost
JCB Backhoe x1	$71,309.20
MowerMax Ditch Mower	$170,400.00
Culvert Ditch Truck	$123,500.00
TOTAL	$365,209.20

Chesterfield County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Town of Patrick Drainage Project	Clean drainage ditches	Town of Patrick	$100,000	High	Rosa Privette 843-498-6994 Mayor.Privette@townofpatrick.com
Gainey Road Project	2 Headwalls and modify the drainage system	Town of Patrick	$627,445	High	Rosa Privette 843-498-6994 Mayor.Privette@townofpatrick.com

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Project Name: Town of Patrick Drainage Project

Project Priority: High

Entity Proposing Project: Town of Patrick

Estimated Costs: $100,000

Point of Contact: Mayor Rosa Privette, 843-498-6994, Mayor.Privette@townofpatrick.com

Details: The Town of Patrick has flooding during periods of heavy rain. The current drainage system is inadequate to handle the increase in high rainfall events over the past few years. The draining ditches need to be cut deeper and redesigned to carry water in a different direction. In addition, the culverts may need to be upsized to account for the increase in the flow.

Project Name: Gainey Road Project

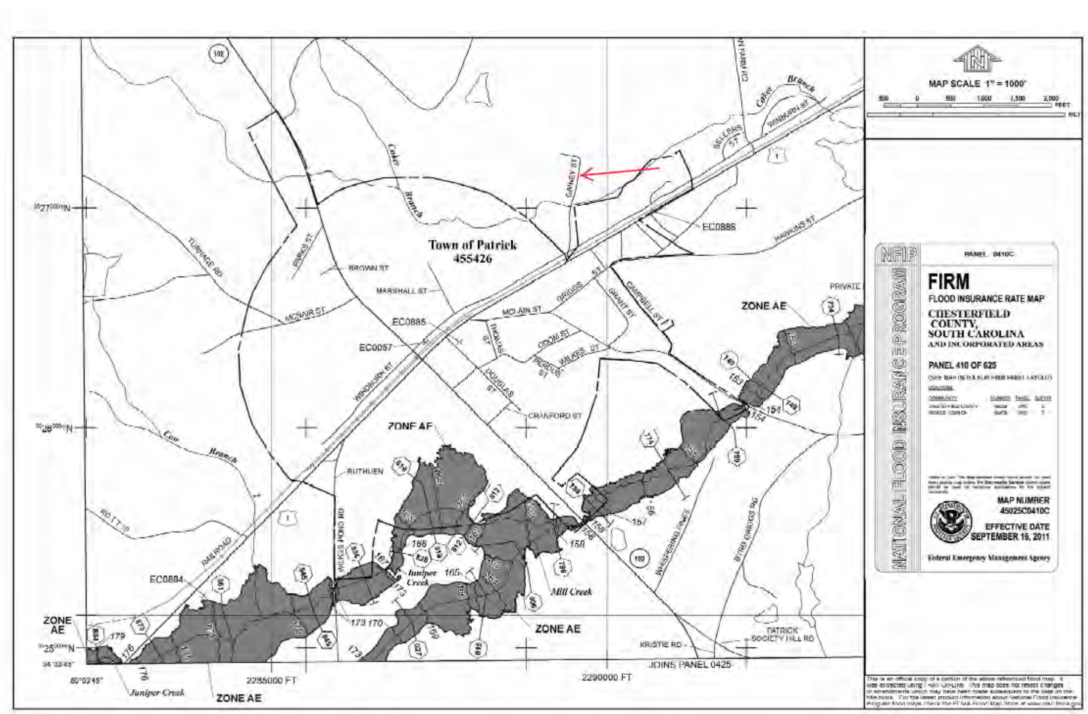
Project Priority: High

Entity Proposing Project: Town of Patrick

Estimated Costs: $627,445

Point of Contact: Mayor Rosa Privette, 843-498-6994, Mayor.Privette@townofpatrick.com

Details: Gainey Road floods during heavy rain. It prevents the residents from leaving their home. The drainage system on Gainey Road is inadequate. Please see below map, Chesterfield Gainey Road Firm Map. An engineer from the Pee Dee Council of Governments developed two cost estimates. One estimate is $399,155. It is for 1000 linear feet on Gainey Road. The second estimate is $627,445. The second estimate is for 2100 linear feet on Gainey Road. A copy of the detailed cost estimate is available upon request. The extent of drainage problems cannot be determined without an in depth field survey.



City of Columbia

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No Data Submitted

Clarendon County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Pocotaligo Channelization and Cleanup[2]	Clean debris out of river and reestablish channel	Clarendon County	TBD	High	William Timmons County Engineer 803-433-3256 btimmons@clarendoncountygov.org
Summerton Floodwater Diversion[3]	Divert floodwater/storm water around Town of Summerton	Clarendon County	TBD	High	William Timmons County Engineer 803-433-3256 btimmons@clarendoncountygov.org

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Project Name: Pocotaligo Channelization and Cleanup

Project Priority: High
Entity Proposing Project: Clarendon County
Estimated Costs: $TBD
Point of Contact: William Timmons, County Engineer, 803-433-3256, btimmons@clarendoncountygov.org

Details: To clean the Pocotaligo River/Swamp of debris and re-establish the channel to ensure proper flow capacity in an effort to mitigate flooding along Interstate 95, US 521, US 301, and the Manning Wastewater Treatment Plant.

Project Name: Summerton Floodwater Diversion

Project Priority: High
Entity Proposing Project: Clarendon County
Estimated Costs: $TBD
Point of Contact: William Timmons, County Engineer, 803-433-3256, btimmons@clarendoncountygov.org

Details: To conduct diversion of floodwater/stormwater around the northern area of the Town of Summerton, across US 15 and into the Taw Caw Creek in an effort to mitigate repetitive flooding.

[2] SDRO Project ID 83: Poticollo Flooding
[3] SDRO Project ID 80: Flooding in Summerton

Clemson University

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No Data Submitted

Colleton County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Beach Nourishment	Enhancing dune feature	Town of Edisto Beach	$18,000,000	1	Iris Hill Town Administrator ihill@townofedistobeach.com
Arc Street/Billow Street	Installing outfall pipe	Town of Edisto Beach	$400,000	2	Iris Hill Town Administrator ihill@townofedistobeach.com
Lagoon System	Hydrologic Study, right size pipes and dredge lagoons	Town of Edisto Beach	$1,625,000	3	Iris Hill Town Administrator ihill@townofedistobeach.com
Fort Street Drainage Project	Clean ditches	Town of Edisto Beach	$350,000	4	Iris Hill Town Administrator ihill@townofedistobeach.com
Groin Maintenance and Repair	Elevating and expanding the groin feature	Town of Edisto Beach	$3,000,000	5	Iris Hill Town Administrator ihill@townofedistobeach.com
Sea Level Rise	Study to identify most impacted areas	Town of Edisto Beach	Unknown	6	Mark Aakhus Assistant Town Administrator maakhus@townofedistobeach.com

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Project Name: Beach Nourishment

Project Priority: 1

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $18,000,000
Point of Contact: Iris Hill, Town Administrator, ihill@townofedistobeach.com

Details: The beach nourishment project needs to be expanded to include storm protection. This is accomplished by enhancing the dune feature along the first 2 miles of Atlantic facing homes to prevent over-wash during storms and King Tides. This will protect structures and critical infrastructure. During Hurricane Dorian, there were 8 breeches of the dune.

Figure 1-Hurricane Matthew 2016

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Project Name: Arc Street/ Billow Street

Project Priority: 2

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $400,000
Point of Contact: Iris Hill, Town Administrator, ihill@townofedistobeach.com

Details: This area is subject to chronic flooding. The solution to this flooding is not simple as it is going to require lowering an outfall pipe into a tidal lagoon within the Ocean Ridge Planned Unit Development.

Figure 2-June 2019 7.5 " rain event

Figure 3-Aerial Arc/Billow

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Project Name: Lagoon System

Project Priority: 3

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $1,625,000
Point of Contact: Iris Hill, Town Administrator, ihill@townofedistobeach.com

Details: There is an interior lagoon system on Edisto Beach that is influenced by tidal flows and street / property storm water. This system lies between Palmetto and Jungle and runs from Whaley Street to Marianne Street. It is highly influenced by street runoff including many state roads. This system increasingly has flooded and impacts properties, as well as roads since all lateral roads are impacted between Whaley and Marianne. Over time, these lagoons have been filled with debris and sediment reducing its holding capacity. A hydrologic study needs to be performed on this system and the pipes interconnecting the lagoons need to be appropriately sized to handle the flows. The lagoons need to be dredged and maintained to allow proper treatment of storm water runoff and reduce flooding by adding capacity.
In addition, there are a system of lagoons that exist in Ocean Ridge that need to be assessed. These lagoons are controlled by flap gates and as sea level rises, constantly cause Dock Site Road to flood.

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Project Name: Fort Street Drainage

Project Priority: 4

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $350,000
Point of Contact: Iris Hill, Town Administrator, ihill@townofedistobeach.com

Details: This area has drainage ditches on a dirt road that are constantly being filled reducing holding capacity. The ditches need to be cleaned and piped or the road needs to be stabilized to prevent further erosion and reduction of capacity.

Project Name: Groin Maintenance and Repair

Project Priority: 5

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $3,000,000
Point of Contact: Iris Hill, Town Administrator, ihill@townofedistobeach.com

Details: Elevating and expanding the groin feature on Edisto Beach would provide a wider beach increasing storm protection. This is needed to protect structures and critical infrastructure.

Project Name: Sea Level Rise

Project Priority: 6

Entity Proposing Project: Town of Edisto Beach
Estimated Costs: $Unknown
Point of Contact: Mark Aakhus, Assistant Town Administrator, maakhus@townofedistobeach.com

Details: As with any coastal community, sea level rise has begun impacting Edisto Beach. King Tides are higher and more frequent which impacts all properties adjacent to water especially the bay side of Scott Creek and Big Bay Creek. Initially, a study would need to be performed to identify areas that will be most impacted. Then a timeline created showing increased impacts as the sea levels rise with solutions.

Darlington County

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Darlington County Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
River Gauges[4]	Install USGA monitored river gauges above Prestwood Lake and on Black Creek	Darlington County	$500,000	High	Molly Odom 843-4450 x 1102 modom@darcoems.net
Stormwater Drainage Study	Completing a stormwater drainage study for flood areas	Darlington County	$2,000,000	High	Terri Cribb 843-398-4011 tcribb@darcosc.net
Drainage Maintenance	Performing regular drainage system maintenance, such as sediment and debris clearance	Roads and Bridges	$100,000	High	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Cleaning Debris from Bridges	Routinely clean debris from support bracing underneath low-lying bridges	Roads and Bridges	$50,000	High	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Stormwater Drains	Routinely cleaning and repairing stormwater drains	Roads and Bridges	$50,000	High	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Storm Drainage System	Install, re-routing, or inspecting the capacity of a storm drainage system	Darlington County	$100,000	High	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Upsize Culverts	Upsize culverts in flood-prone areas	Roads and Bridges	$50,000	High	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Pamphlets	Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property	Darlington County EMD	$500	High	Molly Odom 843-4450 x 1102 modom@darcoems.net
Public Education	Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads	Darlington County EMD	$500	High	Molly Odom 843-4450 x 1102 modom@darcoems.net
Outreach Programs	Using outreach programs to advise homeowners of risks to life, health, and safety	Darlington County EMD	$500	High	Molly Odom 843-4450 x 1102 modom@darcoems.net
Public Awareness	Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works)	Darlington County EMD	$500	High	Molly Odom 843-4450 x 1102 modom@darcoems.net
Stormwater Drainage Study	Completing a stormwater drainage study for flood areas	Darlington County	$2,000,000	High	Terri Cribb 843-398-4011 tcribb@darcosc.net

[4] SDRO Project ID 32: Monitoring System - Robinson Dam to Quinby Dam

Darlington County Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Documenting Flooding	Calculating and documenting the amount of flooding	Darlington County	$500	High	Terri Cribb 843-398-4011 tcribb@darcosc.net
GIS Update	Incorporating floodplain and topographic data into GIS systems	Darlington County	$1,000	High	Terri Cribb 843-398-4011 tcribb@darcosc.net
Flood Risk Database	Developing and maintaining a database to track community exposure to flood risk	Darlington County	$5,000	High	Terri Cribb 843-398-4011 tcribb@darcosc.net
Utilizing Water Resistant Paints	Using water resistant paints or other materials to allow for easy cleanup after floodwater exposure in accessory structures or in a garage area below an elevated residential structure	Long term Recovery Group	$500,000	High	Carol Bishop 843-992-3670 dcltrg@aol.com
Technical Assistance Outreach	Using outreach activities to facilitate technical assistance programs that address measures that citizen can take or facilitate funding for mitigation measures	Long term Recovery Group	$1,000	High	Carol Bishop 843-992-3670 dcltrg@aol.com
Informing the Public	Educating the public about securing debris, propane tanks, yard items, or stored objects that may otherwise be swept away, damaged, or pose a hazard if picked up and washed away by floodwaters	Long term Recovery Group	$1,000	High	Carol Bishop 843-992-3670 dcltrg@aol.com
Public Campaign	Encouraging homeowners to install backflow valves to prevent reverse-flow flood damages	Darlington County Water and Sewer Authority	$500	High	Frank Hough 843-393-8131 x 310
Drainage Capacity	Increasing drainage or absorption capacities within detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridges modification, dike setbacks, flood gates and pumps, or channel redirection	Roads and Bridges	$100,000	Medium	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Retention Pond Capacity	Increasing capacity of stormwater detention and retention basins	Roads and Bridges	$50,000	Medium	Bobby Richardson 843-393-0287 jpeele@darcosc.net

Darlington County Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Bridge Inspections	Inspecting bridges and identify repairs to prevent scour	Roads and Bridges	$80,000	Medium	Bobby Richardson 843-393-0287 jpeele@darcosc.net
Engineering Guidelines	Developing engineering guidelines for drainage from new development techniques	Darlington County	$25,000	Medium	Terri Cribb 843-398-4011 tcribb@darcosc.net
Dam Failure Study and Plan	Developing a dam failure study and emergency action plan	SCDOT	$1,000,000	Medium	SCDOT
Installing Check Valves and Sump Pumps	Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings	Darlington County Water and Sewer Authority	$2,000,000	Low	Frank Hough 843-393-8131x 310

<u>City of Darlington Projects</u>

Project Title	**Project Description**	**Entity Proposing Project**	**Estimated Cost**	**Priority**	**Point of Contact**
Stormwater Drainage Study	Completing a stormwater drainage study to know problem areas	City of Darlington	$100,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Drainage Maintenance	Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detecting and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps	City of Darlington	$250,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Cleaning Debris from Bridges	Routinely clean debris from support bracing underneath low-lying bridges	City of Darlington	$25,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Stormwater Drains	Routinely cleaning and repairing stormwater drains	City of Darlington	$25,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Regrading Pavement	Conforming pavement to land contours so as not to provide easier avenues for stormwater	City of Darlington	$250,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Storm Drainage System	Installing, re-routing, or increasing the capacity of a storm drainage system	City of Darlington	$500,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Raising Utilities	Raising utilities or other mechanical devices above expected flood levels	City of Darlington	$500,000	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com

<u>City of Darlington Projects</u>

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Pamphlets	Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property	City of Darlington	$500	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Public Education	Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads	City of Darlington	$500	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Outreach Programs	Using outreach programs to advise homeowners of risks to life, health, and safety	City of Darlington	$500	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Public Awareness	Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works)	City of Darlington	$500	High	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Upsize Culverts	Increasing dimension of drainage culverts in flood-prone areas	City of Darlington	$500,000	Medium	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Engineering Guidelines	Developing engineering guidelines for drainage from new development techniques	City of Darlington	$100,000	Medium	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Erosion Control	Adopting erosion and sedimentation control regulations for construction and farming	City of Darlington	$5,000	Medium	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com

City of Darlington Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Bridge Inspections	Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour	City of Darlington	$25,000	Low	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Installing Check Valves and Sump Pumps	Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings	City of Darlington	$150,000	Low	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Drainage Capacity	Increase drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channels	City of Darlington	$500,000	Low	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com
Retention Pond Capacity	Increasing capacity of stormwater detention and retention basins	City of Darlington	$25,000	Low	Chief Pat Cavanaugh 843-398-4013 pcavanaugh@rsecueteam.com

City of Hartsville Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Stormwater Drainage Study	Completing a stormwater drainage study to know problem areas	City of Hartsville	$100,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Regrading Pavement	Conforming pavement to land contours so as not to provide easier avenues for stormwater	City of Hartsville	$250,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Drainage Maintenance	Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detecting and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps	City of Hartsville	$250,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Cleaning Debris from Bridges	Routinely clean debris from support bracing underneath low-lying bridges	City of Hartsville	$25,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Stormwater Drains	Routinely cleaning and repairing stormwater drains	City of Hartsville	$25,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Raising Utilities	Raising utilities or other mechanical devices above expected flood levels	City of Hartsville	$500,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Floodproofing Water Treatment Facilities	Floodproofing water treatment facilities located in flood hazard areas	City of Hartsville	$500,000	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Pamphlets	Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property	City of Hartsville	$500	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Public Education	Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads	City of Hartsville	$500	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov

City of Hartsville Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Outreach Programs	Using outreach programs to advise homeowners of risks to life, health, and safety	City of Hartsville	$500	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Public Awareness	Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works)	City of Hartsville	$500	High	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Engineering Guidelines	Developing engineering guidelines for drainage from new development techniques	City of Hartsville	$100,000	Medium	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Storm Drainage System	Installing, re-routing, or increasing the capacity of a storm drainage system	City of Hartsville	$500,000	Medium	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Upsize Culvert	Increasing dimension of drainage culverts in flood-prone areas	City of Hartsville	$500,000	Medium	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Drainage Capacity	Increase drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channels	City of Hartsville	$500,000	Low	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Retention Pond Capacity	Increasing capacity of stormwater detention and retention basins	City of Hartsville	$ 25,000	Low	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov
Bridge Inspections	Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour	City of Hartsville	$25,000	Low	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov

City of Hartsville Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Installing Check Valves and Sump Pumps	Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings	City of Hartsville	$150,000	Low	Chief Jeff Burr 843-383-3000 jeff.burr@hartsvillesc.gov

Town of Lamar Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Stormwater Drainage Study	Completing a stormwater drainage study to know problem areas	Town of Lamar	$80,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Cleaning Debris from Bridges	Routinely clean debris from support bracing underneath low-lying bridges	Town of Lamar	$10,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Stormwater Drains	Routinely cleaning and repairing stormwater drains	Town of Lamar	$10,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Raising Utilities	Raising utilities or other mechanical devices above expected flood levels	Town of Lamar	$50,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Floodproofing Water Treatment Facilities	Floodproofing water treatment facilities located in flood hazard areas	Town of Lamar	$50,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Pamphlets	Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property	Town of Lamar	$500	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Public Education	Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads	Town of Lamar	$500	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Outreach Programs	Using outreach programs to advise homeowners of risks to life, health, and safety	Town of Lamar	$500	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Public Awareness	Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works)	Town of Lamar	$100	High	Mayor Darnelle Byrd-McPherson 843-326-7264
Drainage Maintenance	Performing regular drainage system maintenance, such as sediment and debris clearance, as well as detecting and prevention of discharges into stormwater and sewer systems from home footing drains, downspouts, or sewer pumps	Town of Lamar	$75,000	High	Mayor Darnelle Byrd-McPherson 843-326-7264

Town of Lamar Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Installing Check Valves and Sump Pumps	Depending on its infrastructure capabilities, using check valves, sump pumps, and backflow prevention devices in homes and buildings	Town of Lamar	$75,000	Medium	Mayor Darnelle Byrd-McPherson 843-326-7264
Storm Drainage System	Installing, re-routing, or increasing the capacity of a storm drainage system	Town of Lamar	$125,000	Medium	Mayor Darnelle Byrd-McPherson 843-326-7264
Upsize Culvert	Increasing dimension of drainage culverts in flood-prone areas	Town of Lamar	$25,000	Medium	Mayor Darnelle Byrd-McPherson 843-326-7264
Bridge Inspections	Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour	Town of Lamar	$25,000	Low	Mayor Darnelle Byrd-McPherson 843-326-7264
Elevating Structures	Elevating structures so that the lowest floor, including the basement, is raised above the base flood elevation	Town of Lamar	$300,000	Low	Mayor Darnelle Byrd-McPherson 843-326-7264
Engineering Guidelines	Developing engineering guidelines for drainage from new development techniques	Town of Lamar	$80,000	Low	Mayor Darnelle Byrd-McPherson 843-326-7264
Drainage Capacity	Increase drainage or absorption capacities with detention and retention basins, relief drains, spillways, drain widening/dredging or rerouting, logjam and debris removal, extra culverts, bridge modification, dike setbacks, flood gates and pumps, or channels	Town of Lamar	$125,000	Low	Mayor Darnelle Byrd-McPherson 843-326-7264
Retention Pond Capacity	Increasing capacity of stormwater detention and retention basins	Town of Lamar	$25,000	Low	Mayor Darnelle Byrd-McPherson 843-326-7264

Town of Society Hill Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Stormwater Drainage Study	Completing a stormwater drainage study for known areas of flooding	Town of Society Hill	$80,000	High	Mayor Tommy Bradshaw 843-378-4681
Drainage Maintenance	Performing drainage system maintenance, such as sediment and debris clearance	Town of Society Hill	$15,000	High	Mayor Tommy Bradshaw 843-378-4681
Stormwater Drains	Routinely cleaning and repairing stormwater drains	Town of Society Hill	$15,000	High	Mayor Tommy Bradshaw 843-378-4681
Pamphlets	Annually distributing flood protection safety pamphlets or brochures to the owners of flood-prone property	Town of Society Hill	$500	High	Mayor Tommy Bradshaw 843-378-4681
Public Education	Educating citizens about safety during flood conditions, including the dangers of driving on flooded roads	Town of Society Hill	$500	High	Mayor Tommy Bradshaw 843-378-4681
Outreach Programs	Using outreach programs to advise homeowners of risks to life, health, and safety	Town of Society Hill	$500	High	Mayor Tommy Bradshaw 843-378-4681
Public Awareness	Asking residents to help keep storm drains clear of debris during storms (not to rely solely on Public Works)	Town of Society Hill	$500	High	Mayor Tommy Bradshaw 843-378-4681
Storm Drainage System	Installing, re-routing, or increasing the capacity of a storm drainage system	Town of Society Hill	$125,000	Medium	Mayor Tommy Bradshaw 843-378-4681
Bridge Inspections	Inspecting bridges and identifying if any repairs or retrofits are needed to prevent scour	Town of Society Hill	$10,000	Medium	Mayor Tommy Bradshaw 843-378-4681
Engineering Guidelines	Developing engineering guidelines for drainage from new development techniques	Town of Society Hill	$80,000	Low	Mayor Tommy Bradshaw 843-378-4681
Drainage Capacity	Increase drainage capacities retention basins, drain widening, dredging, rerouting, and debris removal	Town of Society Hill	$125,000	Low	Mayor Tommy Bradshaw 843-378-4681
Retention Pond Capacity	Increasing capacity of stormwater detention and retention basins	Town of Society Hill	$25,000	Low	Mayor Tommy Bradshaw 843-378-4681
Upsize Culverts	Increasing dimension of drainage culverts in flood-prone areas	Town of Society Hill	$25,000	Low	Mayor Tommy Bradshaw 843-378-4681

Town of Society Hill Projects

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Cleaning Debris from Bridges	Routinely clean debris from support bracing underneath low-lying bridges	Town of Society Hill	$15,000	Low	Mayor Tommy Bradshaw 843-378-4681

Dillon County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Julia St[5]	Hydrology Study	Dillon County	$10,000	High	Moses Heyward 843-506-4973 emerg.heyward@gmail.com
Cannon Court[6]	Clean two ditches	Dillon County	$25,000	High	Moses Heyward 843-506-4973 emerg.heyward@gmail.com
Maple Swamp[7]	Clean several ditches	Dillon County	$28,000	High	Moses Heyward 843-506-4973 emerg.heyward@gmail.com
Catfish Creek Canal	Clear debris in the Catfish Canal from Oak Grove to Marion County	Dillon County	$500,000	Low	Moses Heyward 843-506-4973 emerg.heyward@gmail.com
Edwards St	Clean ditches	Town of Latta	$9,000	High	Jared Taylor 843-409-6075 jtaylor@townoflatta.org
Bamberg St	Clean ditches and put in a culvert	Town of Latta	$65,000	High	Jared Taylor 843-409-6075 jtaylor@townoflatta.org
Marion St[8]	Study, clean ditches, put in a drain tile	Town of Latta	$45,000-$180,000	Medium	Jared Taylor 843-409-6075 jtaylor@townoflatta.org
Bacus Rd	Dig a ditch	Town of Lake View	$10,000	Medium	Matthew Elvington 843-992-6337 Matthewelvington@gmail.com
West 4th Ave	Enlarge culverts and drain tiles	Town of Lake View	$500,000	Medium	Matthew Elvington 843-992-6337 Matthewelvington@gmail.com
7th Ave	Replace three broken drain tiles	Town of Lake View	$25,000	Medium	Matthew Elvington 843-992-6337 Matthewelvington@gmail.com
East 3rd Ave and Lake View HS	Dig up drain tiles and replace with a ditch	Town of Lake View	$50,000	Medium	Matthew Elvington 843-992-6337 Matthewelvington@gmail.com

[5] SDRO Project ID 168: 1st Avenue (North)
[6] SDRO Project ID 167: 1st Avenue (South)
[7] SDRO Project ID 170: Canals to Maple Swamp
[8] SDRO Project ID 173: Fire Station Flooding in Latta & SDRO Project ID 174: Library Flooding in Latta

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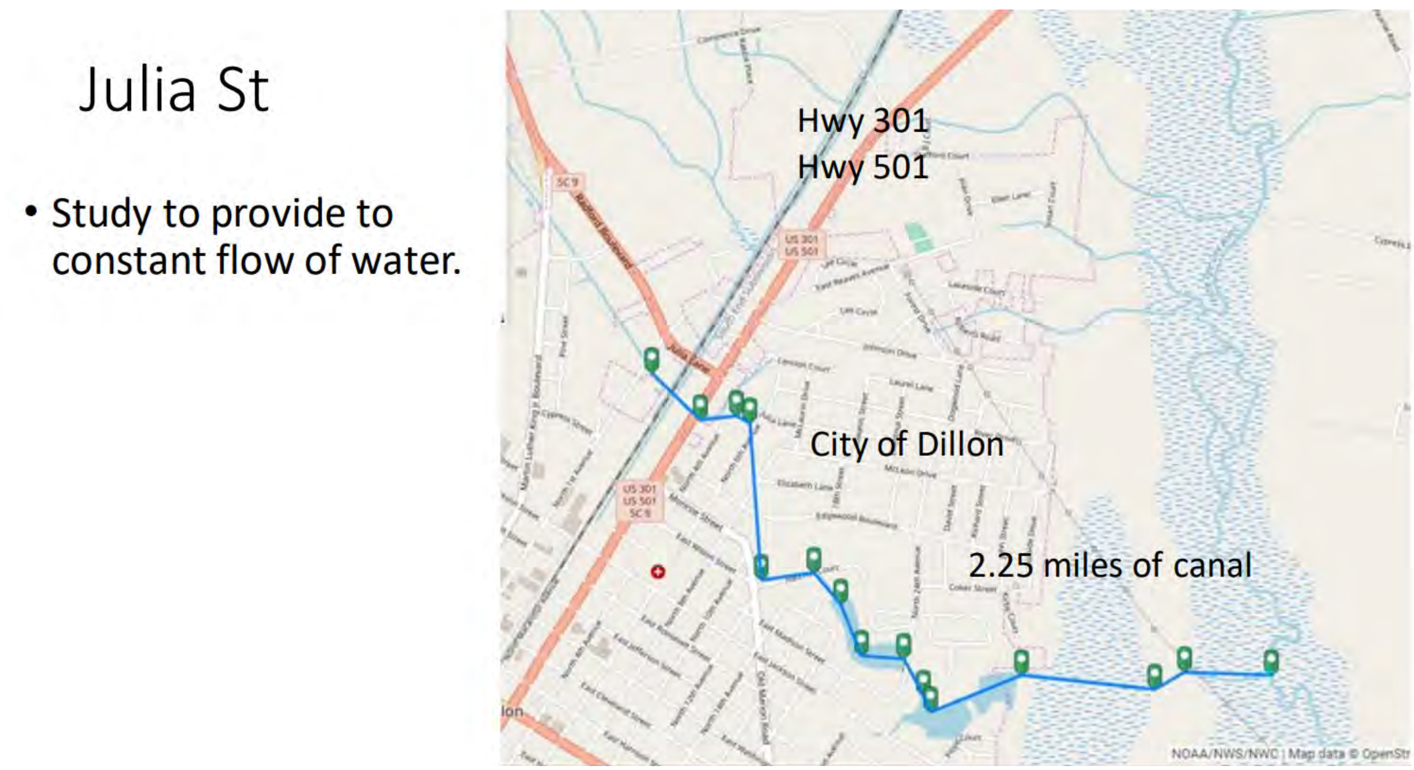
Project Name: Julia Street

Project Priority: High

Entity Proposing Project: Dillon County
Estimated Costs: $10,000
Point of Contact: Moses Heyward, 843-506-4973, emerg.heyward@gmail.com

Details: A Hydrologic and Hydraulic (H&H) study would be beneficial for securing grants to improve the drainage in the area. Dillon has a canal that runs north of the City of Dillon. The canal runs parallel to Julia Street. At Hwy 301 and Hwy 501, it goes into a drain tile. The drain tile opens into a large housing area and then it flows into a dam. From the dam, the water flows to another dam, and then flows into another housing area. When the water leaves the housing area, it flows to the Little Pee Dee River. The area flooded during Hurricane Florence and caused flooding up to 36 inches in the neighborhood. The length of the canal and drain tile is 2.25 miles.



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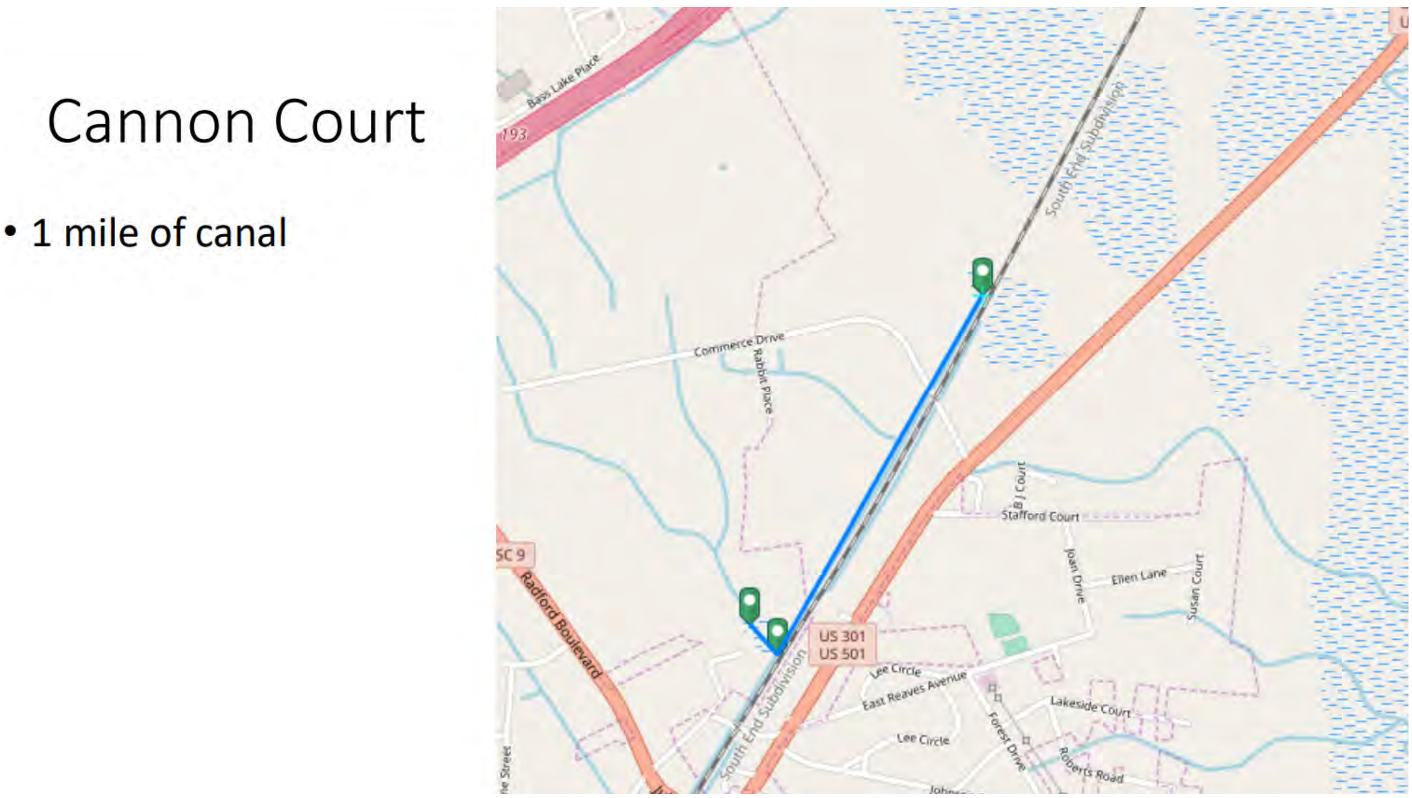
Project Name: Cannon Court

Project Priority: High

Entity Proposing Project: Dillon County
Estimated Costs: $25,000
Point of Contact: Moses Heyward, 843-506-4973, emerg.heyward@gmail.com

Details: Cannon Court Residential Home is a senior care living facility that is located on the Maple Swamp in Dillon. 30 people were evacuated during Hurricane Florence due to flooding. Some of the residents have a medical need. Cannon Court has a ditch that runs beside the facility. The ditch (1 mile) needs to be cleaned of sediment and large trees.



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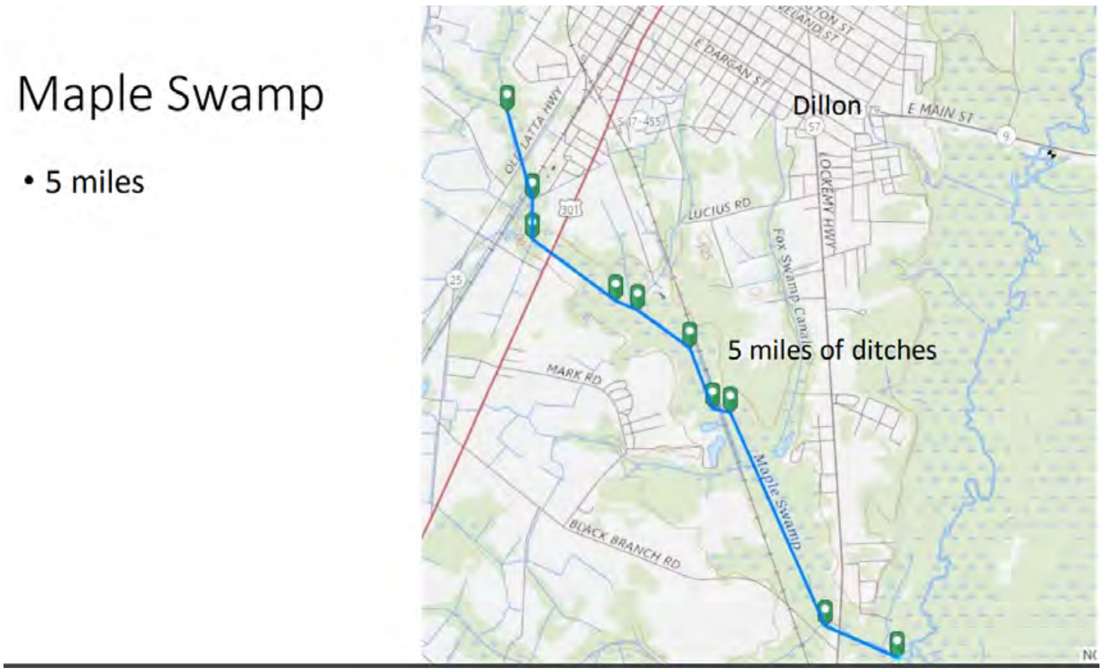
Project Name: Maple Swamp

Project Priority: High

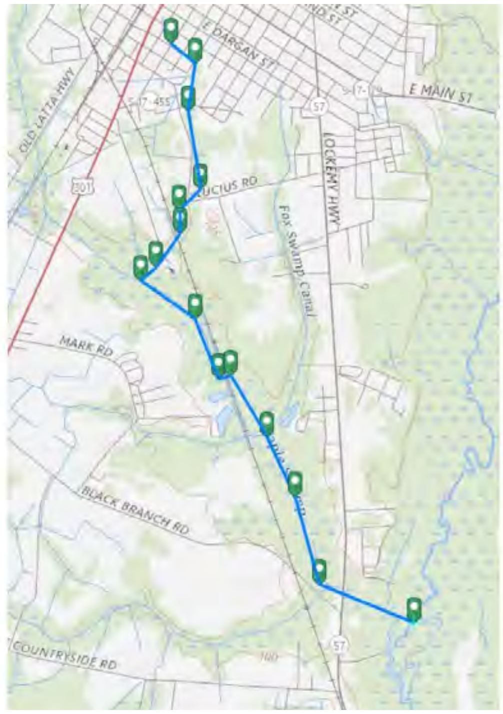
Entity Proposing Project: Dillon County
Estimated Costs: $28,000
Point of Contact: Moses Heyward, 843-506-4973, emerg.heyward@gmail.com

Details: South of Dillon is a low area called Maple Swamp. The Judicial Center and a housing area is located next to the swamp. Several houses flooded during Hurricane Florence. A drainage ditch runs behind the Judicial Center to the Little Pee Dee River. Another branch of the drainage runs into 6th Ave. The ditch needs to be cleaned of sediment and cleared of debris.



6th Avenue

- Part of the Maple Swamp project from the previous slide.



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Project Name: Catfish Swamp in Dillon County

Project Priority: Low

Entity Proposing Project: Dillon County

Estimated Costs: $500,000

Point of Contact: Moses Heyward, 843-506-4973, emerg.heyward@gmail.com

Details: Catfish Swamp is located between Interstate 95 and Latta. The canal needs to be cleared of debris.

- 6 miles of canal

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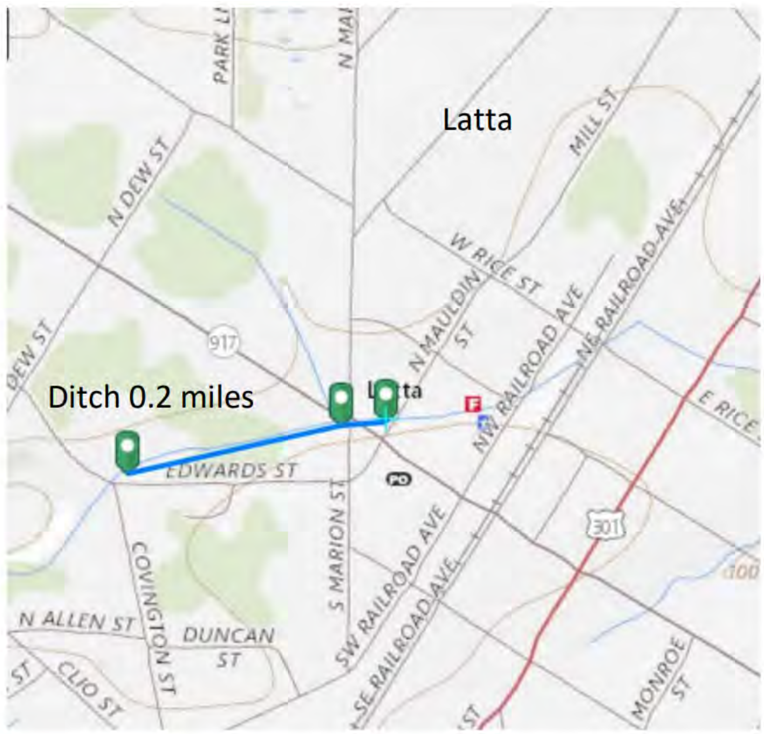
Project Name: Edwards Street

Project Priority: High

Entity Proposing Project: Town of Latta
Estimated Costs: $9,000
Point of Contact: Jared Taylor, 843-409-6075, jtaylor@townoflatta.org

Details: Edwards St. and Covington St. flooded during Hurricane Matthew and Hurricane Florence. Covington St. floods due to a ditch on Edwards St. Cleaning the ditch of small trees and 10 inches of sediment would allow the water to move away from Covington St. It flooded to a depth of 5 feet. Covington St. is a residential section with one church and one business.

Edwards St.



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Project Name: Bamberg St. Drainage

Project Priority: High

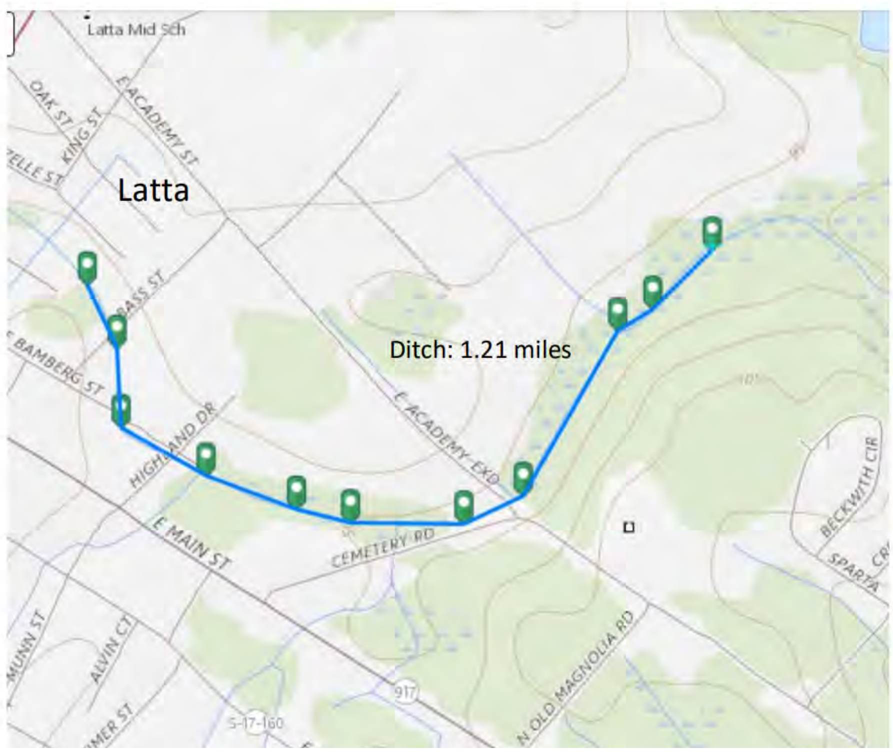
Entity Proposing Project: Town of Latta

Estimated Costs: $65,000

Point of Contact: Jared Taylor, 843-409-6075, jtaylor@townoflatta.org

Details: Bamberg St. and Highland Dr. both flooded during Hurricane Matthew and Hurricane Florence. This project would involve cleaning and widening drainage ditches of sediment and brush and increasing the diameter of one culvert. The Town of Latta has the money allocated to replace a culvert on Bamberg St. Some areas might need rip rap to prevent erosion. The drainage system runs 1.21 miles. The ditch holds back 60% percent of the town's water. Flooding impacts 8 homes and flooding on Highway 301. SCDOT has replaced one of the culverts.

Bamberg St.



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Project Name: Marion St. Drainage

Project Priority: Medium

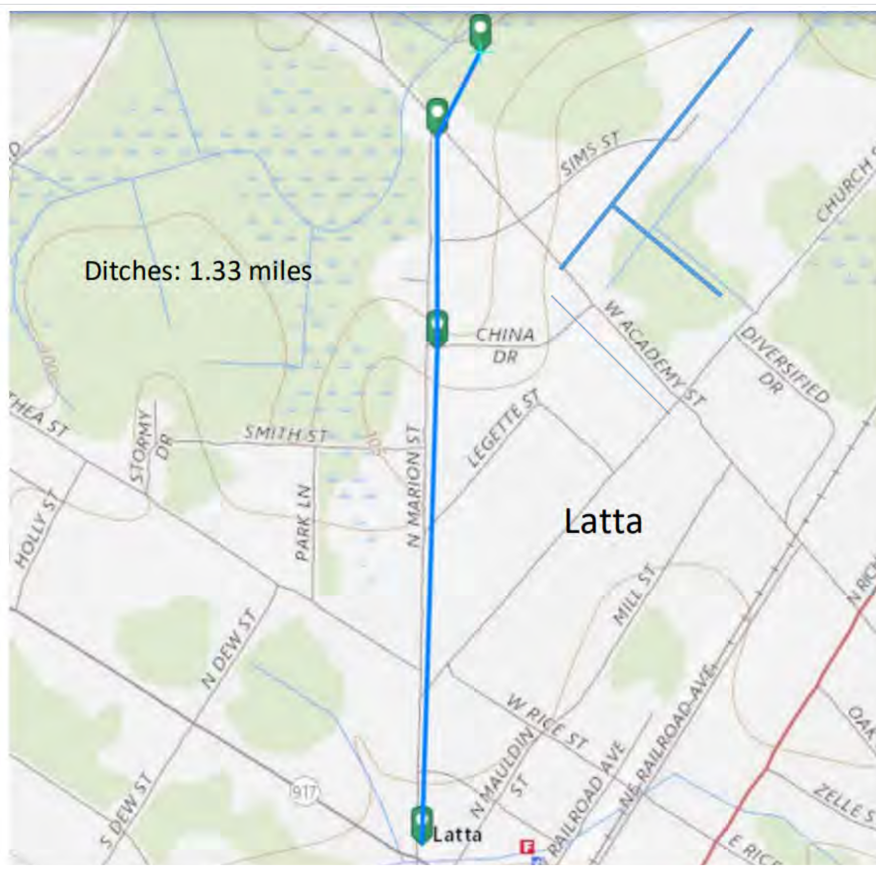
Entity Proposing Project: Town of Latta

Estimated Costs: $45,000-$180,000

Point of Contact: Jared Taylor, 843-409-6075, jtaylor@townoflatta.org

Details: Marion St., Forrest Hills, and Bethea St. experienced drainage problems during Hurricane Matthew and Hurricane Florence. This project involves cleaning several drainage ditches, installing riprap, and engineering costs. Drain tile may have to be installed (1,355 ft.). If this is the case, then the cost may reach $135,000. Together with the others costs the entire project may reach $180,000. The drainage system affects flooding on Highway 301. This is a residential section. The Latta Fire Department, Dillon County EMS Building, and the Rescue Squad Building are located on this drainage system. These buildings flooded during Hurricane Florence.

Marion St.



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Project Name: Bacus Road

Project Priority: Medium

Entity Proposing Project: Town of Lake View

Estimated Costs: $10,000

Point of Contact: Matthew Elvington, 843-992-6337, Matthewelvington@gmail.com

Details: Bacus Road is located in Lake View. Three houses have flooded on Bacus Road due to no outlet for the water. The water comes up to the back door in these homes. SCDOT mentioned that they are reworking Bacus Rd. in the July/August 2019 period. This issue might get resolved during this construction.

Bacus Road

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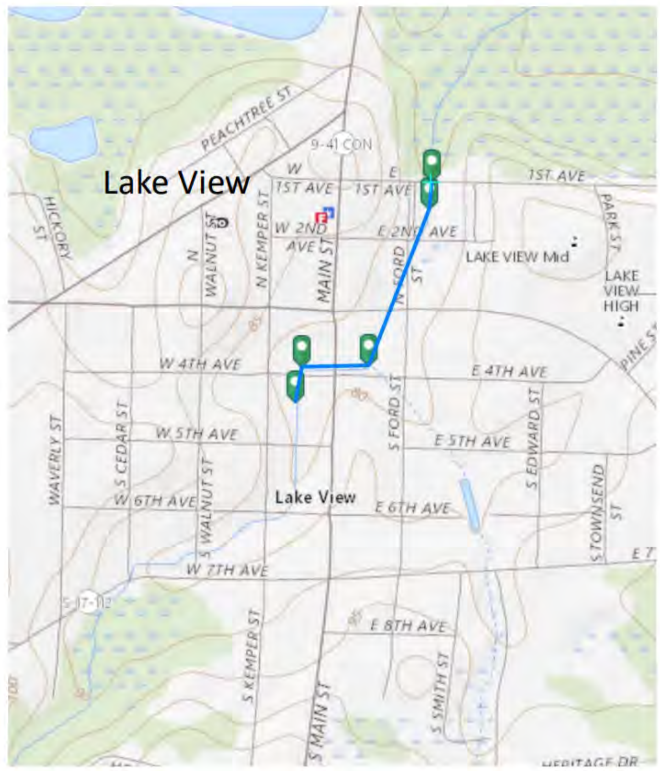
Project Name: West 4th Ave
Project Priority: Medium
Entity Proposing Project: Town of Lake View
Estimated Costs: $500,000
Point of Contact: Matthew Elvington, 843-992-6337, Matthewelvington@gmail.com

Details: When a large rain occurs, 2 houses routinely flood. In order to prevent flooding, the culvert needs to be enlarged. SCDOT talked with the Mayor about West 4th Ave. SCDOT mentioned that if the culvert at West 4th Ave were enlarged, then the culverts downstream would need to be upsized. It would make this a large project.

W 4th Ave.



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Project Name: 7th Ave

Project Priority: Medium

Entity Proposing Project: Town of Lake View

Estimated Costs: $25,000

Point of Contact: Matthew Elvington, 843-992-6337, Matthewelvington@gmail.com

Details: 7th Ave. has problems with flooding due to a broken drain tile. The flooding impacts 7th Ave, 6th Ave, and S Walnut St. A drain tile runs through 7th Ave. Three drain tiles are cracked and the ground is sinking in over the broken drain tile. This project would involve 3 new drain tile and resetting the old drain tile.

7th Ave.

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Project Name: East 3rd and Lake View High School

Project Priority: Medium

Entity Proposing Project: Town of Lake View

Estimated Costs: $50,000

Point of Contact: Matthew Elvington, 843-992-6337, Matthewelvington@gmail.com

Details: East 3rd Ave and Lake View High School floods during thunderstorms. The drain tile does not work correctly on East 3rd Ave. The drain tile runs underneath a burnt down house. The town is interested in purchasing the land. Flooding gets close to one home. Water backs up on the High School property. The Lake View High School serves as a shelter for the community.

East 3rd St. and East 4th St.

Dorchester County

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No Data Submitted

Edgefield County

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No Project Requests for Commission

Fairfield County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Dredging Wateree Rd Cove	Removing silt and stabilizing shore	Fairfield County	$17,500,000	High	Chris Clauson 803-815-4031 chris.clauson@fairfield.sc.gov
Mobile Back Up Generators	Install 2 generators and pigtail connections at all pump stations	Town of Winnsboro	$200,000	High	Trip Peak 803-635-4121 winngas@truvista.net
Dam Construction	Replace earthen dam with a concrete dam	Town of Winnsboro	$10,000,000+	Medium	Otis Williams 803-815-3020 winn2@truvista.net

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Project Name: Dredging Wateree Rd Cove

Project Priority: High
Entity Proposing Project: Fairfield County
Estimated Costs: $ 17,500,000 (Approximately 700 Acres at $25k/Acre)
Point of Contact: Chris Clauson, 803-815-4031, chris.clauson@fairfield.sc.gov

Details: The dredging of the cove is a priority from an environmental standpoint. Excessive silt has eroded into the cover that feeds into Lake Wateree causing a continual erosion of the shoreline and filling of the cove in a way that can cause alteration of the rivers course if left unchecked. Altering the river course could lead to vast flood concerns in areas previously uncharted. Residents and local governments would be left without warning of potential flood hazards. There may be less costly methods available but the silt needs to be removed and the shore needs to be stabilized to ensure further degradation does not occur.
Based on the best data available, the cost would be at least $25,000 per acre.

Project Name: Mobile Back Up Generators

Project Priority: High
Entity Proposing Project: Town of Winnsboro
Estimated Costs: $200,000
Point of Contact: Trip Peak, 803-635-4121, winngas@truvista.net

Details: This project is to install two generators and pigtail connections at all pump stations.
The mobile backup generators will be used to ensure that sewage is not backing up in case of flood damage causing a power failure. An alternate option is to have generators installed at every pump station. Though, in the event of a flood, this would not be ideal as in some instances the pump station would be under water and a generator would only complicate matters, as the diesel on site would be introduced into the water. The intent of the pigtail connections is that every station, if it goes down, could have one of the two generators brought on site and connected allowing the utility department to use discretion when responding. If nothing is done and the sewage is not able, to be pumped then the sewage would make its way into the water and the subsequent environmental concerns would be an issue.

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Project Name: Dam Construction

Project Priority: Medium

Entity Proposing Project: Town of Winnsboro
Estimated Costs: Rough estimate $10,000,000+
Point of Contact: Otis Williams, 803-815-3020, winn2@truvista.net

Details: Existing dam (Jackson Mill Creek Dam) was put in when the Town of Winnsboro constructed the earthen dam to create a fresh water reservoir for water supply. In discussions with the Town, on potential projects, this dam came up as a potential hazard in a time of extreme flooding. Given the dam failures in Columbia in 2015, it was proposed that to further secure the dam and avoid a potential breach, the earthen dam could be replaced with a concrete dam to allow for a greater level of durability. This was not a funding priority of the Town's but given the explanation of the project list generation, this was discussed as a wish list item if money were not an option. Alternate options are to remain as is and accept any risk that may be inherent in relying solely on the earthen dam.

Florence County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
County-Wide Hydrology Study	County-Wide Hydrology Study	Florence County	$500,000	High	Dusty Owens EM Director 843-665-7255 dowens@fcemd.org
Property Buyouts	Buyout of 14 repetitive flood properties	Florence County	$3,000,000	High	Dusty Owens EM Director 843-665-7255 dowens@fcemd.org

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Project Name: Countywide Hydrology Study

Project Priority: High
Entity Proposing Project: Florence County
Estimated Costs: $500,000
Point of Contact: Dusty Owens, EM Director, 843-665-7255, dowens@fcemd.org

Details: Development of a countywide Hydrology study, which incorporates current and future development. This plan will form the basis for future mitigations efforts, identify needs and prioritize projects on a cost benefit ratio basis. This study will also serve as justification for development of more progressive county codes and ordinances. This project is directly addressed in the county's hazard mitigation plan as an initiative.

> -This study should also address concepts for county-wide storm water runoff fees as a funding mechanism for future mitigation projects and maintenance for ongoing projects.
> -This study should also address making current storm water runoff requirements more stringent (IE: subdivision's storm water system built to a 25-year rain event; increasing freeboard to exceed FEMA minimum standards, etc.).

Project Name: Property Buyouts

Project Priority: High
Entity Proposing Project: Florence County
Estimated Costs: $3,000,000
Point of Contact: Dusty Owens, EM Director, 843-665-7255, dowens@fcemd.org

Details: Buyout of repetitive flood sites along Black Creek and Lynches River. There are eight homes on East Black Creek Rd., Nina Lane, and Creekside Dr., which have been flooded by Black Creek several times in the past. There are six homes along First Neck Rd., Mack's Lake Rd., and Sandpit Rd., which have been flooded by Lynches River several times in the past. This project is directly addressed as an initiative in the county hazard mitigation plan.

Georgetown County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Andrews Drainage Project – Phase 2	Construction of drainage system upgrades	Georgetown County	$3,000,000	High	James Coley Capital Projects jcoley@gtcounty.org
Hagley West Drainage	Install drainage tiles	Georgetown County	$325,000	High	James Coley Capital Projects jcoley@gtcounty.org
MLK Area Improvements Phase 1	Improve pond outfall	Georgetown County	$650,000	High	James Coley Capital Projects jcoley@gtcounty.org
MLK Area Improvements Phase 2	Mitigate repetitive flooding	Georgetown County	$1,200,000	High	James Coley Capital Projects jcoley@gtcounty.org
MLK Area Improvements Phase 3	Mitigate repetitive flooding	Georgetown County	$900,000	High	James Coley Capital Projects jcoley@gtcounty.org
Front Street Bulkhead and drainage improvements	Repair bulkhead	Georgetown County	$194,000	High	James Coley Capital Projects jcoley@gtcounty.org
North Litchfield Area Phases 4-7	Address and mitigate severe repetitive flooding on US Hwy 17	Georgetown County	$3,500,000	High	James Coley Capital Projects jcoley@gtcounty.org
Tiller-Commerce Outfall	Mitigate road and business flooding	Georgetown County	$375,000	Medium	James Coley Capital Projects jcoley@gtcounty.org
Front Street Drainage	Drainage system upgrade	City of Georgetown	$1,109,000	High	Orlando Arteago oarteago@cogsc.com
El Cerro Drainage	Drainage system upgrade	City of Georgetown	$1,773,000	High	Orlando Arteago oarteago@cogsc.com
Queen Street Drainage	Drainage system upgrade	City of Georgetown	$1,362,000	High	Orlando Arteago oarteago@cogsc.com
St. James and Church Street Drainage	Drainage system upgrade	City of Georgetown	$192,000	High	Orlando Arteago oarteago@cogsc.com
Highmarket and Lee Street Drainage	Drainage system upgrade	City of Georgetown	$4,411,000	High	Orlando Arteago oarteago@cogsc.com
South Fraiser and Bourne Street Drainage	Drainage system upgrade	City of Georgetown	$1,102,000	Medium	Orlando Arteago oarteago@cogsc.com

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Church and North Merriman Street Drainage	Drainage system upgrade	City of Georgetown	$2,877,000	Medium	Orlando Arteago oarteago@cogsc.com
Cannon Street Drainage	Drainage system upgrade	City of Georgetown	$1,191,000	Medium	Orlando Arteago oarteago@cogsc.com
Highmarket and Broad Street Drainage	Drainage system upgrade	City of Georgetown	$1,941,000	Medium	Orlando Arteago oarteago@cogsc.com
St. James Street Drainage	Drainage system upgrade	City of Georgetown	$554,000	Medium	Orlando Arteago oarteago@cogsc.com
Steel Mill Drainage	Drainage system upgrade	City of Georgetown	$2,149,000	Low	Orlando Arteago oarteago@cogsc.com
Highmarket Street Drainage	Drainage system upgrade	City of Georgetown	$1,547,000	Low	Orlando Arteago oarteago@cogsc.com

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Project Name: Andrews Drainage Project – Phase 2

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $3,000,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Construction of drainage system upgrades in the Town of Andrews identified by Phase 1 of the project.

Project Name: Hagley West Drainage

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $325,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Ties in improved stormwater systems from Phase 1 and Phase 2 to protect homes from repetitive loss flooding from Highway 17 to Hagley Drive in Pawleys Island, SC (unincorporated).

Project Name: MLK Area Improvements Phase 1

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $650,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Improve pond outfall in unincorporated Pawleys Island allowing retention pond levels to be dropped prior to storm events.

Project Name: MLK Area Improvements Phase 2

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $1,200,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Mitigate repetitive flooding in the Bent Tree area of unincorporated Pawleys Island that impacts residential and commercial properties.

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Project Name: MLK Area Improvements Phase 3

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $900,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Mitigate repetitive residential flooding along Parkersville Rd and Fig Ln in unincorporated Pawleys Island.

Project Name: Front Street Bulkhead and Drainage Improvements

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $194,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Repair bulkhead behind Coastal Carolina University's facility to mitigate repetitive flooding that impacts the educations institution.

Project Name: North Litchfield Area Phases 4-7

Project Priority: High
Entity Proposing Project: Georgetown County
Estimated Costs: $3,500,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Address and mitigate severe repetitive flooding on US Highway 17 at multiple locations in the Litchfield Beach area.

Project Name: Tiller-Commerce Outfall

Project Priority: Medium
Entity Proposing Project: Georgetown County
Estimated Costs: $375,000
Point of Contact: James Coley, Georgetown County Capital Projects, jcoley@gtcounty.org

Details: Mitigate road and business flooding on a repetitive cycle in unincorporated Pawleys Island.

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Project Name: Front Street Drainage

Project Priority: High

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,109,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade to mitigate repetitive flooding issues along Front Street.

Project Name: El Cerro Drainage

Project Priority: High

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,773,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at El Cerro on US 17 to mitigate repetitive flooding issues.

Project Name: Queen Street Drainage

Project Priority: High

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,362,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade along Queen Street to mitigate repetitive flooding issues.

Project Name: St. James and Church Street Drainage

Project Priority: High

Entity Proposing Project: City of Georgetown
Estimated Costs: $192,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at St. James and Church Streets to mitigate repetitive flooding issues.

Project Name: Highmarket and Lee Street Drainage

Project Priority: High

Entity Proposing Project: City of Georgetown
Estimated Costs: $4,411,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade along Highmarket and Lee Streets to mitigate repetitive flooding issues.

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Project Name: South Fraiser and Bourne Street Drainage

Project Priority: Medium

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,102,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at South Fraiser and Bourne Streets to mitigate repetitive flooding issues.

Project Name: Church and North Merriman Street Drainage

Project Priority: Medium

Entity Proposing Project: City of Georgetown
Estimated Costs: $2,877,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at Church and North Merriman Streets to mitigate repetitive flooding issues.

Project Name: Cannon Street Drainage

Project Priority: Medium

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,191,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at Cannon Street to mitigate repetitive flooding issues.

Project Name: Highmarket and Broad Street Drainage

Project Priority: Medium

Entity Proposing Project: City of Georgetown
Estimated Costs: $1,941,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at Highmarket and Broad Streets to mitigate repetitive flooding issues.

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Project Name: St. James Street Drainage
Project Priority: Medium
Entity Proposing Project: City of Georgetown
Estimated Costs: $554,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at St. James Street to mitigate repetitive flooding issues.

Project Name: Steel Mill Drainage
Project Priority: Low
Entity Proposing Project: City of Georgetown
Estimated Costs: $2,149,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at Steel Mill Front Street to mitigate repetitive flooding issues.

Project Name: Highmarket Street Drainage
Project Priority: Low
Entity Proposing Project: City of Georgetown
Estimated Costs: $1,547,000
Point of Contact: Orlando Arteago oarteago@cogsc.com

Details: Drainage system upgrade at Highmarket Street to mitigate repetitive flooding issues.

Greenville County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Balfer Drive	Install Culvert	Greenville County	$88,000	High	Hesha Gamble 864-467-7016 hgamble@greenvillecounty.org
Kensington Road	Install Bridge	Greenville County	$310,000	Medium	Hesha Gamble 864-467-7016 hgamble@greenvillecounty.org
Deer Run Road	Install Bridge and road repairs	Greenville County	$460,000	Medium	Hesha Gamble 864-467-7016 hgamble@greenvillecounty.org

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Project Name: Balfer Drive

Project Priority: High

Entity Proposing Project: Greenville County
Estimated Costs: $88,000
Point of Contact: Hesha Gamble, 864-467-7016, hgamble@greenvillecounty.org

Details: This was an area for improvement identified in the Brushy Creek Flood Study. This project includes installing a culvert approximately 6 ft. X 6 ft. X 60 ft. with wing walls and all associated work.

Project Name: Kensington Road

Project Priority: Medium

Entity Proposing Project: Greenville County
Estimated Costs: $310,000
Point of Contact: Hesha Gamble, 864-467-7016, hgamble@greenvillecounty.org

Details: This project includes installing a 25 ft. bridge over Boling Creek on two end bents with piles. This replaces a double barrel pipe that floods.

Project Name: Deer Run Road

Project Priority: Medium

Entity Proposing Project: Greenville County
Estimated Costs: $460,000
Point of Contact: Hesha Gamble, 864-467-7016, hgamble@greenvillecounty.org

Details: This project includes installing a 25 ft. bridge over Devils Fork Creek on two end bents with piles plus associated road repairs. This replaces a 48 in. pipe that floods.

Greenwood County

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No Project Requests for Commission

Hampton County

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No Project Requests for Commission

Horry County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Waccamaw River Clearing and Snagging	Survey, removal and disposal of debris in Waccamaw	Horry County	$2,100,000	High	Tom Garigan Storm Water (O) 843-915-5160 (C) 843-365-2208
Road and Highway Raising	Raising low roads and highways and increasing culvert capacity	Horry County	$250,000+	High	Tom Garigan Storm Water (O) 843-915-5160 (C) 843-365-2208
Watershed Improvement Studies – Crabtree Swamp, Simpson Creek, Buck Creek[9]	Survey to identify opportunities for flow and storage improvements	Horry County	$250,000 per watershed Total: $750,000	Medium	Tom Garigan Storm Water (O) 843-915-5160 (C) 843-365-2208
Bucksport Flood Mitigation Project	Raise road to create a dam preventing flooding	Horry County	$900,000	Medium	Tom Garigan Storm Water (O) 843-915-5160 (C) 843-365-2208
Waccamaw River Diversion Canal	Study of flood reduction benefits of a diversion canal	Horry County	$500,000	Low	Tom Garigan Storm Water (O) 843-915-5160 (C) 843-365-2208

[9] SDRO Project ID 142: Watershed Assessment of Various Areas in Horry County & SDRO Project ID 143: Floodplain Restoration of Crabtree Swamp

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Project Name: Waccamaw River Clearing and Snagging

Project Priority: High

Entity Proposing Project: Horry County
Estimated Costs: $2,100,000
Point of Contact: Tom Garigan, Storm Water, (O) 843-915-5160, (C) 843-365-2208

Details: Recent hurricanes have caused many trees to fall down along the banks of the Waccamaw River and its major tributaries. Often referred to as large woody debris (LWD,) these downed trees are potential hazards to boaters and can cause dams that block flow and increase bank erosion.
The first step is to have a survey conducted to identify the locations and quantity of debris needing removal and identify suitable disposal location(s). Estimated cost of the assessment survey is $100,000. The Waccamaw River and its major tributaries north of Conway up to the NC state line is the area most in need of this work. The length of the project is 40 miles.
The estimated debris removal and disposal costs is $50,000/mile based on a literature review. Total project cost estimate is $2,100,000.

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Project Name: Road and Highway Raising

Project Priority: High

Entity Proposing Project: Horry County
Estimated Costs: $2,100,000
Point of Contact: Tom Garigan, Storm Water, (O) 843-915-5160, (C) 843-365-2208

Details: During recent flood events, many critical highways and roads were blocked by floodwaters. Raising these low areas and possibly increasing bridge and culvert capacity is essential to maintaining emergency access and preventing isolation of communities around the County. Most of these roads are SCDOT highways.
A survey and initial assessment of the feasibility of elevating the areas of critical highways subject to flooding is necessary in order to develop cost estimates. An estimated cost of the survey and feasibility phase would be $250,000. Until this phase is completed, there is no way to develop further project cost estimates.

Here is a preliminary list of potential projects.

- Hwy 701 at Grier Swamp (SCDOT)
- Hwy 905 at Kingston Lake (SCDOT)
- Hwy 710 at Crabtree Canal (SCDOT)
- Hwy 905 at Simpson Creek (SCDOT)
- Hwy 9 Bridge at Waccamaw River (SCDOT)
- Hwy 22 at Waccamaw River (SCDOT)
- Hwy 501 By-Pass at Waccamaw River (SCDOT)
- Hwy 90 at Tilley Swamp (SCDOT)
- Hwy 90 at Steritt Swamp (SCDOT)
- E. Country Club Rd. at Kingston Swamp (County)

Project Name: Watershed Improvement Studies – Crabtree Swamp, Simpson Creek, Buck Creek

Project Priority: Medium

Entity Proposing Project: Horry County
Estimated Costs: $250,000 per watershed, $750,000 for all three
Point of Contact: Tom Garigan, Storm Water, (O) 843-915-5160, (C) 843-365-2208

Details: These watershed canals were originally constructed in the 1960's and 70's but with continued development within the watersheds, they should be re-evaluated to identify any opportunities for flow and storage improvements.
The County has requested that the Corps of Engineers perform these studies.
Approximate costs to conduct updated surveys and a feasibility study is estimated at $250,000 per watershed based on previous similar studies.

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Project Name: Bucksport Flood Mitigation Project

Project Priority: Medium
Entity Proposing Project: Horry County
Estimated Costs: $900,000
Point of Contact: Tom Garigan, Storm Water, (O) 843-915-5160, (C) 843-365-2208

Details: This project would raise Big Bull Landing Road for a length of 2800 ft. to create a dam that would prevent the Pee Dee River from flooding across Bucksport into the Waccamaw River.
Preliminary engineering is complete and the project appears to be feasible.
Estimated construction costs are $900,000.

Project Name: Waccamaw River Diversion Canal

Project Priority: Low
Entity Proposing Project: Horry County
Estimated Costs: $500,000
Point of Contact: Tom Garigan, Storm Water, (O) 843-915-5160, (C) 843-365-2208

Details: While this concept has been studied previously, there is renewed interest in pursuing this project.
New river models have been developed that can be used to more accurately predict flood reduction benefits of a diversion canal.
A re-study of the diversion canal could cost up to $500,000 based on previous studies.

Jasper County

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No Project Requests for Commission

Kershaw County

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No Project Requests for Commission

Lancaster County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Lancaster Soil and Water Conservation District	Five Flood Control Lakes maintenance and/or upgrades	Lancaster County	$35,197,400	High	Elizabeth Evans, Environmental Outreach Stormwater (P) 803-283-0526 (F) 877-636-3050 eevans@lancastercountysc.net Darren Player Lancaster County Emergency Management (C) 803-320-0087 dplayer@lancastercountysc.net
Culvert Replacements in Lower Lancaster County	Replace five culverts	Lancaster County	$5,000,000	High	Elizabeth Evans or Darren Player
Stream Gauging Stations	Install stream monitoring gages	Lancaster County	$195,000	High	Elizabeth Evans or Darren Player
Five Specific Culvert Replacements in Panhandle	Roadway stream-crossing projects replacement	Lancaster County	$4,000,000	High	Elizabeth Evans or Darren Player
Roadway Culvert Efficiency Retrofitting	Improving culvert efficiencies	Lancaster County	$500,000	High	Elizabeth Evans or Darren Player
FEMA Flood Insurance Study Update	FEMA Flood Insurance Study Update	Lancaster County	$1,275,000	High	Elizabeth Evans or Darren Player
Floodplain Purchase/Protection	Purchase floodplains	Lancaster County	$23,000,000	High	Elizabeth Evans or Darren Player

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Project Name: Lancaster Soil and Water Conservation District

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $35,197,400
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Five Lancaster County SWCD dams and reservoirs provide flood peak dampening by holding and metering out excess runoff through the outlet riser system. These ponds are critical in peak flow reduction by utilizing temporary storage above the normal pool and below the dam overflow. This temporary storage protects downstream properties from flooding but impacts several upstream roadways with backwater effects until the lake levels subside.

Campbell Lake Site 7: 34°46'50.8"N 80°41'32.1"W
Ghent Reservoir Site 16: 34°46'16.6"N 80°40'03.6"W
Gills Creek Site 18 A: 34°44'09.0"N 80°42'38.6"W
Bear Creek Site 10D: 34°40'51.9"N 80°41'11.2"W
Little Lynches Creek Site 12: 34°33'12.4"N 80°36'44.9"W

More details for maintenance needed at each of the flood control dams/reservoirs and additional details concerning necessary dam improvements to meet minimum standards for Class C dams is available upon request.

A 20% contingency was added to these estimates due to vastly different construction market from 2010 until 2019.

General maintenance includes:

All five dams are fitted with Asbestos pipe toe drains. They appear to be working but the liability of asbestos and the propensity to failure indicates that a replacement for the systems is in order. The expected life cycle of the pipes is over.

In order to access the risers and gates during an emergency, we need a towing vehicle and zodiac boat with motor, battery, trailer, four emergency signal devices and four life preservers. The estimated cost is $60,000.

Ghent reservoir needs trees/woody vegetation removed from the toe of the dam and area stabilized with geotextile fabric and rip/rap. The project estimated cost is $25,000.

Bear Creek plunge basin need trees and woody vegetation removed at an estimated cost of $5,000.

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Project Name: Culvert Replacements in Lower Lancaster County

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $5,000,000
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Several culverts overtop in Lancaster County; six culverts need to be replaced due to significant limited capacity and or backwater effects from downstream SWCD reservoirs. This creates safety hazards for the traveling public and requires emergency personal to barricade the roadway during each storm. Impacted roadways include:

	Location coordinates
Activity Road	34.8092 - 80.7766
Bayou Lane	34.6351 - 80.7042
Old Farm Road	34.78997 - 80.68168
Thermal Trail	34.6178 - 80.4471

Several roads will need to be elevated several feet to eliminate flooding as they flood due to backwater effects from dams. They include:

	Location coordinates
Hough Road	34.741659, -80.702986
Deer Track Circle	

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Project Name: Stream Gauging Stations

Project Priority: High

Entity Proposing Project: Lancaster County

Estimated Costs: $195,000

Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Digital staff gauges to monitor flow in the streams. These devices monitor and record stream flow, which establishes stream base flow rates and peak flow rates in response to a wide variety of storms. They help predict riverine flooding stage elevations, which ultimately assists emergency personnel in resource allocations during and after storm events.

We propose to install gauges at each of the six Soil and Water Conservation District flood control dams and one at each of the 20 named streams in the county and gauges associated with NRCS dams for a total of 26 gauges at $7,500 each.

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Project Name: Five Specific Culvert Replacements in Panhandle

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $4,000,000
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Several culverts overtop in Lancaster County. Five are in the panhandle and need replacement due to significant limited capacity issues. Photos are available upon request.
As land transitions from rural to urban, the runoff characteristics change dramatically. The peak rate of flow and the flow volume generated increase significantly. These increases put extreme demands on the older infrastructure of under-road culvert crossings, which were not sized to accommodate an urban landscape runoff from upstream. We have several culvert crossings that currently overtop during rainstorms. Black Horse Run Drive, Man-O-War Road, and Calvin Hall Road are a few examples of such a situation.

Other concerns associated with all public infrastructure is deferred maintenance. This is certainly true for the network of culvert crossings under public roadways in the SMS4 service area. One such crossing is under Old Bailes Road, which is structurally failing and too short to adequately support the roadway and fill imposed upon it. The edge of the roadway is literally falling down the slope. This roadway was transferred to the County as a part of the Industrial Park development agreement some years ago. We will need to close the roadway to replace the failing culvert, however we do not have the funding nor do we want to pursue the construction until after SC Highway 160 widening project is complete. Staff have acknowledged each of these concerns and some evaluation has been performed for each problem area.

Preliminary budgets for these projects are as follows:

	Budget	*Location coordinates*
Black Horse Run Road	$750,000	34.997883 -80.849856
Man-O-War Road	$800,000	34.995045 -80.844916
Old Bailes Road	$850,000	34.991753 -80.874297
Calvin Hall Road	$850,000	35.005936 -80.869253
Ander Vincent Road	$750,000	34.917642 -80.793100
Sub-total for these culvert needs	$4,000,000	

We must address the ever-growing backlog of stormwater projects like erosion, failing culverts and blocked inlets now before they worsen into emergencies. We need to reduce pollution in our streets and streams, and we must address the outdated and decaying pipes that pose a risk to public safety. Making improvements now, we can become more proactive in protecting our water quality and thereby increasing the health of our community.

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Project Name: Roadway Culvert Efficiency Retrofitting

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $500,000
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Lancaster County consists of 550 square miles of which, approximately 50 square miles is the panhandle. The panhandle portion of the County represents the fastest growing area due to its close proximity to Charlotte, NC. The lower 500 square miles are generally rural but also include the City of Lancaster, the Towns of Heath Springs, and Kershaw. There are 28 FEMA FIRM mapped stream crossings under Lancaster County roadways. These can be retrofitted with new end sections to minimize inlet flow loss, which improves efficiencies. In order to maximize capacity in the culvert, a new junction box may be required to join the existing culvert with the new inlet section. The new inlet will be sized appropriately for the contributing watershed and the junction box will allow replacement of the culvert under the roadway without affecting the end section or incoming stream /ditch in the future. The new inlet sections will be back-sloped to allow woody debris to float up and water passage underneath. Most of the county is wooded and significant woody debris is washed through the streams and clogs up the roadway culverts. This increases the likelihood of roadway overtopping and washouts. Most existing roadway culvert crossings are undersized and will be upsized when necessary funding is secured. Our objective with this program is to minimize roadway flooding for the most number of roadways/citizens served at the least cost per road by maximizing the flow capacity of the existing culvert.

We estimate there are 50 culvert road crossings that need to be up-fitted. The cumulative preliminary budget estimates for these projects is an average of $10,000 each with a cumulative total of $500,000. This culvert up-fit project would include both Flood Zones A and AE.

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Project Name: FEMA Flood Insurance Study Update

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $1,275,000
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Many of the base flood studies on our current FEMA FIRM panels for streams/rivers within Lancaster County are based on 1981 data and analyses. The land use and modelling capacity has changed significantly in 38 years. We plan to have these streams restudied for more accurate flood projections and improved public safety.

An ultimate buildout land-use floodplain analyses is needed for the high-growth portions of Lancaster County. Currently, development projects are analyzed individually without regard for the other development up and downstream as well as development on the other side of the stream, which may be in another county.

An ultimate conditions analysis would set the ultimate floodplain boundaries and elevations. This would be used as a guide in allowing smart growth along our rivers, streams, and tributaries.

There are 20 named streams in the Lancaster County study with base flood elevations determined, which represents 79 miles of streams. There are another 100 miles of unnumbered Zone A streams which need to be studied to establish a base flood elevation (BFE). Twenty Hydrologic Engineering Center (HEC) models will need to be updated and 25 stream models built on the unnumbered A Zones. We estimate $20,000 per existing stream model and $35,000 to build a new model for each of the 25 Zone A streams for a budget of $1,275,000.

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Project Name: Floodplain Purchase/Protection

Project Priority: High

Entity Proposing Project: Lancaster County
Estimated Costs: $23,000,000
Point of Contact: Elizabeth Evans, Environmental Outreach Stormwater, (P) 803-283-0526, (F) 877-636-3050, eevans@lancastercountysc.net or Darren Player, Lancaster County Emergency Management, (M) 803-320-0087, dplayer@lancastercountysc.net

Details: Lancaster County has 79 linear miles of mapped stream floodplain Zone AE that has been studied to develop a BFE. The 74 linear miles of floodplain noted above represents 15 square miles of Zone AE and 4.2 square miles of floodway. In addition to the 19.2 square miles of Zone AE designation, there is also 22 square miles of Zone A, which means that no formal study has been conducted; therefore, no BFE has been determined. We estimate this to represent 100 miles of stream. The known Zone A streams represent 28 County road crossings of which we estimate 22 are Zone A roadway crossings.

To help counter the effects of urbanization, acquisition of critical areas of floodplain would be conducive to both natural area preservation as well as a barrier protecting the streams and river. Open space and green infrastructure can be part of a critical flood risk management system. The purchase of the floodplain would protect this ecologically sensitive zone from encroachment by development and at the same time provide a natural area for the community to enjoy. The set aside has multiple water quality benefits by maintaining a buffer adjacent to named streams in the County. Lancaster County is poised for explosive growth as the Charlotte metropolitan area growth has already influenced the northern panhandle of the County significantly. The preliminary budget estimate for the Floodplain purchase project is $23M based on $1,000/acre. We do not expect full funding of this item but would like to purchase critical sections before development occurs in the high growth corridor. This would also create a public benefit by adding to the attractiveness of the area.

Laurens County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
New EOC/911 Center	Relocation of EOC and 911 Center	Laurens County	$3,750,000	High	Joey Avery Laurens County Emergency Manager 864-984-0812 javery@co.laurens.sc.us
Wastewater Treatment Facility Generator	Purchase of generator for wastewater treatment facility	Laurens County	$390,000	Medium	John Young Laurens Commission of Public Works 864-681-4332 jyoung@lcpw.com

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Project Name: New EOC/911 Center

Project Priority: High

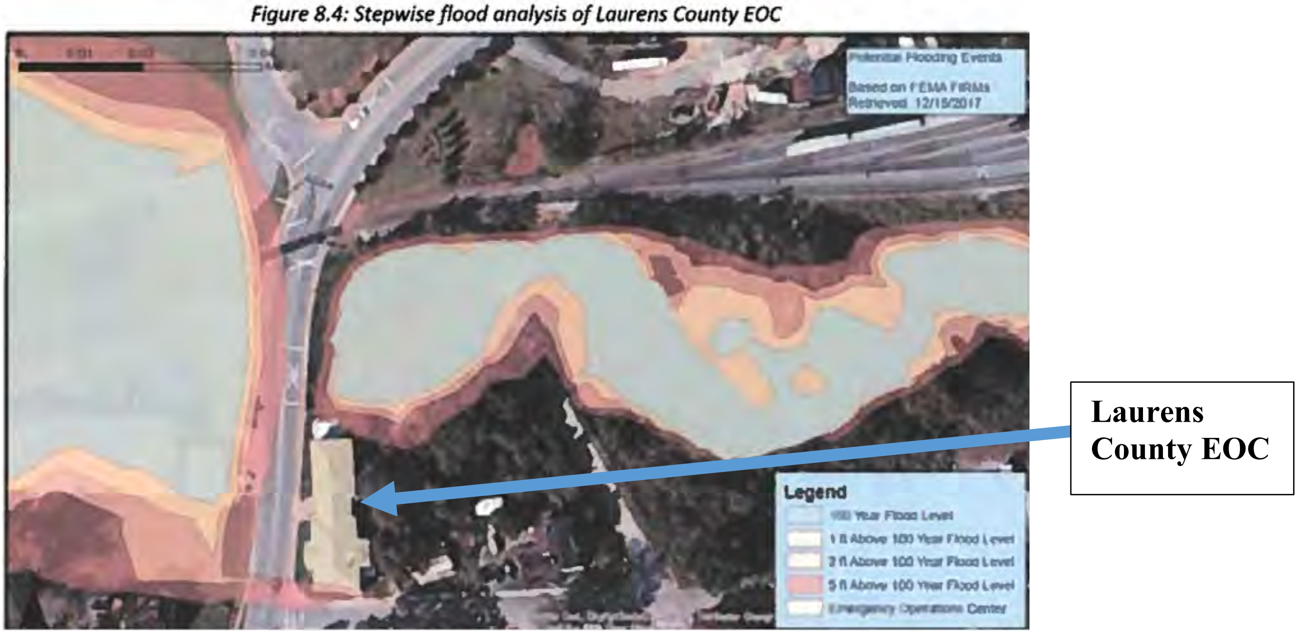
Entity Proposing Project: Laurens County
Estimated Costs: $3,750,000
Point of Contact: Joey Avery, Laurens County Emergency Manager, 864-984-0812, javery@co.laurens.sc.us

Details: A study of the risks and vulnerabilities to the Laurens County Emergency Operations Center (EOC) facility was conducted. In the current location, the resulting analysis indicates the Laurens County EOC could face a flooding threat should the water levels rise 5 ft. above the 100-year floodplain. Specifically, there appear to be two key threats:

1. Access to the facility: In a flood hazard event, the main access road to the facility as well as the parking lot would likely flood, crippling response efforts by making travel to and from the EOC difficult.
2. Operability of critical emergency response equipment and functions: The inundation of the facility is expected to occur near the front and rear entrances. Should this occur, floodwaters would immediately pool in the subterranean levels of the facility where community servers, backup servers, and the Laurens County 911 Center are located. In the event of such a flood hazard event, these critical servers could become in-operational. With these systems offline, the County's response capabilities could be compromised rendering slow support.

Based on the information gathered from the study, it is proposed the EOC and County 911 Center is relocated to another site.

Figure 8.4: Stepwise flood analysis of Laurens County EOC



Additional pictures and background information available upon request.

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Project Name: Wastewater Treatment Facility Generator

Project Priority: Medium

Entity Proposing Project: Laurens County
Estimated Costs: $390,000
Point of Contact: John Young, Laurens Commission of Public Works, 864-681-4332, jyoung@lcpw.com

Details: A 750 KW permanent emergency diesel generator will be installed onsite at the Little River Wastewater Treatment Plant and will power all essential facilities at the plant during a power failure. The project is located at the existing Little River Wastewater Treatment Plant. The plant is a municipal treatment facility with a treatment capacity of 4.5 MGD. The plant is located in the city limits of Laurens adjacent to Little River.

The Little River Wastewater Treatment Plant is not equipped with auxiliary power. Instead, the plant is fed by two separate utility substations; however, both substations are fed from a common primary electrical transmission line. Loss of power would create an emergency situation at the treatment plant since the entire process is dependent upon electricity for power, and would result in the discharge of raw or partially treated wastewater. To maintain constant power, a permanent emergency diesel generator will be installed onsite and will power all essential facilities at the plant. The project will benefit the citizens of Laurens by preventing back up of wastewater and subsequent discharge to basements, streets and property and benefit downstream water treatment plants by protecting the quality of water withdrawn for drinking water. The project construction will be competitively bid to a general contractor and the project will be managed by Commission personnel. Emergency generators are routinely utilized to maintain power at wastewater treatment plants and are considered by regulatory agencies as an acceptable alternative source of power. As such, the project is technically feasible and will ensure that continuous power can be provided at the plant thereby protecting the public health and environment. The project will begin immediately if approved.

Lee County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Study for Main Street in Lynchburg[10]	Study and adding a canal to the Town of Lynchburg	Lee County	$100,000	High	Alan Watkins 803-484-5341 ext. 321 AWatkins@leecounty.sc.org
Canal for King's Avenue Neighborhood-Southwest side of Bishopville[11]	Divert water by adding a drainage ditch to the Western edge of the Town of Bishopville	Lee County	$25,000	Medium	Alan Watkins 803-484-5341 ext. 321 AWatkins@leecounty.sc.org
Canal Ditch at Flower Lane[12]	Study for ditching or enlarging culverts to prevent flooding	Lee County	$150,000	Medium	Alan Watkins 803-484-5341 ext. 321 AWatkins@leecounty.sc.org

[10] SDRO Project ID 81:Main Street Downtown Lynchburg Flooding
[11] SDRO Project ID 82: Drainage North of Bishopville and Kings Ave.
[12] SDRO Project ID 177: Flower Lane

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Project Name: Study for Main Street in Lynchburg

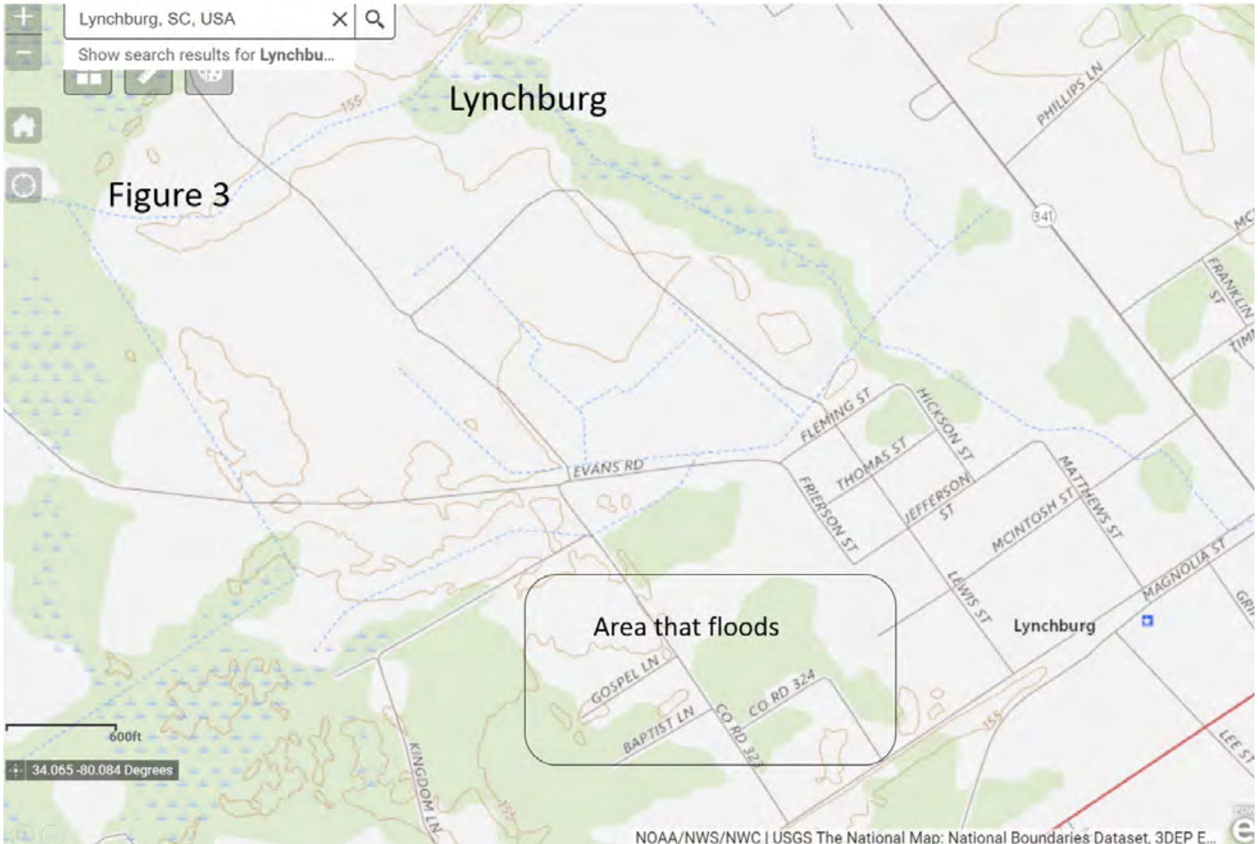
Project Priority: High

Entity Proposing Project: Lee County
Estimated Costs: $100,000
Point of Contact: Alan Watkins, County Administrator, 803-484-5341 ext. 321, AWatkins@leecounty.sc.org

Details: The Main Street area of the Town of Lynchburg has a large drainage canal ditch, which is a collection point for runoff from several streets in Lynchburg as well as surrounding farmland beyond the town's jurisdiction. This canal ditch is an unsightly feature in the community and the SC DOT ditches which drain into this large canal area are not sufficient to handle the volume of water during heavy rain events. The Main Street area floods several times a year due to the current system. There are a number of homes which are directly impacted by the flooding as well as churches and a manned county trash collection site. See Figure 3 and 4 on next page.
The Lynchburg Community flooding issue along Main St. could be mitigated through the following possible solutions:

1) Study the possibility of rerouting the current canal ditch outside of the Main Street area. This would be a very extensive project and require substantial rerouting of current drainage ditching.
2) Enlarging the capacity of the current system and adding additional ditching which may take some of the current run-off outside of the town limits from the farm areas.

Initial Step for the project would be a study of the current system to determine if re-routing of the run-off from surrounding areas outside of Lynchburg is feasible or cost prohibitive. In addition, a study to determine if enlarging the current system would mitigate the current flooding problem.


Lynchburg, SC, USA
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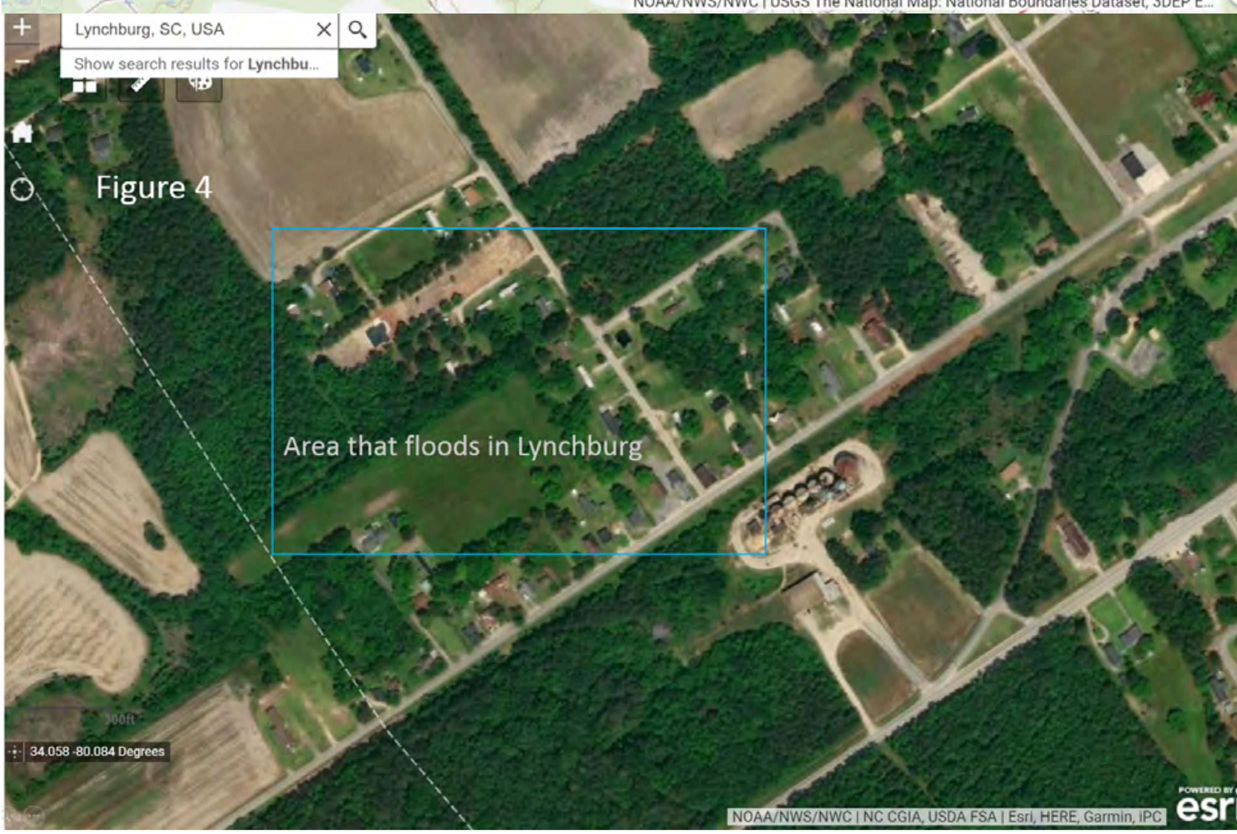
Lynchburg
Figure 3
Area that floods
EVANS RD
FLEMING ST
HICKSON ST
THOMAS ST
FRIERSON ST
JEFFERSON ST
MCINTOSH ST
MATTHEWS ST
LEWIS ST
MAGNOLIA ST
PHILLIPS LN
FRANKLIN ST
GOSPEL LN
BAPTIST LN
CO RD 324
CO RD 323
KINGDOM LN
LEE ST
Lynchburg
600ft
34.065 -80.084 Degrees
NOAA/NWS/NWC | USGS The National Map: National Boundaries Dataset, 3DEP E...


Lynchburg, SC, USA
Show search results for Lynchbu...
Figure 4
Area that floods in Lynchburg
34.058 -80.084 Degrees
NOAA/NWS/NWC | NC CGIA, USDA FSA | Esri, HERE, Garmin, iPC
esri

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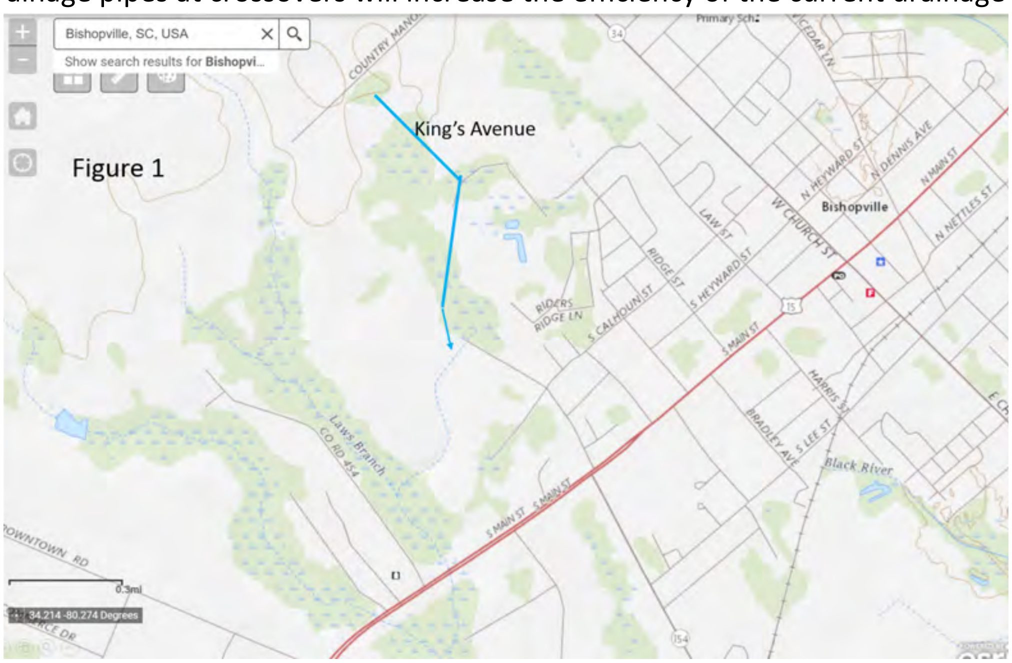
Project Name: Canal for King's Avenue Neighborhood

Project Priority: Medium

Entity Proposing Project: Lee County
Estimated Costs: $25,000
Point of Contact: Alan Watkins, County Administrator, 803-484-5341 ext. 321, AWatkins@leecounty.sc.org

Details: King's Avenue Neighborhood has experienced repeated issues with flooding for a number of years. There is a large drainage canal ditch on the western edge of the neighborhood that drains farmland and runoff from other communities as the water travels towards the various tributaries and wetlands feeding the river. There are also SC DOT drainage ditches which collect water from King's Ave and South Calhoun Street right of way and this water also works its way into the same canal ditch on the western end of King's Ave. 15 households are impacted. See Figure 1 below.
This canal ditch is not on SC DOT right of way and is partially maintained by farmers in the community who work fields directly impacted by the canal ditch. There are sections of the drainage canal ditch not being maintained, as there is no public or private entity claiming the ditch as its responsibility.
The King's Avenue flooding issue could be mitigated through two potential projects.

1) Study the possibility of rerouting the current canal ditch away from the residential communities on the Southwest Side of Bishopville. The farmland runoff could potentially be routed further to the southwest and tie back into the canal ditch that takes the water to the river below the King's Avenue neighborhood.
2) Study the current capacity of the canal ditch, which drains the King's Avenue neighborhood. Clearing debris from the current drainage system and potentially enlarging concrete drainage pipes at crossovers will increase the efficiency of the current drainage system.



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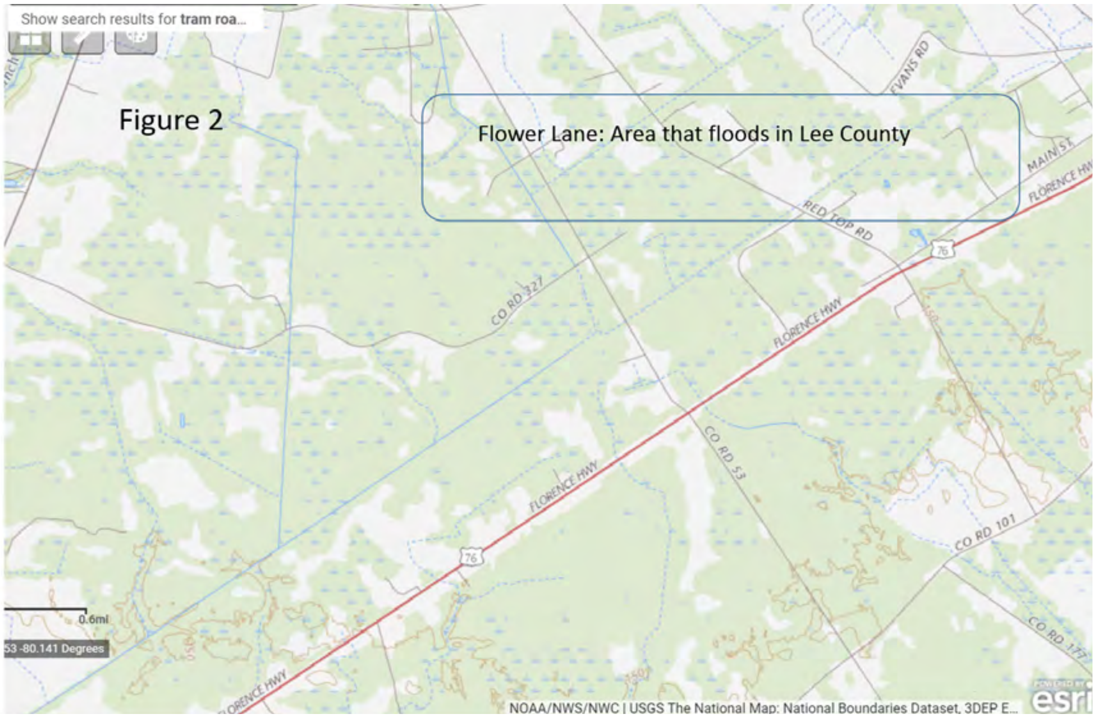
Project Name: Canal Ditch at Flower Lane

Project Priority: Medium
Entity Proposing Project: Lee County
Estimated Costs: $150,000
Point of Contact: Alan Watkins, County Administrator, 803-484-5341 ext. 321

Details: Flower Lane is a rocked county road, which intersects Tram Road east of Hwy 401 near Elliot in lower Lee County. Flower Lane has a large canal ditch that intersects the roadway and runs parallel to Tram Road. The canal ditch which intersects and travels under Flower Lane via a metal culvert is not currently maintained by any public or private entity for long stretches. The County has inquired with the local Soil and Water Conservation Office which does not show this ditch as part of their system for drainage in the county and the canal ditch is not on SC DOT or County right of way in the areas where obstructions exist. This impacts 4 households. See Figure 2 below.
This is a part of a larger problem in other locations in the county where public right of way drainage ditches intersect with private ditches which may or may not be maintained regularly. The unmaintained private areas of the drainage system create bottlenecks for drainage and cause back-ups onto public right of way.
Flower Lane drainage issues:

1) A review of current SC DOT rules regarding not maintaining drainage ditches more than 100 feet off its right of way. Perhaps working with Soil and Water Conservation to develop a plan for maintaining the areas of drainage systems off public right of way through obtaining temporary easements would help alleviate flooding problems throughout the drainage system.

Study this particular system to see if the current drainage system is sufficient for the volume of water being drained from surrounding farmland and public right of way.


Show search results for tram roa...
Figure 2
Flower Lane: Area that floods in Lee County
EVANS RD
MAIN ST
FLORENCE HWY
RED TOP RD
76
CO RD 327
FLORENCE HWY
CO RD 53
FLORENCE HWY
76
CO RD 101
CO RD 171
0.6mi
53 -80.141 Degrees
FLORENCE HWY
NOAA/NWS/NWC | USGS The National Map: National Boundaries Dataset, 3DEP E...
esri

Lexington County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
30 Dry Suits for Lexington County Fire Service	Purchase of Dry suits for response and rescue needs	Lexington County Fire Service	$29,695	High	Brad Amick Battalion Chief 803-518-1983 bamick@lex-co.com
Flat Bottom Aluminum Boat	Purchase of 1 flat bottom boat for response and rescue needs	Lexington County Fire Service	$10,388	High	Brad Amick Battalion Chief 803-518-1983 bamick@lex-co.com
ACELA Monterra High Water Flood Rescue Truck	Purchase of 1 High water rescue truck	Lexington County Fire Service	$119,900	High	Brad Amick Battalion Chief 803-518-1983 bamick@lex-co.com
Rigid Inflatable Boat	Purchase of 1 Rigid Inflatable boat	Lexington County Fire Service	$25,000	High	Brad Amick Battalion Chief 803-518-1983 bamick@lex-co.com
30 Personal Protection Swift Water Rescue Kits	Purchase of 30 Personal Protection Swift Water Kits	Lexington County Fire Service	$24,000	High	Brad Amick Battalion Chief 803-518-1983 bamick@lex-co.com
Old Friars Rd Culvert Modification	Install 2 bigger box culverts	Lexington County Public Works	$1,257,588	High	Derrick Pratt 803-785-7146 dpratt@lex-co.com
Kettering Drive Culvert Modification	Install 2 box culverts	Lexington County Public Works	$148,383	Medium	Derrick Pratt 803-785-7146 dpratt@lex-co.com
Lower Brookshire Drive Culvert Modification	Install concrete drainage pipe	Lexington County Public Works	$234,584	Medium	Derrick Pratt 803-785-7146 dpratt@lex-co.com
Goldstone Drive Bridge Retrofit	Bridge replacement	Lexington County Public Works	$2,300,000	Low	Derrick Pratt 803-785-7146 dpratt@lex-co.com
Cressfell Road Bridge Retrofit	Bridge repair	Lexington County Public Works	$1,340,000	Low	Derrick Pratt 803-785-7146 dpratt@lex-co.com

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Project Name: 30 Dry Suits for Lexington County Fire Service

Project Priority: High

Entity Proposing Project: Lexington County Fire Service
Estimated Costs: $29,695
Point of Contact: Battalion Chief Brad Amick, 803-518-1983, bamick@lex-co.com

Details: To increase the Lexington County Fire Service's response and rescue capabilities to flood water and swift water incidents throughout the incorporated and non-incorporated portions of Lexington County.

Back up documentation with history of flooding and past incident response available upon request.

Program Need

Because of the various types of incidents encountered during the 2015 Flood and locations throughout the county personnel were utilized from various companies to manage these incidents. This personnel utilization from throughout the department caused an inability to get personal protective equipment distributed efficiently. Equipment utilized was also unable to be swapped out between incidents due to the quantity of equipment.

During the event, staff rotation was needed to avoid excessive fatigue. Because of the lack of equipment and the need currently for depth in our equipment cache, individual kits are necessary to allow for staffing rotations to be created, minimizing the need for outside resources. Becoming more self-sufficient allows those resources to be utilized in other jurisdictions without the ability to conduct these types of rescues.
Due to the contaminants in the water, it is necessary to utilize dry suits as much as possible. These dry suits not only protects against any contaminants, but also helps prevent exposure to cold water and abrasions.

The Kokatat SAR Dry Suit is a Gortex suit with Gortex booties. A neoprene neck seal and wristlets prevent water from entering the suit. The program need is to complete the purchase of 30 dry suits to maintain an operational readiness for all personnel. These dry suits are $925 each. A total request of $29,695 is needed to purchase 30 suits.

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Project Name: Flat Bottom Aluminum Boat

Project Priority: High

Entity Proposing Project: Lexington County Fire Service
Estimated Costs: $10,388
Point of Contact: Battalion Chief Brad Amick, 803-518-1983, bamick@lex-co.com

Details: To increase our department's response and rescue capabilities to flood water and swift water incidents throughout the incorporated and non-incorporated portions of Lexington County.

Back up documentation with history of flooding and past incident response available upon request.

Program Need

During the 2015 Flood, several large-scale evacuations were conducted. These events were conducted in slow moving or flat water. This water was contaminated with debris from homes, yards and landscaping. During these evacuations, a need for an aluminum boat capable of carrying forcible entry equipment, resistance from puncture and capable of carrying multiple occupants was identified.
An aluminum flat bottom boat kit comes with a boat, trailer, motor and other ancillary items to operate the boat. The boat system selected is distributed through McLearn Marine and pricing is found through South Carolina state bid pricing.

One boat kit contains:

- 14 ft. War Eagle 548-LDV Boat
- 40 HP Motor
- Trailer
- Ancillary Supplies

The kit price through state bid pricing is $9,800. With the addition of sales tax, it increases the pricing to $10,388 per boat kit.

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Project Name: ACELA Monterra High Water Flood Rescue Truck

Project Priority: High

Entity Proposing Project: Lexington County Fire Service
Estimated Costs: $119,900
Point of Contact: Battalion Chief Brad Amick, 803-518-1983, bamick@lex-co.com

Details: To increase our department's response and rescue capabilities to flood water and swift water incidents throughout the incorporated and non-incorporated portions of Lexington County.

Back up documentation with history of flooding and past incident response available upon request.

Program Need

During the 2015 Flood, several large-scale evacuations were conducted. These events were conducted in slow moving or flat water. This water was contaminated with debris from homes, yards and landscaping. During these types of incidents throughout the country, the use of high water vehicles have become standard practice. The use of high water trucks allows multiple victims to be removed from the hazard area. The standard boat operation can usually safely remove 3-6 victims before boat operations could be affected. A large high water vehicle can double or triple those numbers.
The ACELA Monterra High Water Flood Rescue Truck has 23" of ground clearance. It is equipped with 47" tires, waterproof starter and alternator and a proprietary 50" water fording capability. This water fording capability creates the opportunity to reach victims in four (4) feet of water. Many of the evacuations done during this flood event would have easily been reached.
The 4x4 model of this apparatus is capable of seating up to 17 victims. During the Coldstream evacuation, where 65 victims were removed by multiple boat launches, this could have been handled by 3-4 trips with this truck. The cost on this apparatus is $119,900.

Project Name: Rigid Inflatable Boat

Project Priority: High

Entity Proposing Project: Lexington County Fire Service
Estimated Costs: $25,000
Point of Contact: Battalion Chief Brad Amick, 803-518-1983, bamick@lex-co.com

Details: To increase our department's response and rescue capabilities to flood water and swift water incidents throughout the incorporated and non-incorporated portions of Lexington County.

Back up documentation with history of flooding and past incident response available upon request.

Program Need

During the 2015 Flood, a need to make access to victims in moving water was determined. In the River Chase incident a significant current was encountered that created hydraulics and other hazards that

would better be navigated with a rigid inflatable boat that is advantageous in this environment. This boat is also capable of moving personnel and victims to and from the hazard area easily.
This boat system consists of a boat, trailer, motor and other ancillary items needed to effectively operate it. The approximate cost for this system is $25,000.

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Project Name: 30 Personal Protection Swift Water Rescue Kits

Project Priority: High
Entity Proposing Project: Lexington County Fire Service
Estimated Costs: $24,000 ($800/each)
Point of Contact: Battalion Chief Brad Amick, 803-518-1983, bamick@lex-co.com

Details: To increase our department's response and rescue capabilities to flood water and swift water incidents throughout the incorporated and non-incorporated portions of Lexington County.

Back up documentation with history of flooding and past incident response available upon request.

Program Need
Because of the various types of incidents encountered during the 2015 Flood and locations throughout the county, personnel were utilized from various companies to manage these incidents. This personnel utilization from throughout the department caused an inability to get personal protective equipment distributed efficiently. Equipment utilized was also unable to be swapped out between incidents due to the quantity of equipment.
During the event, staff rotation was needed to avoid excessive fatigue. Because of the lack of equipment and the need currently for depth in our equipment cache, individual kits are necessary to allow for staffing rotations to be created to minimalize the need for outside resources. This will those resources to be utilized in other jurisdictions without the ability to conduct these types of rescues.

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Project Name: Old Friars Rd Culvert Modification

Project Priority: High

Entity Proposing Project: Lexington County Public Works
Estimated Costs: $1,257,588
Point of Contact: Derrick Pratt, 803-785-7146, dpratt@lex-co.com

Details: Old Friars Rd is owned by Lexington County and the culvert crosses below the road through a single 4ft concrete pipe and brick culvert. The 339 ft. culvert path zigzags across the road at an angle, including six 90-degree bends, and passes underground through yards on the upstream and downstream side of the road. This culvert is severely undersized, only providing 13ft^2 whereas a 10-YR storm would require a minimum cross-sectional area of 60ft^2. The proposed modifications are limited by the location of nearby structures and depth under the road. Two 6ft-by-6ft box culverts are proposed which would extend the culvert opening to the low point of the road and maximize the available space to accommodate the more frequent storms and reduce flooding in larger, less-frequent storms. Additionally, minor benefits would be gained by reducing the zigzag pattern down to two 45-degree bends and by the reduced friction provided by the proposed culverts compared to the existing culvert.
Additional cost breakdown and backup documentation available upon request.

Project Name: Kettering Drive Culvert Modification

Project Priority: Medium

Entity Proposing Project: Lexington County Public Works
Estimated Costs: $148,383
Point of Contact: Derrick Pratt, 803-785-7146, dpratt@lex-co.com

Details: Kettering Drive is owned by Lexington County and the culvert crosses below the road through a single 4ft concrete pipe. Flooding has been documented at the home on the upstream side of Kettering Dr. Two concrete 6ft-by-4ft box culverts are proposed.

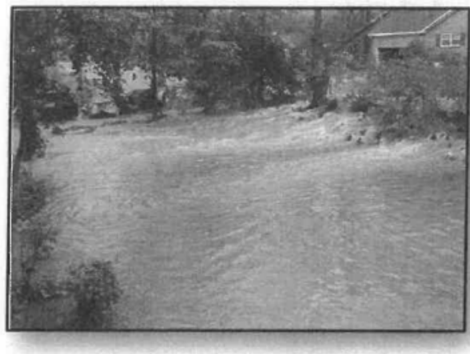

Figure 7. Flooding at home between Kettering and Lower Brookshire Drive

(Photo Courtesy of Mr. Dru Kennedy)

Additional Cost break down and back up documentation available upon request.

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Project Name: Lower Brookshire Drive Culvert Modification

Project Priority: Medium

Entity Proposing Project: Lexington County Public Works
Estimated Costs: $234,584
Point of Contact: Derrick Pratt, 803-785-7146, dpratt@lex-co.com

Details: Brookshire Drive is owned by Lexington County. The culvert crosses Brookshire Drive at the upstream end and again, just before it meets with Kettering Drive. At the lower Brookshire Drive crossing, the addition of a 5ft diameter and a 4ft diameter concrete pipe parallel to the existing 4ft corrugated metal pipe culvert is proposed and was modeled in HEC-RAS.
Additional Cost break down and back up documentation available upon request.

Project Name: Goldstone Drive Bridge Retrofit

Project Priority: Low

Entity Proposing Project: Lexington County Public Works
Estimated Costs: $2,300,000
Point of Contact: Derrick Pratt, 803-785-7146, dpratt@lex-co.com

Details: This project includes replacement of the bridge due to the overall structural condition of both the substructure and superstructure. To minimize the potential for debris build up and maximize the hydraulic opening, the span lengths of the replacement bridge should be increased. A preliminary hydraulic assessment indicates that the elevation of the bridge deck may need to be raised an amount that could have a significant impact on adjacent properties.

This bridge is currently closed to traffic due to its structural condition.

Additional Cost break down and back up documentation available upon request.

Project Name: Cressfell Road Bridge Retrofit

Project Priority: Low

Entity Proposing Project: Lexington County Public Works
Estimated Costs: $1,340,000
Point of Contact: Derrick Pratt, 803-785-7146, dpratt@lex-co.com

Details: This project includes repairing cracks and spalls in the superstructure of the bridge, patch and level approaches, and rework guardrails.

Additional Cost break down and back up documentation available upon request.

Marion County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Hydrology Study	Hydrology Study to reduce county wide flooding	Marion County	$1,000,000	High	David Holcombe 843-431-5009 dholcombe@marionsc.org
Sellers Drainage	Clean ditches	Marion County	$1,000,000	High	David Holcombe 843-431-5009 dholcombe@marionsc.org
Walker St. & Lake St.	Clean ditches	City of Mullins	$150,000	High	David Holcombe 843-431-5009 dholcombe@marionsc.org
Outflow Canal	Enlarge canal	City of Mullins	$500,000	High	David Holcombe 843-431-5009 dholcombe@marionsc.org
Nichols[13]	Clean ditches of sediment and debris	Town of Nichols	$1,460,000	High	David Holcombe 843-431-5009 dholcombe@marionsc.org
Smith Swamp	Clean swamp debris	Marion County	$500,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Catfish Creek	Clean canal of overgrowth	Marion County	$500,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Maple Swamp	Enlarge culverts	Marion County	$250,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Mullins Storm Water Canal	Clean storm water canal	Marion County	$250,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Little Pee Dee	Clean waterway of trees and debris	Marion County	$750,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
NE Front St	Enlarge culvert under the trestle	City of Mullins	$400,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Mullins Storm Water Pipes	Enlarge storm pipes	City of Mullins	$300,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org
Park Ave	Clean ditches and drains	City of Marion	$500,000	Medium	David Holcombe 843-431-5009 dholcombe@marionsc.org

[13] SDRO Project ID 74: Marion County-Levees and Floodwalls

Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Secondary Culverts	Enlarge culverts	Marion County	$250,000	Low	David Holcombe 843-431-5009 dholcombe@marionsc.org

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Project Name: Hydrology Study

Project Priority: High
Entity Proposing Project: Marion County
Estimated Costs: $1,000,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Countywide Hydrology Study. A hydrology study is needed to review waterways, canals, and drainage to determine ways to mitigate flooding.

Project Name: Seller's Drainage

Project Priority: High
Entity Proposing Project: Marion County
Estimated Costs: $1,000,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Clean ditches of sediment and debris that runs from Sellers to the Great Pee Dee River. Work has started on this project.

Project Name: Walker St. and Lake St.

Project Priority: High
Entity Proposing Project: City of Mullins
Estimated Costs: $150,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Clean the outflow ditches on Walker St. and Lake St. Estimated cost of $150,000. Need to clean the ditches to the river.

Project Name: Outflow Canal

Project Priority: High
Entity Proposing Project: City of Mullins
Estimated Costs: $500,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Outflow canal culvert under Hwy 76 in Mullins needs to be enlarged. Another option would be adding another culvert to increase the flow.

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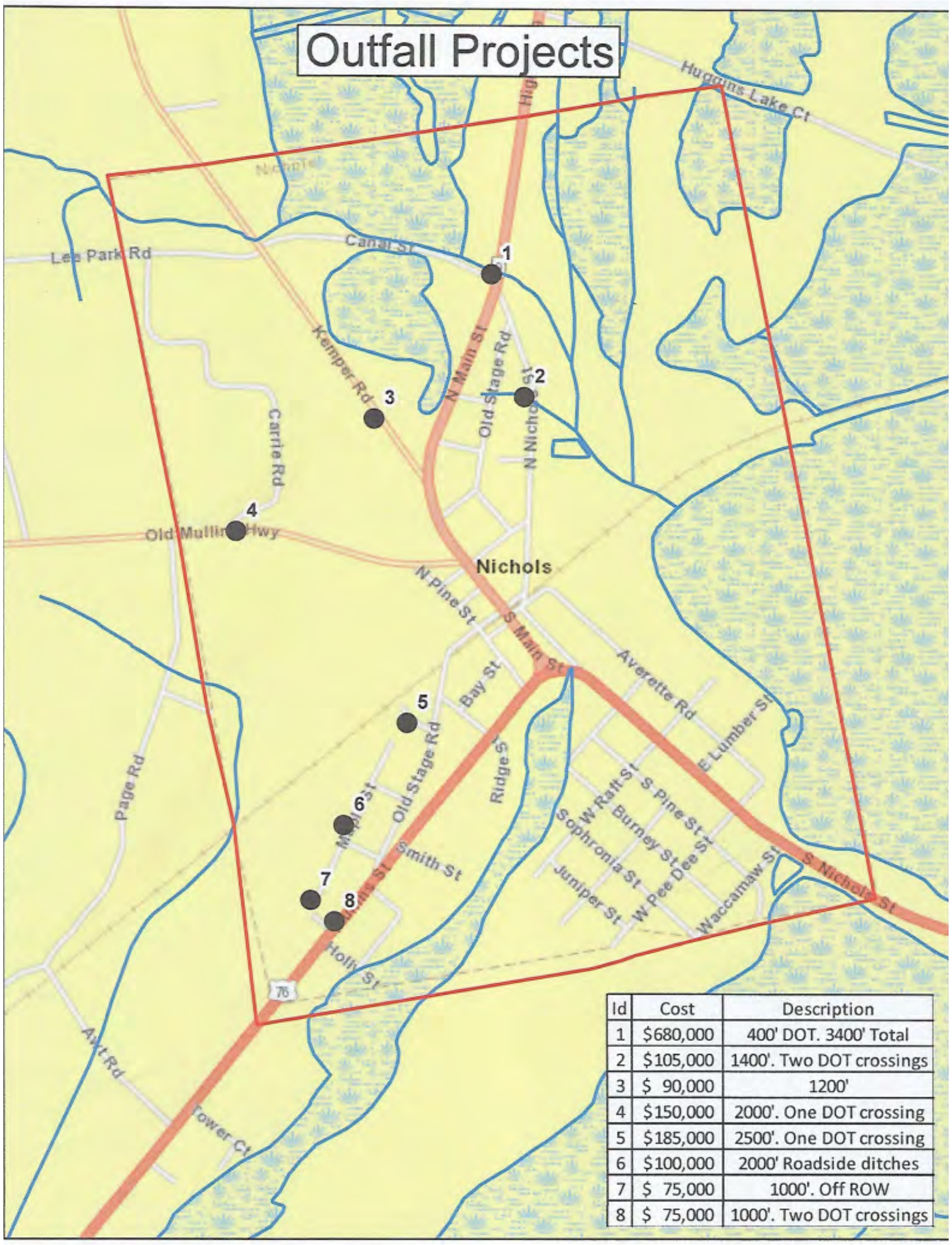
Project Name: Nichols

Project Priority: High

Entity Proposing Project: Town of Nichols
Estimated Costs: $1,460,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: The Town of Nichols has eight outflow ditches to clean. This is estimated to cost $1,460,000. Work has started on this project.



Id	Cost	Description
1	$680,000	400' DOT. 3400' Total
2	$105,000	1400'. Two DOT crossings
3	$ 90,000	1200'
4	$150,000	2000'. One DOT crossing
5	$185,000	2500'. One DOT crossing
6	$100,000	2000' Roadside ditches
7	$ 75,000	1000'. Off ROW
8	$ 75,000	1000'. Two DOT crossings

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Project Name: Smith Swamp

Project Priority: Medium-low

Entity Proposing Project: Marion County

Estimated Costs: $500,000

Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Smith Swamp needs to be cleaned of debris and fallen trees. This operation will allow water to flow from the swamp back to the river.

Project Name: Catfish Creek

Project Priority: Medium
Entity Proposing Project: Marion County
Estimated Costs: $500,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Clear the man-made canal at Catfish Creek. Cleaning the canal will allow water to flow from the City of Marion back to the river.

Project Name: Maple Swamp

Project Priority: Medium
Entity Proposing Project: Marion County
Estimated Costs: $250,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Enlarge the culverts under Highway 378 from Maple Swamp to allow the water to flow from the swamp to the river.

Project Name: Mullins Storm Water Canal

Project Priority: Medium
Entity Proposing Project: Marion County
Estimated Costs: $250,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Clear debris and sediment from the Mullins Storm Water Canal in order to increase the flow.

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Project Name: Little Pee Dee River

Project Priority: Medium

Entity Proposing Project: Marion County
Estimated Costs: $750,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: The Little Pee Dee River needs to have the debris and trash removed (construction material, docks, trees etc.)

Project Name: NE Front Street

Project Priority: Medium

Entity Proposing Project: City of Mullins
Estimated Costs: $400,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Enlarge the Culvert under the trestle on NE Front Street, Mullins.

Project Name: Mullins Storm Water Pipes

Project Priority: Medium

Entity Proposing Project: City of Mullins
Estimated Costs: $300,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Enlarge the storm water pipes to 36 or 42 inches to increase the capacity of the pipes. The area floods during heavy rainfall.

Project Name: Park Ave.

Project Priority: Medium

Entity Proposing Project: City of Marion
Estimated Costs: $500,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Clean ditches and storm water drains and pipes, possibly enlarging storm pipes and culverts, Park Ave, Canal St, West Godbolt St, Spring St, East & West Liberty St, West Baptist St, McEarthern Heights, Miles St, Strawberry St, Holladay St, Montgomery St, Marshall St. Cleaning Catfish Creek and Smith Swamp may alleviate some of the drainage issues in these areas.

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Project Name: Secondary Hwy 9 Culverts

Project Priority: Low

Entity Proposing Project: Marion County
Estimated Costs: $250,000
Point of Contact: David Holcombe, 843-431-5009, dholcombe@marionsc.org

Details: Some of the culverts on secondary Hwy 9 culverts need to be enlarged to allow drainage to move water. It causes flooding on the highway. Estimated cost is $250,000.

Marlboro County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Crooked Creek[14]	Dredge and clean out Crooked Creek	Marlboro County	$10,000,000	High	Steve Akers 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov
Phils Creek	Prevent flooding across Highway 9	Marlboro County	$100,000	High	Steve Akers 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov
Roadside Ditches	Clean out ditches	Marlboro County	$128,000	High	Steve Akers 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov
Cottingham Creek & Three Creeks	Prevent flooding across Highway 38 & 9	Marlboro County	$500,000	Medium	Steve Akers 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov

[14] SDRO Project ID 75: Crooked Creek Flooding

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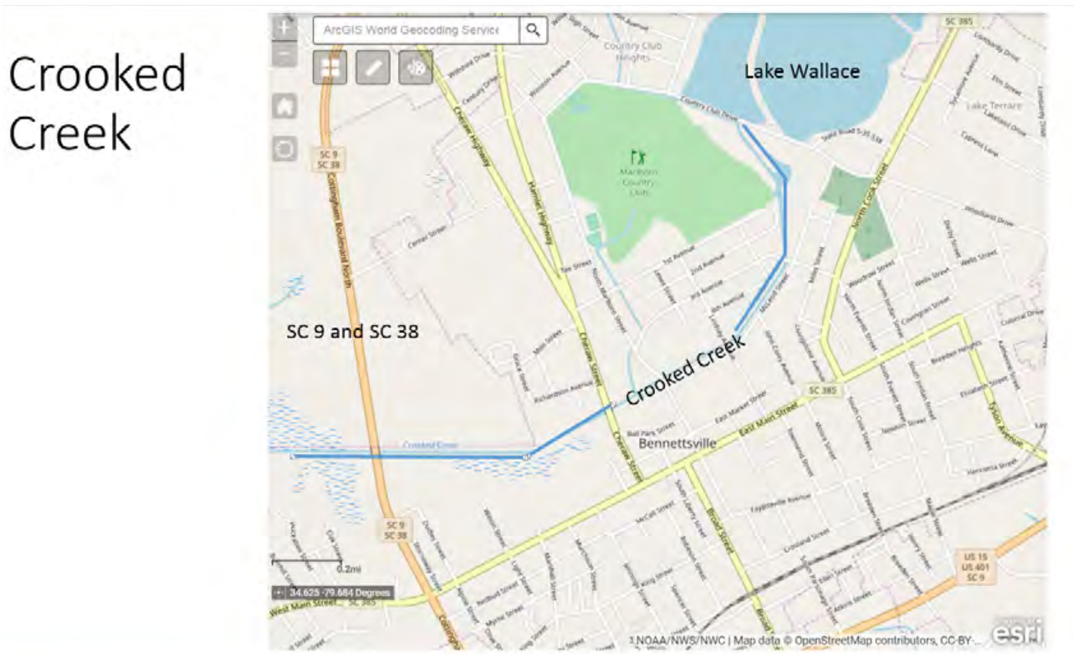
Project Name: Crooked Creek

Project Priority: High

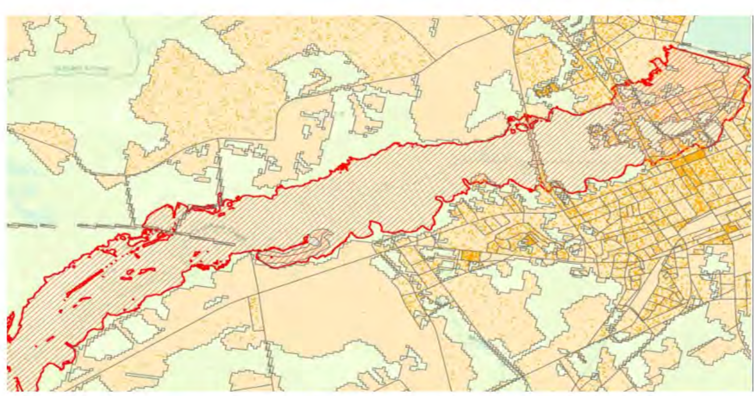
Entity Proposing Project: Marlboro County
Estimated Costs: $10,000,000
Point of Contact: Steve Akers, 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov

Details: Dredge and clean Crooked Creek in the City of Bennettsville. The Army Corp of Engineers conducted a study in the 80’s. The estimate for this project would be $10 million for the approximately 3 mile run of the creek that is affected. This impacts the neighborhoods of Shady Rest and Richardson Park. Please refer to Picture 1. Picture 2 shows the flood model for a dam failure at Lake Wallace.



Picture 1

Flood Model for Lake Wallace



Picture 2

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Project Name: Phils Creek Drainage

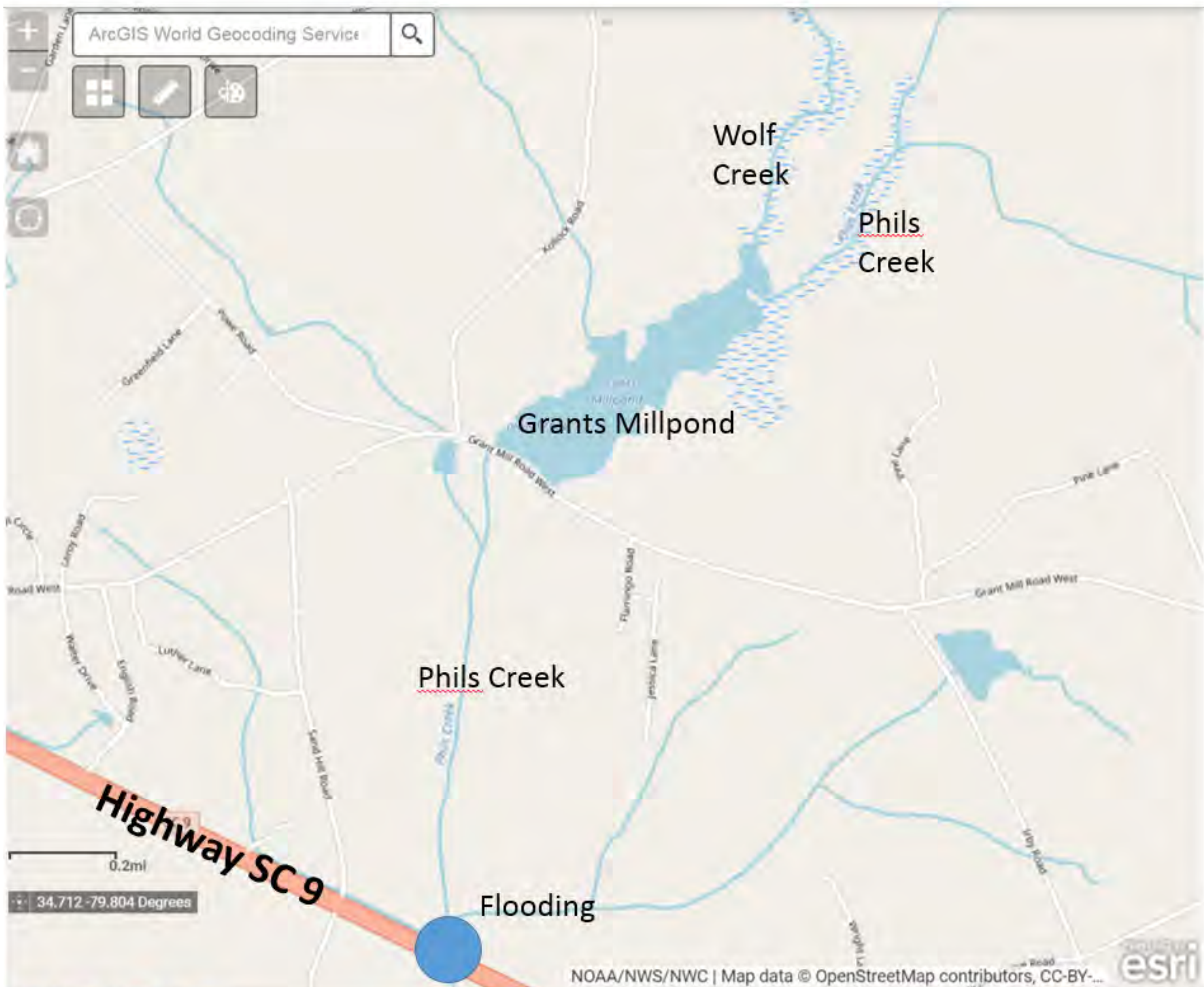
Project Priority: High

Entity Proposing Project: Marlboro County

Estimated Costs: $100,000

Point of Contact: Steve Akers, 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov

Details: A Hydrologic & Hydraulic Study would be needed to determine the drainage necessary for the area. Water crosses the road on Highway 9. Picture 3 illustrates the relationship to Highway 9.



Picture 3

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Project Name: Roadside Ditches

Project Priority: High

Entity Proposing Project: Marlboro County
Estimated Costs: $128,000
Point of Contact: Steve Akers, 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov

Details: Many of the roadside drainage ditches simply are clogged with debris leading to roadway flooding. The roadside ditches are often cluttered and grown in which allows for overflow back onto private properties and roadways. This leads to the overtopping of these ditches in low areas. These are SCDOT roads.

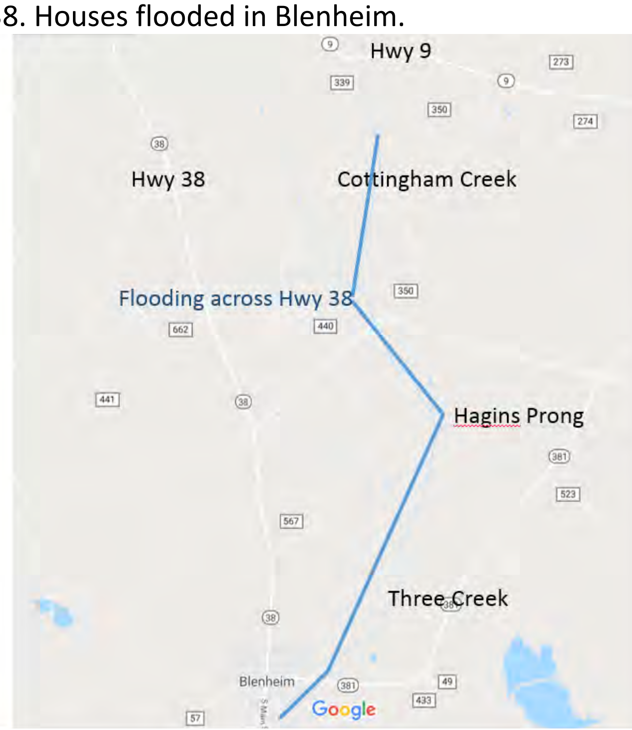
Project Name: Cottingham Creek and Three Creeks Drainage/Watershed

Project Priority: Medium

Entity Proposing Project: Marlboro County
Estimated Costs: $500,000
Point of Contact: Steve Akers, 843-479-5600 ext. 26, sakers@marlborocounty.sc.gov

Details: A Hydrologic & Hydraulic Study would be needed to determine the drainage that would be needed for the area. The ditches and waterways would need to be cleared of trees, debris, and dugout to allow proper drainage from main highways such as SC 38 and SC-9. Reference picture 4. Water crossed the road on Highway SC 38. Houses flooded in Blenheim.

Cottingham Creek and Three Creek Drainage



Picture 4

McCormick County

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No Project Requests for Commission

Newberry County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Wet Weather Pump Station and Storage Reservoir	Construction of a reservoir and pumping station	City of Newberry	$4,000,000	High	Tim Baker tbaker@cityofNewberry.com Office: 803-321-1018 Cell: 803-944-5777

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Project Name: Wet Weather Pump Station and Storage Reservoir

Project Priority: High

Entity Proposing Project: Bush River Waste Water Treatment Plant
Estimated Costs: $4,000,000
Point of Contact: Tim Baker Utility Director, City of Newberry, (O) 803-321-1018, (C) 803-944-5777, tbaker@cityofnewberry.com

Details: Construction of a reservoir and pumping system at the Waste Water Treatment Plant (WWTP) for wet weather events would allow excess flows from infiltration and flooding to be retained and treated without causing disruptions to our WWTP and reduce sanitary sewer overflows (SSOs) on our system. This solution could mitigate both flooding events at our WWTP and the potentially negative environmental impacts caused by sewer overflows.

Estimated cost is $4,000,000 but site availability and topography will be a big cost driver in implementing the project.

From review of rainfall and flow monitoring data obtained last year, we find the following rain event consequences at the WWTP:

Wastewater Volume Above Treatment Capacity

Wet Weather Event	Rain (in.)	Gallons over Capacity
July 2018	2.31	201,000 Gallons
October 2018	2.54	323,000 Gallons
November 2018, #1	1.77	532,000 Gallons
November 2018, #2	2.39	4,264,000 Gallons

We believe that excessive inflow and infiltration from the Bush River and Scotts Creek trunk sewer systems cause numerous SSOs in the community and overwhelm both the hydraulic and treatment capabilities of the Bush River WWTP. The plant is rated at 5 MGD. Compliance with NPDES permit conditions are jeopardized each time significant storm events occur. Furthermore, WWTP recovery to a normal biological treatment state sometimes takes days to reach.

To mitigate these detrimental outcomes to the City's wastewater facilities and the environment, we suggest a wet weather pump station and storage reservoir be constructed. The wet weather pump station would be sized to handle around 5,000 gallons per minute and the storage reservoir to hold up to 5 million gallons. Operationally, the wet weather pump station would come online when flows approach the rated capacity of the WWTP and would bypass these flows to a poly-lined earthen basin. Some type of screening and aeration would need to be provided. When normal flows have returned, the wet weather volume stored would be diverted back to the head of the plant. In effect, the WWTP would be protected and not experience daily flows in excess of 5 MGD.

These proposed wet weather facilities would significantly lessen surcharging in both the Bush River and Scotts Creek trunk sewers that result in documented SSOs during major rain events.

Oconee County

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No Project Requests for Commission

Orangeburg County

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No Project Requests for Commission

Pickens County

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No Project Requests for Commission

Richland County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Hardening Water Supply for Rural Fire-Fighting	Install a private well system to supply pressurized fire hydrant	Richland County	$812,000	High	Michael King Local Disaster Recovery Manager King.Michael@richlandcountysc.gov P 803-731-8362 M 803-760-4296 F 803-798-3401

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Project Name: Hardening Water Supply for Rural Fire-Fighting

Project Priority: High

Entity Proposing Project: Richland County
Estimated Costs: $812,000
Point of Contact: Michael King, Local Disaster Recovery Manager, (O) 803-731-8362, (C) 803-760-4296, (F) 803-798-3401, King.Michael@richlandcountysc.gov

Details: Water plays a vital role in economic stability, safety and overall well-being of residents. In the case of the fire service, it is essential to fire suppression, particularly in rural areas where municipal water mains are not extended and pressurized fire hydrants are non-existent. Fire Departments often rely on natural water sources such as ponds, lakes, and streams for water shuttling operations as part of rural-firefighting maneuvers. In most cases, dry hydrants (non-pressurized pipe systems) are permanently installed in these bodies of water to help transport water from the source to tanker trucks. One end of the dry hydrant sticks out of the ground to give tankers a hose connection and the other end is a strainer submerged in the pond or stream to draw water directly through the system. The dry hydrant system gives trucks access to ponds and streams from main roads leading to quicker response times. In addition, these critical resources benefit homeowners by helping to lower their fire protection classification numbers, which are used to determine insurance rates. Richland County currently has 37 waterpoint/dry hydrant sites located throughout the county.

Natural water points generally provide a relatively inexpensive and effective means of water supply for rural firefighting. However, there are some risks/challenge associated with their use and location.

1. The majority of sites are privately owned and require owner authorization for repairs, improvements and maintenance.
2. Water levels are subject to climatological changes.
3. Access to or along water sites are vulnerable to environmental impacts such as flooding, as well degradation caused by wildlife.
4. Water points containing dry hydrants (non-pressurized systems) are subject to impairments caused by natural disasters such as floods, hurricanes, tornadoes, ice storms, drought, etc., thus making them susceptible to failure and rendering them inaccessible during fire emergencies.

On Sunday, October 4, 2015, Richland County experienced a historic flood event affecting hundreds of residents and infrastructure throughout the County. Waterpoints, located in vulnerable suppression areas, were hit particularly hard by the storm and subsequent storm events. As a result, many of these waterpoints have been rendered out of service and have not been restored due to environmental impacts and low water levels.

Possible Mitigation Actions Estimated Cost

1. Install a private well system to supply pressurized fire hydrant on five County owned properties. $582,500
2. Acquire and install 12’ Diameter-Single Wall-30,000 gallon water storage tanks to be placed at strategic locations. $250,000
3. Extend an existing public water system to support pressurized fire hydrants. UNK Cost

Saluda County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
S-41-78 over Shiloh/Big Creek	Hydraulic study, raise bridge	SCDOT-Saluda	$300,000-$400,000	TBD	Edward T. Gassman GassmanET@scdot.org Office: 864-445-2586 Cell: 864-992-0235
S-41-79 over Branch	Replace, raise and lengthen bridge	SCDOT-Saluda	$300,000	TBD	Edward T. Gassman GassmanET@scdot.org Office: 864-445-2586 Cell: 864-992-0235
S-41-91 over Cross Pipe	Redesign pond relief pipes	SCDOT-Saluda	$50,000	TBD	Edward T. Gassman GassmanET@scdot.org Office: 864-445-2586 Cell: 864-992-0235
Clouds Creek on Murphy Farm Road	Replace wooden bridge with concrete bridge	Saluda County Roads and Bridges	$450,000	High	Billie Corley B.Corley@saludacounty.sc.gov Office: 864-445-2106 Cell: 864-992-0088
Dry Creek on Thunder Rd	Replace wooden bridge with concrete bridge	Saluda County Roads and Bridges	$400,000	High	Billie Corley B.Corley@saludacounty.sc.gov Office: 864-445-2106 Cell: 864-992-0088
Sleepy Creek on Loop-de-Loop Road	Replace Pipe with concrete bridge	Saluda County Roads and Bridges	$600,000	High	Billie Corley B.Corley@saludacounty.sc.gov Office: 864-445-2106 Cell: 864-992-0088
Unnamed Creek on Pou Road	Pipe Replacement	Saluda County Roads and Bridges	$35,000	Medium	Billie Corley B.Corley@saludacounty.sc.gov Office: 864-445-2106 Cell: 864-992-0088

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Project Name: S-41-78 over Shiloh/Big Creek

Project Priority: TBD

Entity Proposing Project: SCDOT-Saluda
Estimated Costs: $300,000-$400,000
Point of Contact: Edward T. Gassman, (O) 864-445-2586, (C) 864-992-0235, GassmanET@scdot.org

Details: The concrete bridge is over-topped regularly during heavy rains. The road has to be closed and then the bridge inspection team has to inspect the bridge before the road can be reopened.
The frequent closures hamper the local citizens and create constant closures for SCDOT personnel to manage.
Possible fixes should include a hydraulic study to determine the hydraulic opening required. Once determined, could the bridge be raised to meet the requirement? Alternatively, maybe installing upstream weirs to meter the water through the existing hydraulic opening would be a solution.
Cost Estimate could be in the $300,000 to $400,000 range.

Project Name: S-41-79 over Branch

Project Priority: TBD

Entity Proposing Project: SCDOT-Saluda
Estimated Costs: $300,000
Point of Contact: Edward T. Gassman, (O) 864-445-2586, (C) 864-992-0235, GassmanET@scdot.org

Details: This structure stays wet and we are in the process of replacing the timber deck on the existing steel stringers. The load posting is at 3 Tons. The bridge has been closed for nearly two years and is on a gravel road.
The structure needs to be replaced, raised and lengthened.
Cost Estimate is around $300,000 for a single span bridge.

Project Name: S-41-91 over Cross Pipe

Project Priority: TBD

Entity Proposing Project: Project: SCDOT-Saluda
Estimated Costs: $50,000
Point of Contact: Edward T. Gassman, (O) 864-445-2586, (C) 864-992-0235, GassmanET@scdot.org

Details: There are two ponds, one on each side of the road. The northern pond is above the road and keeps the road saturated with its runoff. This condition is destroying the roadbed and during the winter, it ices the road.
The ponds relief pipes need to be redesigned and integrated with the roadway's cross drain.
Cost Estimate is around $50,000.

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Project Name: Clouds Creek on Murphy Farm Road
Project Priority: High
Entity Proposing Project: Saluda County
Estimated Costs: $450,000
Point of Contact: Billie Corley, (O) 864-445-2106, (C) 864-992-0088, B.Corley@saludacounty.sc.gov

Details: Wooden bridge needs replacing with a concrete bridge. The bridge is posted at 3 tons. The foundation is deteriorating and the bridge is under water during heavy rains. Replacement cost would be in the $450,000 range.

Project Name: Dry Creek on Thunder Road
Project Priority: High
Entity Proposing Project: Saluda County
Estimated Costs: $400,000
Point of Contact: Billie Corley, (O) 864-445-2106, (C) 864-992-0088, B.Corley@saludacounty.sc.gov

Details: Wooden bridge needs replacing with a concrete bridge. This bridge is posted at 3 tons. The foundation is deteriorating and the bridge is under water during heavy rains. Replacement cost would be in the $400,000 range.

Project Name: Sleepy Creek on Loop-de-Loop Road
Project Priority: High
Entity Proposing Project: Saluda County
Estimated Costs: $600,000
Point of Contact: Billie Corley, (O) 864-445-2106, (C) 864-992-0088, B.Corley@saludacounty.sc.gov

Details: Dual 96” corrugated pipe needs replacing with concrete bridge. Water goes over pipe during heavy rains. Replacement cost estimated at $600,000.00.

Project Name: Unnamed Creek on Pou Road
Project Priority: Medium
Entity Proposing Project: Saluda County
Estimated Costs: $35,000
Point of Contact: Billie Corley, (O) 864-445-2106, (C) 864-992-0088, B.Corley@saludacounty.sc.gov

Details: Two locations have been identified as needing pipe replacement. There are four road crossings utilizing corrugated metal pipe that have deteriorated and need replacement at those two locations. A total of 96 feet of 48-inch reinforced concrete pipe would be needed to complete this project. The estimated total of funding would be $35,000.

Spartanburg County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Bridges and Arch Culvert Replacements	8 Bridge Replacements and 1 Arch Culvert Replacement	Spartanburg County	$10,261,000	High	Ron Kirby, County Engineer 864-595-5336 rkirby@spartanburgcounty.org

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Project Name: Bridges and Arch Culvert Replacements

Project Priority: High

Entity Proposing Project: Spartanburg County
Estimated Costs: $10,261,000
Point of Contact: Ron Kirby, County Engineer, 864-595-5336, rkirby@spartanburgcounty.org

Details: There are 8 bridges that need replacing and 1 arch culvert that needs to be replaced. Detailed studies and cost breakdowns are available upon request. Spartanburg County can provide match funding and in-kind services towards completion of these priority flood mitigation projects.

List of Bridges and Arch Culvert:
-Belcher Road Bridge Replacement
-Brewton Road Bridge Replacement
-Brokman McClimon Arch Culvert Replacement
-Clark Road Bridge Replacement
-Double Bridge Road Bridge Replacement
-Freys Drive Bridge Replacement
-Kist Road Bridge Replacement
-Millertown Road Bridge Replacement
-Waspnest Road Bridge Replacement

Sumter County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Flood Map Revision Implementation	Revise and Implement FEMA Floodplain Mapping	Sumter County	TBD	Medium	Erik Hayes 803-983-8137

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Project Name: Flood Map Revision Implementation

Project Priority: Medium

Entity Proposing Project: Sumter County
Estimated Costs: $TBD
Point of Contact: Erik Hayes, 803-983-8137

Details: Revision and implementation of FEMA floodplain mapping throughout Sumter County.

Union County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Mitigation Plan Update	Update mitigation plan for FEMA Approval	Union County	$5,000	High	Rob Fraim rfraim@countyofunion.com 864-426-4251

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Project Name: Mitigation Plan Update

Project Priority: High

Entity Proposing Project: Union County
Estimated Costs: $5,000
Point of Contact: Rob Fraim, 864-426-4251, rfraim@countyofunion.com

Details: Have COG update mitigation plan for the county for FEMA approval.

University of South Carolina

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No Project Requests for Commission

Williamsburg County

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No Project Requests for Commission

York County

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Project Title	Project Description	Entity Proposing Project	Estimated Cost	Priority	Point of Contact
Dutchman Creek Storm Drain	Improve storm drain	Rock Hill School District 3	$127,459	High	Danny Kelly dkelly@rhmail.org 803-981-1150
Wildcat Creek Tributaries	Stream restoration and culvert replacements	City of Rock Hill	$9,400,000	Medium	David Dickson DavidF.Dickson@cityofrockhill.com 803-329-7096 or Leah Drummeter leah.drummeter@cityofrockhill.com 803-326-3832
Riverview Bridge	Repair or replace existing bridge	City of Rock Hill	$2,850,000	Medium	David Dickson DavidF.Dickson@cityofrockhill.com 803-329-7096 or Leah Drummeter leah.drummeter@cityofrockhill.com 803-326-3832
Stanley-McGuirt Stormwater Project	Replace drainage pipes	City of Rock Hill	$775,000	Medium	David Dickson DavidF.Dickson@cityofrockhill.com 803-329-7096 or Leah Drummeter leah.drummeter@cityofrockhill.com 803-326-3832
Clover Property Buyout	Buyout	Town of Clover	$450,000	Medium	Mark Geouge mgeouge@cloversc.org 803-222-9495 or Allison Harvey aharvey@cloversc.org 803-222-9495

Project Title	**Project Description**	**Entity Proposing Project**	**Estimated Cost**	**Priority**	**Point of Contact**
Sugar Creek Bank Stabilization	Bank Stabilization	York County	$605,000	Medium	Barry McKinnon York County Engineering; 803-818-5781 barry.mckinnon@yorkcountygov.com or Ward Marotti, WK Dickson & Co., Inc. 704-334-5348 919-368-8043 wmarotti@wkdickson.com
Harris Street Park Restoration	Bank Stabilization	City of Fort Mill	$200,000	Medium	Brown Simpson 803-242-0381 Phillip Aycock 803-835-1169
Generators	Buy 12 generators for lift stations	City of Fort Mill	$1,600,000	Low	Ben Wright 803-487-2366

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Project Name: Dutchman Creek Storm Drain
Project Priority: High
Entity Proposing Project: Rock Hill School District 3
Estimated Costs: $127,459
Point of Contact: Danny Kelly, 803-981-1150, dkelly@rhmail.org

Details: There needs to be improvements to the storm drain. The school floods when it rains.

Project Name: Wildcat Creek Tributaries
Project Priority: Medium
Entity Proposing Project: City of Rock Hill
Estimated Costs: $9,400,000
Point of Contact: David Dickson, 803-329-7096, DavidF.Dickson@cityofrockhill.com or
Leah Drummeter, 803-326-3832, leah.drummeter@cityofrockhill.com

Details: The Wildcat Creek Tributary 1 & 7 Storm improvements would include stream restoration and culvert replacements from Heckle to the upper reaches of the tributaries.

Wildcat Creek Tributary 1 work includes replacing the culverts on Luge, Frank, Carolina, Rich, Heyward, Arch Walnut & Chestnut. It would also include removal of an existing pipe behind some homes on Jefferson (which cause house flooding) as well as stream restoration to help with flooding.

Wildcat Creek Tributary 7 work includes replacing the culverts on Frank (there are two separate culverts on Frank for each tributary), Barber, & Lucky as well as stream restoration.
Basic Cost Estimate: The entire project effects +/- 100 homes and is estimated to cost +/- $9.4 M with +/- $900k in engineering/construction inspections.

Project Name: Stanley-McGirt Stormwater Project
Project Priority: Medium
Entity Proposing Project: City of Rock Hill
Estimated Costs: $775,000
Point of Contact: David Dickson, 803-329-7096, DavidF.Dickson@cityofrockhill.com or
Leah Drummeter, 803-326-3832, leah.drummeter@cityofrockhill.com

Details: The City is planning to replace the existing 18 & 24 inch storm pipes on Stanley and McGirt with a 4x3 box culvert and a 42 inch pipe on Odgen to alleviate flooding to residents along Odgen Road. Several homes along Odgen Road have experienced yard and crawlspace flooding resulting in damage to HVAC units, ductwork, water heaters, limited access to their homes, etc. Upsizing the pipes will decrease the frequency of flooding to their properties.
Basic Cost Estimate: The engineering is $75K and the construction is $700K

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Project Name: Riverview Bridge

Project Priority: Medium

Entity Proposing Project: City of Rock Hill
Estimated Costs: $2,850,000
Point of Contact: David Dickson, 803-329-7096, DavidF.Dickson@cityofrockhill.com or
Leah Drummeter, 803-326-3832, leah.drummeter@cityofrockhill.com

Details: The proposed project at Riverview Bridge would include replacement and/or upgrades to the existing bridge. The initial thought is to replace the bridge with a bottomless culvert, if possible. The creek would also be improved by installing slope benching and restoring the stream between Riverview and Celanese in order to reduce the water surface elevation and hopefully the potential flooding of the 1st floors.

Documents with locations of buildings at risk for 1st flood flooding due to elevations lower than the 100 yr. flood elevation is available upon request.

The City currently has an engineering consultant performing the preliminary work on this to see what specific direction the project should take in project activities.

The estimated cost is $2.6M with =/-$250K in engineering.

Project Name: Clover Property Buyout

Project Priority: Medium

Entity Proposing Project: Town of Clover
Estimated Costs: $450,000
Point of Contact: Mark Geouge, 803-222-9495, mgeouge@cloversc.org or
Allison Harvey, 803-222-9495, aharvey@cloversc.org

Details: Buyout of repetitive flooded property

Project Name: Sugar Creek Bank Stabilization

Project Priority: Medium

Entity Proposing Project: York County
Estimated Costs: $605,000
Point of Contact: Barry McKinnon, York County Engineering, 803-818-5781,
barry.mckinnon@yorkcountygov.com or
Ward Marotti, WK Dickson & Co., Inc., 704-334-5348, 919-368-8043, wmarotti@wkdickson.com

Details: Bank stabilization at broken force main sewer pipe

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Project Name: Harris Street Park Restoration

Project Priority: Medium
Entity Proposing Project: City of Fort Mill
Estimated Costs: $200,000
Point of Contact: Brown Simpson, 803-242-0381 and Phillip Aycock, 803-835-1169

Details: Bank stabilization project. Details with coordinates available upon request.

Project Name: Generators

Project Priority: Low
Entity Proposing Project: City of Fort Mill
Estimated Costs: $1,600,000
Point of Contact: Ben Wright, 803-487-2366

Details: To purchase generators for twelve of our 30+ lift stations located at various locations throughout our sewer collections system. These generators would be used to provide emergency power to the lift stations in the event of an outage of the power grid or other loss of power. This would help to prepare for natural disasters, such as hurricanes, as well as any other potential causes of power outages. Emergency power would help to avoid sanitary sewer overflows to surface water caused by lift station outages.

Project ID	Project Name	Council of Government	County	Municipality	Location	Description	More Information Included?	Type	Cost Estimate Low	Cost Esstimater High	SCEMD Project Title
2	California Branch Drainage Study	Berkley, Charleston, Dorchester	Berkeley	Town of Moncks Corner	California Branch of Berkley County	Airport diversion to divert drainage away from the Berkley County Airport. Cross Pipe Improvements for Whiteville Road, Jolly Lane, and Haynesville Road Extension. Property Buyout purchase homes starting on Winter Street.		Storm Drain Improvements	**$1,300,000.00**	**$30,900,000.00**	California Branch
80	Flooding in Summerton	Santee Lynches	Clarendon	Town of Summerton	Summerton near apartments that are LMI	Severe flooding in Summerton near apartments that are LMI. Possible solution is to divert flood water across US 15 to the north end of the Taw Caw Creek.	As shown in the Summerton Flood Water Diversion Preliminary Report, there were a few inches of flooding all around the post office. Address/street corners for detailed location of exact flooding.	Storm Drain Improvements	**No Cost Estimate**	**No Cost Estimate**	Summerton Floodwater Diversion
83	Poticollo Flooding	Santee Lynches	Clarendon	Manning	Poticollo in Manning	Flooding issues in Poticollo of Manning		Storm Drain Improvements	**No Cost Estimate**	**No Cost Estimate**	Pocotaligo Channelization and Cleanup
32	Monitoring System - Robinson Dam to Quinby Dam	Pee Dee	Darlington	City of Darlington	City of Darlington between Robinson Dam and Quinby Dam	Communities between Hartsville and Darlington are affected. Implement stream gauge to help with evacuation.	Black Creek affects ~60% of the county and only has two stream gauges, but needs more. There is nothing to measure water level after Preswood Dam. Preswood Dam and Robinson Dam (Northwest of Hartsville area) release water rapidly	Storm Drain Improvements	**$500,000.00**	**$500,000.00**	River Guages
167	1st Avenue (South)	Pee Dee	Dillon	City of Dillon	1st Avenue (South)	30 houses impacted by flooding. Apartment complex was under water. Fire Station was underwater!!! Intersection of 1st Avenue and Howard Street underwater. 50% greater LMI		First Responders	**$25,000.00**	**$25,000.00**	Cannon Court
168	1st Avenue (North)	Pee Dee	Dillon	City of Dillon	1st Avenue (North)	Cypress Street to Radford Blvd - 10 houses flooded and commercial buildings flooded. Apartment complex under water. Title Loan under water.		Buyout/Relocate/Elevate	**$10,000.00**	**$10,000.00**	Julia St
170	Canals to Maple Swamp	Pee Dee	Dillon	City of Dillon	Canals to Maple Swamp	Overflowing -> Maintenance issue. Joint City and County		Maintenance	**$28,000.00**	**$28,000.00**	Maple Swamp
173	Fire Station Flooding in Latta	Pee Dee	Dillon	Town of Latta		The Latta Fire Station was flooded during Hurricane Florence and needs to be moved to a site with higher ground.		First Responders	**$45,000.00**	**$180,000.00**	Marion St.
174	Library Flooding in Latta	Pee Dee	Dillon	Town of Latta		The Dillon County Library in Latta was flooded during Hurricane Florence.		Other			
142	Watershed assessment of various areas in Horry County	Waccamaw	Horry	City of Conway	Riverstone, Kingston Lakes, Crabtree Swamp, Socastee, and Middle Waccamaw	Perform watershed assessment. Hydrologic connections and opportunity for enhancement of water quantity and water quality projects and conveyance.		Hydrologic & Hydraulic Analysis	**$250,000.00**	**$250,000.00**	Watershed Improvement Studies – Crabtree Swamp, Simpson Creek, Buck Creek
143	Floodplain Restoration of Crabtree Swamp	Waccamaw	Horry	City of Conway	Crabtree swamp of Horry County	Id potential project location and implement a floodplain restoration project. Include bike/pedestrian train along the banks of Crabtree.	Crabtree swamp runs through Conway and is an area that floods extensively into neighborhoods. It was a natural stream that was channelized in the 1970's. In the 2010's, Conway and partners restored two 1/2 mile sections to a more natural state.	Other			
81	Main Street Downtown Lynchburg Flooding	Santee Lynches	Lee	Lynchburg	Downtown Lynchburg of Lee County	Area floods, diversion of the flow going into downtown. Possible project is to divert water to the Lynchburg River.		Storm Drain Improvements	**$100,000.00**	**$100,000.00**	Study for Main Street in Lynchburg
82	Drainage North of Bishopville and Kings Ave.	Santee Lynches	Lee	Bishopville	North of Bishopville and Kings Ave.	There are large areas of agricultural farmland that drain in close proximity to communities. Possible solution is to redirect or create better drainage		Storm Drain Improvements	**$25,000.00**	**$25,000.00**	Canal for King's Avenue Neighborhood-Southwest side of Bishopville
177	Flower Lane	Santee Lynches	Lee	Lynchburg	Flower Lane	Flower Lane; county road which intersects Tram Road, State Road off Highway 401	4 mobiles homes are impacted. Flower lane is a county road which intersects Tram Road east of Highway 401 near Elliot in Lower Lee County. Flower Lane has a large canal ditch that runs parallel to Tram Road. The canal ditch intersects and travels under Fl	Storm Drain Improvements	**$150,000.00**	**$150,000.00**	Canal Ditch at Flower Lane
74	Marion County - Levees and floodwalls	Pee Dee	Marion	Town of Nichols		Need to construct various levees and floodwalls to prevent future flooding.		Reservoir / Dam	**$1,460,000.00**	**$1,460,000.00**	Nichols
75	Crooked Creek Flooding	Pee Dee	Marlboro	Bennettsville	Shady rest Area of Marlboro	Ditches need maintenance. During significant rain events, Crooked creek floods the Shady Rest area.	Shady Rest is a neighborhood in the City of Bennettsville. It consists of lower income and minorities. Every time there is a storm, Crooked Creek floods due to the ditches not being maintained. The watershed ditches have not been maintained for 30-40 years	Maintenance	**$10,000,000.00**	**$10,000,000.00**	Crooked Creek
									$13,893,000.00	**$43,628,000.00**	
									Low	**High**	

Appendix – South Carolina Emergency Management Division
Local Floodwater and Drainage Mitigation Projects

Mitigation Funding Sources

Pre-Disaster Mitigation (PDM). Administered by the Federal Emergency Management Agency (FEMA), the PDM program provides funding to support hazard mitigation projects (structural and non-structural) undertaken by local, county, and state government agencies. The program funds up to 75 percent of approved mitigation project costs (the other 25 percent is paid by the local/county/state government entity that applied). A higher federal share may be approved by FEMA for small, impoverished communities (as defined by 44 CFR 201.2). Applications are accepted annually; for the current grant cycle (FY2019), applications are due to the South Carolina Emergency Management Division (SCEMD) by 10 January 2020. SCEMD serves as the recipient and pass-through entity for these funds and supports applicants in SC in preparing and submitting project applications. A specific amount of funding is set aside for each state and federally recognized tribe (currently set at $575,000 per State/Tribe), and projects not submitted under the state's allotment compete nationally for other PDM funds. In future years, changes to federal statutes will transition the PDM program to the Building Resilient Infrastructure and Communities (BRIC) program, and additional federal dollars will be available. Details on programmatic changes are pending with FEMA. PDM Fact Sheet.

Hazard Mitigation Grant Program (HMGP). FEMA makes HMGP funds available after a state has received a federal disaster declaration. The purpose of the program is to reduce future disaster impacts. The program funds up to 75 percent of approved mitigation project costs (the other 25 percent is paid by the local/county/state government entity that applied). The amount of funds available under HMGP is based on the estimated total federal assistance under the disaster declaration. SCEMD serves as the recipient and pass-through entity and supports local, county, and state agencies in developing mitigation projects and submitting applications. Potential applicants submit a pre-application and then work with SCEMD mitigation specialists to prepare a full application. Projects are ranked based on criteria established by the state's Interagency Coordinating Committee. Deadlines for submission for HMGP grants resulting from past years' disasters, including Hurricane Florence (DR-4394), have closed. A small amount of HMGP funds will be available related to this year's Hurricane Dorian (DR-4464); the application period is open and pre-applications are due to SCEMD by 28 February 2020. HMGP Guide for State/Local Governments.

Economic Development Administration (EDA) Disaster Grants. Administered by the Economic Development Administration in the U.S. Department of Commerce, EDA grants have been funded by Congress to assist with expenses related to flood mitigation, infrastructure restoration, and long-term recovery in areas affected by disasters declared in 2018 and tornadoes and floods in 2019. For the EDA's Atlanta region, which includes SC, $140 million was allocated. The federal share awarded with this program ranges from 50 percent federal funding to 80 percent federal funding (Native American tribes may apply for 100 percent funding). Applications are accepted on a rolling basis. Applications should be consistent with the agency's Disaster Recovery Investment Priorities. EDA Disaster grants FY2019.

ACKNOWLEDGMENTS

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