Horry County
South Carolina

Flood Resilience Master Plan

SUMMARY REPORT

SEPTEMBER 2021

SHERWOOD DESIGN ENGINEERS
ONE ARCHITECTURE & URBANISM / CASE CONSULTANTS INTERNATIONAL / WESTERN CAROLINA UNIVERSITY

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executive summary

OVERVIEW

Horry County (the County) is situated within South Carolina's coastal plain and is bordered by North Carolina to the north and the Atlantic Ocean to the east. Water is a prominent natural feature throughout Horry County, encompassing 10 percent of the County's almost 1300 square miles. Horry County is low-lying and contains the major waterways of the Pee Dee River, the Waccamaw River, and the Atlantic Intracoastal Waterway, all of which flooded during Hurricane Florence. The County has experienced steady growth over the past decade and its population has swelled by almost 25% since 2010, to 351,029 residents. With a temperate climate, a relatively inexpensive cost of living, and Myrtle Beach as a regional destination, Horry County is projected to double in size by 2040. With all of the projected growth, the County, which has been primarily rural, is quickly becoming suburban. This expansive growth increases pressure on infrastructure and government services.

PLAN SCOPE AND FOCUS

Horry County has long recognized its vulnerability to storm events and flooding. The County's geological characteristics are conducive to flooding and its proximity to the Atlantic seaboard places it in the pathway of hurricane systems. The County sits at the base of several significant inland watersheds that stretch to North Carolina and neighboring counties. The County is continually evolving its level of preparedness as the threat of storm impacts and flooding increase.

Horry County recognizes the need to understand the impacts of flooding and to put measures in place that can increase resilience to future flood events. The Horry County Flood Resilience Plan (The Plan) is a component of the County's Hazard Mitigation Plan and focuses on the development of flood mitigation strategies for the unincorporated areas of Horry County.

The Plan provides a roadmap for County government and the community to build a partnership to successfully adapt to future flood conditions. The Plan also includes a study of the movement of floodwater in selected pilot communities to describe how flooding caused by different types of storms may damage existing assets. Finally, the Plan includes a series of suggested physical interventions and interrelated policies and programs that can be piloted locally and enacted throughout the County to build the foundation for a long-term resilient future.

PROJECT GOALS

In 2018, flooding caused by Hurricane Florence inflicted damage throughout Horry County. Florence was one in a sequence of destructive storms affecting the South Carolina coast in quick succession, making it increasingly evident that major storm events threaten to undermine the fabric of entire communities within Horry County. The goals set forth in the Plan embody a holistic approach to prioritize the preservation of existing communities and planning for future resilience. These objectives are derived from interactions with community members over the course of several years and multiple storm events. They form the basis for building an effective response to future flooding and a pathway for Horry County to achieve long-term resilience.

GOALS:

- Ensure that communities are informed about their vulnerability to flooding.
- Recognize the close-knit nature of communities and their desire to remain intact.
- Establish policies that promote resilient development.
- Pilot practical and replicable interventions.
- Create geographically-appropriate solutions catered to specific resilience needs.
- Build resilience into county-wide infrastructure improvements.
- Improve the integrity and appearance of the community through flood prevention.

FLOOD RESILIENCE STRATEGY

The effects of Hurricane Florence were felt across South Carolina and beyond. The response from the State, the County, and the community was immediate and has continued as many residents struggle to move back into their homes and to make the necessary repairs. The strong network of government and volunteer organizations continues to provide assistance and advocate for ways to build increased resilience into Horry County's flood management efforts. The Horry County Flood Resilience Plan is one component of a series of actions being taken to secure a resilient future.

The County has been developing a number of strategic policy directives designed to decrease vulnerability to flooding. These measures are aimed at securing funding at the State and Federal level to enable proactive and resilient solutions. The Plan and its recommendations support this effort. The Plan contains complementary and additional long-term initiatives focusing on solutions to combat flooding and county-wide strategies to enact policy changes and secure funding.

SUMMARY OF STORM IMPACTS

Hurricane Florence made landfall on the North Carolina coast on September 14, 2018. However, the floodwaters that most significantly impacted Horry County did not crest for several days. As the storm tracked inland, it released an unprecedented volume of rainfall that worked its way through the extensive Pee Dee and Waccamaw River systems. Within Horry County, both rivers swelled beyond their banks for a period of more than eight days, beginning on the 20th of September.

Florence was unique in the number of homes impacted and extent of flooding, but it was merely the latest in a series of major storms causing riverine flooding in Horry County. Hurricanes Matthew and Joaquin caused significant damage, as did multiple, less severe storms. These storms are taxing the infrastructure of the County, stressing available resources, and creating patterns of repetitive loss that threaten to impair the economy and quality of life for the people who call Horry County home.

SUMMARY OF KEY CHALLENGES AND OPPORTUNITIES

Hurricane Florence exposed the magnitute of the County's vulnerability to flooding. Like Matthew and Joaquin before it, Florence impacted communities previously considered to be safe from flooding. Both established and more recently-constructed communities were affected. The challenges and opportunities relating to flooding affect the County's ability to withstand the impact of all types of flooding and its capacity to build back stronger after impacts are felt. Key Risks and Vulnerabilities in Horry County:

- Low-lying and relatively flat topography.
- Historical development patterns impacted properties in the floodplains vulnerable to flooding.
- Reduction of water storage within floodplains and wetlands as a result of development.
- Evacuation routes and key roadways are compromised during flooding events, limiting access and emergency response.
- Sea level rise combined with hurricane storm surge hinders the ability of the riverine water system to discharge into the Atlantic Ocean.

TARGET COMMUNITIES

The unincorporated Horry County communities of Bucksport, Longs, Red Bluff, Socastee and unincorporated Conway were designated as the areas of focus for this report. Each target community experiences flooding from multiple waterways and has been impacted by multiple storms from localized rain events to hurricanes. Flooding in each community is uniquely affected by the relationship of drainage basins, stream confluences, and topography in the area. The target communities are representative of flooding conditions that are experienced throughout the County. Therefore, solutions piloted in these communities can be evaluated for potential applilcation in other parts of the County.

1.0
overview and context

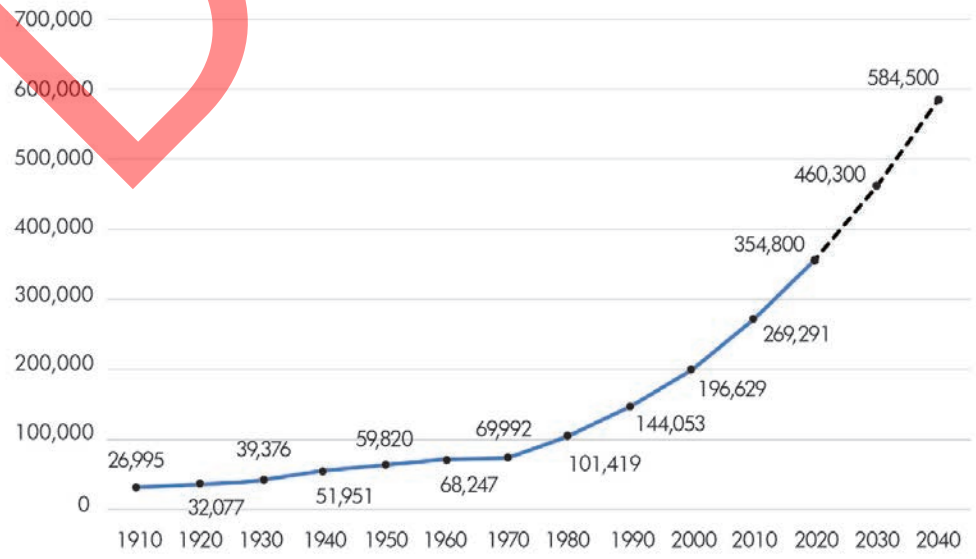
1.1
Planning Area

COMMUNITY CONTEXT

Horry County is situated in the northeastern corner of South Carolina, bordered by North Carolina to the north, the Atlantic Ocean to the east, and the Lumber and Little Pee Dee Rivers to the west. Horry County's extensive network of rivers, streams, and wetlands have been essential to residents for generations and sustained the rice, turpentine, and logging industries during the 18th and 19th centuries. Today, Horry County's access to the Atlantic Ocean, the Atlantic Intracoastal Waterway (AIWW) and other bodies of water in the region make it both a local and national tourist destination. Water drives the tourism economy and has resulted in Horry County becoming a premier destination for people looking to relocate to a warm climate. Horry County provides a much needed affordable and amenity-rich refuge that is attracting senior living to the region. As the population grows, there is ample opportunity to integrate new development into the County in a manner that minimizes flood risk. It starts with the recognition of the flood and storm risks within the region, combined with the application of proper measures to ensure that new development is risk tolerant.

The County's population has more than doubled over the past 30 years. In 2018, the U.S. Census Bureau identified the County as part of the second fastest growing Metropolitan Statistical Area in the nation for a third consecutive year. In 2019, an estimated 351,029 residents called Horry County home, up from approximately 270,000 residents in 2010. By 2040, the year-round population is projected to nearly double. The fastest-growing segment of the population is retirees, many of whom are living on fixed incomes. An increase in housing demand and a lack of available supply has resulted in higher home sale prices and a shortage of affordable housing. The U.S. Census Bureau also reports

HISTORIC POPULATION AND CENSUS PROJECTION



Sources: SC Revenue and Fiscal Affairs Office and Research, Horry County Planning & Zoning, graphic from *Imagine 2040*

that from 2012 to 2018, the average single-family home price rose by over 50 percent from $154,500 to $238,000. This increase in home prices, particularly near the coast, is leading the largely service economy-based workforce to move further from their jobs. The Bureau reports that 14.3 percent of the population lives below the federal poverty level.

The significant influx of new residents is expanding neighborhoods across the County, not only in Myrtle Beach and the largely suburban zone that lies between Conway and Myrtle Beach, but also in the historically rural western sections of the County, an area largely composed of unincorporated communities . In the County's comprehensive plan, *Imagine 2040*, it is estimated that over 70 percent of projected new residents will reside in unincorporated jurisdictions. This growth will continue to add pressure on County ressources with increased impacts to natural systems, and will require the construction and management of roads, sewers, and storm water management systems.

REGIONAL GEOGRAPHY

Horry County is the largest county by land area in South Carolina. It comprises 1,255 square miles of mostly flat topography, with elevations that range up to approximately 150 feet above sea level. Horry County is dominated by the Little Pee Dee and Waccamaw River watersheds. These watersheds, as well as many others in North and South Carolina, are part of the larger Yadkin/Pee Dee River Basin. Horry County is situated near the lowest point in this watershed before water exits the system through Winyah Bay. The headwaters of the Yadkin/Pee Dee River Basin begin in the Appalachian Mountains of North Carolina, hundreds of miles upstream of Horry County. The County rests in a large lowland basin that receives water from over 14,000 square miles of land and almost 6,000 miles of streams and rivers. The system flows through 21 counties and almost 100 municipalities, many of which are highly populated. As this larger region grows and attracts new residents, increased tree cutting and clearing and the loss of natural permeable surface to development increase the footprint of the floodplain and reduce the storage capacity throughout the system.

The rivers in Horry County flow southward on a primarily gradual slope through forested swamps and expansive floodplains. These rivers widen and merge with downstream rivers and have meandered over time to create the current coastal floodplain. Part of the floodplain is designated as the Waccamaw National Wildlife Refuge, but many homes and businesses also sit within this area. The flat topography and low elevation allow water to crest the banks during periods of high flow, filling up the adjoining creeks and tributaries which overflow into the larger floodplain.

The relatively flat conditions and the confluence of multiple waterways can cause floodwaters to "back-up" in times of high flow. Although the County's stormwater ordinance requires reduced run-off rates from development, new development builds up and fills the land and creates additional impervious surfaces, increasing run-off and reducing the storage capacity of the floodplain and surrounding lands .

Horry County contains a portion of the Atlantic Intracoastal Waterway (AIWW), which was constructed by the United States Army Corps of Engineers (USACE) in the 1930s to provide a safe transportation route for commerce along the Eastern Seaboard. This tidally influenced waterway runs parallel to the Atlantic Ocean and is a significant recreational and commercial asset to the community. The AIWW connects to the Atlantic Ocean near the border with North Carolina through the Little River Inlet and continues south for over 70 miles before reconnecting with the ocean at Winyah Bay.

TARGET COMMUNITIES

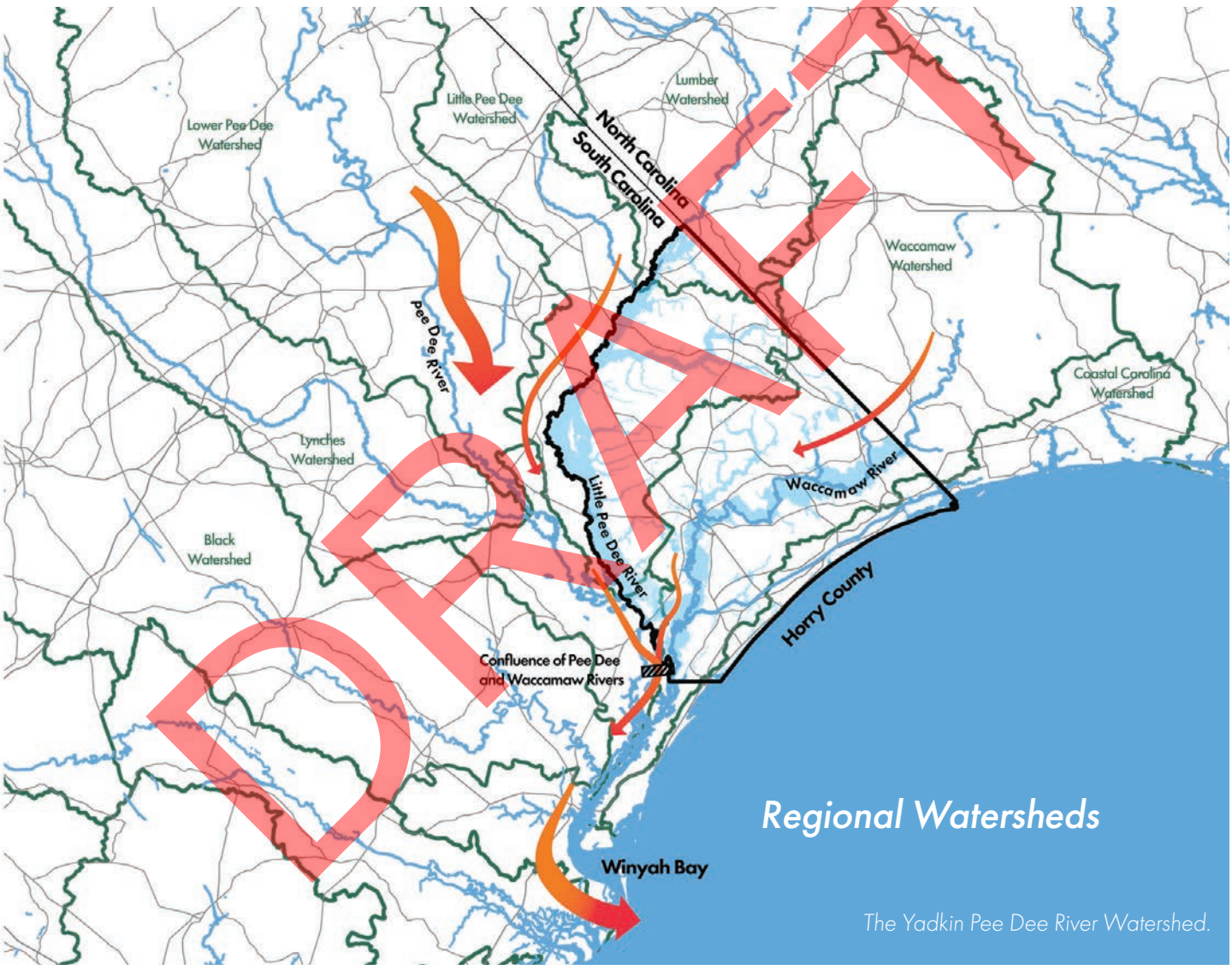
The unincorporated Horry County communities of Bucksport, Longs, Red Bluff, and Socastee were designated as the areas of focus for this report. Each of these communities has been continually impacted by riverine flooding and is representative of other areas in the County that also experience flooding from multiple waterways. Moreover, flooding in each community is uniquely impacted by the relationship of drainage basins, stream confluences, and topography in the area. The target communities are representative of flooding conditions experienced in many areas adjacent to the local waterways. With the exception of Bucksport, the target communities are representative of areas where the piloted solutions can be evaluated and applied across Horry County.

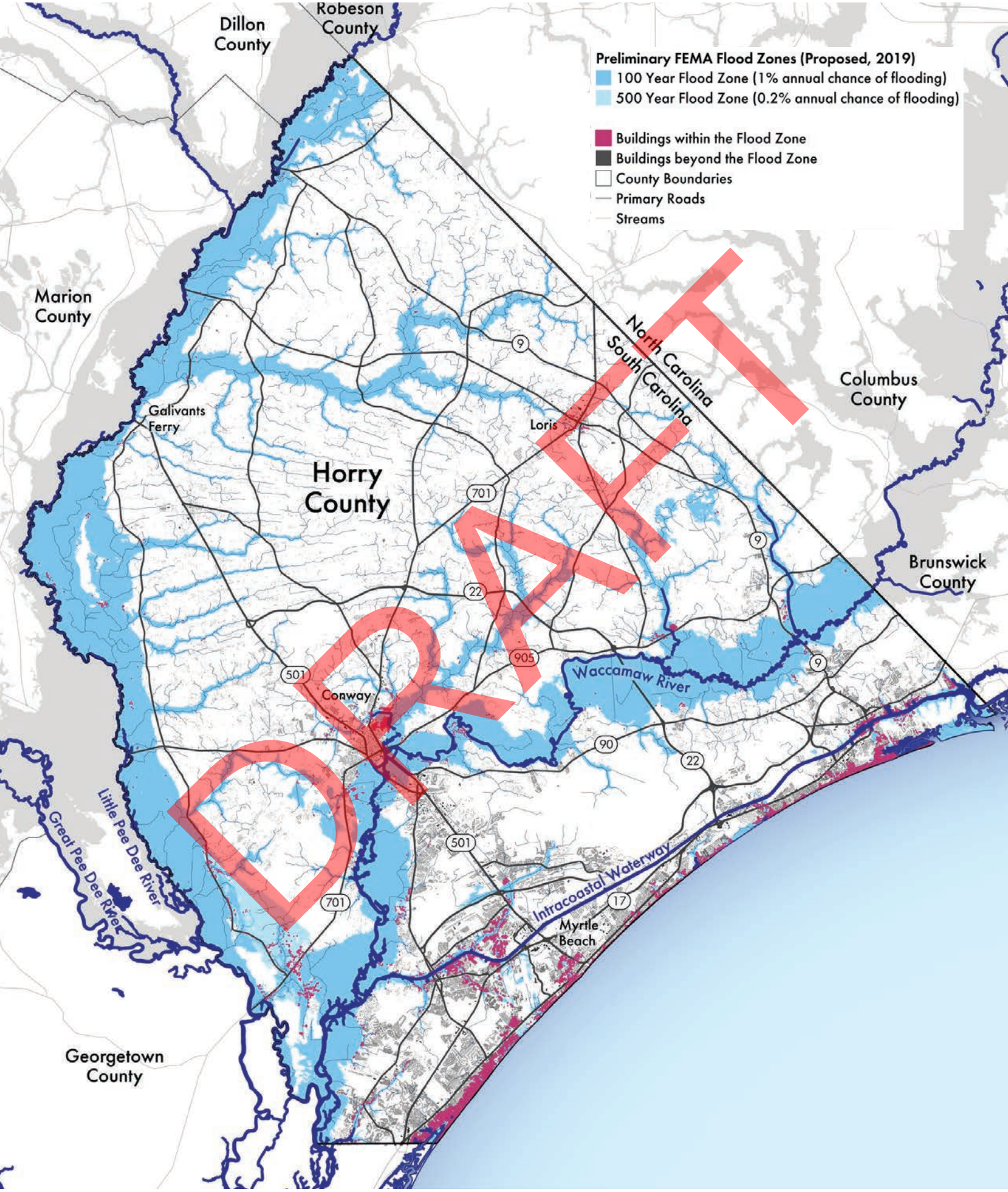
The communities illustrate the diverse impacts flooding has on the communities throughout the County.

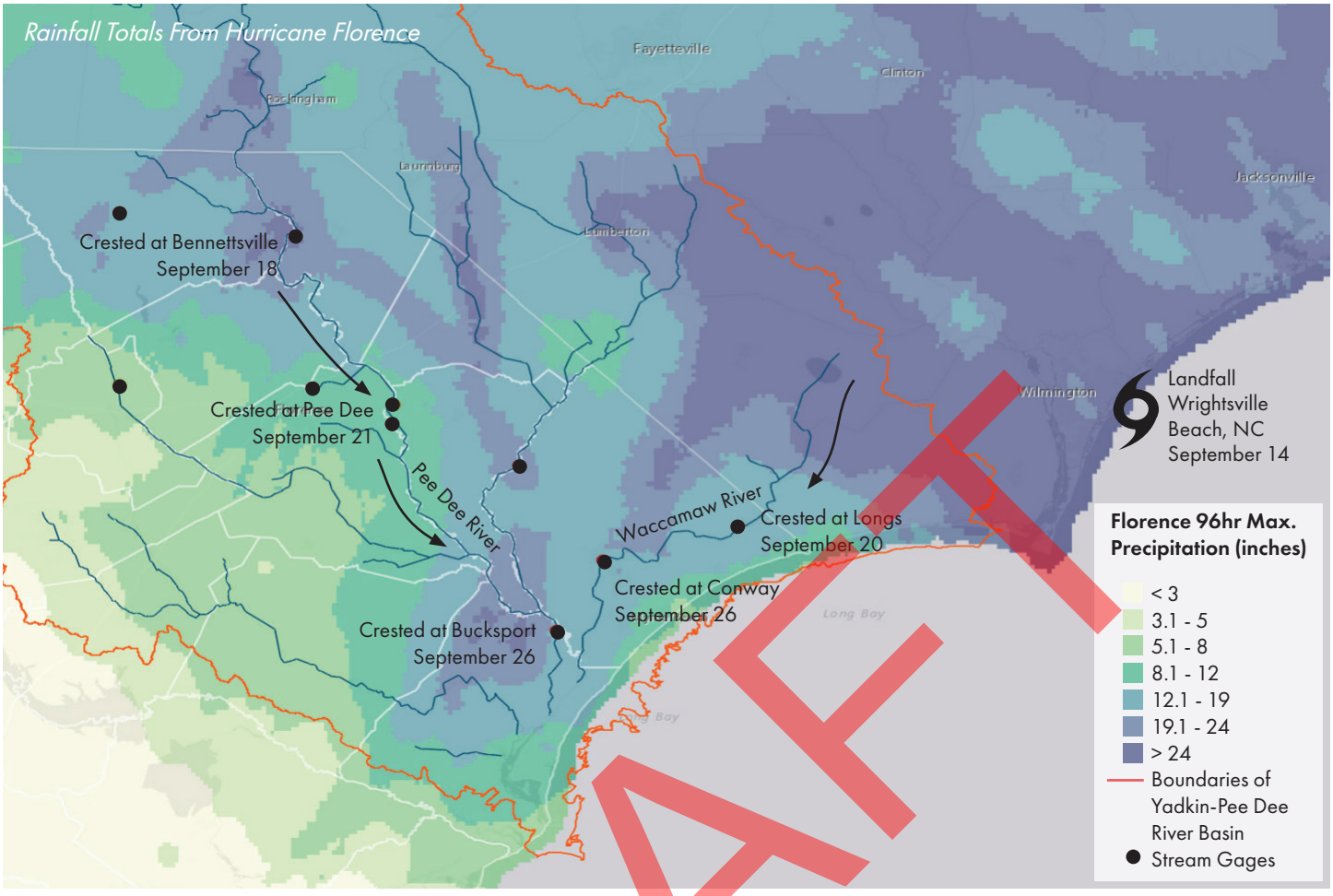
- Bucksport illustrates the regional basin relationships of the Waccamaw and Pee Dee Rivers.

- Socastee represents the Intracoastal Waterway impacts, including the relationship between flow patterns, elevations, and the Waccamaw and Pee Dee Rivers.

- Longs and Red Bluff exhibit the impact of flooding along the upstream tributaries of Simpson Creek and Buck Creek and their confluence with the Waccamaw River.




Preliminary FEMA Flood Zones (Proposed, 2019)
100 Year Flood Zone (1% annual chance of flooding)
500 Year Flood Zone (0.2% annual chance of flooding)
Buildings within the Flood Zone
Buildings beyond the Flood Zone
County Boundaries
Primary Roads
Streams
Dillon County
Robeson County
Marion County
Columbus County
Brunswick County
Georgetown County
Horry County
Galivants Ferry
Loris
Conway
Myrtle Beach
North Carolina
South Carolina
Waccamaw River
Intracoastal Waterway
Little Pee Dee River
Great Pee Dee River
9
22
501
701
905
90
17
DRAFT



1.2

Nature and Categorization of Storm Impacts

DESCRIPTION OF HURRICANE FLORENCE STORM DAMAGE

Hurricane Florence made landfall on September 14, 2018, along the southeastern coast of North Carolina, near Wrightsville Beach. At landfall, Florence was a Category 1 storm with a central pressure of 956 millibars and sustained winds of almost 80 knots. Florence was not a major producer of storm surge. The highest storm surge was measured in North Carolina, along the Neuse River near Pamlico Sound.

After making landfall, Florence tracked westward, weakening to a tropical storm by September 15, 2018. The storm continued moving slowly west, then north, taking over two days to traverse South Carolina before crossing into western North Carolina on September 17. Florence moved particularly slowly across northeastern South Carolina, at approximately 2 to 3 miles per hour in the 36 hours after landfall.

While Florence did not produce a major storm surge, its damage came from its prodigious rainfall amounts. Many communities in southeastern North Carolina and northeastern South Carolina received 10 to 20 inches of rain from the storm. The storm set new state rainfall records for tropical cyclones in both states. The heaviest rain was concentrated in a wedge between Charleston, South Carolina and New Bern, North Carolina extending westward to Charlotte, North Carolina. Over 30 inches of rain were measured in a few North Carolina locations, exceeding the highest single-storm rainfall amounts ever seen in this portion of the state. A weather station in Loris, South Carolina recorded 23.63 inches of rain, setting a new state tropical cyclone rainfall record for the state of South Carolina. The slow-moving nature of this storm combined with the consistent volume of rainfall produced throughout its track across the region made the storm even more impactful than larger storms moving more quickly. Florence is on record as the wettest tropical cyclone to ever affect the Carolinas, ranking amoung the

10 wettest overall among tropical cyclones that have hit the United States with regard to total rainfall based on a four-day event covering at least 20,000 square miles (Hurricane Harvey in 2017 was the all-time wettest).

Florence was responsible for 19 deaths in the Carolinas, nine of which were in South Carolina from vehicle-related flooding and from trees toppled by high winds. South Carolina Emergency Management Division reported 11,386 homes with moderate or major damage across the state, 455,000 people were evacuated, 187,000 suffered power outages, and 11 dams breached or failed. None of the 11 dams that breached or failed were in Horry County, but were located in Chesterfield County, Darlington County, Dillon County, Marion County, and Marlboro County. On September 26, raw sewage flowed from the Conway Wastewater Treatment Plant into a tributary that feeds into the Waccamaw River. There was widespread roadway damage throughout the region. In Horry County alone, there were at least 465 roads that were closed. Estimated monetary damages in South Carolina from Florence totaled $2 billion.

IMPACT OF FLORENCE ON HORRY COUNTY

While Florence was a coastal storm, the severe impacts felt by Horry County were primarily from inland flooding that took place in the days and weeks after the hurricane made landfall. Storm surge was relatively minor along the Grand Strand in Myrtle Beach, with minimal surge inundation reported. However, roughly 80,000 customers were without power across the Grand Strand area during the storm. The maximum storm tide was measured at Surfside Beach and was approximately 6.4 feet above mean (average) sea level. The significant levels of rainfall in both North and South Carolina from the storm that landed upstream of Horry County, slowly flowed down the drainage basins, merging with already flooded rivers and streams. While streams in the County began to rise just after Florence made landfall, the Pee Dee and Waccamaw Rivers in Horry County did not crest until September 26, twelve days after landfall and eight days after the storm had dissipated over New England. Rivers continued to crest downstream over the next several days. The Waccamaw River crested at its upstream gauge near Longs on September 21, near Conway on September 26, and at its downstream gauge near Bucksport on September 27. Similarly, the Little Pee Dee River crested upstream at Galivants Ferry on September 21, and downstream on the Pee Dee River near Bucksport on September 27. Historic data shows that Hurricanes Florence (2018), Matthew (2016), Joaquin (2015), and Floyd (1999) resulted in four of the highest five crests recorded in the area.

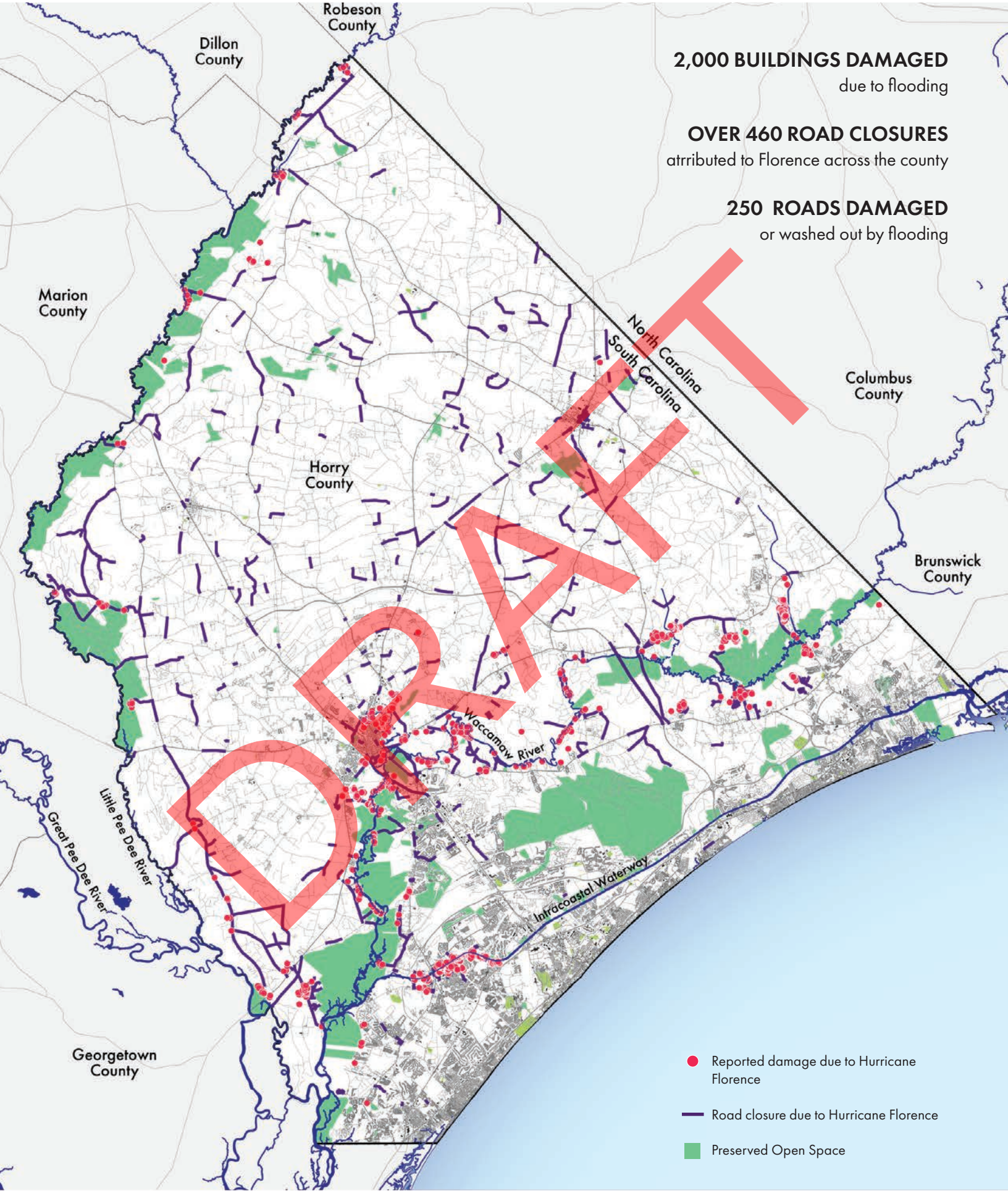
Many stream gauges in the region set new records for flood elevation, exceeding those set by Hurricane Matthew in 2016. Record flooding was documented at several USGS stream gauge locations in Horry County, including the Little Pee Dee River at Galivants Ferry, the Pee Dee River at Bucksport, and the Waccamaw River at Longs and Conway Marina. The gauges along the Little Pee Dee/Pee Dee Rivers recorded peak water-level rises approximately 14 to 16 feet above normal and gauges on the Waccamaw River recorded rises of around 13 to 19 feet above normal. Along the Intracoastal Waterway (near the confluence with the Waccamaw River at Socastee), gauges recorded peak water-level rises of approximately 9 to 10 feet above normal.

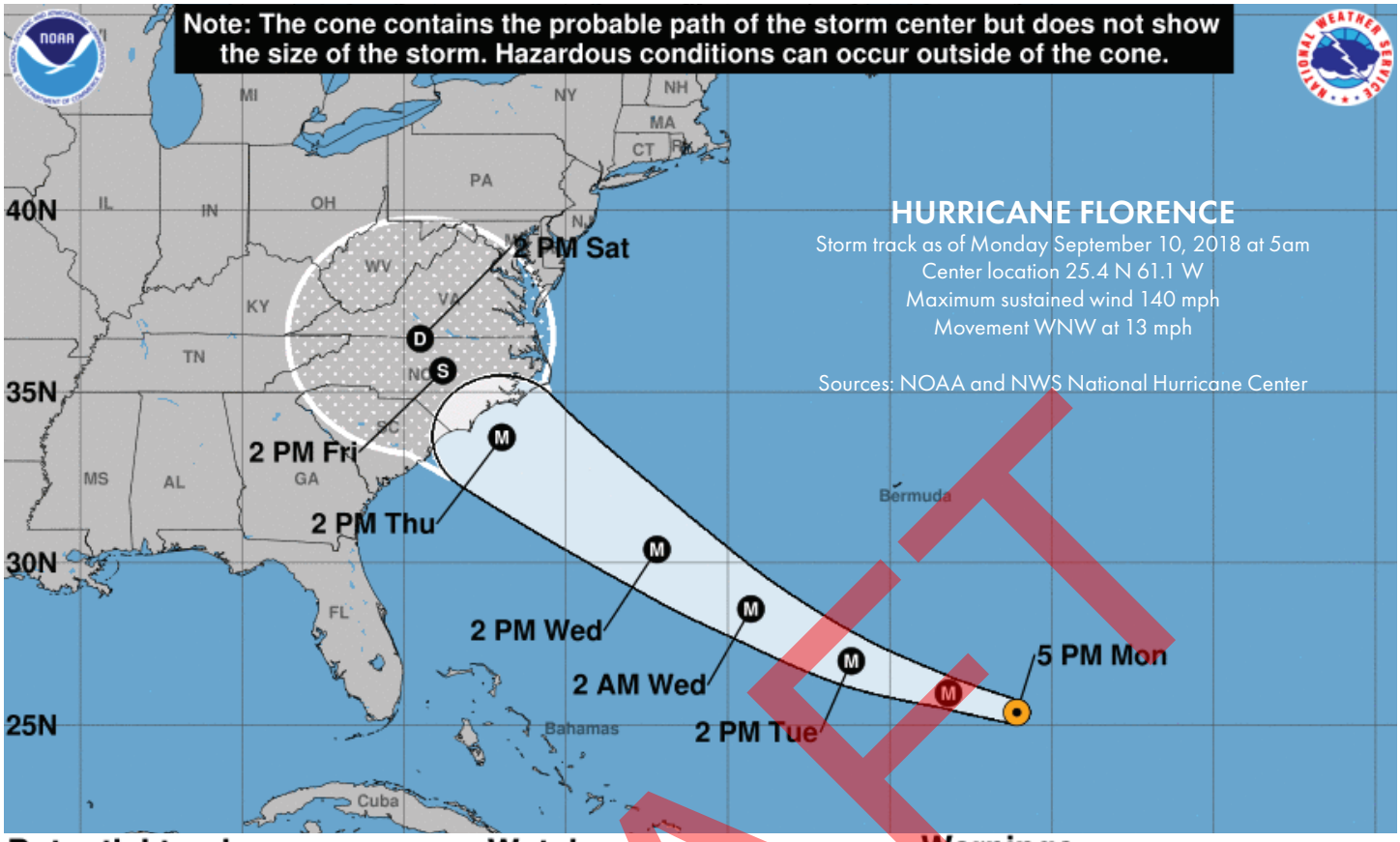
The extensive and prolonged flooding in Horry County during Florence was due to a combination of widespread unprecedented rainfall across the entire Pee Dee drainage basin that was further exacerbated by the low elevation and relief of the landscape (flat land near sea level) and the fact that the outfall to the Atlantic Ocean is more than 30 miles further south (at Winyah Bay). As a result, the stream channels were unable to accommodate and quickly drain the excessive rainfall.

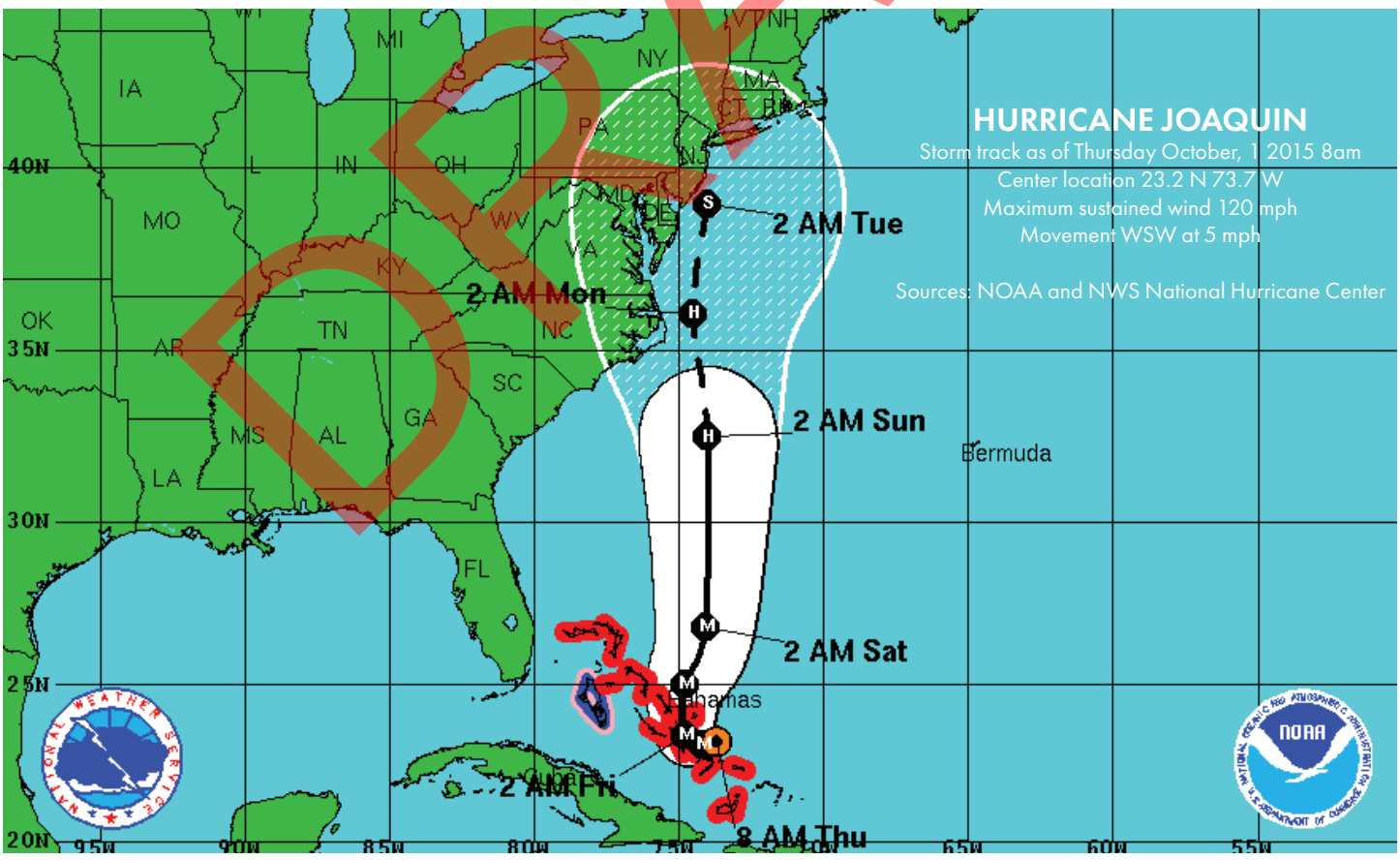
For the inland communities in Horry County, such as Loris, flash flooding caused by the storm's record rainfall was the primary issue during Florence. The community of Dongola in western Horry County was isolated by flooding for ten days. Flood levels of up to eight feet were registered in communities south of Myrtle Beach near the Intracoastal Waterway. Trees were blown down by high winds across the northern portion of Horry County. Flooding from Florence caused major damage to infrastructure. The Horry County post-storm assessment documented approximately 2,000 buildings with flood damage. The total market value of properties (parcels) with flood-damaged buildings has been estimated at $400 million. While approximately 2,000 buildings were damaged during Florence, just under 400 Florence-related permits have been received (including residential and commercial buildings) in the unincorporated area of the County, with 34 of these permits to elevate the building and 40 to demolish. There are numerous properties that remain in disrepair.

Aerial view of flood barrier construction on U.S. Highway 501 Bypass following Hurricane Florence
Source: SCDOT

In addition to building damage, over 460 road closures were attributed to Florence across Horry County, and more than 250 of these roads were either washed out or damaged by flooding. Some portions of primary routes were closed for up to two weeks. In the weeks directly following Florence, major travel routes including SC HWY 9 and SC HWY 22 were closed due to flooding. SC HWY 501 was the only access road between land to the west of the Waccamaw River and the beach, and one lane on each side of the highway were closed to be secured with sandbags, causing commute times to be greatly increased . The partial closure of SC HWY 501 proved especially problematic as the highway was already a roadway with one of the highest volumes in the County, serving over 40,000 vehicles on an average day. SC HWY 9 reopened October 1, 2018, although westbound lanes were still flooded, traffic was diverted in the eastbound lanes. These closures severely restricted travel in the region, limiting the ability of evacuees to return home and the trucking of supplies. A large group of residents were forced to stay in hotels for long periods of time and were unable to commute to work, compounding financial difficulty.


Robeson County
Dillon County
Marion County
Horry County
Columbus County
Brunswick County
Georgetown County
North Carolina
South Carolina
Waccamaw River
Great Pee Dee River
Little Pee Dee River
Intracoastal Waterway
2,000 BUILDINGS DAMAGED
due to flooding
OVER 460 ROAD CLOSURES
atrributed to Florence across the county
250 ROADS DAMAGED
or washed out by flooding
DRAFT
Reported damage due to Hurricane Florence
Road closure due to Hurricane Florence
Preserved Open Space


Note: The cone contains the probable path of the storm center but does not show the size of the storm. Hazardous conditions can occur outside of the cone.
HURRICANE FLORENCE
Storm track as of Monday September 10, 2018 at 5am
Center location 25.4 N 61.1 W
Maximum sustained wind 140 mph
Movement WNW at 13 mph
Sources: NOAA and NWS National Hurricane Center
2 PM Sat
2 PM Fri
2 PM Thu
2 PM Wed
2 AM Wed
2 PM Tue
5 PM Mon
Bermuda
Bahamas
Cuba
40N
35N
30N
25N
Potential track area:
Day 1-3
Day 4-5
Watches:
Hurricane
Trop Storm
Warnings:
Hurricane
Trop Storm


HURRICANE JOAQUIN
Storm track as of Thursday October, 1 2015 8am
Center location 23.2 N 73.7 W
Maximum sustained wind 120 mph
Movement WSW at 5 mph
Sources: NOAA and NWS National Hurricane Center
2 AM Tue
2 AM Mon
2 AM Sun
2 AM Sat
2 AM Fri
8 AM Thu
Bermuda
Bahamas
40N
35N
30N
25N
20N
95W
90W
85W
80W
75W
65W
60W
55W
Potential Track Area:
Day 1-3
Day 4-5
Watches:
Hurricane
Trop.Storm
Warnings:
Hurricane
Trop.Storm

IMPACTS FROM RECENT STORMS

While Hurricane Florence was the most recent storm to affect Horry County, there have been multiple major events since 2015 that have had both immediate and cumulative impacts on the County. It is important to understand the cumulative impact of all of these storms when developing strategies for mitigation of flood impacts.

Matthew (2016)

Hurricane Matthew was a Category 5 hurricane that made landfalls in Haiti, Cuba, and Grand Bahama Island, before striking the United States as a Category 1 hurricane in central coastal South Carolina, hugging the Carolina coast before veering out to sea. Although no deaths were reported in Horry County, Matthew was directly responsible for 585 deaths, mostly in Haiti, during its time as a named storm from September 28 to October 9, 2016. Matthew produced torrential rains from central Florida to the Virginia Tidewater region with the heaviest rains falling in a band ranging from the central Georgia coast, through all of eastern South Carolina, across inland areas throughout North Carolina's coastal plain, and in coastal southeastern Virginia. The highest total rainfall from Matthew was 18.95 inches, recorded near Evergreen in Columbus County, North Carolina. Rainfall amounts over 17 inches were measured at locations in Cape Canaveral, Florida, in Savannah, Georgia, and in Hope Mills, North Carolina.

Horry County experienced moderate storm surge and large waves during Matthew, causing severe erosion in some locations along the Grand Strand. High water marks collected by USGS after the storm show storm surge inundation was approximately 1-3 feet above ground level. Maximum storm tide was measured around 12 feet above NAVD88, which is 9.5 feet above MHHW. More than 12 inches of rainfall was recorded in Horry County during Matthew over a seven-day period. Flooding began along the Waccamaw and Little Pee Dee Rivers in the County around October 9 and took several weeks to recede. The post-storm assessment in Horry County documented approximately 1,200 buildings with flood damage.

Joaquin (2015)

Hurricane Joaquin was a Category 4 storm that generated strong winds and storm surge that devastated parts of the Bahamas and brought heavy rains to the Carolinas. Although the center of Joaquin never came closer than 600 miles to the East Coast of the United States, Joaquin interacted with non-tropical weather systems active over the eastern United States to create a multi-day rainfall event with historic flooding from Charleston to Columbia, setting a variety of rainfall records across the state of South Carolina. Greater than 1,000-year rainfall levels were recorded in Mount Pleasant, Sumter, and Kingstree, with 500-year rainfall levels exceeded in Columbia, Charleston, and Manning. Joaquin was active as either a tropical storm or hurricane from September 28 to October 7, 2015, and created riverine flooding that kept some rivers above flood stage into mid-October. Joaquin formed near the Bahamas and became the strongest Atlantic hurricane of non-tropical origin since the onset of satellite records.

A deep amplitude East Coast upper trough closed off across the southeast states for several days while a surface front meandered across the area. Moisture from the Gulf of Mexico and Atlantic Ocean continued to feed the storm and tropical moisture from the periphery of Hurricane Joaquin, well off the coast, helped to boost precipitation to near record levels. Rainfall amounts averaged 10 to 15 inches across the area during the event, with some locations reporting up to 2 feet of rainfall. The storm produced rare flash flooding and significant coastal flooding during high tide. Historic and widespread riverine flooding followed.

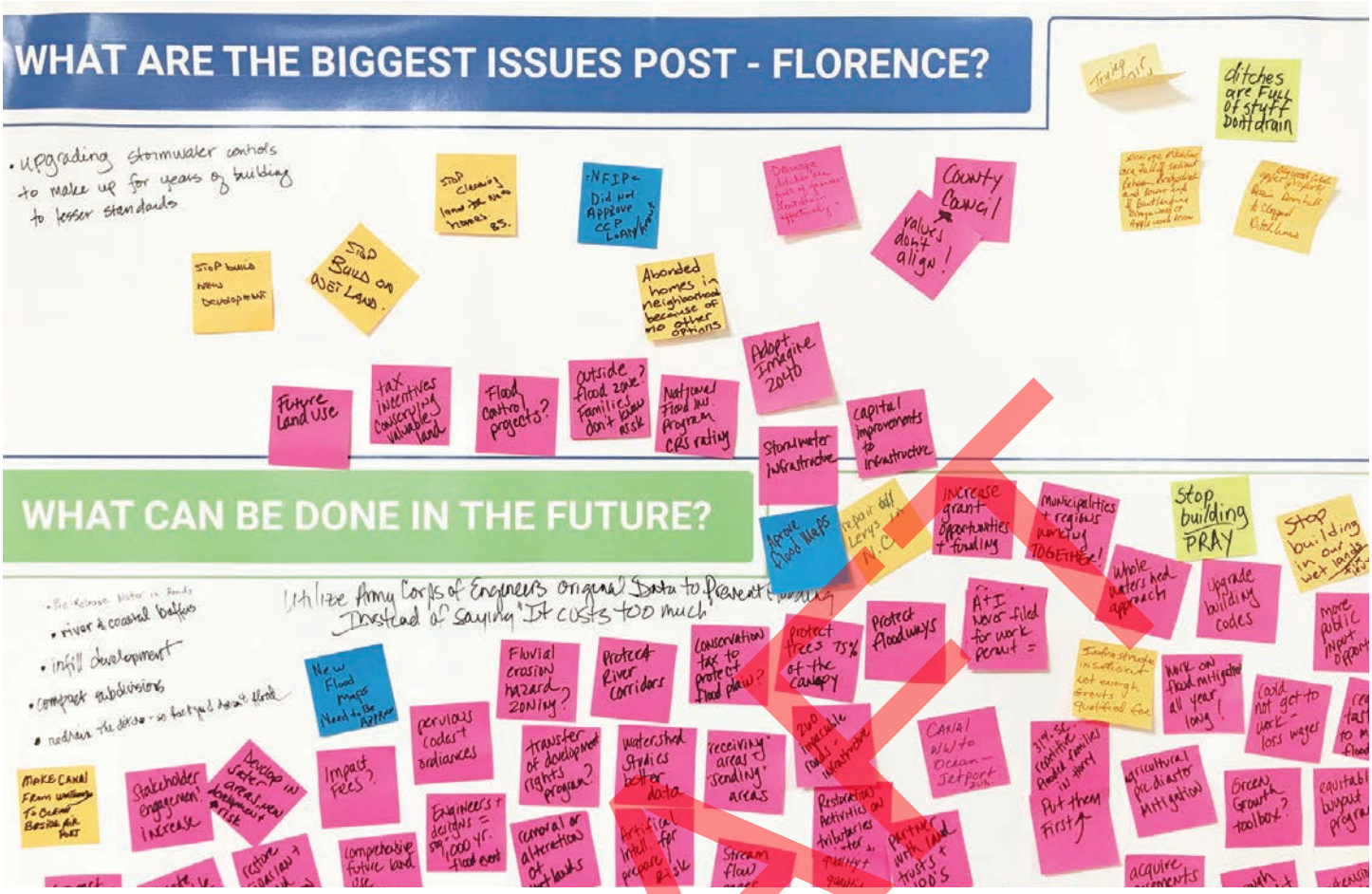
In Horry County, storm surge was moderate; the highest USGS storm tide measurements from Joaquin were approximately 9 feet above NAVD88, which is 6.5 feet above MHHW. However, more than 15 inches of rainfall were recorded in Horry County during Joaquin over a seven-day period. Flooding began along the Waccamaw and Little Pee Dee Rivers around October 3 and took weeks to recede. The post-storm assessment in Horry County documented approximately 400 buildings with flood damage.

Flooding following Hurricane Florence
Source: Wade Spees for The Post and Courier

Flooding in Socastee along the Intracoastal Waterway following Hurricane Florence
Source: Drone video by Chuck Liddy, Myrtle Beach Online

Flooding in the Polo Farms neighborhood following Hurricane Florence
Source: The Associated Press

Flooding in the Aberdeen neighborhood of Longs following Hurricane Florence
Source: Horry County Emergency Management



Community Resilience

The frequency and severity of the storms that have impacted Horry County in recent years have taken a toll that goes beyond physical damage. The burdens, psychological and financial, of building back can be traumatic and the continued threat of future flooding places additional stress on those who have been impacted. Some residents may have the means to build back following a storm, but not all are able to find the necessary resources, and even fewer are able to sustain recovery when repeatedly impacted. The succession of destructive storms that result in repetitive flooding events can erode residents' confidence in the safety of an area and its resilience to flooding, as well as residents' financial stability. Residents with more financial resources are better able to recover, and to recover more quickly, than those of more limited means. Communities with greater social cohesion may demonstrate more resilience, as those with access to resources extend help to their neighbors.

Whereas long-time residents who experienced previous flood events are familiar with emergency protocols and relative flood risk, newer residents are often unfamiliar with Horry County's vulnerability to flooding and the prevalence of hurricanes. This knowledge gap could lead to less-informed decisions regarding evacuation, property protection, and the flood risk of prospective properties. The distribution of information through news outlets, official social media representatives, and printed publications informs residents about the types of flood events, where they occur, and the likelihood of flooding in each area. The "Know Your Zone" signage initiative referenced in the County's *Imagine 2040 Comprehensive Plan* is an excellent example of how the County is informing the community about hurricane safety and how property may be affected during storms.

COMMUNITY ENGAGEMENT

In November 2018, in the wake of Hurricane Florence, the third major riverine flooding event in four years, Horry County applied to and received funding from FEMA's Hazard Mitigation Grant Program (HMGP). FEMA HMGP funding was awarded to develop a Flood Resilience Plan as an annex to the County's All-Hazards Mitigation Plan, approved by FEMA in January 2016. With this funding, the Horry County Council commissioned the development of the plan. As a first step in the development of the plan, meetings

with residents and local leaders were coordinated in order to hear concerns and generate ideas for improving resiliency in the area.

From October 22 through 25, 2019, meetings were held with community groups, including one in each of the three target areas, and attended by County and local officials. The primary aim of these engagement sessions was to hear the concerns of residents and to generate ideas for addressing the flooding experienced in Horry County. Public meetings were held during the evening in Socastee, Longs/Red Bluff, and Bucksport. Further input was obtained during meetings and focus groups, including County board and commission members, County staff, Voluntary Organizations Active in Disaster (VOAD) members, public safety and utility providers, conservation organizations, and the business community.

Surveys were distributed and collected at the public engagement sessions. In Bucksport, Longs/Red Bluff, and Socastee, 35, 30, and 36 surveys were collected, respectively. The public engagement sessions and survey results revealed interesting distinctions among the communities. The Bucksport and Socastee areas reported more extensive flood damage from both Hurricanes Matthew and Florence than the Longs and Red Bluff areas, which were mainly affected by Florence. In Longs/Red Bluff, only eight people reported damage due to Hurricane Matthew, while 22 and 29 people in Bucksport and Socastee, respectively, identified damage from Matthew in Bucksport and Socastee. In Bucksport, a smaller percentage of the sample population (37 percent) reported that they own flood insurance, compared to the sample populations in Socastee or Longs/Red Bluff, where 72 and 80 percent, respectively, report that they have flood insurance.

Across all three target communities, most property owners with flood damage confirmed that their damage was from riverine flooding, which indicated that flooding occurred two or more days after the hurricane(s), unlike flash flooding which occurs the same day as a storm event. Across all the sample populations in the three target communities, reports of at least some damage due to Hurricane Matthew or Hurricane Florence was high. The percentage of the sample populations that reported damage to either of the two storms was 83, 87, and 95 percent in Bucksport, Longs/Red Bluff, and Socastee, respectively. The table on the following page summarizes attendance at each public engagement session, as well as additional pertinent information from the surveys collected at each session.

INCORPORATION OF COMMUNITY INPUT

During the public meetings and through survey feedback, Horry County residents voiced varied opinions as to the causes and potential solutions for extreme flooding. Members of the public felt that both old and new developments significantly contributed to flooding within the County. Conversations during these meetings revealed that informing community members about the characteristics of different flooding types can help balance the perceived role of development in causing all flooding. While development can certainly contribute to flash flooding issues, it is a much less significant factor in the riverine flooding and storm surge events in our area that are the focus of the current planning effort.

Another consistent theme from public comment was that deferred maintenance of waterways, primarily involving maintaining ditches and dredging or de-snagging significant streams, rivers, and the AIWW was a major contributing factor to the recent major flooding events. Some members of the public felt that major engineering solutions could be effective in addressing large-scale flooding events, while others suggested that there was no way to "engineer our way out of this problem."

Many felt existing and proposed federal flood maps, including FEMA FIRMs, failed to capture the magnitude of recent flooding. Some community members in Socastee favored buyouts of entire neighborhoods as a solution. Conversely, Bucksport community members preferred solutions that allowed them to remain in their communities with family and friends.

Another comment that repeatedly surfaced questioned the role of highway infrastructure in contributing to floodwater accumulation by effectively creating dams where roads crossed waterways or where roads were of higher elevation than surrounding properties. Clear cutting of properties for either logging or development was another concern to the community members.

The public input collected during these engagement sessions was critical to the development of the plan. The collective wisdom of the community helped identify key issues that needed to be further explored during plan development.

Key issues included:

- The types of flooding Horry County experiences, and how to communicate that information
- The hydrologic and geologic characteristics that influence how flooding strikes different communities in different ways and at different times, sometimes in ways which are not reflected in the current and proposed FEMA flood zone designations assigned to the properties
- The role of new development in affecting flooding impacts
- The potential for engineering solutions to address specific flooding challenges
- The need for a greater understanding about the County's regulatory structure regarding low-impact development and stormwater management
- The importance of tree preservation and forestry management to overall County resilience

SUMMARY OF PUBLIC ENGAGEMENT ATTENDANCE AND SELECTED SURVEY INFORMATION

Description	Location		
	Bucksport	Longs/Red Bluff	Socastee
Attendance	81	90	84
No. of surveys collected	35	30	36
Storm damage			
None	6	4	2
Matthew	22	8	29
Florence	25	25	34
Type of flooding			
Riverine	19	20	26
Flash	4	5	3
Storm surge	0	0	1
Know their flood zone			
Yes	9	11	16
No	19	18	20
Have flood insurance			
Yes	13	24	26
No	20	5	7

Horry County officials assess flooding in Bucksport following Hurricane Florence
Source: Wade Spees, The Post and Courier

Working with the USACE in support of FEMA, state officials, and local partners, members of the South Carolina Army National Guard install barriers along U.S. Highway 501 in Horry County in September 2018.
Source: USACE photo by Edward N. Johnson

2.0 risks and vulnerabilities

2.1

Flood Overview and Trends

TYPES OF FLOODING

According to recent research, hurricanes today are producing 10-30 percent more rain than in the past, an alarming trend that is projected to continue. According to the 2014 National Climate Assessment, the "intensity, frequency, and duration of North Atlantic hurricanes, as well as the frequency of the strongest hurricanes, have all increased since the early 1980s." Scientists attribute heavier rainfall to higher concentrations of water vapor in the atmosphere due to warmer temperatures, warmer near-shore waters, and changes in the general atmospheric circulation that leads to slower-moving hurricanes.

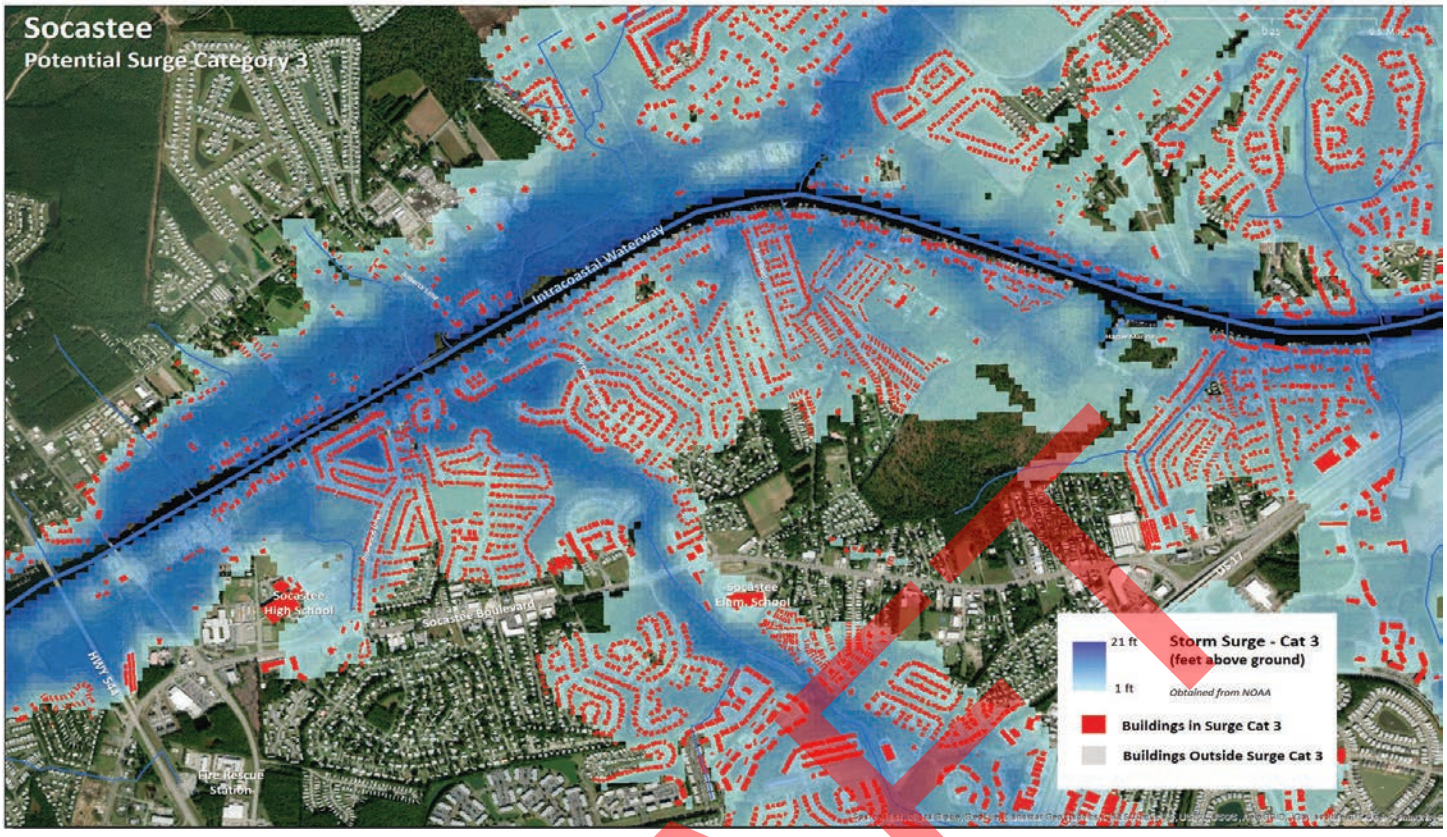
According to NOAA's National Centers for Environmental Information, hurricanes are moving approximately six percent slower in the North Atlantic region based on trend analysis between 1949 and 2016. This area of analysis includes Horry County. Rainfall amounts from hurricanes will be amplified due to prolonged periods of time over both water and land, allowing more moisture to be gathered from the water and delivered to the land. Hurricane rainfall in the future is thus more likely to resemble that from hurricanes Floyd, Matthew, and Florence. Evidence to support this trend is seen in the magnitude of rainfall that has been recorded in multiple recent storms. Hurricane Harvey, which was the most significant rainfall event in recorded history, dropped more than 60 inches of rain over Nederland, Texas in the Houston area in 2017. Hurricane Florence, in 2018, has been categorized as having the ninth highest rainfall of any storm to make landfall in the United States. Imelda, a tropical cyclone that also battered southeast Texas in 2019, was the fifth wettest on record. Three of the ten wettest storms in recorded history occurred in the last three years.

The types of flooding created by Hurricanes Joaquin, Matthew, and Florence are known as riverine and flash flooding. Riverine flooding is typically characterized by widespread rainfall across a river basin resulting in stormwater that progressively accumulates in volume as it moves downstream. This was represented in the way the Waccamaw River crested after Hurricane Florence, with Bucksport experiencing higher levels and cresting later than Conway. Conway crested on September 26 at 21.16 feet, and Bucksport crested on September 27 at 26.67 feet.

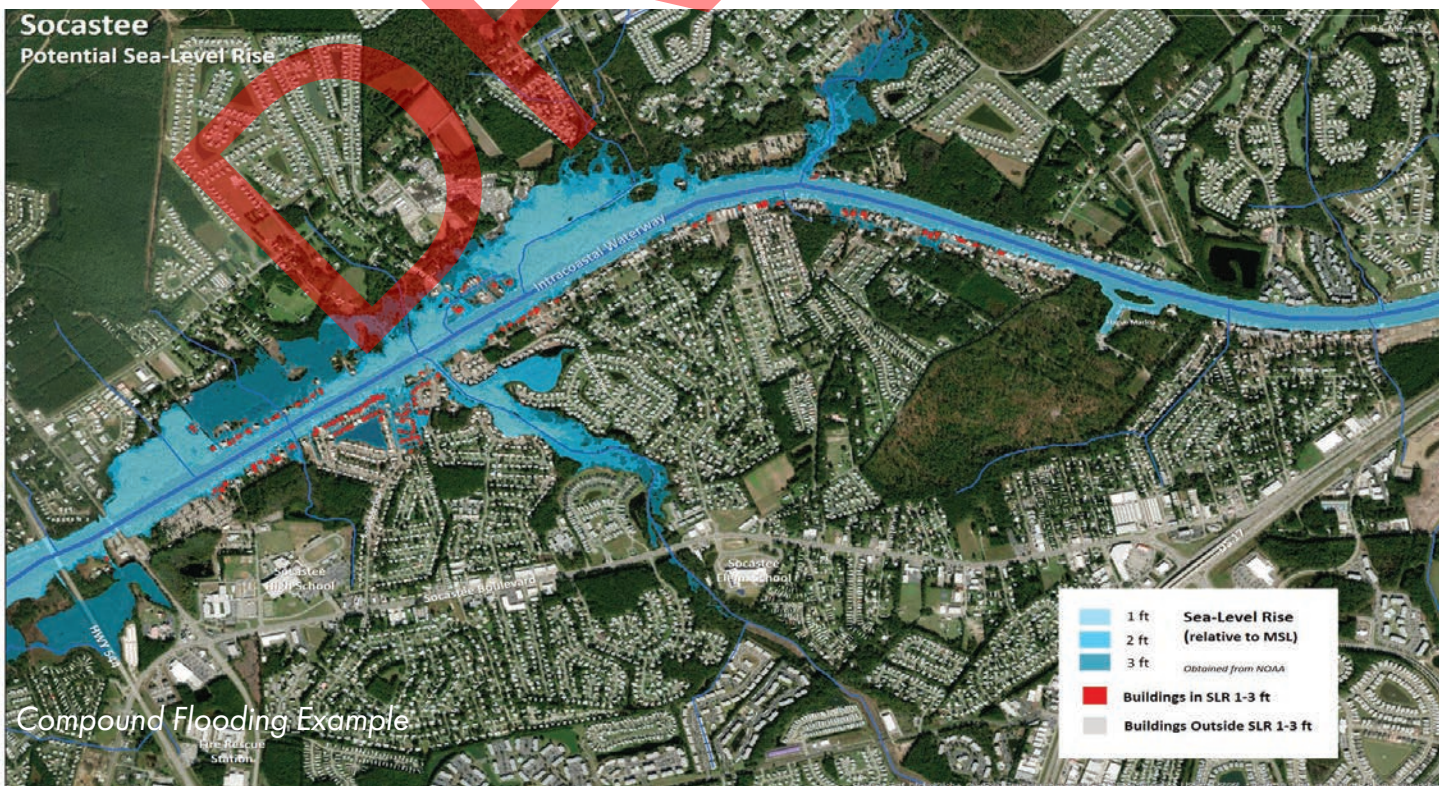
In addition to riverine flooding, there are three other types of flooding that have the potential to impact Horry County riverine communities.

Flash flooding occurs when rainfall volumes exceed what can be absorbed or retained on a development site, causing runoff that affects adjoining properties and streets. As its name implies, flash flooding is felt immediately during and shortly after a storm and is seldom a multi-day event.

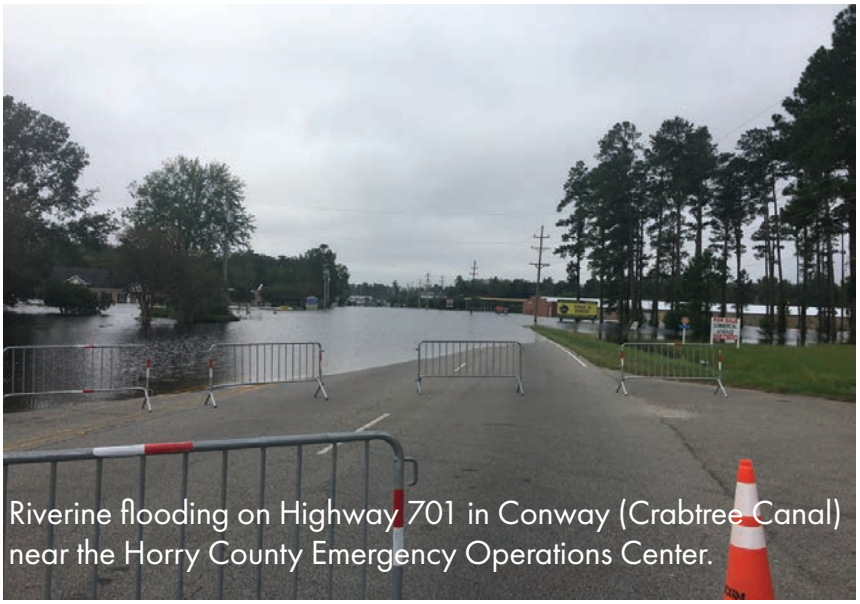
Storm surge is flooding driven by high winds associated with tropical or subtropical storm systems like hurricanes and nor'easters. Storm surge primarily affects properties in the immediate coastal zone, but strong storm surge events can force floodwaters up rivers and into floodplains. Like flash flooding, storm surge is a short-term event.



Compound flooding happens when flash flooding, riverine flooding, or storm surge combine to raise the local water table and increase the extent of flooding beyond what would be expected from a single flooding type. Compound flooding will happen when the ground is saturated from prior rains or from a naturally high water table, and two or more additional flooding types occur. Rainfall from a thunderstorm that falls onto ground already saturated from prior storms can combine the effects of flash flooding and riverine flooding, for instance, resulting in a compound flooding event.



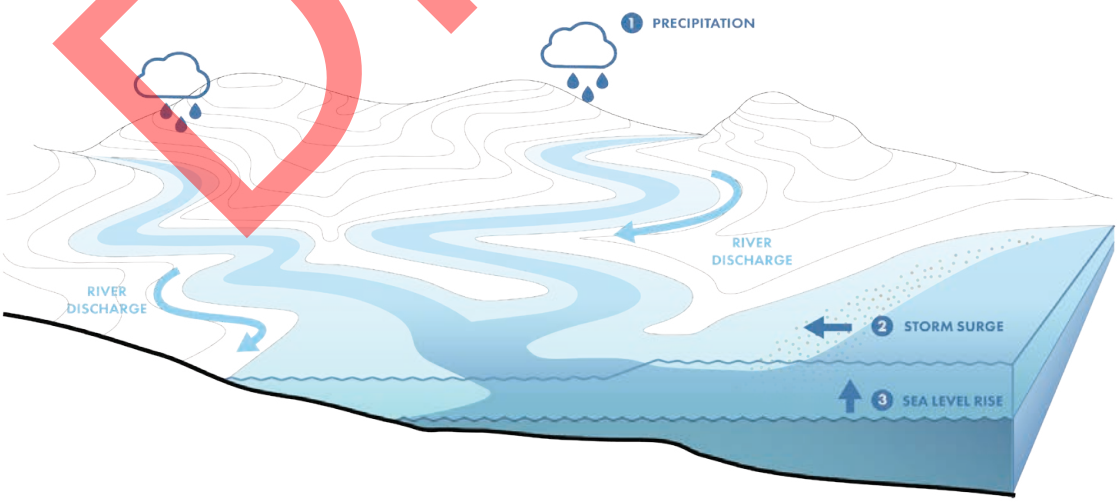
Compound Flooding Example



Riverine flooding on Highway 701 in Conway (Crabtree Canal) near the Horry County Emergency Operations Center.

Flash flooding on Suggs Street in Lo[illegible]fter Hurricane Florence.

COMPOUND FLOODING



This graphic highlights how 1) heavy rain from tropical systems can cause rises in waterway water levels while 2) storm surge from the tropical system pushes water inland as the system moves ashore. This on top of continued 3) sea level rise creates compound flooding events that are more severe than any one factor on its own.

DESCRIPTION OF STORM IMPACTS

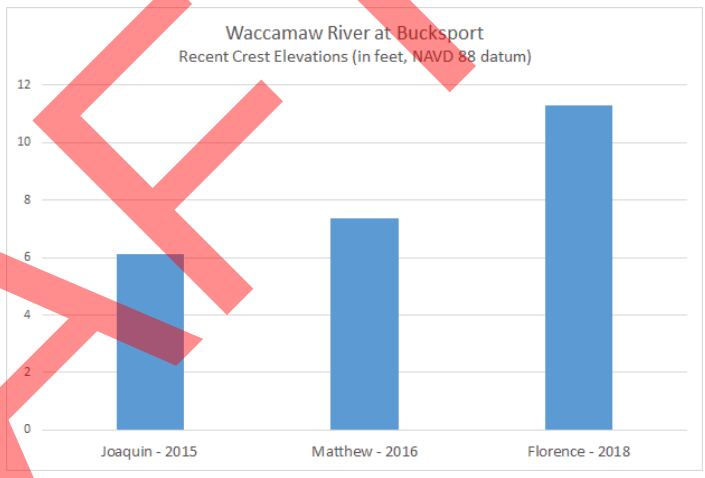
Horry County and its municipalities have experienced a large number of storms over the past several decades. Some storms have made a direct, perpendicular strike on the coast. These storms can result in significant storm surge flooding from the ocean, major wave-driven coastal erosion, significant oceanfront property damage, and localized flooding from precipitation (i.e. Hugo, 1989). Some tropical storms pass slightly offshore as they track northward. Typically, these storms result in low to moderate storm surge, significant beach erosion, localized property damage, local flooding, and back-up into the Pee Dee, Waccamaw, and Intracoastal Waterway systems (i.e. Maria, 2017).

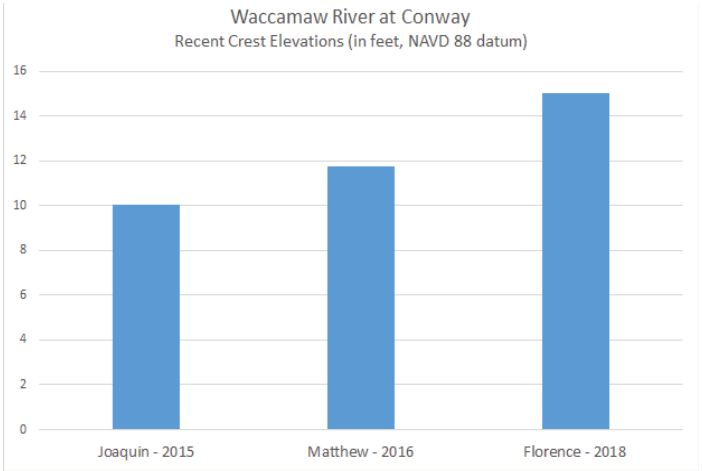
Some tropical storms stall inland after making landfall. Such storms have the capacity to release significant precipitation in the larger watersheds of the Pee Dee and Waccamaw Rivers, impacting Horry County from the west and north. These types of storms have been termed by meteorologists as wet microbursts or "rain bombs." Regardless of the initial impact on the coast, the additional and often much more significant damage from these storms results from inland riverine flooding, which is separate from flooding that results from local rainfall. The storms that stall inland threaten the larger portion of rural Horry County (i.e., Florence, 2018).

RESPONDING TO MULTIPLE STORM IMPACTS

Given the varied nature of possible storm impacts, Horry County must prepare for the possibility of both significant coastal flooding and large-scale riverine flooding well inland of the coast and tidal influence. Storm surge flooding occurs coincident with storm impact and typically recedes rapidly. Inland flooding develops over a period of days and can peak more than a week after the storm has crossed the coast. Typically, the same storm will not produce both effects. For example, Hurricane Hugo (1989) produced significant coastal surge, flooding, and overwash, but only produced localized flooding. Florence (2018) and Floyd (1999) produced little coastal surge and ocean flooding, but disastrous inland flooding. The impacts of all types of storms will increase in the future as the average temperatures tend to warm and the precipitation potential for tropical systems increase. Horry County must prepare to manage this dual threat from sea and land.

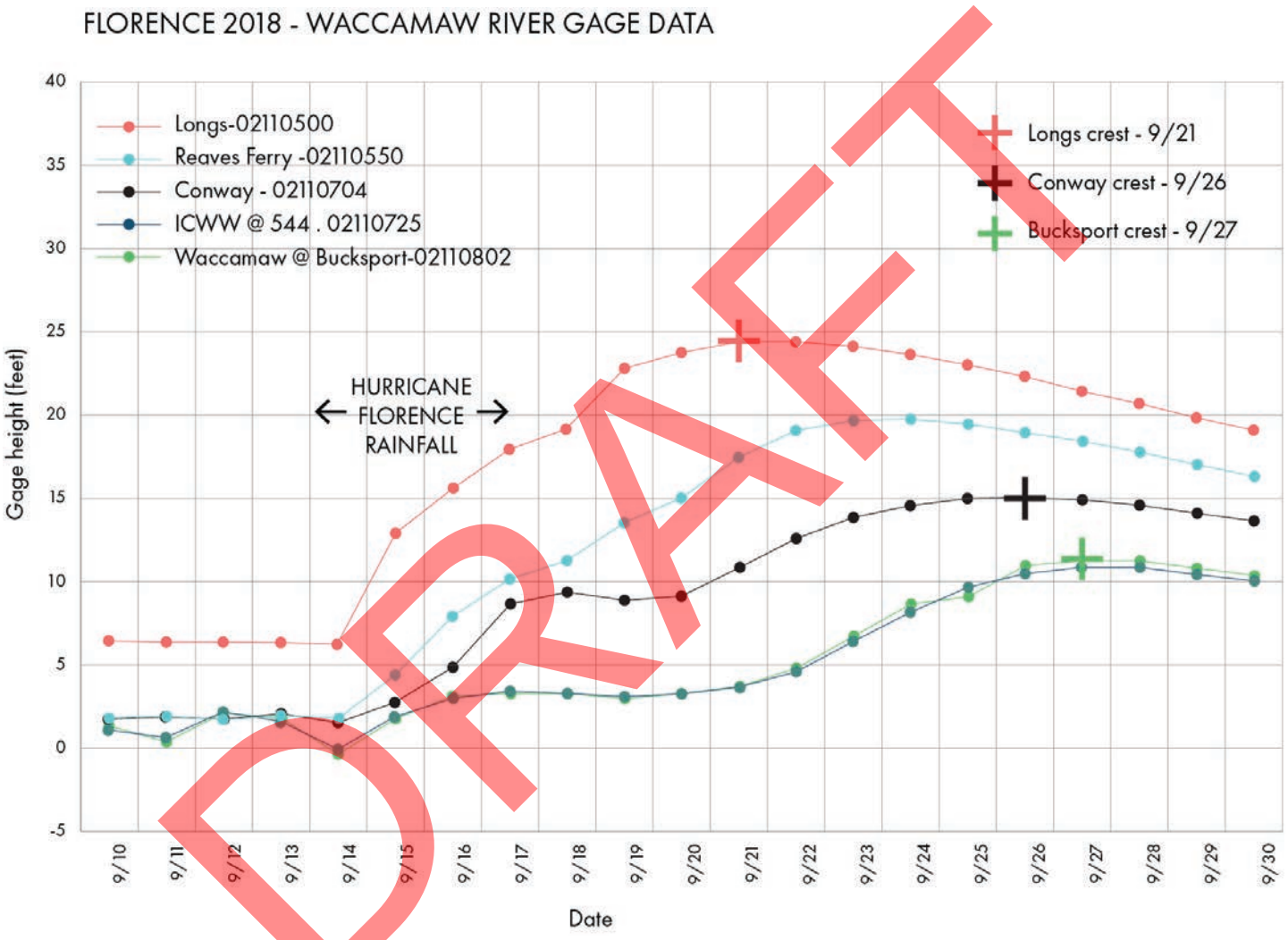
While Florence produced record rainfall and river flooding within multiple inland communities across Horry County, it was likely not a worst-case scenario for the entire County. For example, a major storm surge coming up through Winyah Bay has the potential to cause more extensive flooding in lower elevation inland communities (i.e., Bucksport, Socastee). Storm surge is exacerbated by higher seas, which rise due to sea-level rise and kind tides. Consequently, Horry County can expect to experience future hurricanes with characteristics like Joaquin, Matthew, and Florence, with extensive riverine and compound flooding effects that can last for days or weeks. Storm surge flooding associated with tropical systems will continue to represent a risk for the County, particularly in the immediate coastal zone and along rivers and floodplains.

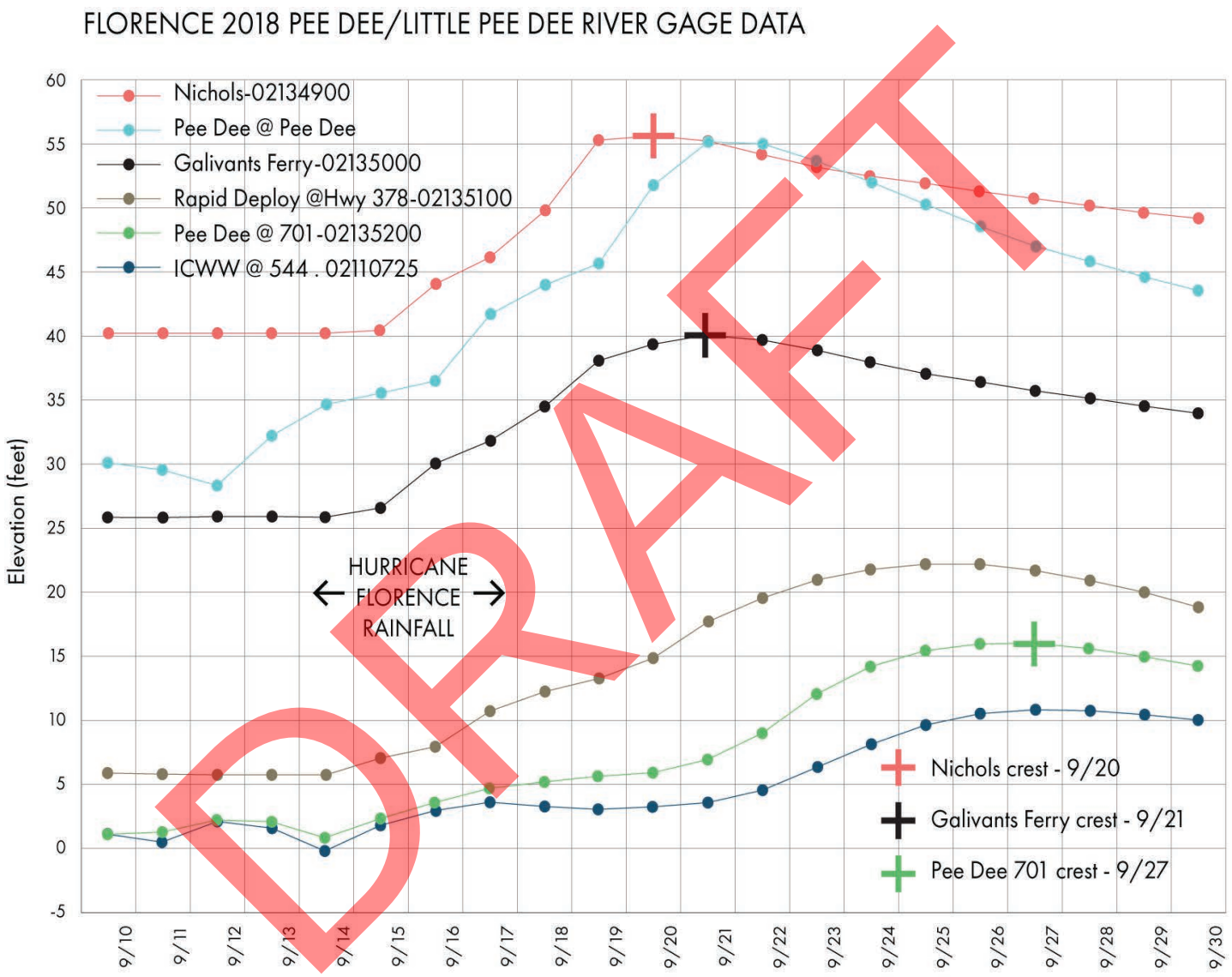




DELAYED FLOODING DURING FLORENCE

Due to the size and elevation of the Pee Dee River watershed, the largest amounts of riverine flooding associated with Florence happened days and weeks after the storm. The amount of stormwater from the Waccamaw compounded as the runoff for over 7,200 square miles of the watershed slowly culminated and conveyed towards the coast, raising the water elevations of the rivers and the Intracoastal Waterway.




FLORENCE 2018 PEE DEE/LITTLE PEE DEE RIVER GAGE DATA
Nichols-02134900
Pee Dee @ Pee Dee
Galivants Ferry-02135000
Rapid Deploy @Hwy 378-02135100
Pee Dee @ 701-02135200
ICWW @ 544 . 02110725
Elevation (feet)
60
55
50
45
40
35
30
25
20
15
10
5
0
-5
HURRICANE
FLORENCE
RAINFALL
Nichols crest - 9/20
Galivants Ferry crest - 9/21
Pee Dee 701 crest - 9/27
9/10
9/11
9/12
9/13
9/14
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9/29
9/30

An officer with the South Carolina State Highway Patrol surveys the extent of flooding on S.C. Highway 22 in September 2018.
Source: Jason Lee, the Sun News via AP

2.2

Key Risks and Vulnerabilities

When Hurricane Florence made landfall, many residents in Horry County were still recovering from the damaging effects of Matthew and Joaquin. The cumulative impact of these three successive storms within four years was particularly devastating and exposes the County's vulnerability to flooding. Widespread localized flooding during heavy rainfall events has further stressed communities susceptible to flooding and exposed additional vulnerabilities the County is working to address, such as roadway access, property damage, sewer back-ups and environmental impacts. The following key areas describe the primary challenges Horry County faces in achieving a flood resilient future.

TOPOGRAPHY

The County sits at a low elevation relative to sea level and has broad, flat topography. Horry County is positioned at the lowest elevation of two expansive river systems, the Pee Dee and Waccamaw. The majority of development in the County is located in the lowest elevations, east of the Waccamaw River and closer to the beach. These watersheds drain vast areas of land area that extend to the far north and west beyond Horry County into neighboring counties and coastal North Carolina. Rain that falls upland in these watersheds must flow through Horry County before reaching the coast, where storm surge, king tides, and rising sea levels can delay drainage and cause floodwaters to back up into communities along the Waccamaw and Pee Dee Rivers. As Horry County's topography and elevation cannot be modified, it is especially important to identify areas that are vulnerable to flooding and preserve or enhance natural systems that promote the infiltration, drainage, and detention of stormwater.

STORAGE CAPACITY

Tributaries, wetlands, swamps and other natural features serve as water storage during rain events and help to control the flow of water through Horry County. As a region develops, many of these natural flood management systems are re-purposed or converted into conveyance channels, and many of the sites are raised to support development and create detention ponds. As the floodplain expands and as larger, wetter storm events impact the region, our need to capture and store water in these natural features increases. While development sites in Horry County delay the release of site runoff, and are not set within the FEMA designated floodplain, they are no longer serving as places for water storage and conveyance within the watershed Over time, as more land within the floodplain is developed, floodplain storage and drainage capacity are at risk of being reduced. This issue is exacerbated when there is already limited storage capacity available in natural conditions due to the combination of a high water table and low land elevations. In order to leverage natural features to manage flooding, it is optimal to maintain forested land and wetlands in designated floodplains, minimize impervious surfaces to allow infiltration into the soil, and allow rivers and creeks to meander along their natural course, which reduces flooding by delaying the contribution of runoff to larger systems.

STORM SURGE

As sea levels rise, coastal communities will contend with encroaching tides, beach erosion, and a migrating shoreline. Storm surges will be correspondingly elevated and the base level of the rivers that flow into the Atlantic Ocean will also rise depending on the duration of time that a storm is at sea and the intensity of the storm. Hurricanes Joaquin, Matthew, and Florence were characterized by extreme rainfall that led to destructive riverine flooding in inland areas. However, Horry County's coastal location also leaves it highly vulnerable to flooding due to storm surge, shallow coastal flooding that often occurs during extreme high tides, spring tides when combined with rainfall, and sea level rise. In the case of a severe storm surge, many of the same communities that flooded during Florence could be impacted again with the source of flooding from the eastern coast rather than inland rainfall. An analysis of the potential impacts of severe storm surge was not within the scope of this Plan. However, coastal flooding due to sea level rise and storm surge should be considered as part of Horry County's efforts to establish long-term flood resilience, because impacts could range inland, beyond the immediate coastline, and impact the Waccamaw River and Intracoastal Waterway.

REPETITIVE FLOODING

Some areas in the County are prone to consistent flooding events, which threaten not only the infrastructure of the area and safe egress within the area, but also the residents' motivation and capacity to rebuild after a storm event. Due to the repetitive nature of flooding events in the area, damage to property occurs continually, and often, communities have not repaired or rebuilt after one storm before another impacts the community. Additionally, some of the same characteristics that affect communities in large flood events are evident in smaller more localized events. This includes spotty and frequent localized flooding near homes and communities that damages property at a much smaller scale after localized cloudburst storm events. The repetitive nature of flooding exposes community members to constant visual reminders of the vulnerabilities their community faces.

HISTORIC DEVELOPMENT PATTERNS

Recent storm events were among the most damaging and extensive in the history of Horry County, reaching communities that had not previously experienced flooding. The County has been in existence for more than two centuries and much of its historic and contemporary commerce is deeply connected to the water. Most of Horry County's communities benefit from close proximity to the waterways, including the county seat of Conway. In 1975, a feasibility study of requirements was conducted to analyze flooding throughout the county. Although the initial vulnerabilities were determined at that time, many historic developments that were not previously considered vulnerable are now experiencing flooding, leaving a considerable number of residents with difficult decisions. While the County has established standards for new development due to specific vulnerabilities, many historic developments date back to a time when flood management standards did not exist or were not as strict as current regulations. Flood management policies can acknowledge and alleviate the risks of existing communities while ensuring that future practices do not increase vulnerability. This is particularly relevant as hurricanes and intense rainfall events become more frequent.

STORM DAMAGE TO THE NATURAL FLOW OF LOCAL RIVER SYSTEMS

Horry County has a vast system of larger and smaller rivers and tributaries. These all contribute to the storage and flow of water through the region. Despite continued maintenance

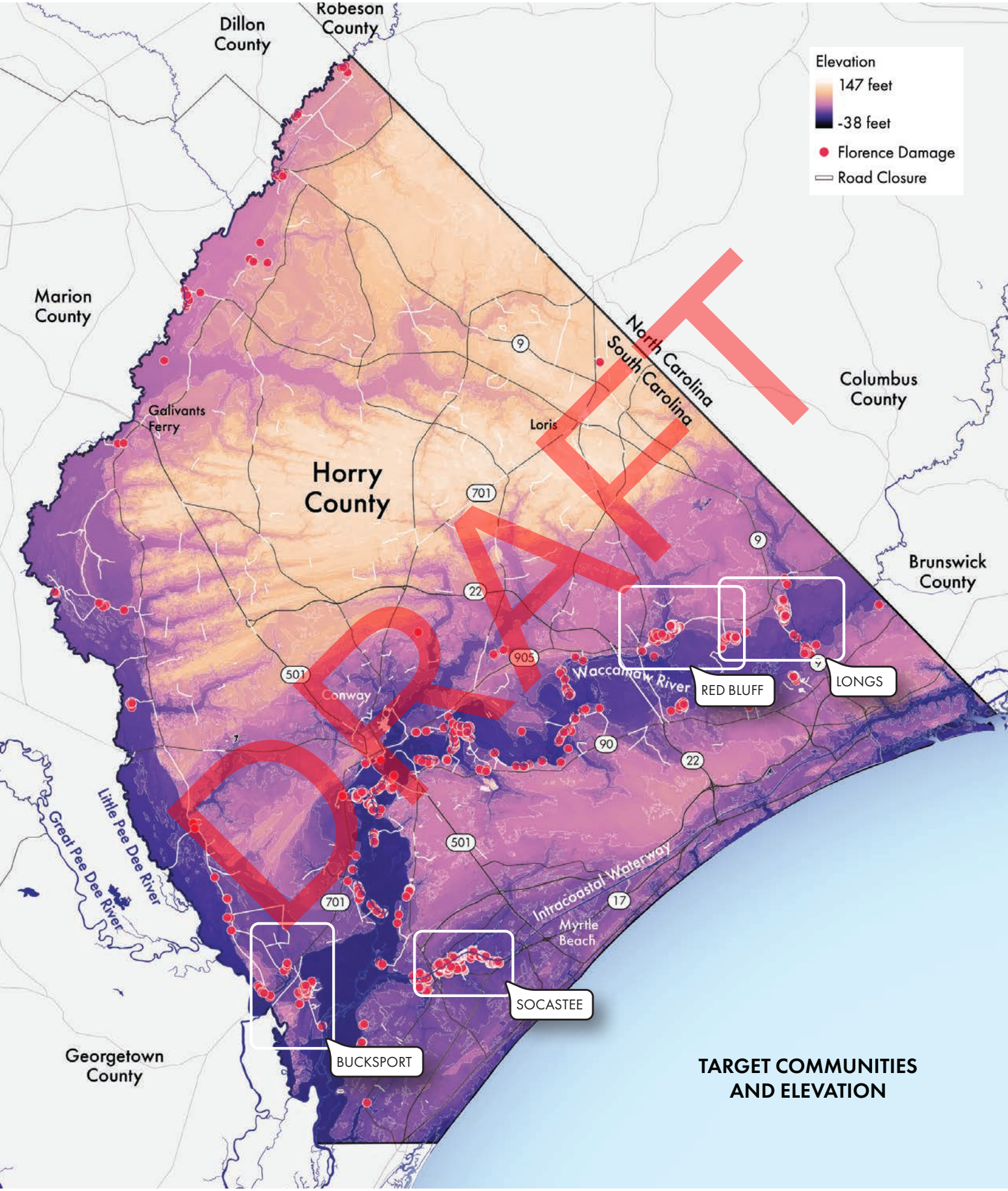
of these systems, the number of storms and the extent of storm damage inevitably increases the amount of limbs, trees and other snags and blockages that reduce the flow rates within the system. The accumulation of debris can contribute to local flooding and impacts the system at large.

EGRESS AND EVACUATION ROUTES

Hurricane Florence resulted in the temporary closure of approximately 465 roads in the County. This proved problematic as flooding conditions continued to worsen in the days following Florence as stormwater continued to drain throughout the watershed towards the ocean. Most neighborhood roads faced the constriction of travel due to flooding about a week after the storm made landfall. The closure of the less traveled neighborhood roads hindered residents' ability to travel or access necessities, like groceries. Additionally, some of the roads that were closed were major travel arteries that are primarily used for means of egress. The closure of these travel arteries resulted in the limitation of resident mobility, the impediment to the flow of goods and services throughout the County, and the constriction of residents' access to jobs and other necessities, such as grocery stores, schools, and hospitals. Some of the roads that were closed and are major arteries of ingress and egress include portions of SC HWY 501, SC HWY 22, SC HWY 9, and Pee Dee Highway. Several major roadways in the County are under review for road raising by the State to enable passage during future storm events. The pressure on the local roadway network from new development will increase the need for adequate evacuation capacity in the future. One of the most consistent concerns raised during community engagement was the inability to access homes after the storm to gauge damage, collect supplies, and return home after evacuating to begin repairs. The extended road closures, both in and out of the County, also impaired the immediate bounce back of the tourism-based job centers at the beach, which were largely unaffected by Florence's flood damage.

POPULATION GROWTH AND FUTURE DEVELOPMENT PATTERNS

The population of Horry County is expected to double in the next 20 years. Growth patterns and population shifts create pressures for new land development across the County. Development engenders the removal of forest and tree canopy, creates impervious areas, and requires new road infrastructure, culverts, and other conveyance structures. The compounding effects of these necessary actions reduce the capacity of the land to store water, thereby increasing the amount of water that cannot be infiltrated and needs to be drained during a rainfall event, exacerbating the naturally occurring flooding issues in the area. As new development remains a critical economic driver, the County has an opportunity to ensure that this new development is balanced with a proactive approach to flood resiliency by encouraging growth in areas that are safe from flooding and incorporate resilient design strategies.



TARGET COMMUNITIES AND ELEVATION

Vulnerabilities in Target Communities

Three target communities that were the focus of this study all have a significant number of buildings, transportation, and infrastructure assets that are highly vulnerable to flooding. Infrastructure vulnerability is often described as a combination of exposure and sensitivity. Assets in these communities are not only highly exposed to flooding, which means they are within a hazardous location (i.e., in a FEMA Special Flood Hazard Area or flooded in a past storm), but many are highly sensitive as well. Sensitivity is related to how an asset would fare if flooded, and is a factor of the physical characteristics of the asset, such as elevation above the ground, age, construction, and condition. The following sections describe each of the target communities, including general characteristics, past storm impacts, and major infrastructure vulnerabilities.

- Bucksport Target Area
- Longs/Red Bluff Target Area
- Socastee Target Area

Bucksport

Bucksport is the most downstream target community, located in southwestern Horry County and nestled between the Great Pee Dee and Waccamaw Rivers, just to the north and east of their confluence. To the west of Bucksport, these two major rivers are connected by Bull Creek, a former channel of the Great Pee Dee. This community is bordered on three sides by the expansive floodplain and wetlands of the Waccamaw National Wildlife Refuge. Overall, Bucksport is low-lying, particularly in developed areas where elevations rarely exceed 17 feet above sea-level.

Bucksport consists of a mixture of residential neighborhoods, small commercial businesses, churches, and public infrastructure including a community center and a water treatment facility. The 2010 US Census Data listed the average age of residents in the Bucksport community is 45 years old, and approximately 70 percent of the homes are owner-occupied (2010 US Census Designated Place data).

Bucksport was named after Captain Henry Buck, who moved to South Carolina in the early 1800's, and opened several lumber mills in the area, taking advantage of the large supply of hardwood, pine, and cypress trees.

DAMAGE FROM FLORENCE

During Florence, flooding came from both the Pee Dee and Waccamaw Rivers. The stream gauge on the Pee Dee River west of Bucksport recorded a peak stage on September 27 around 14 feet above normal.

ASSET VULNERABILITY

Many roads in the Bucksport community are also highly vulnerable to flooding. Bucksport Road, the primary road in the community, was flooded for almost two weeks during Florence. Almost all other residential roads in the area were also flooded to some extent. These extended road closures limited the ability of residents to return home after the storm, check on flooded homes, and even travel to work.

Similar to Socastee, only a small area of Bucksport is included in a Special Flood Hazard Area in the effective (1999) FEMA maps. Most of the buildings flooded during Florence are instead in the X zone (minimal flood hazard). The preliminary FEMA maps show significant change in this area, with most of the Florence-flooded properties within the Special Flood Hazard Areas (100-year floodplain) once the maps are approved. This means when the new maps become effective, over 100 buildings in the Bucksport area will be non-conforming, which could severely impact property and resale values.

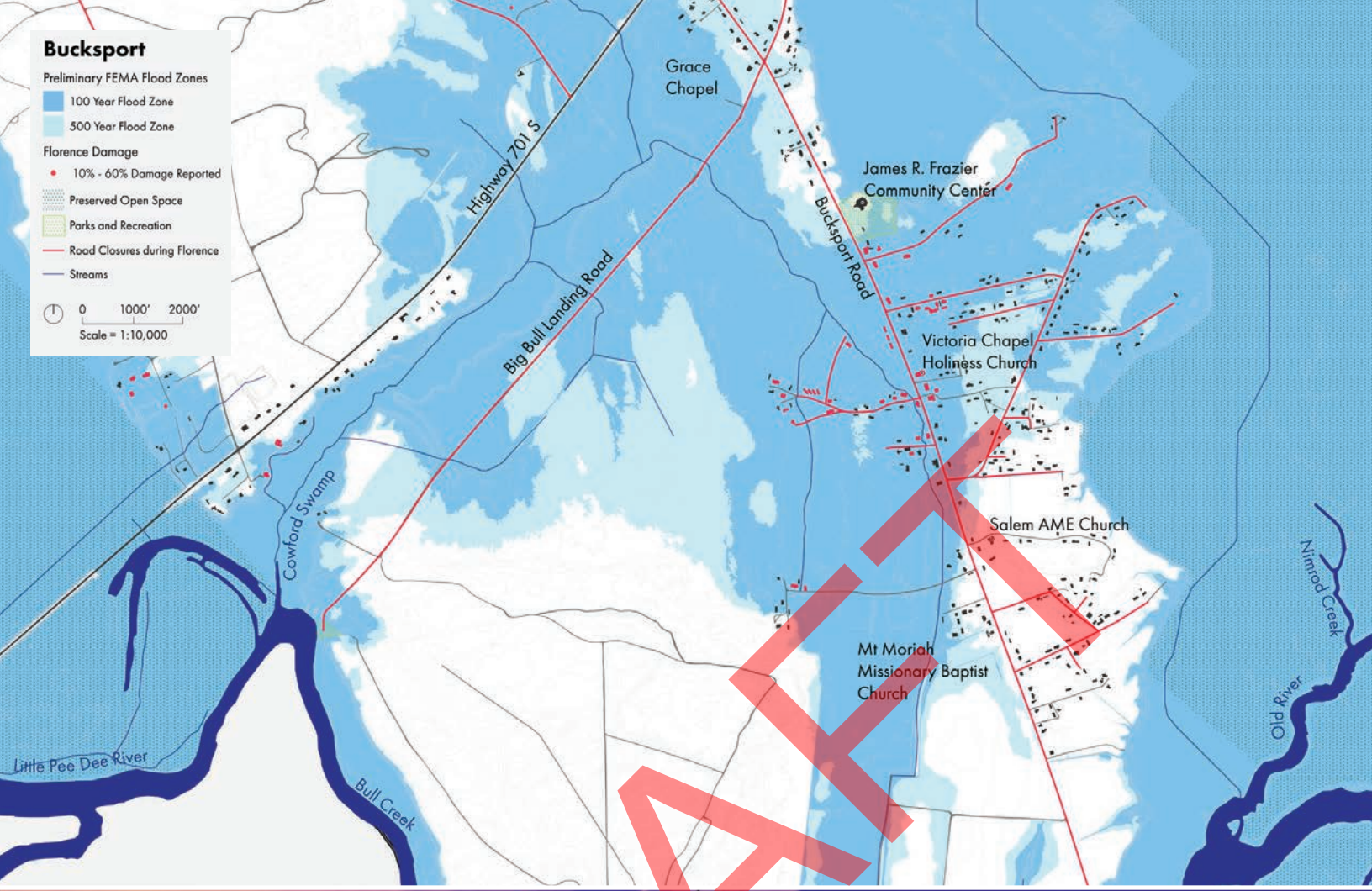
The homes in Bucksport are primarily owner occupied (over 70 percent), compared to many Horry County communities which have a high number of vacation properties, secondary homes, and rentals. In addition, much of the land is part of heirs' property. Issues linked to heirs' property commonly arise when there is more than one property owner holding the land, typically descendants of a common ancestor, and the land is passed down without clear title. A single parcel may have many owners without clear proof of ownership, making it difficult to access credit for loans or participate in any programs offered by the Federal Government to assist property owners to repair damage after storms. This has been (and will continue to be) a major issue for residents in Bucksport trying to access post-storm funding to make home repairs/improvements after major flooding events.

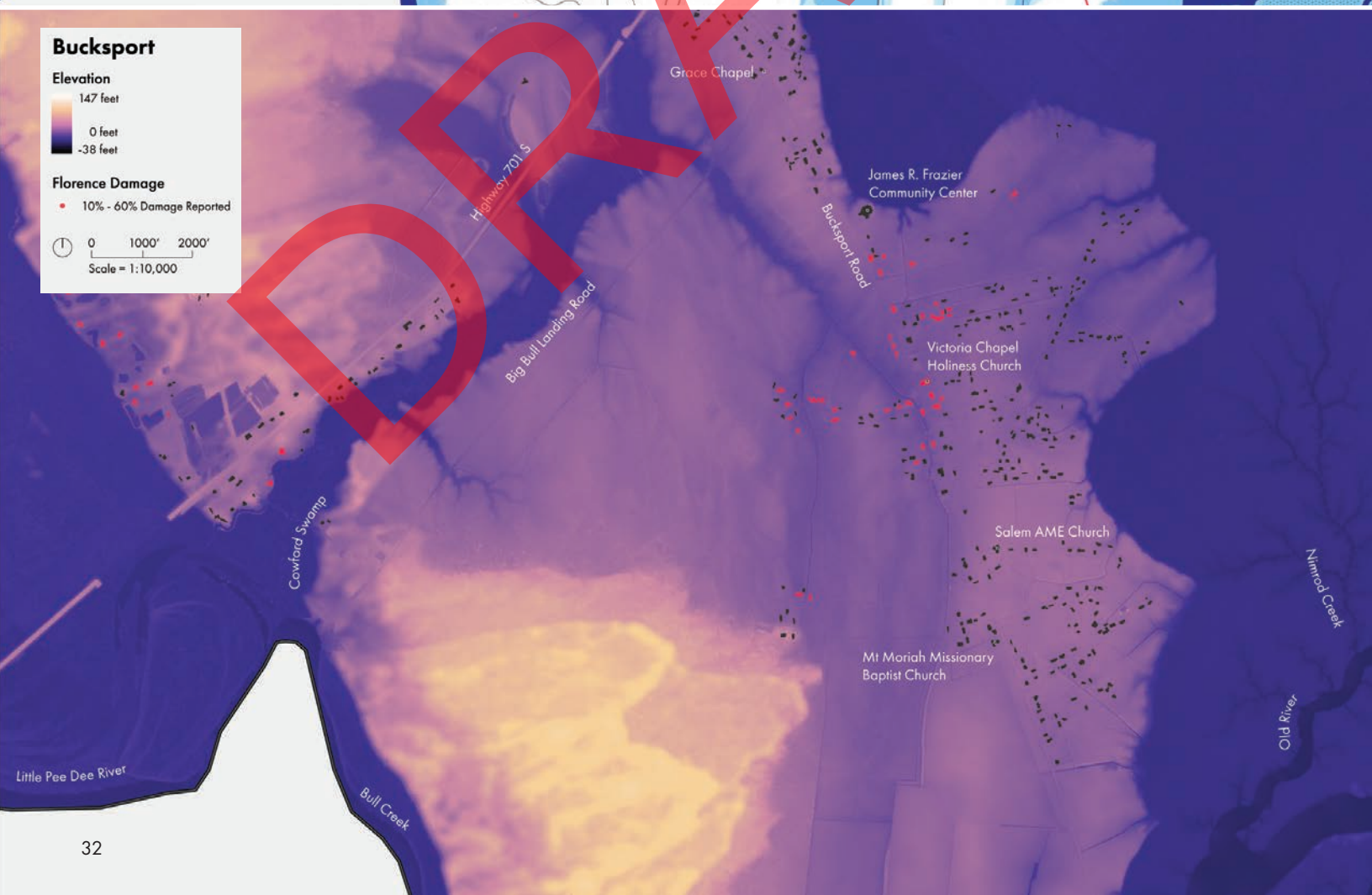
Image: Residents of Bucksport shared their experiences with flooding and recovery during the community engagement meeting in October 2019.

VULNERABILITIES IDENTIFIED DURING PUBLIC ENGAGEMENT WORKSHOP

Like Socastee, Bucksport is also a location of repeated flooding. It is a socially close-knit community with a general reluctance on the part of residents to move to other areas of Horry County, because that would mean having to leave friends and family. This is both a strength and a vulnerability, as the community will be united by projects which keep their neighborhoods intact, but reluctant to accept buyouts of repetitive loss properties.

Common themes that were mentioned by Bucksport residents during the public engagement meetings mentioned elevating highways, such as SC HWY 22, SC HWY 501, Port Harrelson Road, and SC HWY 701. The residents also frequently talked about the inability to travel on the roadways and travel to check on their homes or travel to work.


Bucksport
Preliminary FEMA Flood Zones
100 Year Flood Zone
500 Year Flood Zone
Florence Damage
10% - 60% Damage Reported
Preserved Open Space
Parks and Recreation
Road Closures during Florence
Streams
0 1000' 2000'
Scale = 1:10,000
Grace Chapel
Highway 701 S
James R. Frazier Community Center
Bucksport Road
Big Bull Landing Road
Victoria Chapel Holiness Church
Cowford Swamp
Salem AME Church
Nimrod Creek
Mt Moriah Missionary Baptist Church
Old River
Little Pee Dee River
Bull Creek


Bucksport
Elevation
147 feet
0 feet
-38 feet
Florence Damage
10% - 60% Damage Reported
0 1000' 2000'
Scale = 1:10,000
Grace Chapel
Highway 701 S
James R. Frazier Community Center
Bucksport Road
Big Bull Landing Road
Victoria Chapel Holiness Church
Cowford Swamp
Salem AME Church
Nimrod Creek
Mt Moriah Missionary Baptist Church
Old River
Little Pee Dee River
Bull Creek

A ramp up to an elevated home in Bucksport in October 2019
Source: WCU/SDE/CASE/ONE

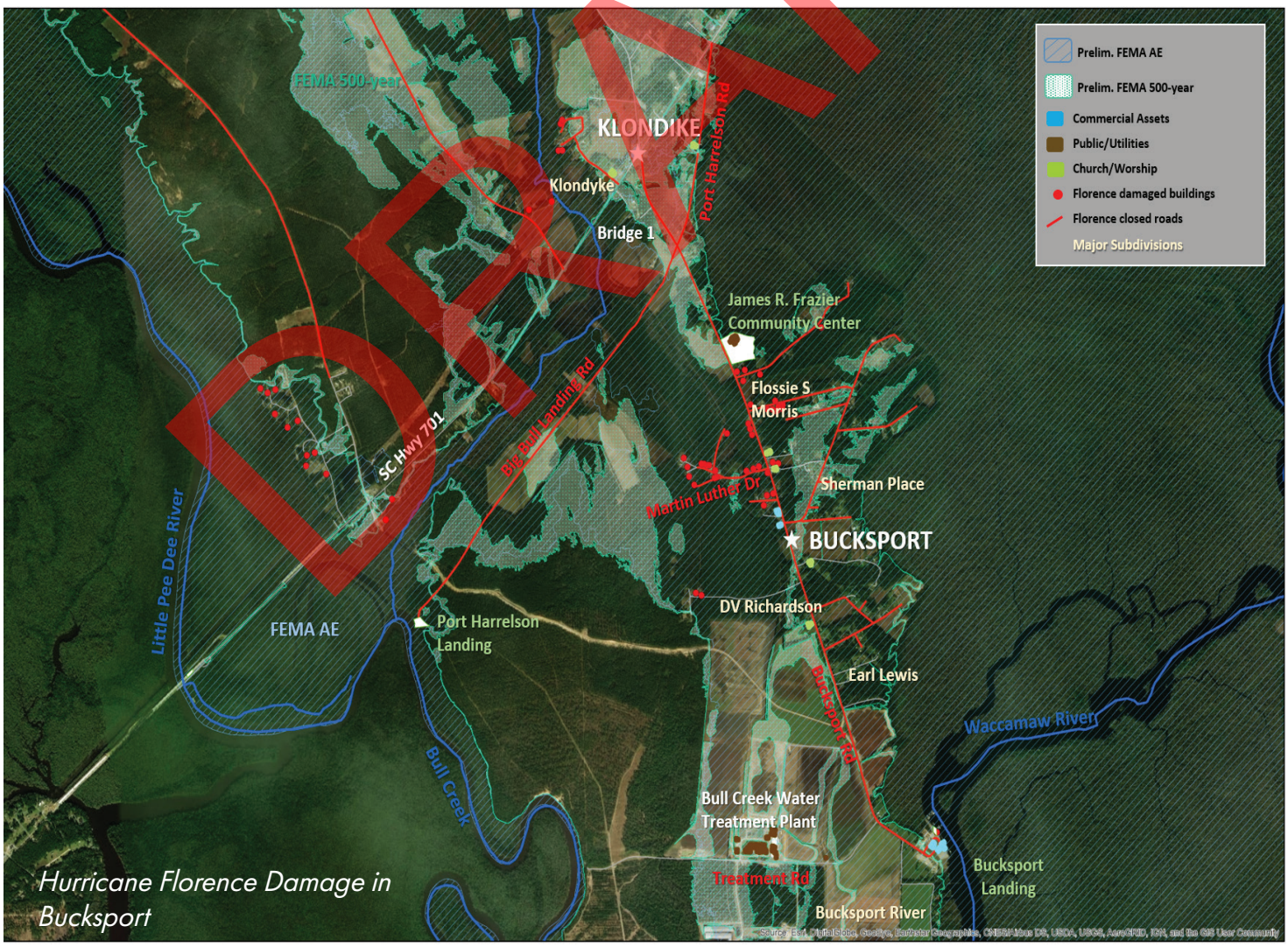
A drainage corridor in Bucksport in October 2019
Source: WCU/SDE/CASE/ONE

BUCKSPORT ASSET INVENTORY

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Transportation		
Hwy 701		AE, 500-year, X
		AE
Mosdell Drive	Yes	AE
Port Harrelson Road	Yes	AE
Big Bull Landing Road	Yes	AE
Mishoe Road	Yes	AE
Ole Bellamy Drive	Yes	AE
Bethune Drive	Yes	AE
Martin Luther Drive	Yes	AE
Mahalia Drive	Yes	AE
Magnum Drive	Yes	AE
Broadway Street	Yes	AE
Rutledge Street	Yes	AE
Railroad Drive	Yes	AE
Old Magnolia Lane	Yes	AE
Sherman Place	Yes	AE
Beth Drive	Yes	AE
Isabella Drive	Yes	AE
Still Meadow Drive	Yes	AE
Glover Road	Yes	AE
Ole Moore Drive	Yes	AE
Treatment Road		AE, 500-year, X
Bridge 1 (Cowford Swamp - HWY 701)		AE
Major Subdivisions		
Buck Forest		AE, 500-year

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Subdivisions		
Bucksport Heights	Yes	AE, 500-year
Bucksport River		AE
DV Richardson		AE, 500-year
Earl Lewis		AE
Flossie S Morris	Yes	AE, 500-year
Klondyke		AE, 500-year
Sherman Place		AE, 500-year
Recreation		
Bucksport Landing	Yes	AE
Port Harrelson Landing	Yes	AE
Major Commercial & Public Structures		
Bethel Seventh Day Adventist Church		AE, 500-year
Bucksport Marina	Yes	AE
Car Wash		500-year
Glenda's		AE
GSWSA Bull Creek Water Treatment Plant		AE, 500-year
Horry Telephone Cooperative Inc		AE, 500-year
James R. Frazier Community Center		AE
Jerusalem Baptist Church		AE
Mt. Moriah Baptist Church		AE
Salem AME Church		AE
Store - Bucksport Road		AE
Store - Hwy 701		500-year
Victory Church	Yes	AE
Victoria Chapel Holiness Church	Yes	AE

Bucksport is located on a peninsula between the Little Pee Dee and Waccamaw rivers. This area experienced flooding as water breeched Big Bull Landing Road and crept in the community through the drainage system. The community also experienced flooding from the opposite side from the Waccamaw River. The flooding from these two rivers converged and washed over Bucksport Road, the main point of access in the community. Many homes were damaged during Florence; however, after the waters subsided, the availability of public recovery assistance was limited. At the time, the area was not located in the regulatory flood zone, which meant that few property owners had flood insurance. In addition to this, heir's properties had limited public funding opportunities because the property ownership was not determined. During public input sessions, residents expressed their desire to repair their homes and remain living in their community. Moving forward, the County will need to continue to coordinate with residents to help them receive assistance. Additionally, the federal government is working to revise their funding assistance programs to provide assistance to heir's properties that are damaged in future floods.



Hurricane Florence Damage in Bucksport

Longs

Longs is the northernmost impacted community targeted in this study, located north of the confluence of the Waccamaw River and Buck Creek. Longs lies a few miles southwest of the North Carolina border, near the intersection of SC HWY 9 and SC HWY 905. This small unincorporated community consists primarily of residential neighborhoods, subdivisions, small commercial businesses, and golf courses. The average age of residents in the Longs community is 47 years old, and approximately 61 percent of the homes are owner-occupied (2010 census block data).

DAMAGE FROM FLORENCE

During Florence, the Waccamaw River gauge near Longs recorded a peak stage on September 21, 2018, of approximately 18 feet above normal. A second stream gauge along Buck Creek also recorded a peak stage of almost 15 feet above normal. Buck Creek is a tributary of the Waccamaw River, and properties and infrastructure near the confluence of these two water bodies experienced widespread flooding.

Post-storm assessments in the greater Longs vicinity showed that more than 130 buildings were damaged by flooding during Florence. Approximately 15 of these buildings were also damaged during Matthew in 2016. The highest concentration of buildings damaged by Florence flooding in Longs were in Aberdeen Country Club, which lies northwest of the Waccamaw/Buck Creek confluence. A majority of the neighborhood was flooded (more than 100 buildings), with some buildings inundated by over three feet of water.

ASSET VULNERABILITY

Most of the buildings in Longs that are highly vulnerable to flooding are residential or small commercial businesses. This includes multiple single and multi-family homes within Aberdeen Country Club, a cluster of homes located less than a mile north in the Rolling Ridge Subdivision, and several small commercial businesses along SC HWY 9, south of the Waccamaw River. These buildings are not only highly exposed to flooding, but many are highly sensitive as well. Most buildings in this area are not elevated on stilts or pilings, although some homes in the Aberdeen neighborhood were built on ground elevated with fill material, and many were still flooded during Florence. This indicates that the height of elevation was not sufficient to reduce sensitivity and overall vulnerability.

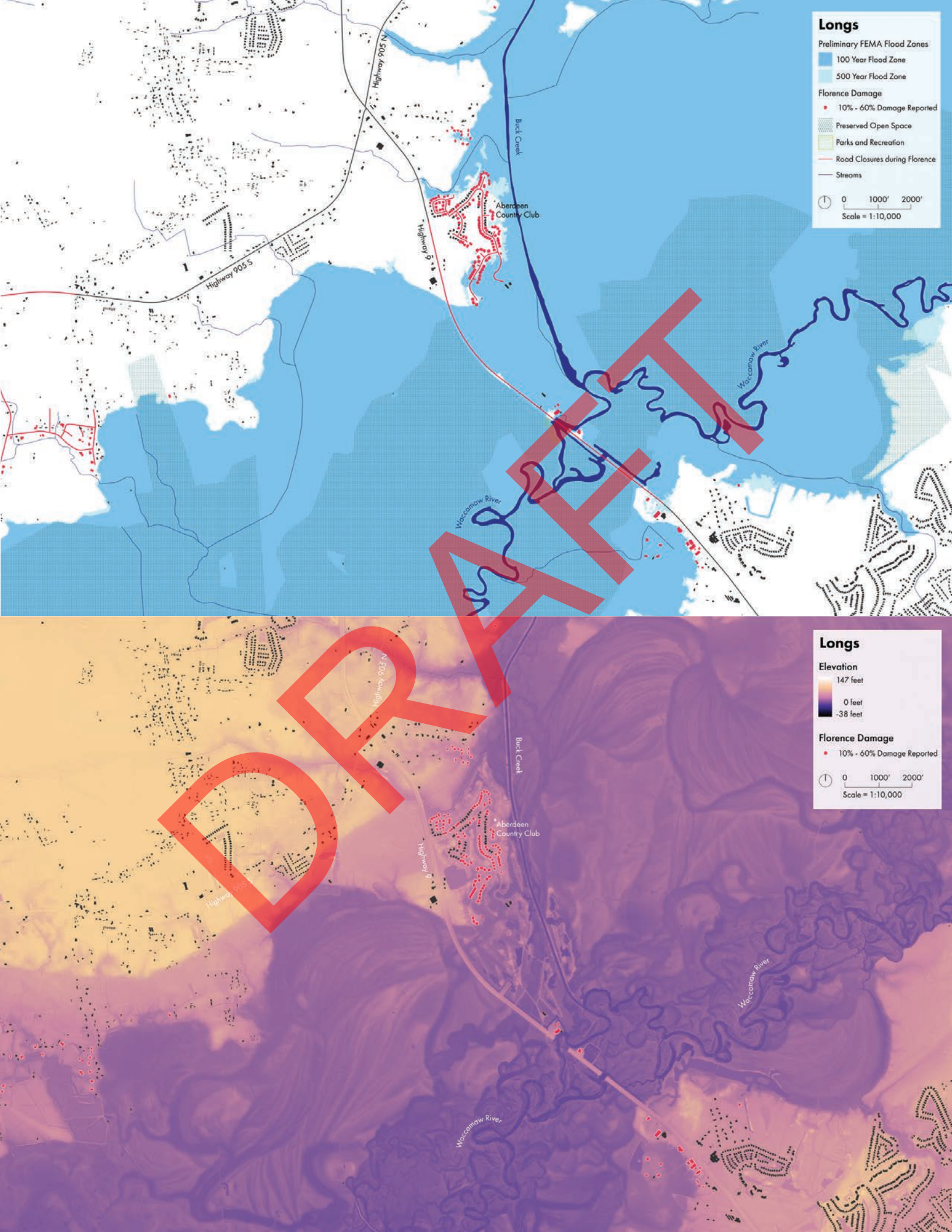
In addition to building vulnerability, Longs has several transportation corridors that are highly susceptible to flooding. During Florence, a number of major roads were flooded, causing extended closures and in some cases washout damage. The portion of SC HWY 9 that stretches across the Waccamaw floodplain south of Aberdeen, which is the primary route for those traveling to Little River and North Myrtle Beach, was closed for nearly two weeks after Florence due to flooding and washout, as was the major evacuation corridor of SC HWY 905 just west of Longs near Chestnut Crossroads. Another section of SC HWY 905 that runs across Buck Creek (northeast of Longs) was also closed due to flooding for almost seven days. While flood waters do not always cause extensive physical damage to roads, the extended closures severely restrict travel, limiting the availability of supplies and hindering residents trying to return home.

On both sides of the Waccamaw River, there are established communities that were built before recent development regulations were put in place. These historic settlement areas may be more prone to flooding from storms that are producing flooding that extends beyond what was previously the designated floodplain. There are many creeks and streams that feed the Waccamaw River in this area and contribute to the overall storage capacity in this section of the County. Much of the flooding in the area emanated from these streams and systems that feed the Waccamaw. Buck Creek and Simpson Creek are notable examples.

Another factor that adds to the overall vulnerability of infrastructure and future development in Longs is the discrepancy between where flooding has occurred in the past, and the areas designated as highest risk by FEMA. Much of the area that was flooded during Florence (and Matthew) is not located within FEMA's Special Flood Hazard Areas, commonly known as the 100-year floodplains. For instance, most of the buildings in Aberdeen that flooded during Hurricane Florence are not in the Special Flood Hazard Area or FEMA maps. Instead, in both FEMA maps most properties in this neighborhood are within the X zone (minimal flood hazards, outside the 500-year flood zone). Future structures built in zone X are not required to build to the same standards as those in the Special Flood Hazard Areas.

Image: Residents of Longs, Red Bluff, Little River, and nearby communities shared their experiences with flooding and recovery during the community engagement meeting in October 2019.

Longs is among the fastest growing areas within the county, with future growth projected at 368% according to *Imagine 2040,* Horry County's long-range plan. There are 38 planned subdivisions (i.e., incomplete, not-started, or active rezoning case) upstream from Longs within the Buck Creek watershed. These landscape changes have the potential to impact the downstream reaches of the watershed during future floods.


Longs
Preliminary FEMA Flood Zones
100 Year Flood Zone
500 Year Flood Zone
Florence Damage
10% - 60% Damage Reported
Preserved Open Space
Parks and Recreation
Road Closures during Florence
Streams
0 1000' 2000'
Scale = 1:10,000
Highway 905 N
Highway 905 S
Buck Creek
Aberdeen Country Club
Waccamaw River
Waccamaw River
Longs
Elevation
147 feet
0 feet
-38 feet
Florence Damage
10% - 60% Damage Reported
0 1000' 2000'
Scale = 1:10,000
Highway 905 N
Highway 905 S
Buck Creek
Aberdeen Country Club
Waccamaw River
Waccamaw River
DRAFT

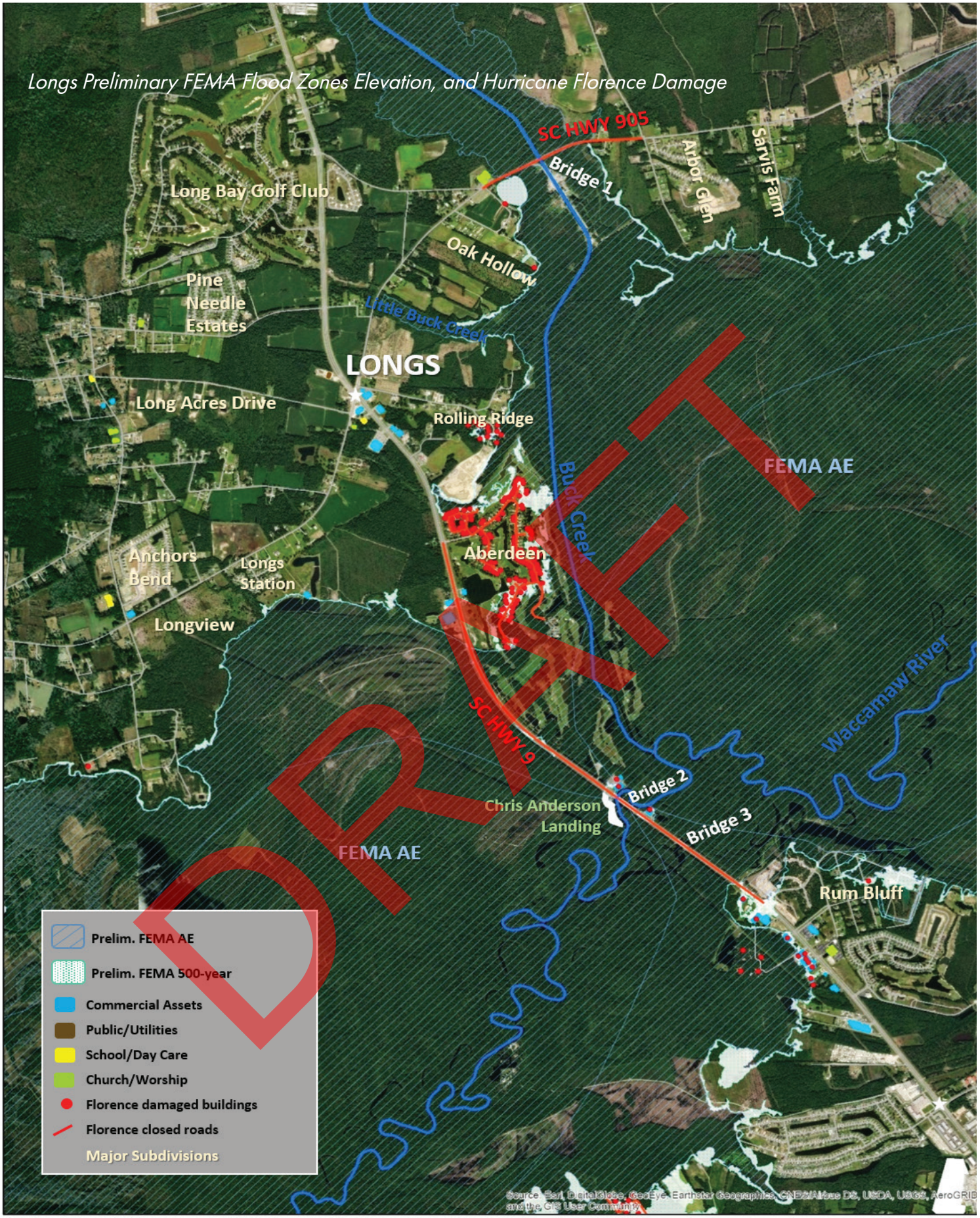
Flooding in Aberdeen following Hurricane Florence
Source: Department of Natural Resources (DNR)

View of Aberdeen
Source: realtor.com

LONGS ASSET INVENTORY

SC HWY 905	Yes	AE
Bridge 1 (Buck Creek - SC HWY 905)	Yes	AE
Bridge 2 (Waccamaw - SC HWY 9)	Yes	AE
	Yes	AE
Major Residential Subdivisions		
Aberdeen Country Club	Yes	AE, 500-year, X
Long Bay Golf Club		X
Pine Needle Estates		X
Arbor Glen		X
Sarvis Farms		X
Rolling Ridge	Yes	AE, 500-year, X
Oak Hollow	Yes	AE, 500-year, X
Rum Bluff	Yes	AE, 500-year, X
Long Acres Drive		X
Anchors Bend		X
Longs Station		X
Longview		X
Recreation		
Chris Anderson Landing	Yes	AE
Major Commercial and Public Structures		
A Plus Auto Sales		X
Big E's	Yes	500-year
Bottle Bungalow Liquor		X
Buck Creek Baptist Church		X
Canipes Candy Factory	Yes	AE, 500-year
Carefree Exterior	Yes	500-year
Claridy Funland Day Care		X
Clubhouse - Freemont Road		X
Coastal Sleep Lab		X

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Cornell & Diehl - SMH Buildings LLC		X
Designed for Life LLC	Yes	X
Dollar General		X
Ebenezer School		X
Ebenezer UMC Church		X
Exxon Tiger Mart		X
EZ Storage of Horry County LLC		X
Food Lion		X
Freedom Deliverance Center		X
Freemont Baptist Church		X
Golden Paws		X
Horry's Restaurant	Yes	500-year
Horry Telephone Coop Inc.		X
Kevins Auto Repair	Yes	500-year
Laudisi Enterprises		X
Little River Alternators	Yes	X
Living Water Baptist Church		X
Longs Head Start		X
Longs Mini Storage		X
Minuteman - Marathon Gas & Little Caesars		X
Norris Property LLC		500-year
Rustically Refined - Designed for Life LLC	Yes	X
Sand Beachwear Inc	Yes	X
SC DOT		X
Shell Station		X
Southern Breeze Contracting LLC		X
Southern Breeze Car Wash		X
Strategic Business Concepts LLC	Yes	X
Sun Colony Plaza		X
Williams Arcade		X
Wynna Renea LLC	Yes	AE


Longs Preliminary FEMA Flood Zones Elevation, and Hurricane Florence Damage
SC HWY 905
Bridge 1
Arbor Glen
Sarvis Farm
Long Bay Golf Club
Oak Hollow
Pine Needle Estates
Little Buck Creek
LONGS
Long Acres Drive
Rolling Ridge
Buck Creek
FEMA AE
Aberdeen
Anchors Bend
Longs Station
Longview
Waccamaw River
SC HWY 9
Bridge 2
Bridge 3
Chris Anderson Landing
FEMA AE
Rum Bluff
DRAFT
Prelim. FEMA AE
Prelim. FEMA 500-year
Commercial Assets
Public/Utilities
School/Day Care
Church/Worship
Florence damaged buildings
Florence closed roads
Major Subdivisions
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID and the GIS User Community

Red Bluff

The community of Red Bluff is located north of the confluence of the Waccamaw River and Simpson Creek. Todd Swamp, a tributary of Simpson Creek, also runs through a portion of this community. Red Bluff is located several miles southwest of Longs along SC HWY 905, and in this study, includes the small community of Chestnut Crossroads (northeast). These small unincorporated communities are primarily residential neighborhoods, subdivisions, a small number of commercial businesses, and timber farms. According to the 2010 census data, the average age of residents in this community is 40 years old, and approximately 66 percent of the homes are owner-occupied (2010 census block data).

DAMAGE FROM FLORENCE

During Florence, a rapid-deployment gauge on the Waccamaw River near Red Bluff recorded a peak stage on September 23, 2018, of approximately 18 feet above normal. The highest concentration of buildings damaged in this community was in the Polo Farms neighborhood, which is situated east of Simpson Creek (a tributary of the Waccamaw River). Other damaged buildings were located near Todd Swamp. Most buildings in the Red Bluff vicinity were inundated by less than one foot of water during Florence, with some flooded up to four feet. Post-storm assessments in the greater Red Bluff area showed almost 200 buildings were damaged by flooding.

ASSET VULNERABILITY

Residential structures make up the majority of the high-vulnerability buildings in the Red Bluff area. This includes single family homes in the RL Wiggins Jr Lots (west of Simpson Creek) and Polo Farms subdivision, as well as scattered homes in south Chestnut Crossroads. Most of these buildings are both highly exposed to flooding (in a hazardous location), and highly sensitive (would not fare well if flooded). The Polo Farms neighborhood was built on ground elevated with fill material; however, most were still flooded during Florence, indicating that the elevation was not sufficient to mitigate flooding.

Red Bluff has several transportation corridors that are highly vulnerable to flooding. They include large portions of four major highways, including SC HWY 22, SC HWY 554, SC HWY 31, and SC HWY 905. During Florence, significant portions of these highways were closed for extended periods of time due to flooding. A portion of SC HWY 905 stretching across most of the Red Bluff and Chestnut Crossroads community was closed for nearly two weeks after Florence, and SC HWY 31 was closed across the Waccamaw River floodplain for nearly a month. Secondary roads near the damaged homes in this area (such as in Polo Farms) were also flooded for several weeks. There are also numerous bridges in this community that were closed along with the roads during Florence. While flood waters do not always cause extensive physical damage to roads and bridges, the extended closures severely restricted travel, limiting the availability of supplies and hindering residents trying to return to home after evacuating for the hurricane.

As in Longs, much of the Red Bluff area that was flooded during Florence is not classified in FEMA's highest risk zones. The Polo Farms neighborhood was originally within the FEMA-designated AO zone in the effective (2003) FEMA maps. The developer and engineer of Polo Farms requested (and was granted) multiple Letter of Map Revisions (LOMRs). These removed the area from this zone and placed it in the X zone, which denotes minimal flood hazards. The LOMRs were based on an engineering study showing that the neighborhood had sufficient elevation from fill to be outside the 100-year floodplain. The preliminary FEMA maps do include portions of the Polo Farms neighborhood in the Special Flood Hazard Area. However, many Florence-damaged homes in this area are well outside the preliminary FEMA 100- and 500- year floodplain. These inconsistencies between where flooding has occurred in the past and the areas designated as highest risk by FEMA add to the overall vulnerability of current properties and future development in this area.

VULNERABILITIES IDENTIFIED DURING PUBLIC ENGAGEMENT WORKSHOP

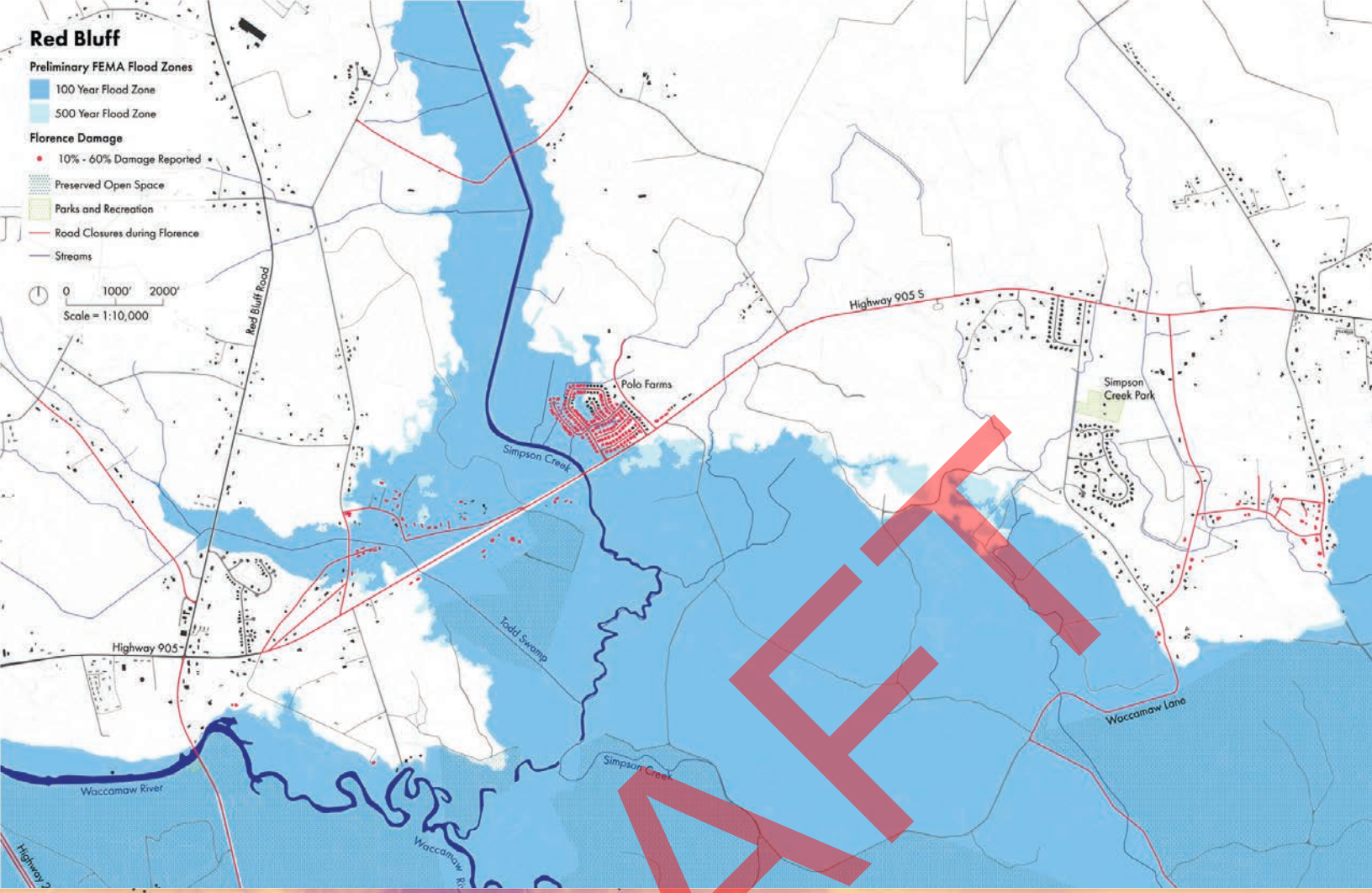
Due to their geographic proximity and their shared characteristic of having been built during the 2000s, the Longs and Red Bluff communities were grouped together for the workshop. A significant similarity regarding vulnerability and resilience involves the transportation network serving both communities. Several anecdotal comments during the public engagement process indicated that roadways in this part of Horry County often appear to create dam conditions at river and stream crossings during flood events. Additionally, some of the installed stormwater management features were identified as potentially ineffective at addressing the level of flooding experienced during Hurricane Florence.

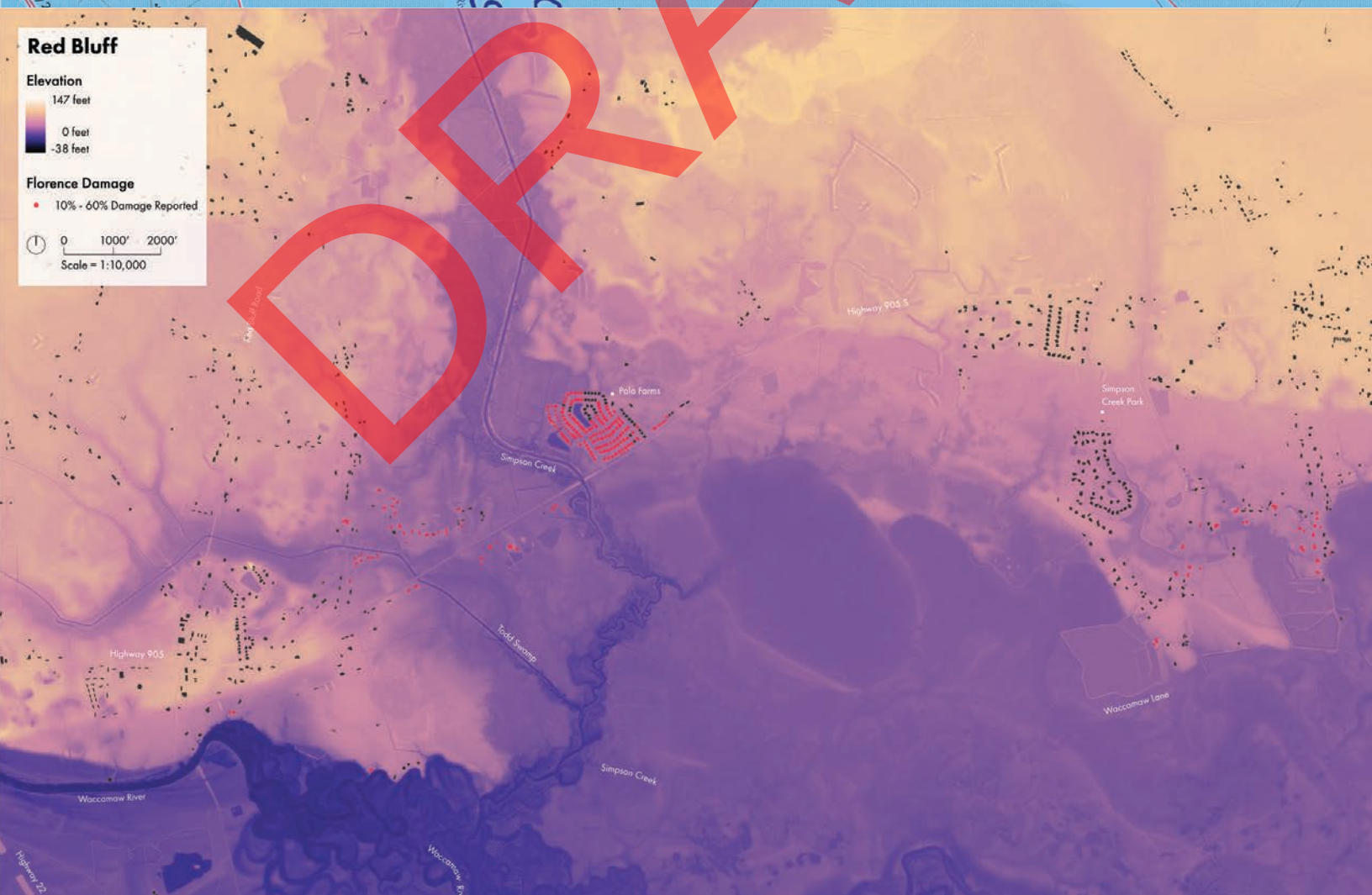
Image: Residents of Longs, Red Bluff, Little River, and nearby communities shared their experiences with flooding and recovery during the community engagement meeting in October 2019.

For example, residents indicated that the berms installed in the Aberdeen neighborhood were insufficient to hold back floodwaters from Buck Creek, and a backflow situation at the Polo Farms neighborhood in Red Bluff siphoned stormwater into the neighborhood through the retention ponds, both seeming to cause an earlier onset of flooding. In general, although infeasible due to the balance of costs and benefits, the community identified dredging as a potential relief mechanism, both by dredging the Waccamaw, and the smaller systems that feed the Waccamaw, like Buck Creek and Simpson Creek.

Some common themes expressed by the residents of these communities regarding vulnerability, resiliency, and potential solutions included dredging the Waccamaw River, clearing Buck and Simpson Creek, and implementing more road drainage, especially on SC HWY 57 and SC HWY 90.

A significant number of the workshop attendees reside outside the target area between the eastern shore of the Waccamaw River and SC HWY 57. The consistent message from these residents is that flooding happens often (even during localized rain events), blocks local streets, and impacts many houses during Florence.


Red Bluff
Preliminary FEMA Flood Zones
100 Year Flood Zone
500 Year Flood Zone
Florence Damage
10% - 60% Damage Reported
Preserved Open Space
Parks and Recreation
Road Closures during Florence
Streams
0 1000' 2000'
Scale = 1:10,000
Red Bluff Road
Highway 905 S
Polo Farms
Simpson Creek Park
Simpson Creek
Todd Swamp
Highway 905
Waccamaw River
Waccamaw Lane


Red Bluff
Elevation
147 feet
0 feet
-38 feet
Florence Damage
10% - 60% Damage Reported
0 1000' 2000'
Scale = 1:10,000
Highway 905 S
Polo Farms
Simpson Creek Park
Simpson Creek
Todd Swamp
Highway 905
Waccamaw Lane
Waccamaw River

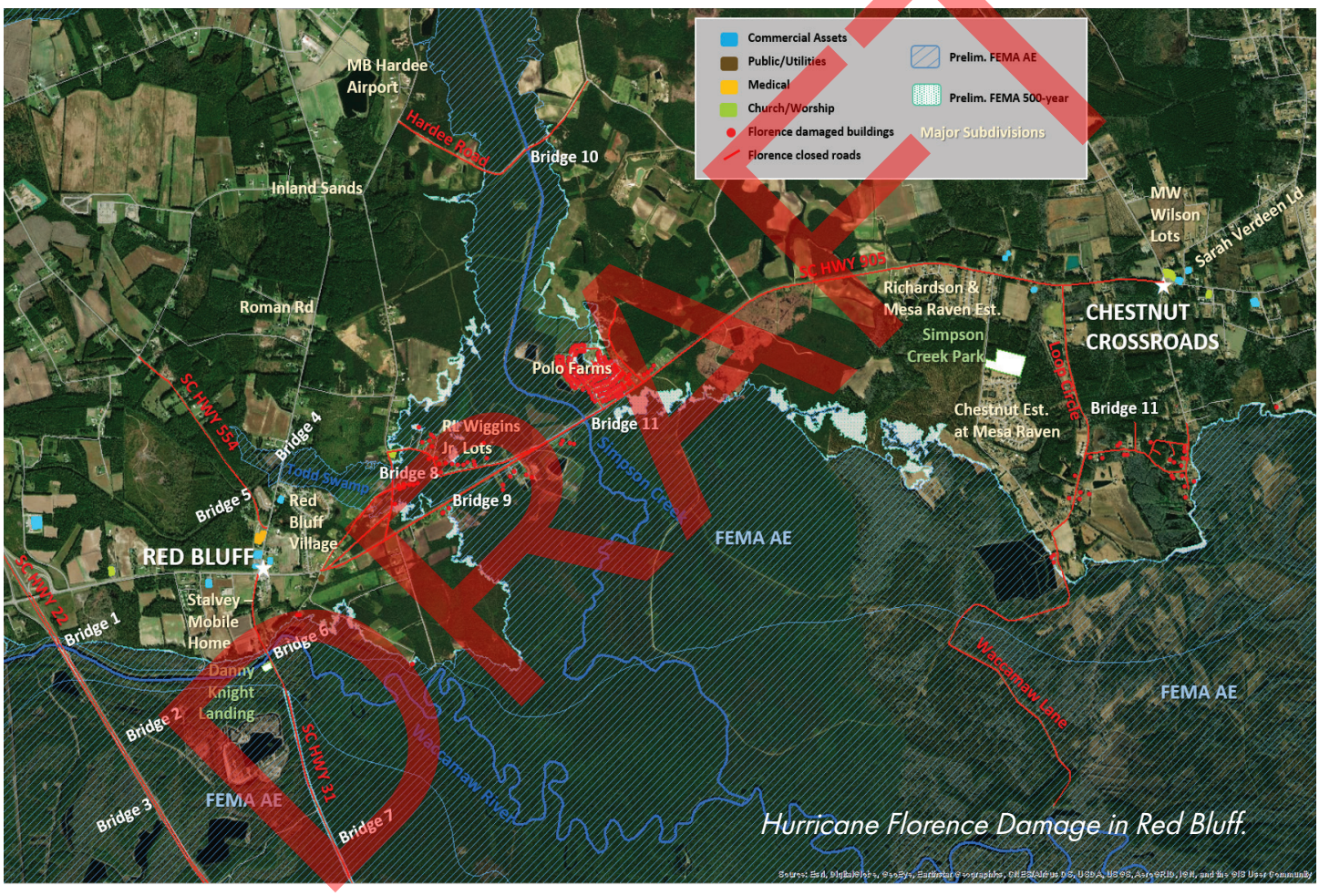
A detention pond in Polo Farms in October 2019
Source: WCU/SDE/CASE/ONE

A drainage corridor in Polo Farms in October 2019
Source: WCU/SDE/CASE/ONE

RED BLUFF ASSET INVENTORY

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Transportation		
SC HWY 22	Yes	AE
		AE
	Yes	
Bridge 1 (Waccamaw River - SC HWY 22)	Yes	
Bridge 2 (Jones Big Swamp - SC HWY 22)	Yes	
Bridge 3 (Jones Big Swamp 2 - SC HWY 22)	Yes	
Bridge 4 (Todd Swamp - Red Bluff Road)	Yes	
Bridge 5 (Todd Swamp - SC HWY 554)	Yes	
Bridge 6 (Waccamaw River - SC HWY 31)	Yes	
Bridge 7 (Waccamaw River Swamp - HWY 31)	Yes	
Bridge 8 (Todd Creek - McNeil Chapel)		AE
Bridge 9 (Todd Creek - SC HWY 905)	Yes	AE
Bridge 10 (Simpson Creek - Hardee Road)	Yes	
Bridge 11 (Simpson Creek - SC HWY 905)	Yes	AE
Major Subdivisions		

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Subdivisions		
RL Wiggins Jr Lots	Yes	AE
Polo Farms		
Richardson/Mesa Raven Estates		X
Chesnut Estates at Mesa Raven		X
Mary Williams Wilson Lots		X
Recreation		
Major Commercial & Public Structures		


Commercial Assets
Public/Utilities
Medical
Church/Worship
Florence damaged buildings
Florence closed roads
Prelim. FEMA AE
Prelim. FEMA 500-year
Major Subdivisions
MB Hardee Airport
Hardee Road
Bridge 10
Inland Sands
Roman Rd
SC HWY 905
Richardson & Mesa Raven Est.
Simpson Creek Park
MW Wilson Lots
Sarah Verdeen Ld
CHESTNUT CROSSROADS
Loop Circle
Bridge 11
Chestnut Est. at Mesa Raven
Polo Farms
SC HWY 554
Bridge 4
Todd Swamp
Bridge 5
Bridge 8
Bridge 9
RL Wiggins Jr. Lots
Simpson Creek
Red Bluff Village
RED BLUFF
FEMA AE
SC HWY 22
Bridge 1
Stalvey – Mobile Home
Bridge 6
Danny Knight Landing
Bridge 2
SC HWY 31
Waccamaw River
Waccamaw Lane
Bridge 3
Bridge 7
DRAFT
Hurricane Florence Damage in Red Bluff.

Socastee

The target community of Socastee is adjacent to the Intracoastal Waterway, approximately four miles east of the confluence with the Waccamaw River. Socastee is an established community that consists of a mixture of older subdivisions from the twentieth century as well as new construction. Socastee is more developed than the other target communities (in the 90th percentile of population density compared to other South Carolina areas) and consists of a mixture of residential neighborhoods and subdivisions, commercial businesses, and public infrastructure, such as schools and churches. The average age of residents in the Socastee community is 38 years old, and approximately 67 percent of the homes are owner-occupied.

DAMAGE FROM FLORENCE

During Florence, the river gauge along the Intracoastal Waterway in Socastee recorded a peak stage on September 27, 2018, of approximately nine feet above normal. Much of this community was built on the low-lying geomorphic floodplain of Socastee Swamp (now bisected by the AIWW), which was flooded as water backed up at the confluence with the Waccamaw River. A large number of buildings in the Socastee community were damaged by flooding during Hurricane Florence. Some of the worst flooding was concentrated in the Rosewood, Bridge Creek, Lawson's Landing, and Watson's Riverside neighborhoods, with water levels up to six feet in some homes. Post-storm assessments in the Socastee vicinity showed almost 565 buildings were damaged by flooding.

ASSET VULNERABILITY

Overall, Socastee is low in elevation, with a large portion of the area less than ten feet above sea-level. When low lying land is poorly drained, it retains water for longer periods, and the ability for water to infiltrate is restricted due to the decreased void space, and thus increasing the amount of surface runoff. As a result, this community had particularly high water levels during Matthew and Florence.

Of all the target communities, Socastee has the highest number of properties identified as repetitive loss. Repetitive loss properties are defined as having two or more claims of more than $1,000 paid by the National Flood Insurance Program (NFIP) in a ten-year period. The last NFIP Repetitive loss report was completed in 2018, prior to the onset of Hurricane Florence. At that time, data showed approximately 50 properties were identified as repetitive loss in the Socastee area. It is anticipated that this number will substantially increase due to Florence impacts. Analysis of post-storm damage data from this area shows approximately 320 buildings were damaged during Matthew and 565 during Florence (using the Socastee Census Designated Place boundary).

Most of the high vulnerability buildings in the Socastee area are residential. This includes mostly single-family homes in the Rosewood, Bridge Creek, Lawson's Landing, Watson's Riverside, Island Reef, Bellamy, and Harbour Town subdivisions. Many of the homes that were built directly on the Intracoastal Waterway are elevated several feet above the ground (on blocks/stilts), and therefore, set above the floodplain. However, the predominant development typology of most homes is slab on grade construction. Many of the homes that were built at-grade or raised slightly above grade (some are in the process of being elevated post-Florence) were severely flooded during Florence. In addition to flooding during Hurricane Florence, repetitive flooding in this area often occurs in the absence of severe storms, due to the position of this area downstream from other areas that may be experiencing extreme storms. Because many of these homes are older, had recent or repetitive losses, and were built at grade, there is a high overall risk to flooding in this community.

Transportation corridors in the Socastee community are also highly vulnerable to flooding. Numerous residential streets in Socastee were closed during Florence, particularly in the subdivisions with a high number of damaged homes. While flood waters do not always cause extensive physical damage to roads, the extended closures severely restrict travel, hindering residents trying to return to home.

In much of Socastee, only a narrow strip of land that is less than several hundred feet wide along the Intracoastal Waterway is included in a Special Flood Hazard Area in the effective (1999) FEMA maps. Less than 20 percent of the buildings damaged by flooding during Florence (96 of 565 total) were within the effective FEMA SFHA (using the Socastee Census Designated Place Boundary). Most of the buildings and roads flooded during Florence are instead in the shaded X zone (moderate flood hazard, in the limits of the 500-year floodplain). The effective maps grossly underestimate the flood risk in this area, and most

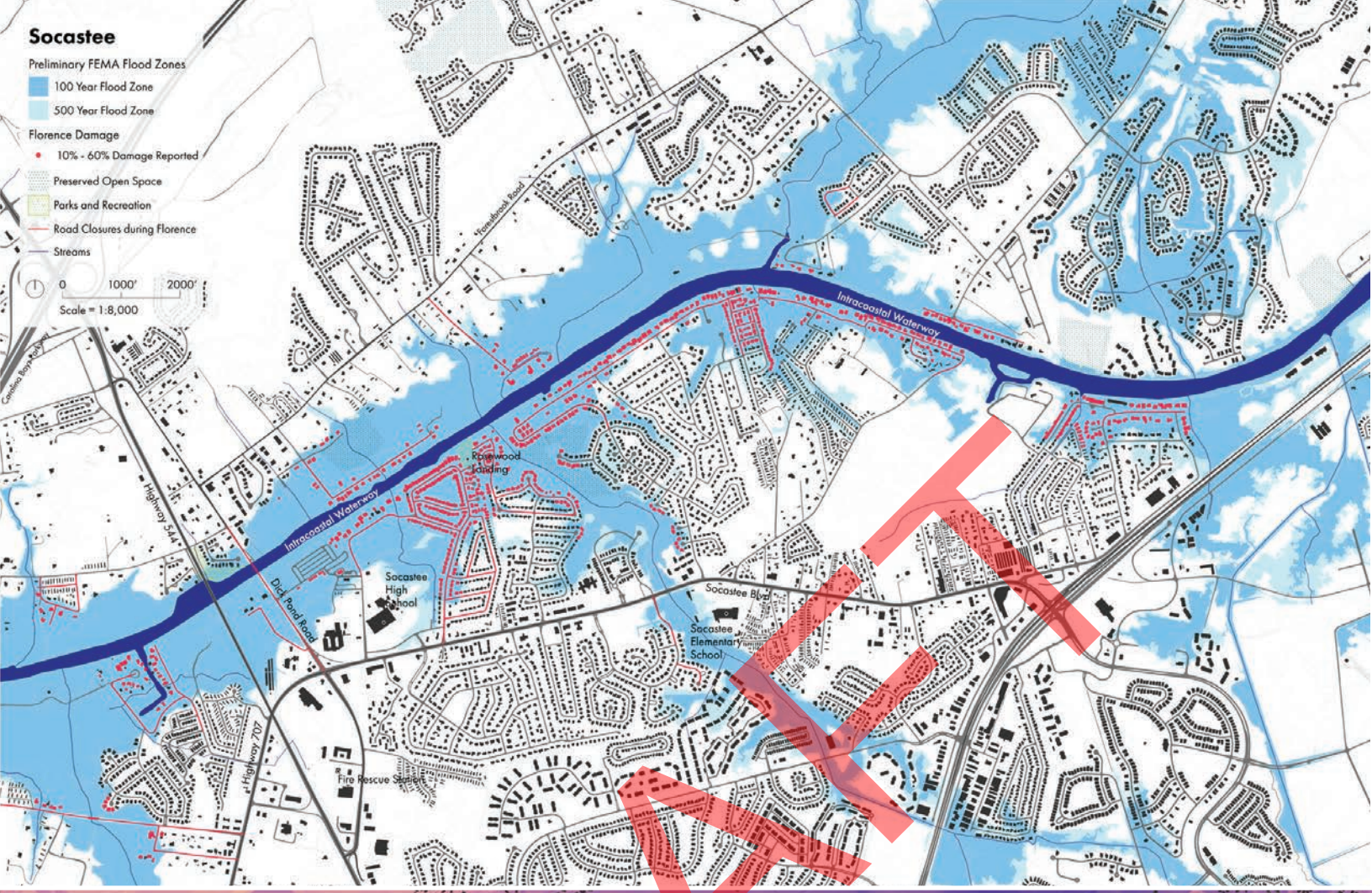
Image: Residents of Socastee and nearby communities shared their experiences with flooding and recovery during the community engagement meeting in October 2019.

of the Florence-flooded properties will be included in the Special Flood Hazard Area once the preliminary maps are approved. This means that when the new maps become effective, hundreds of buildings in the Socastee area will be non-conforming, severely impacting property and resale values. Although this designation will not change the physical vulnerability of assets in Socastee, it increases the economic vulnerability of residents.

Because this community is generally at a low elevation, longtime residents are accustomed to occasional flooding. Newer residents are less inclined to accept flooding conditions, even if their properties are elevated out of the reach of the floodwaters. Two of the older neighborhoods in Socastee, Rosewood and Bridge Creek were particularly hard hit by Florence and residents showed interest in a buyout solution. Preserving the physical integrity of neighborhoods in Socastee has emerged as a challenge, with piecemeal structural elevation practices creating an inconsistent community appearance, where some houses are not elevated, others are elevated through the use of fill, and others elevated with pilings. Additionally, many neighborhoods have unrepaired and/or abandoned homes which negatively impact neighborhood integrity.

While some property owners repaired their homes, a series of floods have resulted in some homes being abandoned and have left many property owners awaiting the initiation of a buyout program. As long-term residents have left and homes sat vacant, there remains a void in the heart of Socastee that will undoubtedly have impacts on the community for years to come.

Some of the common themes conveyed by the residents of Socastee regarding vulnerability, resiliency, and potential solutions included improving the stormwater ditches to prevent blocking, dredging the creeks and ditches, and elevating development.


Socastee
Preliminary FEMA Flood Zones
100 Year Flood Zone
500 Year Flood Zone
Florence Damage
10% - 60% Damage Reported
Preserved Open Space
Parks and Recreation
Road Closures during Florence
Streams
0
1000'
2000'
Scale = 1:8,000
Intracoastal Waterway
Rosewood Landing
Highway 544
Dick Pond Road
Socastee High School
Socastee Blvd
Socastee Elementary School
Highway 707
Fire Rescue Station
DRAFT

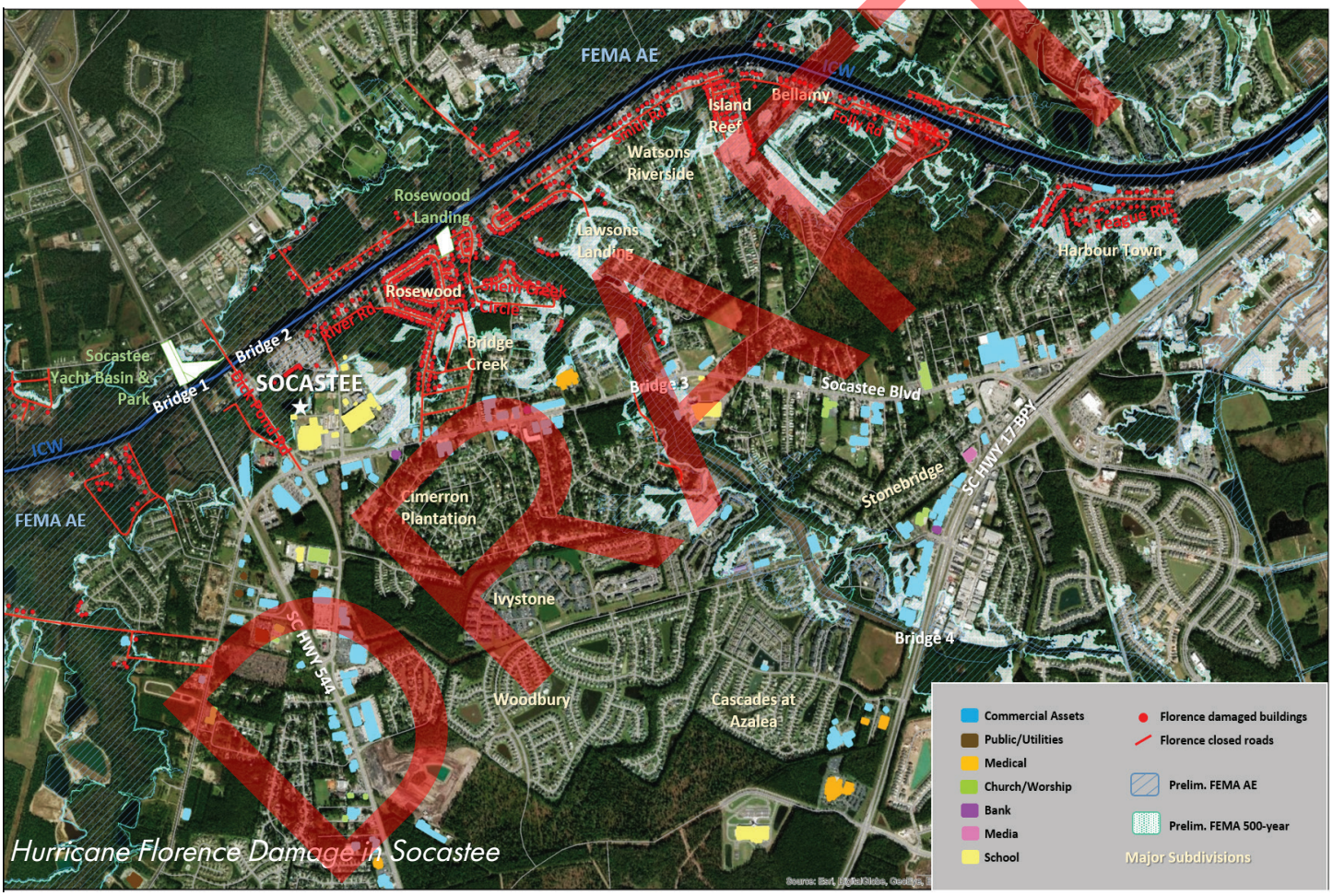

Socastee
Elevation
147 feet
0 feet
-38 feet
Florence Damage
10% - 60% Damage Reported
0
1000'
2000'
Scale = 1:8,000
Intracoastal Waterway
Rosewood Landing
Highway 544
Dick Pond Road
Socastee High School
Socastee Blvd
Socastee Elementary School
Highway 707
Fire Rescue Station
DRAFT

Damaged property in Socastee in October 2019
Source: WCU/SDE/CASE/ONE

A house in Socastee under reconstruction in October 2018
Source: WCU/SDE/CASE/ONE

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Transportation		
SC HWY 17 BYP		AE, X
Socastee Boulevard		AE, X
Dick Pond Road	Yes	AE
River Road		AE
Rosewood Drive	Yes	AE
White Pine Drive	Yes	AE
Cottonwood Drive	Yes	AE
Shem Creek Circle	Yes	AE
Smith Blvd	Yes	AE
Folly Road	Yes	AE
Riverside Drive	Yes	AE
Teague Road	Yes	AE
Brandy Mill Boulevard	Yes	AE
Palmetto Point Boulevard		AE, X
Ed Smith Avenue	Yes	AE
Roberta Lane	Yes	AE
Bridge 1 (ICW & SC HWY 544)		AE
Bridge 2 (ICW & Dick Pond Road)	Yes	AE
Bridge 3 (NF Swamp & Socastee Boulevard)	Yes	AE
Bridge 4 (S NF Swamp & SC HWY 17 BYP)		AE
Major Subdivisions		
Rosewood Estates	Yes	AE, 500-year, X
Bridge Creek	Yes	AE, 500-year, X
Silver Creek		AE, 500-year, X
Lawsons Landing	Yes	AE, 500-year, X
Watsons Riverside	Yes	AE, 500-year, X
Inland Reef	Yes	AE, 500-year, X
Bellamy Estates & MHP	Yes	AE, 500-year, X
Lauderdale Bay HPR		AE, 500-year, X
Harbour Towne		AE, 500-year, X
Wildwood Ranchette		AE, 500-year, X
Worthington Estates		X
Stonebridge		AE, 500-year, X
Brandy Mill		AE, 500-year, X
Ivystone LLC Apts		X

Infrastructure or Asset	Florence Damage	FEMA Prelim. Flood Zone
Major Subdivisions		
Cimmeron Plantation		X
Woodbury		X
Palmetto Glen		X
Cascades at Azalea Lakes		
Recreation		
Major Public Structures		



Hurricane Florence Damage in Socastee

3.0
policy and project considerations

The previous chapters emphasize the many types of flooding that impact Horry County, such as inland flooding from large storm events, coastal flooding from coastal surge events, localized flooding from storms, and compound flooding when more than one of these scenarios occurs in combination.

The policy and project considerations for flood resilience are summarized into the following categories:

Neighborhood Design

Develop design strategies to assist future development and mitigate flood risks.

Infrastructure Improvements

Identify infrastructure projects that could assist in flood mitigation strategies.

Education & Community Planning

Develop communication efforts to inform residents of the flood risk and neighborhood plans for repetitive loss properties.

Recovery

Strengthen policies and procedures for post-storm recovery efforts.

Policy Development

Implement and strengthen regulations and policies to create more resilient communities.

Buyouts

Implement buyouts for selected areas that have experienced severe repetitve loss due to flooding.

3.1 policy development

3.1.1

Flood Ordinance Policy Revisions

POLICY DESCRIPTION AND CONSIDERATIONS

The Horry County Flood Ordinance was adopted in 1987 with the goal of protecting human life and health, minimizing property damage, and encouraging appropriate construction practices to minimize public and private losses due to flood conditions, by requiring that areas vulnerable to floods, including facilities which serve such uses, be protected against flood damage at the time of initial construction. The Flood Ordinance provisions attempt to control the alteration of natural floodplains, stream channels, and natural protective barriers which help control flood waters. The provisions also control filling, grading, dredging and other development which may increase flood damage or erosion. Additionally, the ordinance prevents or regulates the construction of flood barriers which unnaturally divert floodwaters or which may increase flood hazards to other properties.

The County has drafted a comprehensive revision to the Flood Ordinance, entitled Horry County Flood Damage Prevention Ordinance (Flood Ordinance). The proposed Flood Ordinance includes a higher level of regulatory standards than the prior ordinance, including:

- Prohibiting critical facilities from being located within the FEMA 100-year floodplain AND the 500-year floodplain.
- Modifying requirements to ensure that construction in Coastal A Zones (also known as LiMWA, Limit of Moderate Wave Action) must meet the same requirements as construction in coastal V Zones (coastal high hazard areas).
- Increasing the freeboard requirement from one foot to three feet.
- Modifying the definitions for *Substantial Damage* and *Substantial Improvement* to establish a 50 percent of market value threshold.

In addition to these proposed revisions, the County may wish to consider additional modifications to further strengthen the Flood Ordinance. These include raising freeboard levels and preservation of the floodplain.

RAISING FREEBOARD LEVELS

The designation of a freeboard height to which buildings should be raised can be regulated within an established FEMA 100 or 500-year Flood Insurance Rate Map (FIRM) flood zone. The current recommendation is to raise freeboard levels from one foot to three feet. Raising freeboard levels safeguards new development taking place in this zone from flood waters. This freeboard requirement should be applied to the raising of structures (as opposed to fill), consistent with the goal of preserving available floodplain storage.

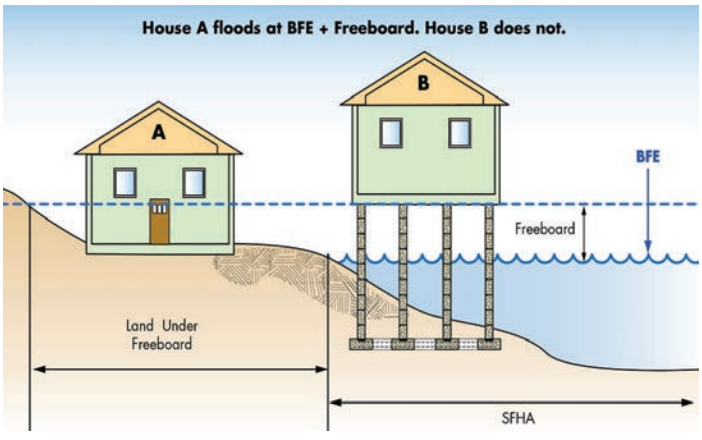


Illustration of the importance of freeboard use in flood prone community construction.

PRESERVATION OF THE FLOODPLAIN

Additionally, floodplains perform vital natural functions such as temporary storage of floodwaters, moderation of peak flood flows, maintenance of water quality, groundwater recharge, prevention of erosion, and habitat for diverse natural wildlife populations, recreational opportunities, and aesthetic quality. Limiting fill in the flood hazard zone within the floodplain would balance the need to reduce flood vulnerabilities with the need for growth in the County. Responsible growth and safe building practices can continue throughout the County, along with adequate protections to preserve the floodplain. In order to preserve the floodplain in the County, the Flood Prevention Ordinance could consider provisions to limit or prohibit the raising of homes through the use of fill in areas that are deemed to be within the special flood hazard area. The ordinance may consider precluding the allowance of a Letter of Map Revision (LOMR) from fill to ensure that the expanded flood zone within the County remains intact moving forward.

The County may wish to study appropriate areas to adopt more stringent floodplain boundaries to preserve the flood plain. This may include establishing a future floodplain, identifying undeveloped properties subject to future flooding, and providing opportunities to institute flood resilient developmental development approaches for future developments.

These additional recommendations are consistent with and support the establishment of a new, expanded regulatory flood zone, beyond which FEMA regulates . Recent storms have generated flood levels that have exceeded the designated FEMA flood zone in multiple areas of the County. The new regulatory zone would correspond to the future FEMA floodplain derived from the updated FIRM maps or potentially to a new Florence-adjusted base flood elevation zone that responds to the actual flood levels that occurred in the County due to Hurricane Florence. The early adoption of a supplemental flood zone would minimize development delays while the County awaits the new map adoption by FEMA. An early adoption would also address vulnerability concerns in areas of the County that are outside the current FEMA designation zone that have experienced recent flooding.

COMPENSATORY STORAGE

Floodplains provide a valuable function by storing floodwaters. When fill or buildings are placed in the flood fringe, the flood storage areas are lost and flood heights will go up because there is less room for the floodwaters. It is therefore recommended that compensatory storage be provided when fill is used for development within the Special Flood Hazard Area Zone, compensatory storage shall be used. Compensatory storage would be provided to offset any loss of flood storage capacity to the Base Flood Elevation or Supplemental Flood Elevation, whichever is higher. It is also recommended that engineering analyses be required in order to confirm the sufficiency of the compensatory storage. Compensatory storage would mean a volume not previously used for flood elevation, up to and including the 100 year flood elevation or Supplemental Flood Elevation, whichever is higher, which would be displaced by the proposed project. Compensatory storage can be provided at lower elevations within the Special Flood Hazard Area or Supplemental Flood Zone where there is no fill associated with the construction project. All compensatory storage would be provided within the same development or within one upstream or downstream FIRM panel cross section line. No area below the waterline of a pond or other body of water would be credited as compensating excavation. If a compensatory strategy is implemented, additional test pits should be excavated to demonstrate that the proposed compensatory storage will not intercept the seasonal high groundwater table.

PROJECT BENEFITS

Flood Prevention Ordinance revisions enable Horry County to coordinate policies with resilient strategies proposed within this Flood Resilience Plan.

Comparative Flood Regulations in Horry County

CRS Communities	Requirements
Horry County	1ft freeboard. No standards for critical facilities, SD/SI (Substantial Damage/ Substantial Improvement) 50% over 5 years.
City of Myrtle Beach	3ft freeboard requirement, Critical Facilities to be located outside the 500-year floodplain, SD/SI 50% over 10-year period cumulative.
City North of Myrtle Beach	1ft freeboard. No higher standards for critical facilities, SD/SI 48% over 5 year period.
Town of Surfside Beach	3ft freeboard. Critical facilities to be located outside the 500-year floodplain, SD/SI 48% over 5 year period.
Non-CRS Communities	**Requirements**
City of Conway	2ft freeboard
Town of Aynor	1ft freeboard

3.1.2

Supplemental Flood Zone Designation and Adjusted Base Flood Elevation (BFE)

PROJECT DESCRIPTION AND CONSIDERATIONS

Components of development regulations often respond to the requirements of the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Mapping (FIRM) program. FIRM maps delineate the special hazard areas and the risk of flooding under multiple storm frequencies. Horry County's first FEMA FIRM maps were produced in 1982. The maps have undergone one full revision with new maps going into effect in 2003. Roughly 50% of existing development in the County is regulated under the FIRM provisions.

The U.S. Census population count for Horry County as of July 1, 2019, was 354,081. The County's *Imagine 2040 Comprehensive Plan* projects the population to increase by 200,000 residents between 2020 and 2040. Since new construction must adhere to County regulations, by 2040, approximately 75% of County development will have been constructed post-FIRM adoption. While the regulations put in place provide a high level of flood protection, a significant number of homes built in flood prone areas prior to the establishment of flood regulations will remain at risk.

In 2006, FEMA began the process to update the FIRM maps in Horry County. The preliminary revision of these maps (PFIRM) extend the Special Flood Hazard boundary in many locations in the County. An analysis of the PFIRM maps show that, in multiple locations, the flooding from Hurricane Florence extended beyond the preliminary flood hazard zones (both the proposed 100 and 500-year FEMA floodplain designations), and inundation levels exceeded the base flood elevation (BFE) values. It is important to note that current County flood regulations apply to the current 100-year FEMA floodplain. Post-storm assessments confirm that approximately 500 structures that sit outside both the existing 100 and 500-year FEMA floodplains were damaged during Florence. Many of these structures will lie outside the proposed FEMA floodplain boundary as well.

An assessment of the proposed supplemental flood zone boundary in the Longs/Little River pilot study area confirms that for many residences flooding from Florence would exceed the proposed FEMA flood mapping. The pilot effort encompasses approximately 10% of the FEMA AE zone within Horry County. Applying this methodology to other areas in the County adjacent to FEMA's Special Flood Hazard Areas (SFHA), where flooding and damage from Florence and other storms of record have been documented, can be utilized to generate a comprehensive Countywide assessment. In some areas of the County, the preliminary SFHA (AE zone or 100-year floodplain) more accurately reflects the extent and height of flooding during Florence (i.e., Socastee and Bucksport). In these areas, the FEMA data are largely reflective of the flooding that took place during Hurricanes Matthew and Florence. To determine which areas would benefit from a supplemental flood zone, an analysis comparing the preliminary FEMA data to Florence flood elevations and damage throughout the County was needed.

The County continued the study to include all of the

unincorporated areas and establish a comprehensive Florence-adjusted BFE, assessing the difference between FEMA's proposed FIRM maps and the adjusted BFE levels. This effort gauged the gaps between PFIRM designation and Florence adjusted BFE throughout the County.

This information could be utilized to develop new guidelines and regulations concerning development locations and construction techniques. The supplemental flood zones and adjusted BFEs could guide development policy, establish conservation zones, and/or inform regulations regarding freeboard inside FEMA zones or establishment of finished flood heights in potential flood overlay districts outside of the FEMA mapped zones. This effort can support additional recommendations.

SUPPLEMENTAL FLOOD ZONE DESIGNATION METHODOLOGY

The County has developed a methodology based on scientific evidence to create a supplemental flood zone and adjusted BFE designation for the unincorporated areas of the County, using flooding and damage data from Hurricane Florence. This methodology was piloted in the Longs/Red Bluff community, where flooding from Florence exceeded the preliminary FEMA SFHAs (AE or 100-year zone) and the 500-year flood zone. The study area includes multiple communities to the north and south of the Waccamaw River, including: Red Bluff, Chestnut Crossroads, Longs, Stephens Crossroads, Wampee, Star Bluff Crossroads, and the unincorporated area east of the intersection of HWY 90 and HWY 22. A detailed explanation of the research effort and mapping is included in the appendix to the report.

Analysis and mapping has been conducted in order to:

- Identify an adjusted BFE for buildings in the existing preliminary FEMA zones
- Develop a supplemental flood zone with adjusted BFEs outside FEMA zones, based on historic flood elevations.

Within the study area, specific flood elevations using Florence data from stream gauges, USGS high water marks, and post-storm damage reports have been estimated. Based on these data, the Florence flood elevations within the study area range from 21 to 25 feet above NAVD88. An adjusted BFE can be established by comparing the FEMA BFE to Florence flood elevations and using the higher elevation value. These elevation values are then mapped to establish the supplemental flood zone. The resulting flood zone boundary line (polygon) approximates the probable extent of flooding by Hurricane Florence. This supplemental flood zone has been seamlessly appended to the existing preliminary FEMA Special Flood Hazard Area (AE zone or 100-year floodplain), allowing for the establishment of a flood zone that incorporates the latest flood data (post-Florence).

In much of the study area, the BFE values in the preliminary FEMA flood maps are lower than the adjusted BFEs determined from Florence flood data. As a result, five adjusted BFE zones have been established, where the adjusted BFE applies to both the preliminary FEMA flood zones and the new supplemental flood zone. For the pilot exercise, a single adjusted BFE has been applied across each of these supplemental flood zones (i.e., Zone 21, BFE = 21 feet above NAVD88). It is important to note that in addition to seeing the increased extents of the geographic boundary, Florence flood elevations were significantly higher than what has been mapped by FEMA. Typically, in each of these zones, the Florence adjusted base flood elevation exceeds the FEMA designation by four to five feet. This is a significant finding that requires consideration when examining the build-to height of any future development within these zones and for locations that are within the Florence adjusted BFE zone outside of the FEMA Flood zone.

The five new zones with Florence-adjusted Base Flood Elevations include:

ZONE 21

Red Bluff and communities just east of HWY90/HWY22 intersection. Note that this zone potentially may include more communities outside the pilot study area (see blue arrow in figure).
Original BFE within preliminary FEMA AE Zone:
16-17 feet above NAVD88
Zone 21 Adjusted BFE = 21 feet above NAVD88

ZONE 22

East Red Bluff, west Chestnut Crossroads, west Star Bluff Crossroads.
Original BFE within FEMA AE Zone:
17-21 feet above NAVD88
Zone 22 Adjusted BFE = 22 feet above NAVD88

ZONE 23

East Chestnut Crossroads, southwest Longs, east Star Bluff Crossroads, Wampee, west Stephens Crossroads
Original BFE within preliminary FEMA AE Zone:
18-20 feet above NAVD88
Zone 23 Adjusted BFE = 23 feet above NAVD88

ZONE 24

Southeast Longs/Aberdeen, north Stephens Crossroads.
Original BFE within FEMA preliminary AE Zone:
20-22 feet above NAVD88
Zone 24 Adjusted BFE = 24 feet above NAVD88

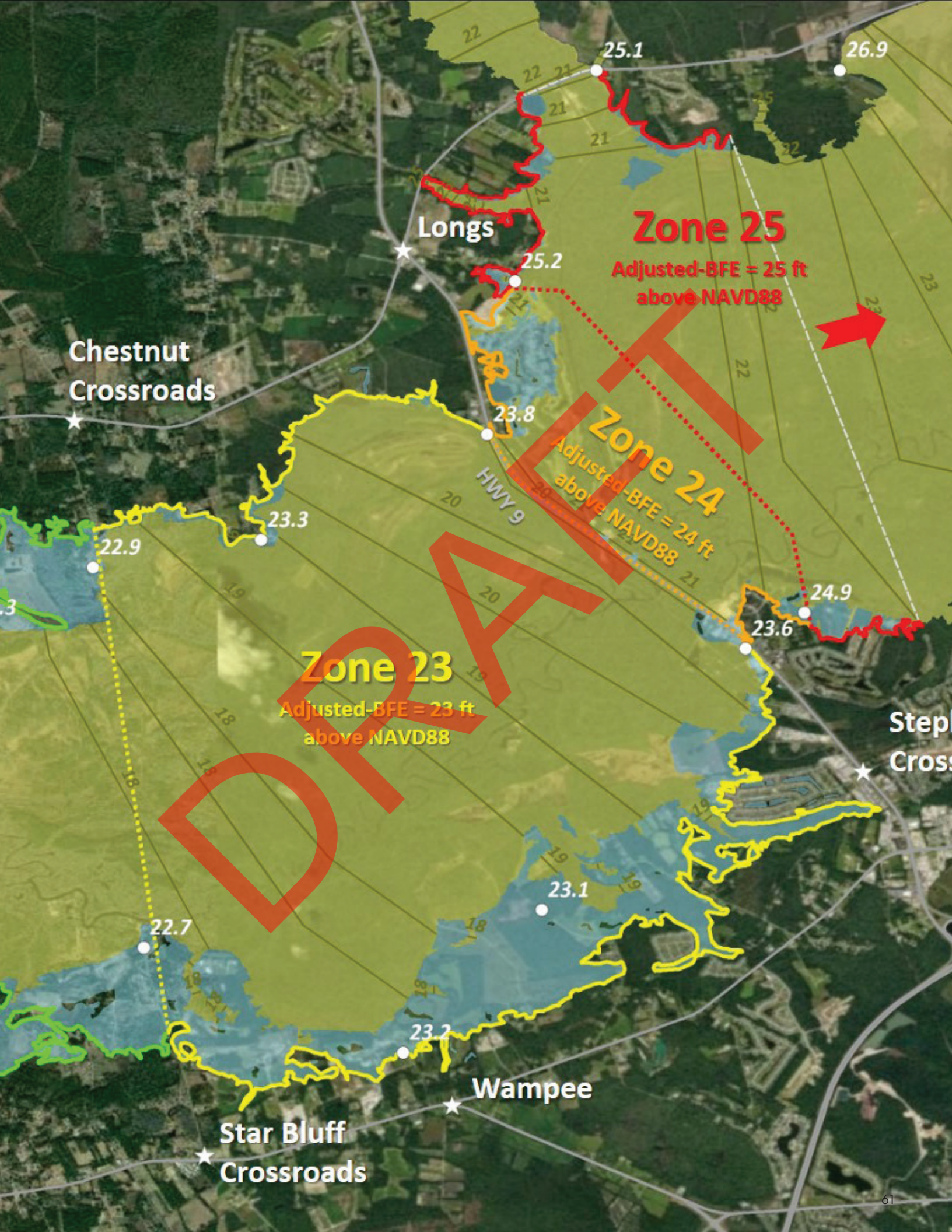
ZONE 25

Northeast Longs, northeast Stephens Crossroads. Note that this zone potentially may include more communities outside the pilot study area (see red arrow in figure).
Original BFE within preliminary AE Zone:
21-22 feet above NAVD88
Zone 25 Adjusted BFE = 25 feet above NAVD88

PROJECT BENEFITS

A supplemental flood zone (SFZ) identifies properties damaged by Florence that are located outside the designated FEMA flood zone. The SFZ establishes a zone based on flood elevations (heights) from Florence to calculate an adjusted BFE. The adjusted BFE value can serve as a tool to guide future resilient development approaches.

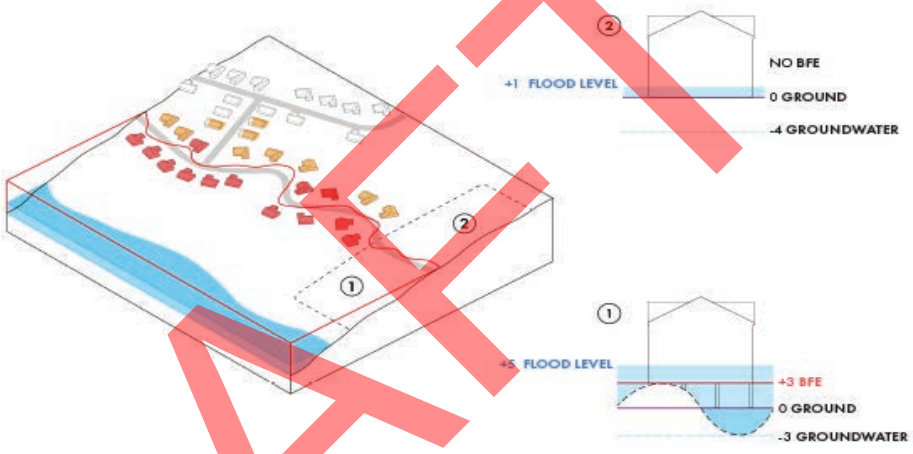

FEMA AE Zone (preliminary)
Supplemental Flood Zone
17 FEMA BFE Cross-sections (ft above NAVD88)
Florence Damage
USGS Flood Elevation Data Florence (ft above NAVD88)
DRAFT
HWY 905
21.9
Red Bluff
21.6
21.3
Zone 21
Adjusted-BFE = 21 ft above NAVD88
Zone 22
Adjusted-BFE = 22 ft above NAVD88
HWY 22
21.8
22.2
HWY 90


25.1
26.9
Longs
Zone 25
Adjusted-BFE = 25 ft
above NAVD88
25.2
Chestnut
Crossroads
23.8
Zone 24
Adjusted-BFE = 24 ft
above NAVD88
HWY 9
23.3
22.9
24.9
23.6
Zone 23
Adjusted-BFE = 23 ft
above NAVD88
DRAFT
Steph
Cross
23.1
22.7
23.2
Wampee
Star Bluff
Crossroads

UTILIZATION OF SUPPLEMENTAL FLOOD ZONE TO MINIMIZE FUTURE FLOOD DAMAGE

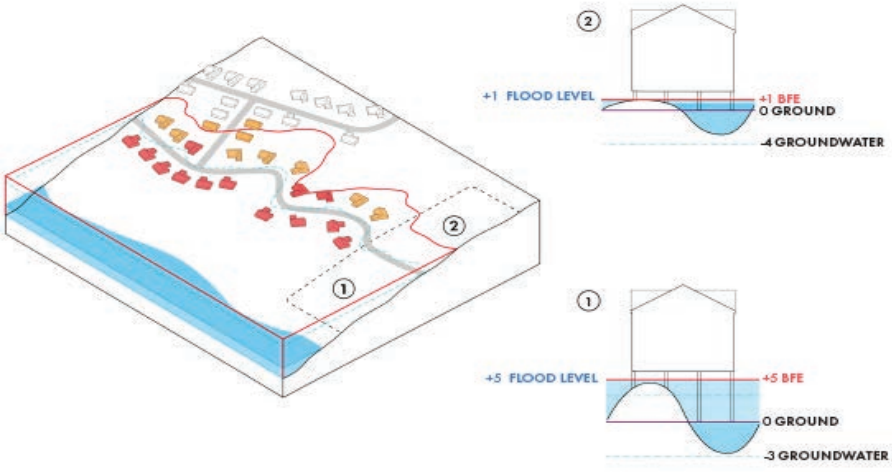
Many of the structures damaged during Florence sit outside the existing FEMA floodplains and may not fall within the proposed updates to the FEMA floodplains. In order to better identify which buildings may be at risk, the County performed a study to adjust the base flood elevations (BFEs) to include data from Hurricane Florence. Identifying these supplemental flood zones can help property owners better understand their risk of flooding.

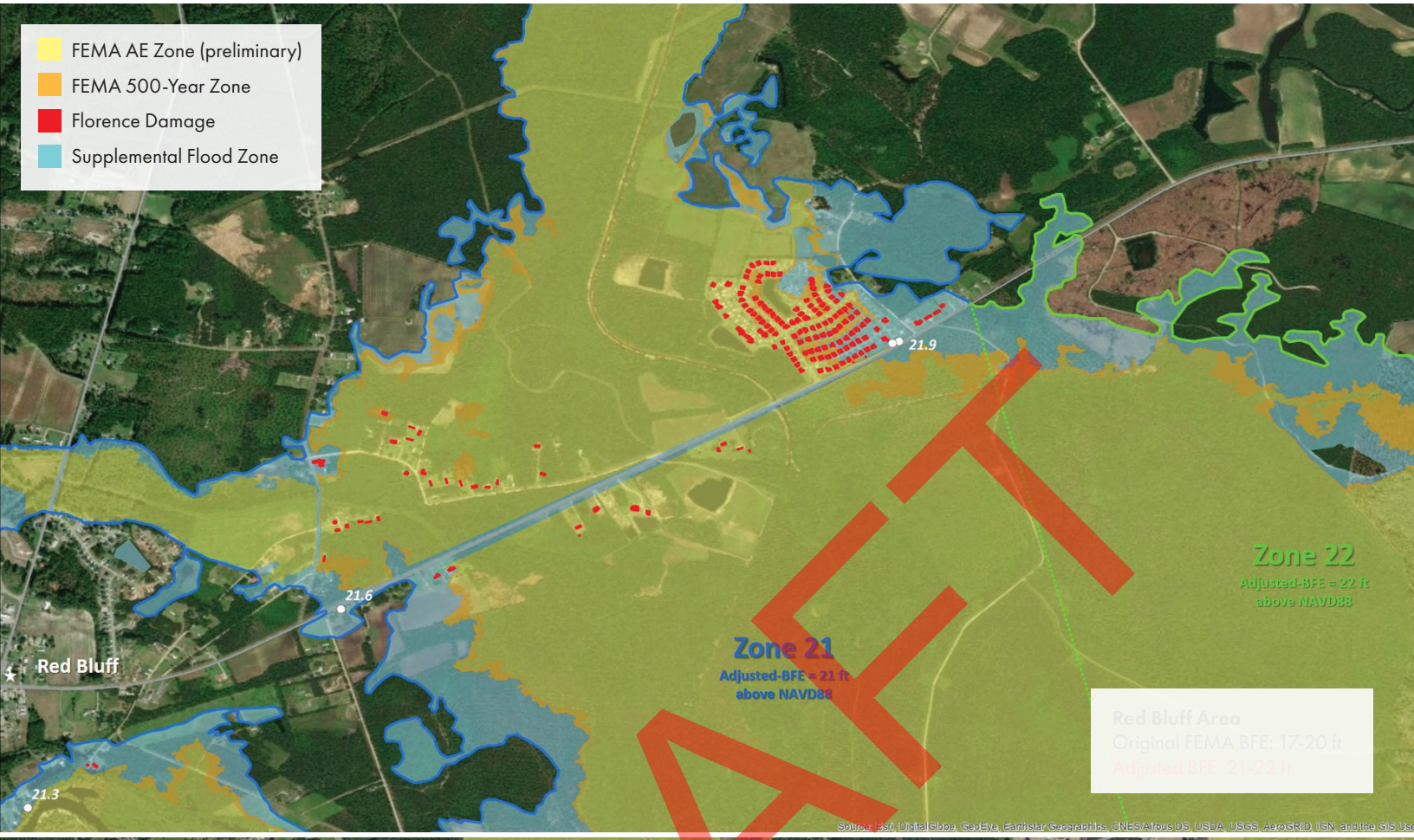
FEMA FLOOD ZONE

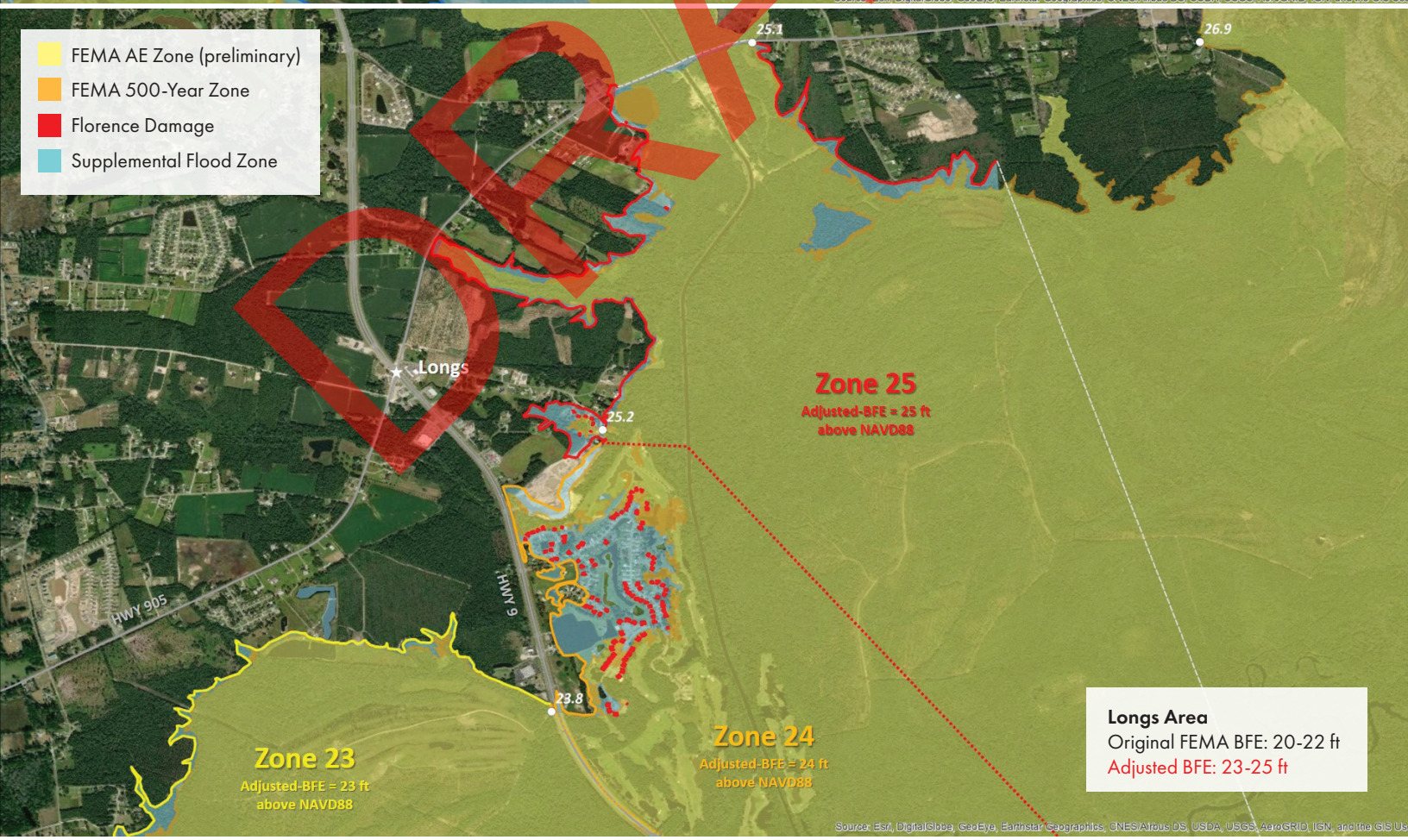


Ensuring that the regulated flood hazard area and BFE reflects observed flood levels helps property owners elevate buildings and minimize potential damage due to flooding. Wherever fill is used to elevate, an equal volume of ground can be removed to compensate for the volume of floodplain storage lost to fill. This should apply with areas where the supplemental flood zone exceeds the extent of the FEMA and special flood hazard area.

SUPPLEMENTAL FLOOD ZONE




FEMA AE Zone (preliminary)
FEMA 500-Year Zone
Florence Damage
Supplemental Flood Zone
21.9
21.6
Red Bluff
21.3
Zone 22
Adjusted-BFE = 22 ft
above NAVD88
Zone 21
Adjusted-BFE = 21 ft
above NAVD88
Red Bluff Area
Original FEMA BFE: 17-20 ft
Adjusted BFE: 21-22 ft
DRAFT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS Us


FEMA AE Zone (preliminary)
FEMA 500-Year Zone
Florence Damage
Supplemental Flood Zone
25.1
26.9
Longs
25.2
HWY 905
HWY 9
23.8
Zone 25
Adjusted-BFE = 25 ft
above NAVD88
Zone 24
Adjusted-BFE = 24 ft
above NAVD88
Zone 23
Adjusted-BFE = 23 ft
above NAVD88
Longs Area
Original FEMA BFE: 20-22 ft
Adjusted BFE: 23-25 ft
DRAFT
Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS Us

Comprehensive Buyout and Area Reuse Strategy

PROJECT DESCRIPTION

Buyout programs support hazard mitigation, floodplain management goals, and resiliency by removing homeowners who have suffered repetitive loss or severe repetitive flood losses from the floodplain, thus reducing vulnerability to future flooding events. The goal of implementing a buyout program in Horry County is focused on the prevention of repetitive loss and the reduction of extreme risk to human health and safety.

The objectives of a buyout program include:

1. Acquiring properties that have been subjected to multiple floods and implementing a re-purposing strategy.

2. Assisting homeowners to move to an area with a reduced risk of flooding.

3. Returning properties in the floodplain to natural and beneficial functions, aiding in the storage of floodwaters.

4. Eliminating future flood damages and health and safety risks for owners and rescuers.

5. Reducing repetitive subsidized flood insurance payments and federal disaster assistance.

Once area property owners have indicated interest and the flood-prone or repetitive loss neighborhoods have been identified the County will implement a prioritization methodology that provides clear process to identify eligible and high priority candidates. There are multiple considerations that inform an effective prioritization structure.

- **Preservation of neighborhood integrity and value** - the relative proximity of buyout properties, the ability to connect contiguous sites, and the ability to connect contiguous sites to existing public land.

- **Storm mitigation value** - ability for the site to contribute to flood management or flood storage.

- **Ongoing Maintenance Costs** - the ability to identify a maintenance structure and maintenance partner to maintain properties as part of a reuse strategy.

- **Replicability and Scalability** - how the reuse strategy for the site can be replicated or expanded upon in the same area in the future.

BUYOUT PROPERTY REUSE STRATEGIES

In addition to establishing eligibility priorities, the County is putting in place strategies for reuse of buyout properties. Buyout programs are voluntary. A buyout program that lacks a coordinated reuse strategy can result in a patchwork application of buyouts in a neighborhood that has been impacted. A negative perception of community can take place in neighborhoods where bought-out properties become interspersed with repaired structures. Buyouts also result in a social impact to a community. Neighborhoods with a strong sense of social identity that have buyouts can suffer from a loss of community cohesion, as persons whose properties are bought typically leave the community or region entirely. There are process and logistical issues to be overcome, including decision-making about program eligibility for individuals and neighborhoods, and neighborhood or community impact assessment.

The acquisition of entire neighborhoods may occur over many years. It is important to coordinate efforts within a buyout community to guard against the deterioration of community fabric resulting from the buyout process. Comprehensive and coordinated re-use strategies that aim to convert buyout lots to public amenities, flood mitigation and performative landscapes can help to alleviate deterioration of community value. Decisions for reuse strategies are navigated through a decision tree that starts with identifying a spatial pattern of buyout properties and the financial implications of maintenance. The spatial patterns of acquired properties should directly correlate with the strategies for their reuse and the subsequent fiscal efficiency of a buyout strategy.

The most important factor in determining efficiency both fiscally and with regards to ecological services is the scale and pattern of the buyout. Spatial patterns include (1) contiguous, (2) moderately-connected or (3) checkerboard.

CONTIGUOUS BUYOUT PATTERN

Certain properties, by nature of their location, can prove to be highly valuable for flood mitigation and flood protection. In Horry County, it is recommended that a buyout program strategically select sites that can facilitate stormwater retention through restoration, and in turn would not be suitable for recreational purposes.

Restored lands are likely to play a more important role in stormwater retention, filtration, and discharge dynamics. Incentives for restored wetlands include not only their ability to mitigate surrounding flooding risks but may also earn discounts on flood insurance premiums for community residents through the FEMA Community Rating System (CRS).

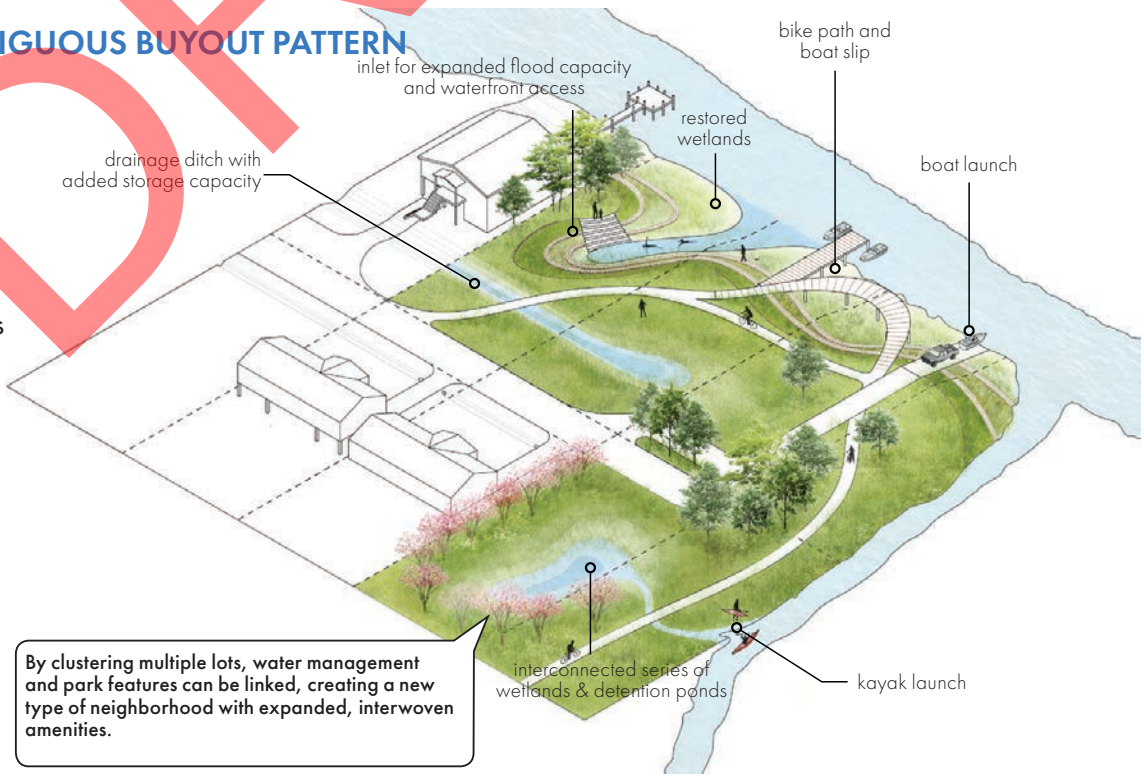
Partnerships are key in restoration approaches that seek to optimize reuse potential. There are opportunities to leverage existing programs in the state, such as South Carolina's Forest Renewal Program, or through various federal grants and wetland restoration programs focused on conservation.

The County can expand the creation of critical wetland sites if contiguous buyouts can be connected to wetland mitigation efforts for major reconstruction projects planned throughout the County. Focusing multiple programs towards open space acquisitions that are contiguous, serves to preserve the floodplain and contribute to naturalized storage capacity. An approach of this nature would enhance the value of buyout efforts, create conservation areas that are available and recognizable by the public, and improve the value of communities adjacent to these preservation/conservation zones.

Horry County seeks to mitigate challenges to buyouts by focusing on these strategies with its buyout program. A significant focus on the development of property reuse strategies can provide for effective property reuse that does not diminish from the overall value of the community, creates opportunities for amenities and provides direct stormwater management value.

EXAMPLE OF CONTIGUOUS BUYOUT PATTERN

Potential Uses:
Large Detention Ponds
Wetland Restoration
Reforestation
Multipurpose Parks
Boat Marinas
Bikeways and Greenways



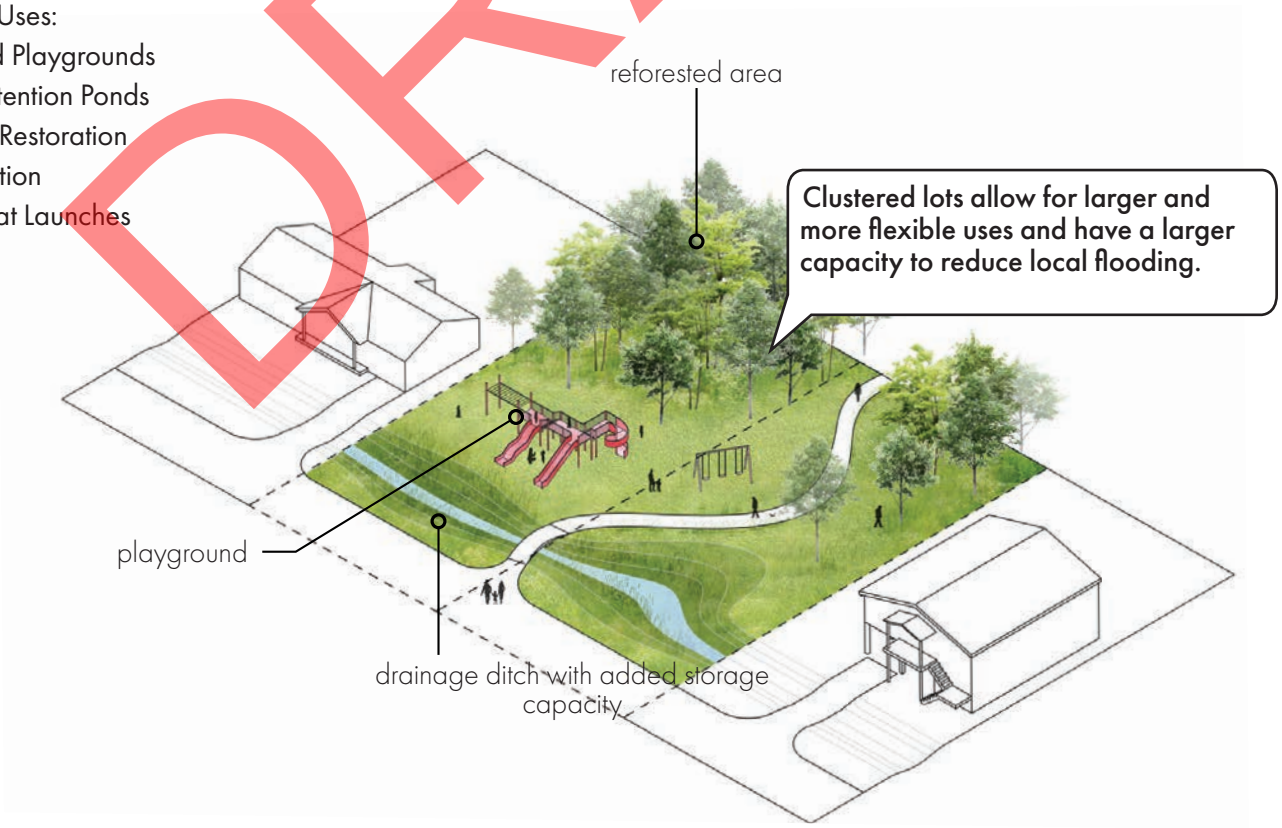
MODERATELY-CONNECTED BUYOUT PATTERN

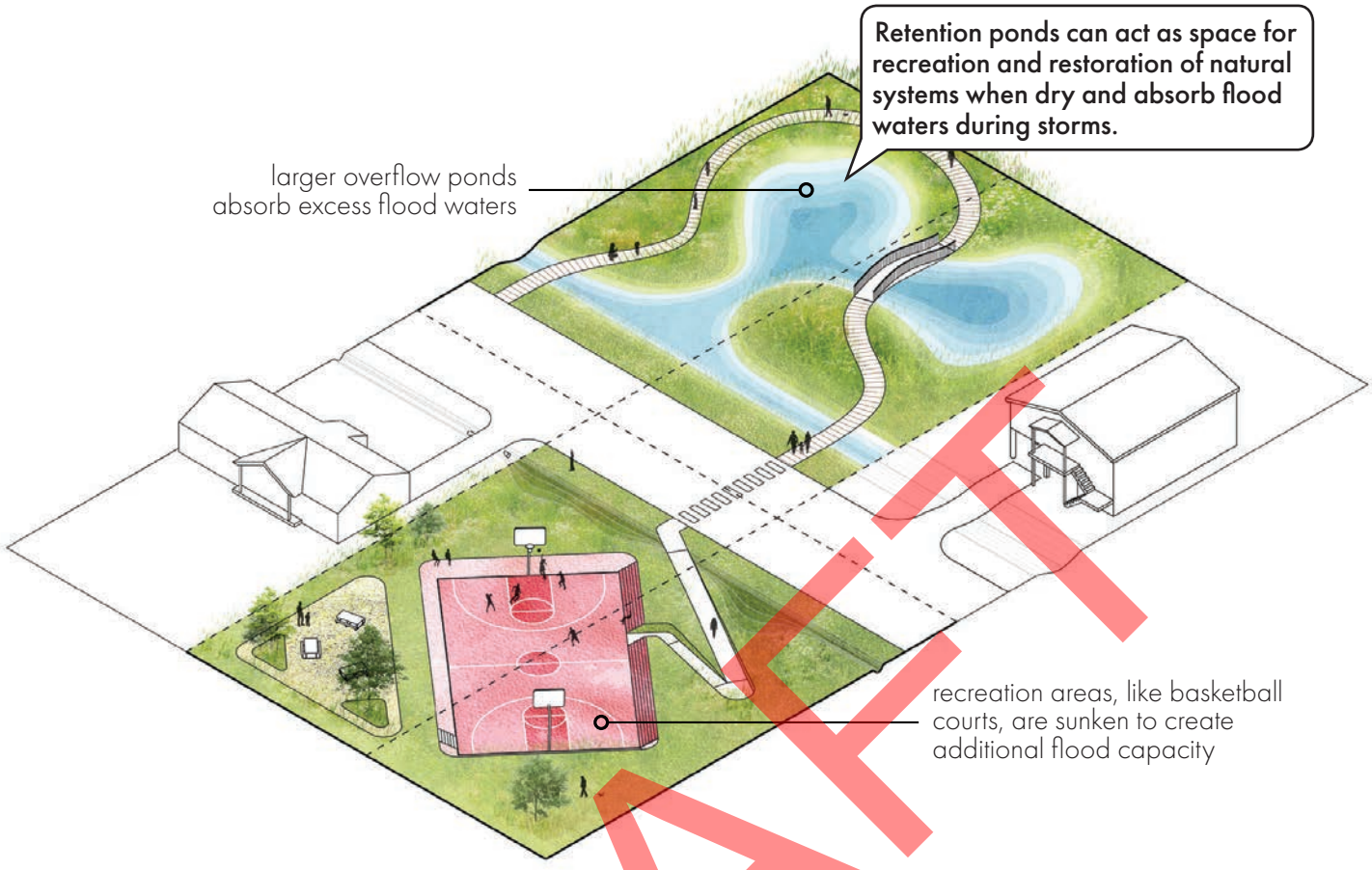
Buyouts of moderately connected properties lend themselves to recreational uses, such as nature parks, playgrounds, educational exhibits, disc golf courses, dog parks and athletic fields. Proximity to current open spaces and recreational areas should play a key role in buyout prioritization. In this case, because of the increased utility of the open space, it becomes more appealing for conservation programs or other local entities with maintenance infrastructure to provide a management resource.

One approach to connecting buyouts to amenity space with a management entity is to identify specific existing gaps in community amenities that can incentivize participation in reuse planning. An opportunity to coordinate larger County strategies for open space expansion can be coordinated to align capital costs for amenity development with buyout programs. Moderately connected buyouts are likely to require for some or all infrastructure to remain. While this approach can result in maintenance costs, it can also serve as an asset for accessing and serving recreational areas.

EXAMPLE OF MODERATELY CONNECTED BUYOUT PATTERN

Potential Uses:
Parks and Playgrounds
Small Detention Ponds
Wetland Restoration
Reforestation
Small Boat Launches

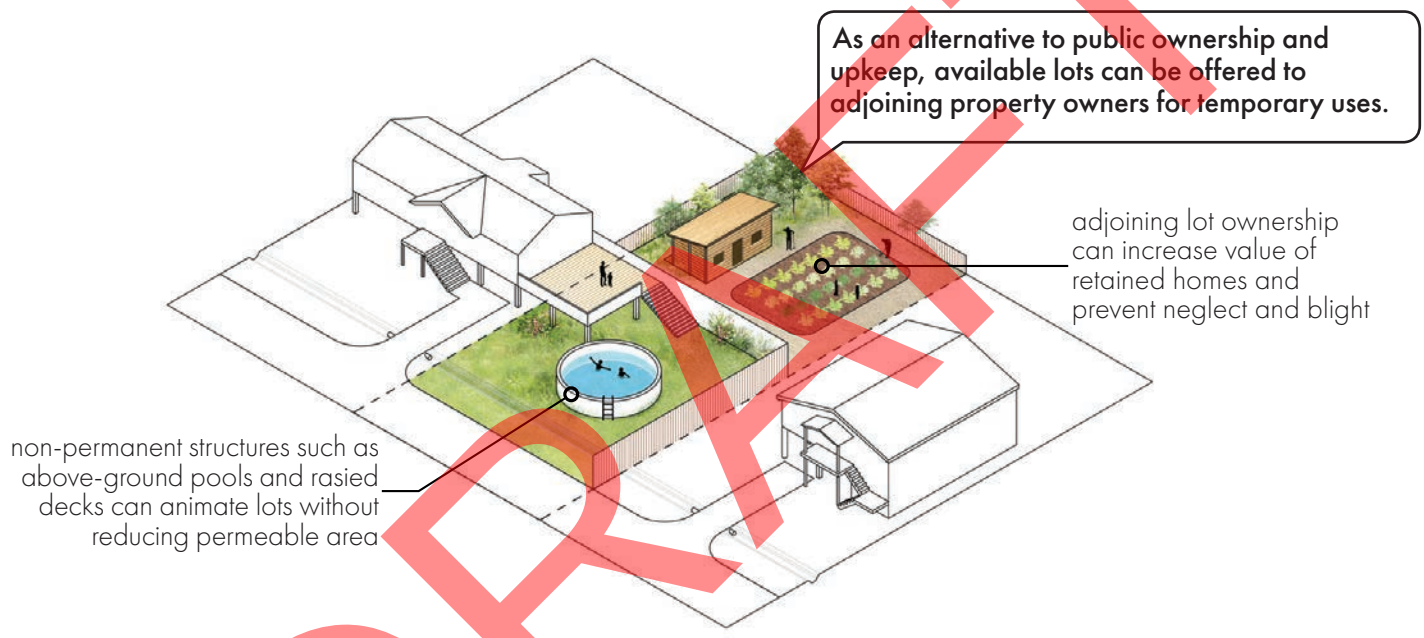



Retention ponds can act as space for recreation and restoration of natural systems when dry and absorb flood waters during storms.
larger overflow ponds absorb excess flood waters
recreation areas, like basketball courts, are sunken to create additional flood capacity

CHECKERBOARD BUYOUT PATTERN

Enacting buyouts in a neighborhood where many property owners are not interested in or capable of being considered for a buyout program can result in a checkerboard pattern, where bought out properties are scattered or randomly dispersed. This pattern requires some or all infrastructure to remain, thereby limiting potential cost savings associated with infrastructure removal. Checkerboard patterns typically result in higher maintenance costs unless there is an ability to share costs with non-profits or other government entities. Buyout best practices avoid a checkerboard approach except in cases where a property is directly adjacent to existing natural resources or a recreational area that can incorporate the property. Properties adjacent to wetlands or other natural resources present a clear case for restoration.

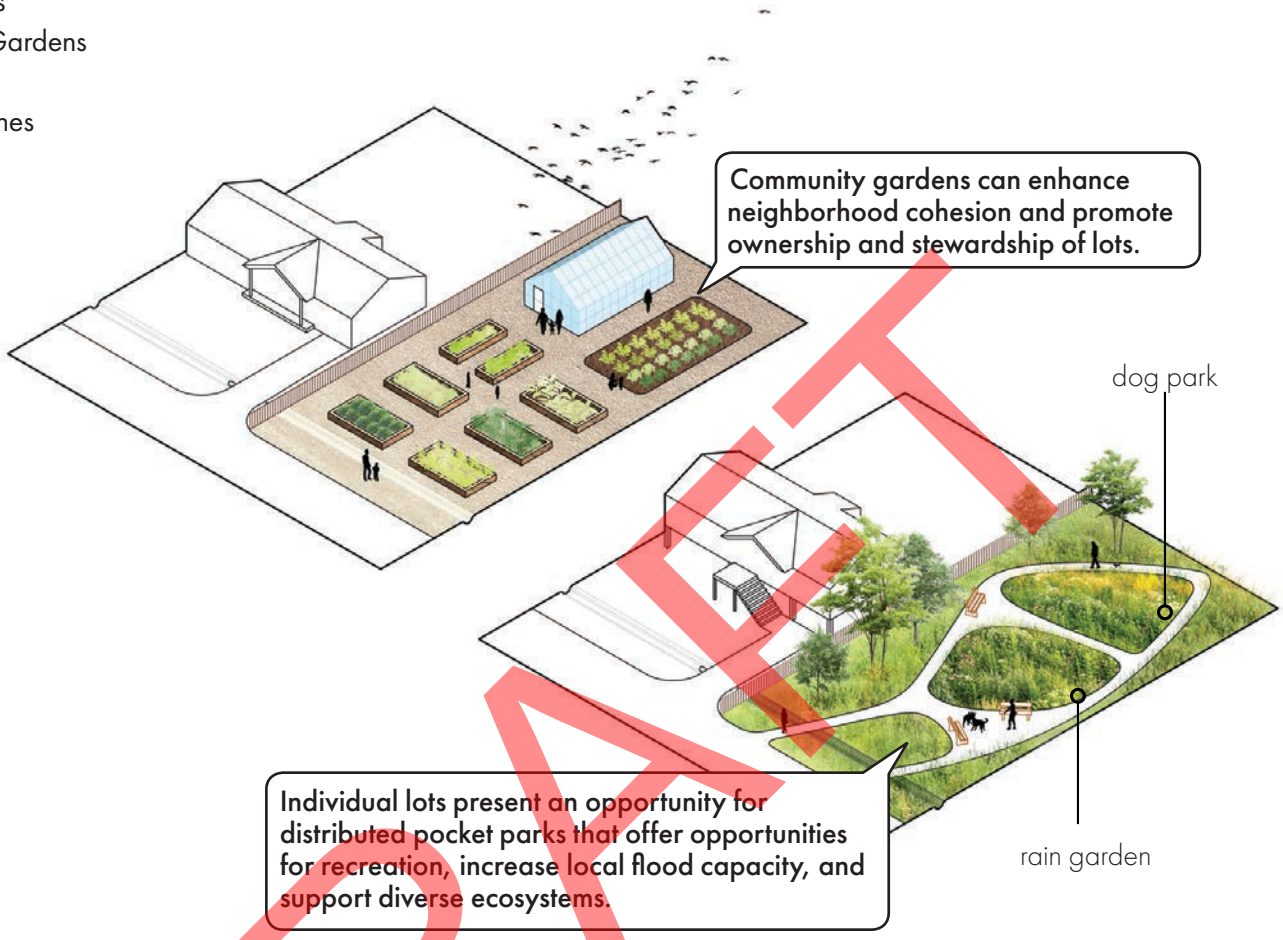
EXAMPLE OF CHECKERBOARD BUYOUT PATTERN



Strategies that have been effectively utilized in buyouts subject to checkerboarding include community gardens and pocket parks. Community gardens can increase property value and can be implemented as a shared amenity within a homeowner association (HOA). Pocket parks can be replanted with low-maintenance native plants that can play a significant role in absorbing stormwater, filtering pollutants and retaining sediments while also providing neighborhood amenities.

An example of a successful technique that has alleviated the burden of maintenance on the local jurisdiction is the New York Rising program. The program model involves the leasing or deeding of land to adjacent property owners who bear the responsibility of maintenance costs while restricting the use of the property to open space. Leasing at a nominal fee can offer an effective solution to formally designate responsibility for maintenance without creating additional maintenance responsibilities for public entities.

Potential Uses:
Rain Gardens
Community Gardens
Pocket Parks
Kayak Launches



In conclusion, the Horry County buyout program can play a pivotal role in providing relief to families that have experienced flooding. Buyouts may be considered where large, contiguous areas can be repurposed. However, other buyout reuse options may also be considered when they are cost effective, feasible, and the preferred alternative for the community. The following approach could become part of the County's buyout and reuse process:

- Maintain a database of interested property owners seeking buyouts to inform priority buyout areas in the short and long term as funding becomes available.
- Coordinate near-term buyout properties with available grant funding.
- Develop neighborhood master plans, when necessary, to repurpose large, contiguous buyout areas as recreational and stormwater assets.

PROJECT BENEFITS

Developing reuse strategies for buyout properties within communities creates opportunities for flood mitigation measures and amenities for remaining residents. These efforts increase the attractiveness of the community while also strengthening its economic base. As buyout properties can be integrated into larger flood management purposes through the creation of performative infrastructure strategies, the buyout properties can serve to enhance local flood management and contribute to larger regional storage needs. A strategy for buyout reuse reverses the perception of blight, keeps sites from becoming dumping grounds and preserves the fabric of the community.

3.2
Resilient Neighborhood Design Strategies

Major residential subdivisions in Horry County are typically homogenously designed with similar lot sizes and dimensions. Because of the relatively flat terrain in the County, most major subdivisions include fill and grading of the overall site to ensure the development drains to stormwater retention ponds. The modification of the natural topography, including the clearing of trees, filling of the floodplain, and the filling of riparian and wetland fringes, can alter the natural flood capacity of the landscape. The cumulative impacts of this type of development combined with new growth, the County's flat terrain, and increasing rainfall patterns could alter the size of the floodplain over time.

There are a number of Resilient Neighborhood Design Strategies that can provide alternatives to modifying the natural topography of an entire development site in order to meet zoning, land development regulations and stormwater

Flooding in the Aberdeen Country Club after Hurricane Florence.
Souce: Tyler Fleming/Post & Courier.

design standards. The creation of riparian and wetland buffers, expansion of tree preservation regulations, and the establishment of resilient subdivision design standards will all help preserve the landscape's natural flood storage capacity. In addition, they can maintain hydrologic connectivity within and between watersheds, reduce pollutant loading into receiving waterbodies, and preserve habitat for wildlife. The recommendations in the following section provide an implementation roadmap for many of the strategies within the *Imagine 2040 Comprehensive Plan*. They can be adopted together or pursued incrementally either countywide or in select areas of the County.

Flooding in Cameron Village after Hurricane Florence.
Source: V. Blandin/WPDE

3.2.1

Creation of Riparian and Wetland Buffers

PROJECT DESCRIPTION

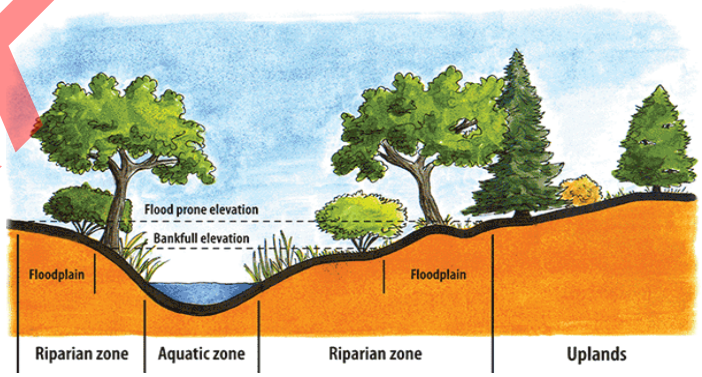
An important first step in minimizing future flood damages is to preserve the flood storage capacity of the natural landscape. Rivers, streams, wetlands, and other waterbodies make up approximately 38 percent of the entire County and are located on most sites that are under consideration for development. As additional development occurs to meet increasing demand, more pressure will exist to convert floodplains, wetlands, and their fringes into raised development plots for residential subdivisions. Currently, Horry County does not have any regulations that limit or prohibit fill in wetlands, as it relies upon the U.S. Army Corps of Engineers and SC DHEC-OCRM to regulate wetland impacts and when wetland buffers are necessary. Similarly, the County does not prohibit fill in the regulatory flood zone.

Horry County may also consider establishing riparian and wetland buffers to preserve the landscape's natural flood storage capacity and minimize future flood risks. Jurisdictions throughout the Country, including Summerville, SC and Charleston County, SC, use riparian and wetland buffers or setbacks to preserve critical natural areas, natural water flows, and water quality. Riparian and wetland buffers could be established as a requirement of all major residential developments, and even commercial sites, or could be required only within a designated riparian corridor, watershed, or defined area as an overlay. The protected buffer area should extend a designated width beyond the edge of existing mapped water bodies, including rivers, creeks, and wetlands. The typical practice for rivers is to extend a buffer 100 feet from the top of the bank for flood attenuation. For delineated wetlands, the buffer area should minimally extend 50 feet from the edge. These policies could apply to jurisdictional and non-jurisdictional wetlands.

There are typically two tiers, or zones, of use impact associated with riparian and wetland buffers. The first tier, an "inner zone", is left in its natural state or returned to an enhanced state, if already impacted. The second tier, a "transition zone", serves as a transitional zone between the protected area and the buildable area. Using this approach, development in the transitional zone would be restricted to uses that support wetland and waterway health. Fill would be prohibited in both the inner zone and transition zone. The following image illustrates the inner and outer boundary limits for streams and wetlands and identifies acceptable uses and treatments within each zone.

Inner Zone - The distance nearest to either side of the water body from the tops of bank would be defined as the stream management zone or inner zone. No modifications to elevation, slope, or vegetation would be permitted in this zone, except for rehabilitation purposes to enhance ecology and hydrology.

Transition Zone - This zone would serve as a transition between natural and developed areas. Permitted uses would aim to clean and filter run-off water and slow velocities to maintain internal channel geometries. Permitted measures within a transition zone may include managed plantings, passive recreation (i.e. trails), pervious surfaces, removal of invasive species and vegetation management to reduce wildfire risk.



Source: https://slco.org/watershed/streams-101/the-riparian-zone/

For streams and rivers, the inner zone could extend 25' from the top of the bank and the transition zone could extend an additional 75' from the edge of the inner zone to the development zone. For jurisdictional and non-jurisdictional wetlands, the inner zone should also extend 25' out from the edge of the mapped wetland and an additional 25'-50' transition buffer could be established beyond the inner zone. The width of the transition zone may vary for jurisdictional versus non-jurisdictional wetlands or based upon their size. If within a major subdivision, these areas may also be platted as open space under the management of the HOA. Additionally, the provisions for vegetation

management would need to be further guided by covenants and restrictions.

If a developer within the regulated geography chooses to modify or remove wetlands or natural water bodies, this would warrant the replacement of wetlands at 2 to 1 replacement value in another area on the site or within the same watershed. Another alternative would be to contribute towards the acquisition of open space within the same watershed.

The ability to manage and maintain ditches in proper working order is also critical to the County's overall stormwater management system. Because ditches do not exhibit the same natural conditions as wetlands or other waterbodies, they should not be upheld to the same buffer standards. It is recommended that a 20' maintenance zone be established from the top of bank on one side of ditches. This zone would ensure that the conveyance structures can easily be accessed and maintained. The maintenance zone should be located outside of newly plotted lots within subdivisions. In areas that are already developed or developed as individual lots, the 20' zone should be designated open space. Previously established lots would be grandfathered. This zone is crucial as maintenance is important to ensure that water can flow within and off the site as designed. Ensuring fee-simple platted maintenance access to and around future stormwater ponds may also be considered to keep the area free of obstructions and alterations. It would also provide additional storage space should a rain event occur that exceeds the pond's design standards.

CONSIDERATIONS

Multiple measures would be required to establish riparian and wetland buffers in unincorporated Horry County. These could occur concurrently or in sequential order.

- Revise Horry County Land Development Regulations to prohibit the platting of wetlands and stormwater maintenance easements in the lots of major residential developments.

- Revise stormwater easement standards for ditches and ponds to allow for a 20' maintenance area from the finished top of bank outside of the property lines and within the common area or open space for the development. Ditch easements could minimally run continuously on one side to ensure adequate maintenance equipment access.

- Map riparian corridors and potential wetlands utilizing County-collected, high resolution land cover data. This information may be used to map and evaluate different riparian and wetland buffer scenarios to determine appropriate buffer widths.

- Establish riparian and wetland buffer regulations for all new major residential developments. These regulations would prohibit fill and grading and limit tree removal within the buffer area. Establishing an overlay in which buffers are required is an alternative to creating county-wide riparian and wetland buffer regulations. An overlay could also allow for riparian and wetland setbacks for other types of land uses.

- Develop model covenants and restrictions for the management of wetlands and buffers in major residential developments.

- Revise Horry County Land Development Regulations to prohibit fill within the regulatory flood zone of all major and minor residential developments, including commercially reviewed multi-family developments. If these restrictions are included in the Land Development Regulations or Stormwater Ordinance, and not the Horry County Flood Prevention Ordinance, it could allow relief for developers and property owners through design modifications, onsite mitigation, or fees, as fill does not have to be prohibited in order for Horry County to be part of the National Flood Insurance Program.

PROJECT BENEFITS

Riparian and wetland buffers offer numerous benefits, including temporary flood storage, delay of runoff entering water systems, increased absorption of runoff, shoreline stabilization, and minimized infrastructure damage as a ramification of flooding. Through maintaining the natural function of the corridor closest to the water systems, this part of the floodplain can provide a place for temporary storage during storm events when the excess water from the wetlands or channel spills over from the banks into the buffer area, without threatening infrastructure. These corridors also minimize the amount of impervious land near the water bodies, thereby allowing for maximum absorption of runoff into the ground before the runoff enters the waterbodies, thereby contributing to minimizing fluvial flooding. In

addition, undisturbed buffers allow the vegetation to reduce the velocity of runoff migrating into waterbodies and flooding areas further downstream. Secondary benefits of requiring riparian and wetland buffers include the protection of contiguous habitat and the dedication of land that can serve as passive recreation.

TABLE 1: RIPARIAN CORRDIORS

Inner Zone	
Definition	The first tier, an "inner zone," would be a zone left in its natural state or returned to an enhanced state, if already improved. The distance nearest to either side of the water body from the tops of bank would be defined as the stream management zone or inner zone. No modifications to elevation, slope, or vegetation would be permitted in this zone, except for rehabilitation purposes to enhance ecology and hydrology.
Permitted measures	For streams, the inner zone should extend 25 feet nearest to either side of the top of the stream bank and the transition zone should extend an additional 75 feet from the edge of the inner zone to the development zone. For jurisdictional and non-jurisdictional wetlands, the inner zone should also extend 25 feet out from the edge of the mapped wetland and either a 25 or 50 foot transition buffer beyond the inner zone should be established.
Transition Zone	
Definition	The second tier, a "transition zone", would serve as a transitional zone between the protected area and the buildable area. Development in the transitional zone would be restricted to uses that support wetland and waterway health. This zone would serve as a transition between natural and developed areas. Permitted uses would aim to clean and filter run-off water and slow velocities to maintain internal channel geometries.
Permitted measures	Permitted measures within a transition zone may include: • The removal of invasive species • Managed planting • Passive recreation (i.e. trails) • Pervious surfaces

Expanded Tree Preservation Standards

PROJECT DESCRIPTION

Imagine 2040, the County's Comprehensive Plan (Natural Resources Element), states "A majority of properties are being clear cut to meet stormwater grading needs to prevent flood damage, in exchange, there is a decrease in tree canopy to absorb flood waters." While compensation is made through the design of engineered stormwater systems, preserving the mature tree canopy can effectively provide for flood storage and slow runoff rates, while also preserving the existing ecology. The Environmental Protection Agency (EPA) states:

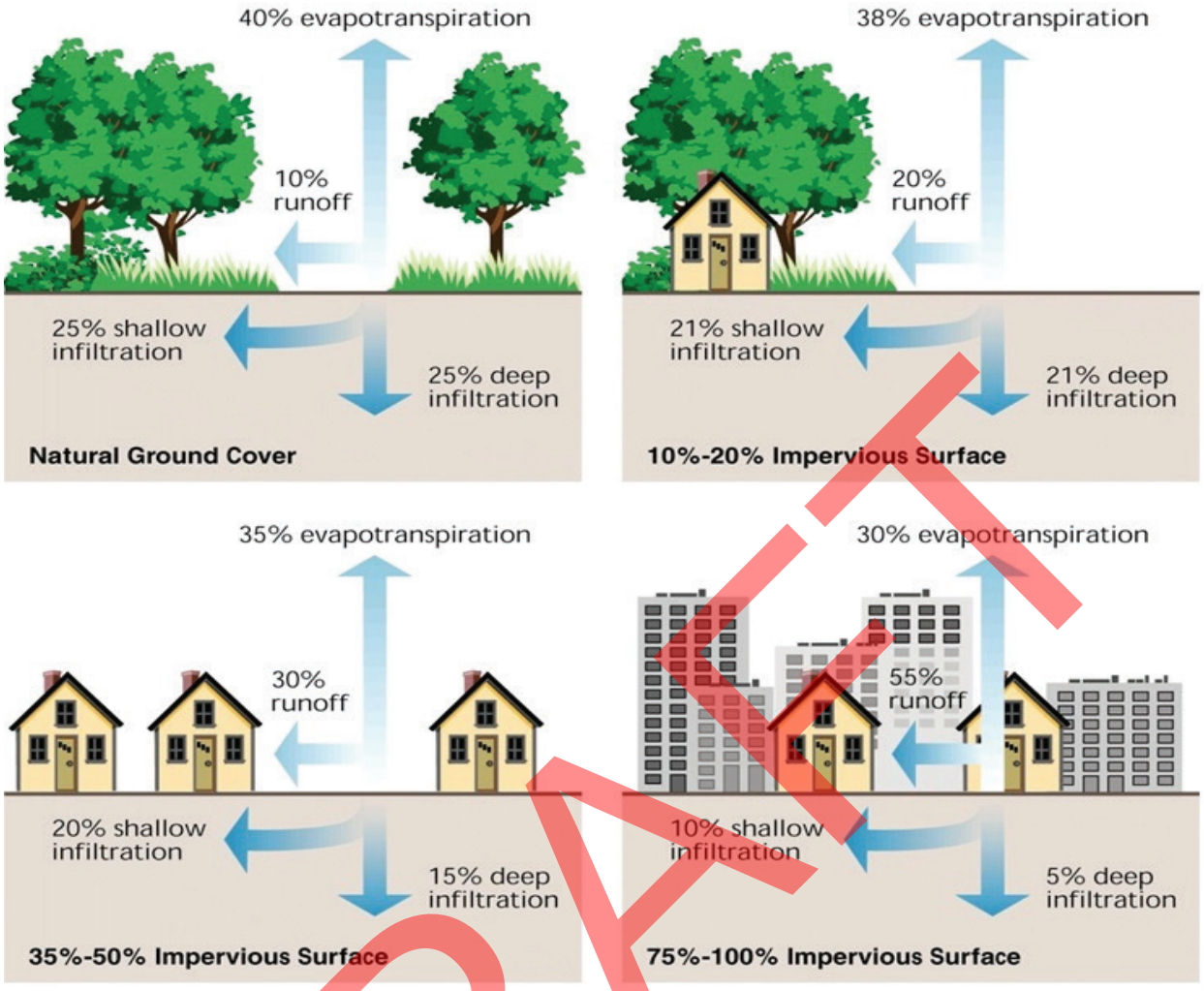
> Mature trees provide significant stormwater quantity and rate control benefits through soil storage, interception, and evapotranspiration. A tree with a 25-foot diameter canopy and associated soil can manage the 1-inch rainfall from 2,400 square feet of impervious surface. Interception and evapotranspiration also decrease runoff volume with larger trees providing exponentially more benefit than smaller trees.

The Landscape Buffer and Tree Preservation Ordinance is the County's primary tree preservation tool. It sets forth tree preservation requirements and beautification standards for multi-family and other commercially reviewed developments along major roadways. Additionally, it requires the preservation of specimen live oaks over 24" diameter at breast height (DBH) throughout all unincorporated areas. It also provides developers with options to incorporate low impact development design into landscaping requirements. It does not include tree protection standards for major and minor residential developments.

Horry County has a number of tools that support the protection and preservation trees. The County has a Conservation/Preservation zoning district which allows for the voluntary conservation of natural areas, which typically includes preserved forestlands and wetlands. Within Multi-Residential (MRD) Districts, the County provides for sustainable development standards that include the preservation of portions of the development site in a natural vegetated state. MRD is a commonly use performance-based zoning district that developers voluntarily opt to use because they can earn flexibility in residential design standards and increased density through better site design. Beyond these voluntary options, the County's Land Development Regulations require both active and passive open space in all major residential developments with greater than or equal to two units/acres of gross density. These areas often include woody wetlands, but the upland open space is often cleared and graded as part of an overall stormwater master plan and is then replanted to be aesthetically pleasing to buyers. At this time, these spaces are not required to retain predevelopment tree canopy or to replace a portion of it. Similarly, there are no other required measures to preserve tree canopy in residential subdivisions beyond a landscape buffer along the frontage of specific County roads defined in the Landscape Buffer and Tree Preservation Ordinance and corridor overlays that are primarily focused on regulating aesthetics.

An incentive for tree preservation in major residential subdivisions could be built into the County's Landscape Buffer and Tree Preservation Ordinance and augmented within the Multi-Residential District to protect groups of trees within the upland areas. Combining tree preservation with a wetland protection strategy could have the additional value of increasing water storage capacity and improve runoff water quality. In such a stormwater sensitive location as Horry County, most development types, including subdivisions, commercial & industrial developments, and multifamily housing, should have tree preservation and planting (landscaping) requirements regardless of their location.

Multiple effective tree preservation programs in other jurisdictions take advantage of a combination of incentive-based structures, planning and design guidelines, and ordinances. For instance, many communities utilize what are called "tree save" standards for residential and commercial development, which require tree preservation as part of site development requirements. The City of Charlotte, NC requires that 10 percent of the area of a site under development for residential purposes be set aside to preserve mature trees existing on the site. The preservation requirement increases to 15 percent of total site area for commercial development. Charleston, SC has placed a priority on protecting clusters of pine trees during construction, especially in areas where they do not threaten current or future structures. Horry County has a significant pine tree canopy. Pine trees are very effective sources for water storage due to the high leaf areas index



Above image illustrates that the preservation of tree canopy results in a higher rate of evapotranspiration and infiltration along with less runoff. From: Stream Restoration: Principals, Processes, and Practices (FISRWG 1998).

of pine needles. The County could consider an incentive designed specifically for the preservation of pine tree stands or other groves of trees.

Additionally, the City of Pine Lake, Georgia provides developers with stormwater credits per inch of the DBH for preserving existing trees under 12" DBH, and 20 gallons of credit per inch of DBH for preserving existing trees over 12" DBH. This approach is not directly replicable in Horry County as stormwater fees are established after a development site has sold and individual homes have been built. Tree preservation could serve to reduce the overall volume of water that needs to be retained onsite. A tree survey would need to be conducted prior to development to identify protected trees prior to construction plan approval. Protected trees would need to be verified prior to final plat approval or a certificate of occupancy is granted. Tree survey conditions for major residential developments would be similar to those already required for commercially reviewed sites where the Landscape Buffer and Tree Preservation Ordinance already applies.

Beyond revising the Landscape Buffer and Tree Preservation Ordinance, tree preservation in major and minor subdivisions could occur through the creation of an overlay for a specific community, watershed, or other geographic area of concern. In all cases, with new regulations, there will need to be adequate enforcement personnel, whether in planning, code enforcement, or stormwater management. For major residential developments, homeowner's associations also serve as another layer of protection for preserved trees both within common areas and on privately owned lots.

CONSIDERATIONS

There is an opportunity to enhance existing policies to support the preservation of tree canopy within Horry County and to tie tree preservation into a larger strategy for naturalized

stormwater protection in areas where development is rapidly occurring proximate to flood hazard areas and waterbodies. The following are a suite of options for the County to pursue to preserve and restore tree canopy:

- Require the preservation of 10 percent of the predevelopment tree canopy (DBH), including specimen trees, within the upland areas of all major residential subdivisions. This would require a predevelopment tree survey and calculation of the predevelopment DBH. Preferably, the trees would be protected within neighborhood open space to ensure they are maintained by the homeowner's association and are protected through covenants and restrictions.

- Incorporate tree canopy preservation as a component of an existing overlay, and not necessarily as a standalone regulation for the entire County. Such requirements could follow the bounds of an existing community overlay or be combined with a Riparian and Wetland Buffer overlay. An overlay could specifically include tree canopy requirements for major residential subdivision, but it could also apply tree preservation requirements for minor and commercial development.

- Expand the list of specimen tree species beyond live oaks over 24" DBH or establish a minimum size, for instance 36" DBH, in which any protected tree would also be classified as a specimen tree.

- Amend the Landscape Buffer and Tree Preservation Ordinance to require the planting of a tree on every residential lot within a major subdivision prior to issuing the Certificate of Occupancy (CO) of a new home.

There are multiple options for Horry County to expand the preservation of the tree canopy within residential subdivisions. Any of these alternatives would build upon existing regulations and the proposed strategies in the Riparian and Wetland Buffers section and Resilient Subdivision Design Standards described in the next section.

PROJECT BENEFITS

Horry County can benefit from major residential development standards which promote the preservation of mature trees and tree stands. These standards can help to improve post-development stormwater management and can address public concerns associated with site clearcutting. Tree preservation standards can be established so incentive-based zoning or other preservation provisions do not result in any loss of allowable site density and can achieve design flexibility around natural systems. Additional benefits of this strategy include the reduction of local heat island effects, reductions in the need for total fill, and the connection of ecological systems across multiple sites. Beyond the stormwater and ecological benefits, tree preservation is also proven to result in higher sale prices for new homes and higher property values overtime.

3.2.3

Resilient Subdivision Design Standards

Horry County's zoning and land development regulations, as with most jurisdictions, result in predictable subdivision design, but do not necessitate that development avoid vulnerable and environmentally sensitive areas. There are currently large swaths of the County that are already zoned to allow for major residential subdivisions in rural and often environmentally constrained areas of the County, including much of the Commercial Forest Agricultural zoned lands. Establishing resilient subdivision design standards would permit residential density to remain the same as the underlying zoning would allow; but would concentrate development on a portion of a site in exchange for reduced density or no development in large, contiguous, and often environmentally constrained portions of a site. Minimum lot sizes, lot widths, and setbacks would be alleviated to ensure that the developed portion of the site is as compact as possible, leaving at least half of the site as undisturbed, contiguous open space which would include floodplains and wetlands.

It is recommended that Horry County incorporate resilient subdivision design standards into its zoning ordinance. Such developments are recommended to be allowed as "by right" development that allows the property owner to develop or redevelop without requiring the site to be rezoned, if it is consistent with adopted development standards and plans for the area. Adopting a floating zone is another alternative that would require a developer to petition for the zone. The City of Conway, the City of Myrtle Beach, and Charleston

County, are all nearby jurisdictions in which similar ordinances have been adopted. In many communities, the option for a cluster or conservation design is voluntary and rarely implemented, if at all. The preferred alternative would be to define a geographic area, through an overlay, in which resilient subdivision design standards would be required for major residential developments. This approach would ensure that the desired interconnected network of open space, wetland, and floodplain protection, as described within *Imagine 2040* and the *Horry County Parks and Open Space Plan*, would be realized.

1-Undeveloped *2-Typical Subdivision* *3-Resilient Subdivision Design*

POLICY CONSIDERATIONS

In Horry County, it is recommended that resilient subdivision design standards be allowed in all residential zoning districts and be required within a geographically defined overlay including environmentally sensitive, flood prone areas. The County may wish to consider resilient subdivision design standards applying to plots of land that are a minimum of 20 contiguous acres and meet one of the following conditions:

1. Floodway or Special Flood Hazard Area (SFHA); or
2. Florence Adjusted Base Flood Elevation (BFE); or
3. Shoreline along waters of the United States (tributaries or larger); or
4. Wetlands (including non-jurisdictional) present on 40% of the site; or
5. Continuously forested acreage over 50% of the property; or
6. Adjacent to existing conservation or recreation property that is owned or managed by a Federal, state or local government, or conservation entity.

To qualify, a development master plan should be submitted to the County, along with construction plans for the first phase of development. Conceptual lot yield layouts should be provided to the County in early phases of project that conform to current zoning and meet all requirements provided by the Land Development Regulations. This will help determine the number of dwelling units that could occur within the net buildable area and will serve as the baseline for adhering to the requirements of the incentives.

Conditions of the resilient subdivision design typically include the following:

1. 100' riparian buffer adjacent to shoreline of waters of the United States
   ii. 25' riparian stream buffer, including an easement for maintenance on the side closest to the shoreline; and
   iii. 75' transitional buffer.
2. 75' buffer adjacent to properties under existing conservation managed by a Federal, State, or local government, or conservation entity.
3. 50' riparian wetland buffer (includes non-jurisdictional features) for wetlands 3 acres or larger.
4. 25' riparian wetland buffer (includes non-jurisdictional features) for wetlands less than 3 acres.
5. No modifications to elevation, slope, or vegetation is permitted in the riparian stream and wetland buffers except for rehabilitation to enhance ecology and hydrology, to provide access for the uses allowed herein, or stormwater conveyance.
6. All residential lots platted outside of the SFHA and buffer areas.
7. No grading, fill or permanent structure within the SFHA (see exceptions below).
8. No grading, fill or permanent structure within the Florence adjusted BFE (see exceptions below).
9. No land disturbance in wetlands (includes non-jurisdictional features).
10. Minimum 35' setback from adjacent existing roadways.
11. No tree removal in applicable forestland (under brushing allowed).
12. 50% of the property to remain undeveloped and shall be identified as a Conservation Area.

There should be exceptions for the aforementioned conditions. Roads, utilities, active recreational open space, stormwater retention, and conveyances could still be allowed in the Special Flood Hazard Areas. Within delineated buffers and conservation areas, there could be allowances for passive recreational features (ie. gazebos, benches, and elevated walkways) and easements for drainage, access, and utilities.

To encourage implementation of resiliently designed subdivisions, the following incentives could be incorporated into the development:

- Remove minimum setback requirement (except for

adjacent existing roadways)

- Remove minimum lot size restriction
- Remove minimum street frontage
- Remove minimum lot width
- Allow for required parking to be partially or wholly met through common parking and/or reduce parking requirements
- Perimeter landscape buffers may be waived except along Collector or Arterial roads
- Private roads (access and alley only) may be held in common
- Alley ways may serve as primary access to 3 lots/units with 1 point of ingress/egress with an 18' pavement width. An alley cannot originate from another alley
- Conservation areas shall count towards the required open space
- Maximum density shall be capped at 25% above the number of lots/units allowed in a Yield Plan developed for the underlying zoning.

While this could be an option for all residential developments in the County, an overlay in the most hazard prone areas of the County may be considered to have the greatest impact and to achieve the future land use goals of the *Imagine 2040 Comprehensive Plan* and low impact development strategies supported by the Horry County Stormwater Manual. Establishing an overlay may also be an appropriate first step to pilot the previously-mentioned strategies for the creation of Riparian and Wetland and for Expanded Tree Preservation Standards within major residential subdivisions.

PROJECT BENEFITS

Establishing resilient subdivision design standards would transform the residential subdivisions in the County, resulting in more uniquely designed communities that avoid natural hazards and preserve open space for habitat, recreation, and flood attenuation. The Center for Watershed Protection indicates that such developments can result in a 40-60% decrease impervious surfaces, particularly when more narrow streets can be utilized, resulting in a 20-60% reduction in annual runoff volume. Other benefits include less pollutant runoff flowing into receiving waterbodies and the preservation of tree canopy and habitat.

Beyond the environmental benefits, such developments can be significantly less expensive to build than traditional developments because less road, utility, and stormwater infrastructure is required in comparison to typical residential developments. One case study indicates that the average cost to construct such a development cost $7,400 less per unit to construct and homes sold more rapidly than those in similar homes in traditional subdivisions. The residents indicated that they would be willing to pay $2,000 more on average for the proximity to open space. In Horry County, a developer could save over $600 for every linear foot of roadway that does not have to be constructed, resulting in significant cost savings for a neighborhood design that is less impactful on the environment and more resilient to flooding.

Beyond cost savings and return to the developer, the protected open space would likely include streams, wetlands, woodlands, and even farmland that would serve as neighborhood amenities, improving the quality of life for residents. The open space could be maintained as common areas, or could be transferred to a conservation organization if it meets the organization's selection criteria and is within their priority acquisition area. The other alternative would be to establish a conservation easement on the property with the homeowner's association being responsible for its maintenance. Both alternatives would provide the developer with tax benefits and ensure the site is managed appropriately.

3.3
Resilient Infrastructure Considerations

Throughout the County, there are locations where flooding is acute and localized improvements can be implemented to mitigate against flood conditions. To determine improvements for drainage to reduce flooding, the system must first be analyzed. This analysis will help determine deficiencies in the drainage system and provide opportunities for improvement. The studies can also be used for future development in the area by providing an overall watershed stormwater model.

3.3.1
Watershed Hydrology Modeling

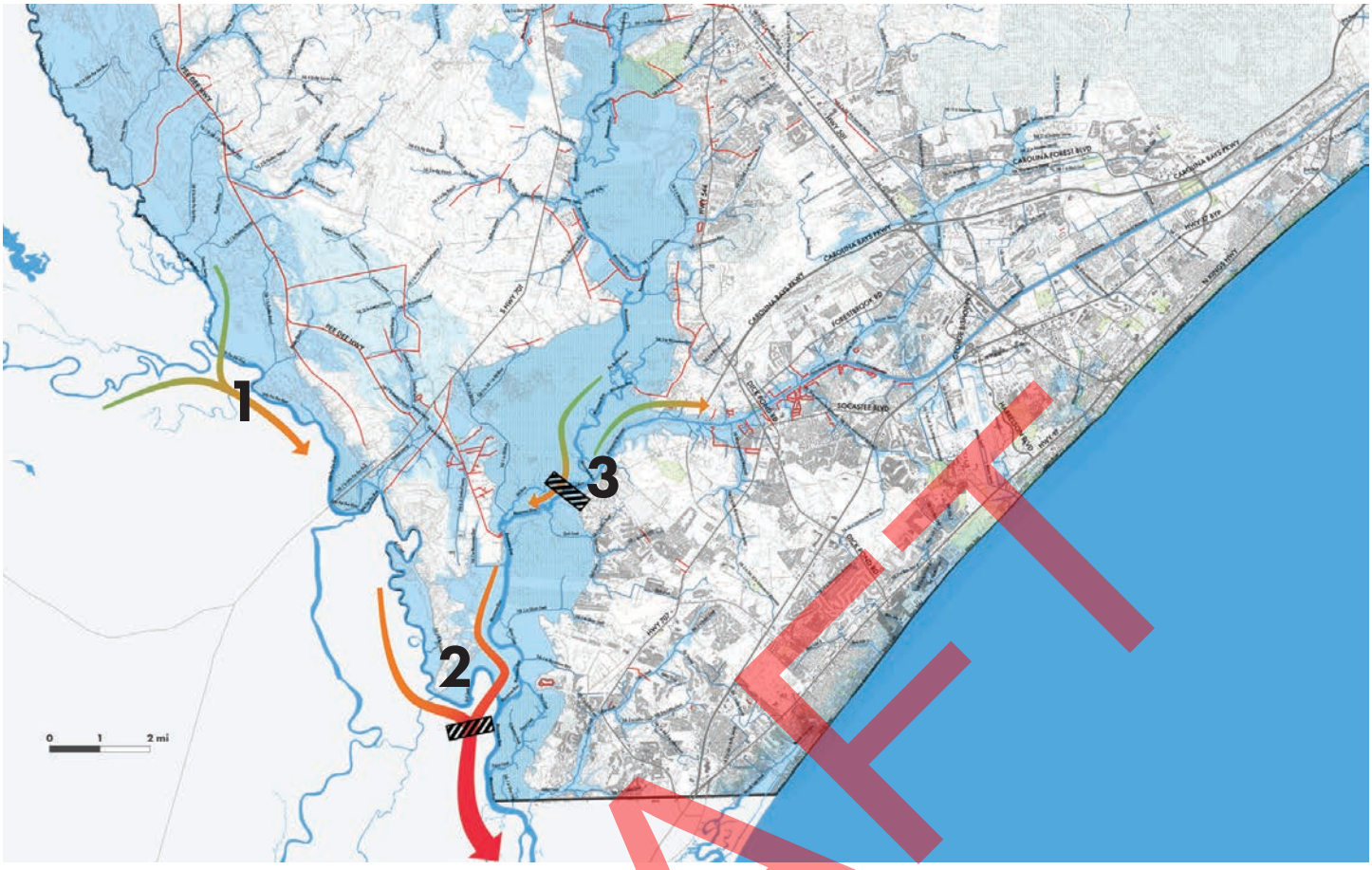
PROJECT DESCRIPTION AND CONSIDERATIONS

Horry County's watersheds and riverine systems are dynamic. To determine specific infrastructure improvements, watersheds need to be analyzed using Hydrology and Hydraulics (H&H) studies to determine greatest impact on localized flooding. H&H models simulate the movement of water, including the volume and rate of flow as it moves through a watershed, basin, channel, or man-made structure and can be used to predict stormwater runoff, and sedimentation. H&H studies can provide a comprehensive understanding of flooding dynamics, to more effectively target locations for critical drainage infrastructure improvements. The H&H studies should utilize existing conditions as well as incorporate potential development to determine what effects, if any, would be experienced as the County grows within its Comprehensive plan.

The first step would be to prioritize the most impacted watersheds so that funds can be distributed strategically to advance modelling and to inform decisions concerning future capital investments and master planning efforts. The models should be calibrated to yield precise results. Historic events, or data collected from gauges, should be used to both calibrate and validate the updated model prior to the simulation of design storms. Historic precipitation data could be obtained from USGS precipitation gauges for calibration purposes.

PROJECT BENEFITS

There are multiple benefits to the development of comprehensive models for watersheds within the County. The information enables scenario testing and detailed flood risk analyses. The model would incorporate wetlands and floodplains in the area which would be used to determine the effect of any impacts to these critical natural features. Drainage patterns and conveyances would be analyzed, critical pinch points would be identified, establishing flow paths and run-off volume potential. Identified deficiencies would be used to as an opportunity to model improvements.



1 *Rainfall runoff from the large upland watershed collected in the Pee Dee River as it moved toward the coast.*

2 *Water built up in Winyah Bay, where the watershed drains to the coast. Because the Pee Dee is at a higher elevation than the Waccamaw, it created a dam, backing up the Waccamaw's flow.*

3 *As the Waccamaw backed up, it pushed water back up the Intracoastal Waterway, filling the floodplain of the former Socastee Swamp and flooding Socastee.*

The image above illustrates how the interaction of two large watersheds at Bucksport causes water to back up into Socastee. Rainfall runoff from as far upland as North Carolina and Virginia drains through the Pee Dee and Waccamaw Rivers until they meet at a confluence point near Bucksport. From there, water is conveyed as one river towards the coast. The Pee Dee River sits at a higher elevation than the Waccamaw River, creating a dam-like phenomenon that causes water to back up into the Waccamaw River and breach the banks around the Socastee area.

3.3.2

Resilient Infrastructure Design Strategies

PROJECT DESCRIPTION AND CONSIDERATIONS

After Hurricane Florence, the Pee Dee and Waccamaw Rivers began rising to an elevation that introduced a larger backwater condition in the many tributary streams and wetlands, underneath roadways, and past homes. As this backwater increased, culverts under roadways conveying runoff began to fill and eventually overtopped roads. This created a dangerous situation in which isolated pockets of homes that may not have been damaged from floodwaters still could not be accessed safely.

The tributaries that drain into these large rivers wind through many communities, crossing under local roads via structures that allow water to flow from one side of the street to the other. These areas are susceptible to water backing up into zones that are closer to the main riverway. As waters rise, roads become inundated with water, thereby inhibiting ingress and egress to and from communities. The safety concerns that communities face from roadway flooding can be mitigated with the raising of the major flood prone arteries, as well as by increasing culvert capacity.

Determining the appropriate infrastructure improvements to advance requires the development and analysis of a detailed hydraulic model. An example of software that fits the needs of this analysis is the U.S Army Corps of Engineers' HEC-RAS program, paired with the hydrologic analysis program HEC-HMS from the same agency. This program captures the topography of the County, the reaches of each river, and the hydraulic structures (ie. culverts) with which the reaches interact as inputs, thereby determining which hydraulic structures would fail in different storms under various conditions. A comprehensive model that focuses on the major rivers and the local reaches feeding into the river systems would yield accurate results to inform culvert sizing and design decisions.

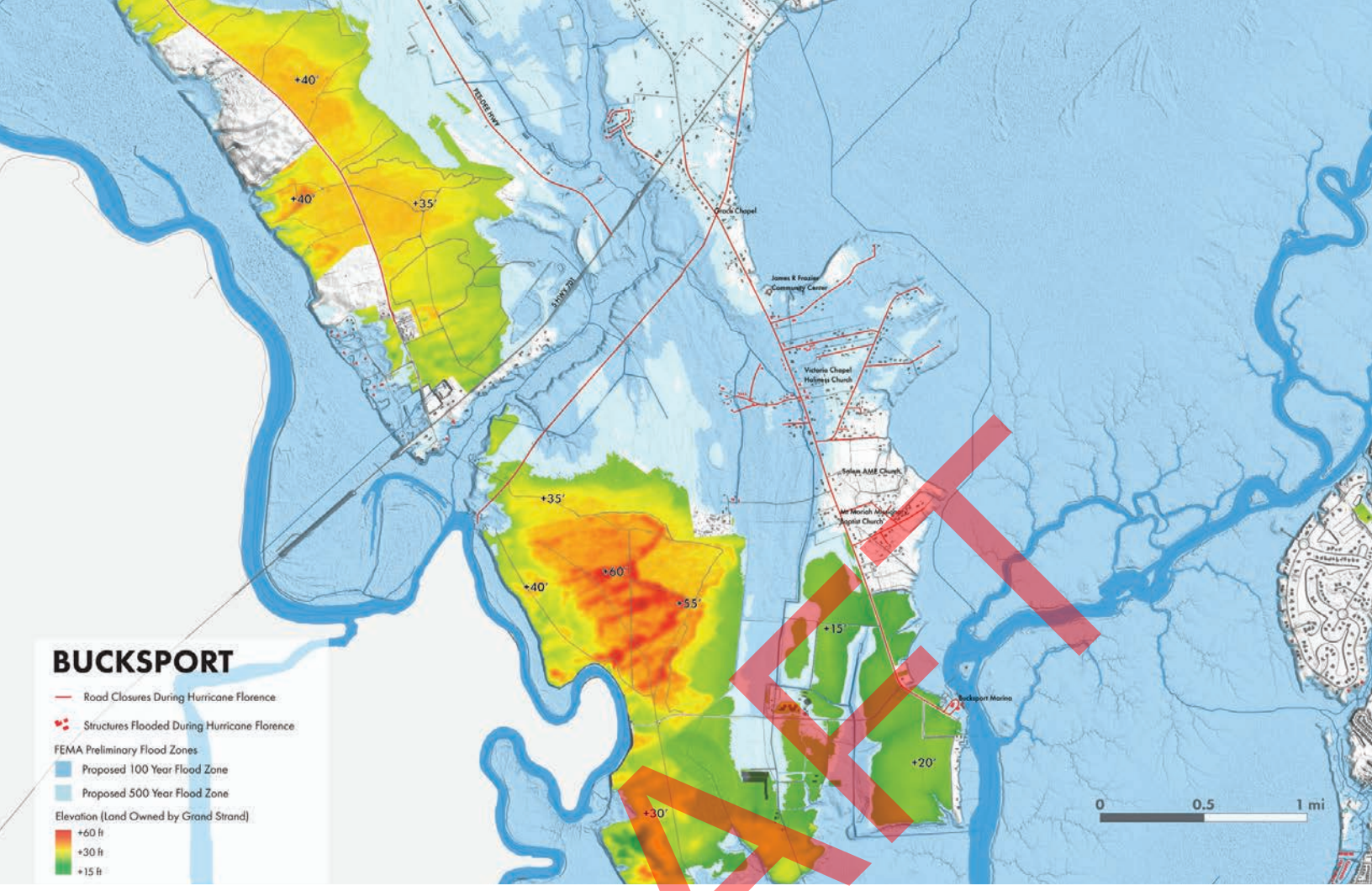
Incorporation of the plan would address improvements to SC Hwy 90, SC Hwy 905, SC Hwy 9, SC Hwy 501 Bypass SC Hwy 701 North of Conway, and SC Hwy 22 as well as other major arteries to address future flooding and protect the health, safety, and welfare of residents and visitors.

One project identified in this process was in the Bucksport area. Bucksport lies in between the Pee Dee and Waccamaw Rivers, where residential developments are spaced far apart and interspersed with many single family homes, creating a patchwork of roads, small clusters of homes and isolated developments. Big Bull Landing Road extends from Bucksport Road to Port Harrelson Landing on the Pee Dee River. The existing road follows the land contours until its destination. The elevation of the road varies from approximately 8 feet MSL to 15 feet MSL. Runoff from the Bucksport Community travels under Big Bull Landing Road 1,600 feet southwest of Bucksport Road to the Pee Dee River. During the past several flood events, the Pee Dee River backflows through the culverts and over Big Bull Landing Road and causes significant flooding in the Bucksport Community.

This pilot project would raise Big Bull Landing Road, making the flooding less likely by creating a levee/dam at the existing crossline. The existing culvert under Big Bull Landing Road would remain and be extended in each direction to allow for the additional width of the fill slopes. During a flooding event, the culvert would be blocked to prevent water from the Pee Dee River backing up into the community. Since it can take approximately two or three weeks for upstream floodwaters to reach and impact this area, there would be ample time to block this culvert prior to floodwaters reaching this location.

PROJECT BENEFITS

A systematic approach to create infrastructure projects along roadways within the County would serve to improve access and maintain major arteries of egress or alleviate flooding in critical areas.


BUCKSPORT
Road Closures During Hurricane Florence
Structures Flooded During Hurricane Florence
FEMA Preliminary Flood Zones
Proposed 100 Year Flood Zone
Proposed 500 Year Flood Zone
Elevation (Land Owned by Grand Strand)
+60 ft
+30 ft
+15 ft
+40'
+35'
+60'
+55'
+15'
+20'
+30'
PEE DEE HWY
Oracle Chapel
James R Frazier Community Center
Victoria Chapel Holiness Church
Solam AME Church
Mt Moriah Missionary Baptist Church
Bucksport Marina
0
0.5
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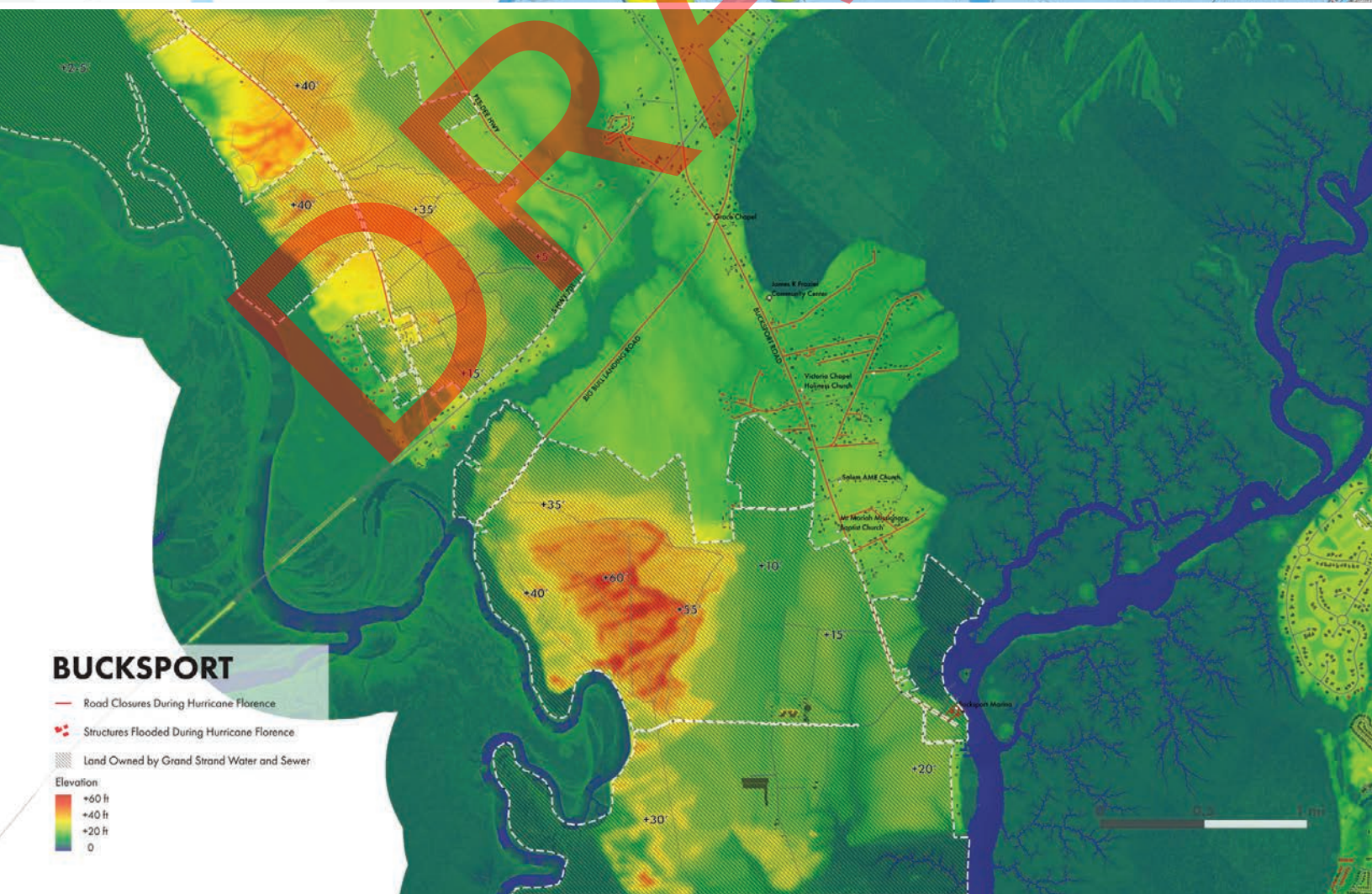

BUCKSPORT
Road Closures During Hurricane Florence
Structures Flooded During Hurricane Florence
Land Owned by Grand Strand Water and Sewer
Elevation
+60 ft
+40 ft
+20 ft
0
+40'
+35'
+60'
+55'
+15'
+10'
+20'
+30'
PEE DEE HWY
BUCKSPORT ROAD
BIG BULL LANDING ROAD
Oracle Chapel
James R Frazier Community Center
Victoria Chapel Holiness Church
Solam AME Church
Mt Moriah Missionary Baptist Church
Bucksport Marina

Watershed Management and Regional Storage Improvements

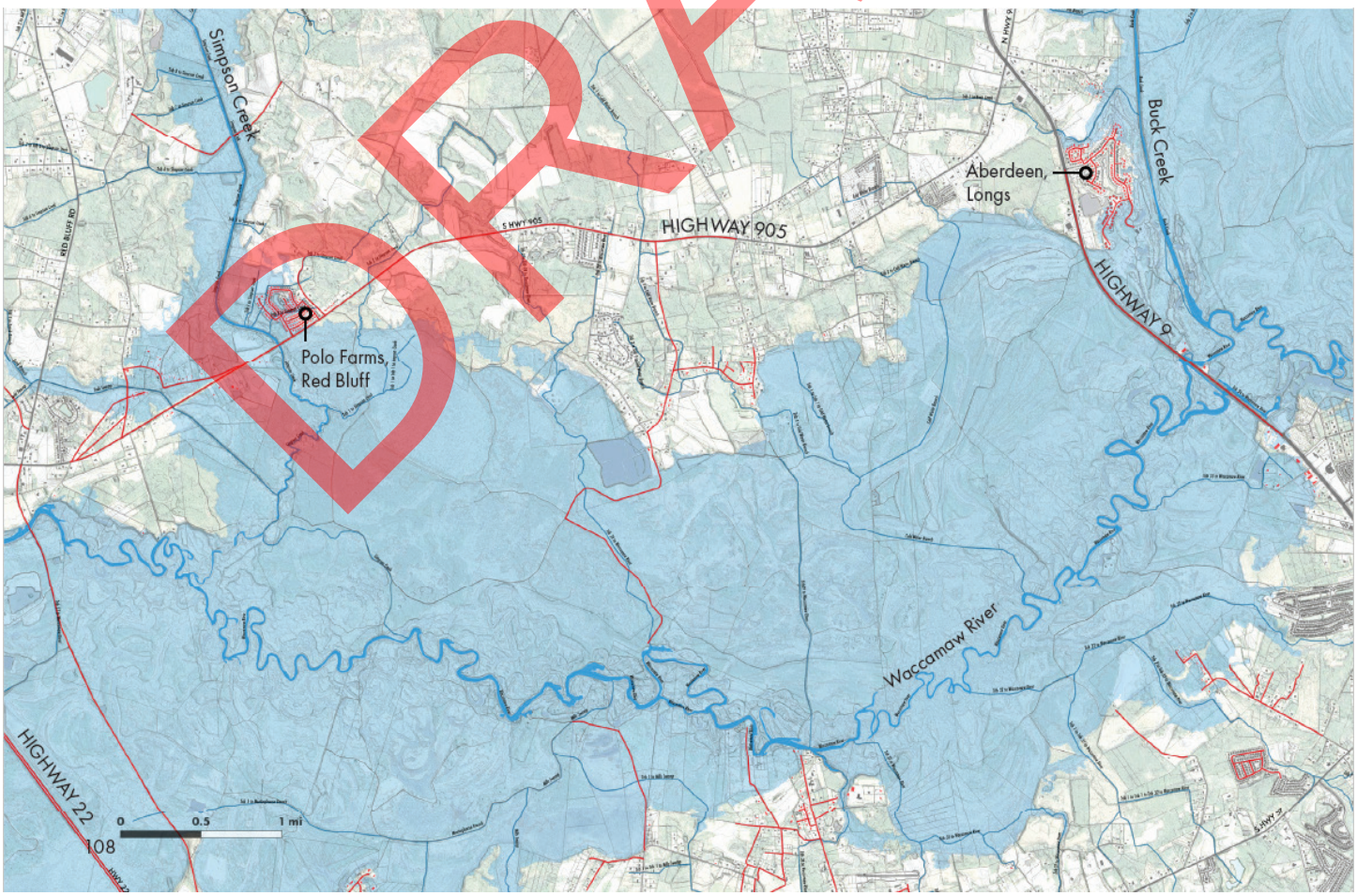
PROJECT DESCRIPTION

In a flood situation, timing is a critical factor. The stage elevation of the river increases whenever water volumes enter the river system at a rate faster than they can drain out of the system, thus causing the river channel to exceed capacity and causing waters to rise. If less water can be introduced into the river system through increased upstream storage and detention within the reaches and tributaries, stress on capacity to exceed flow rate will be reduced, slowing the rise of water.

Large rivers like the Pee Dee and the Waccamaw contain a multitude of smaller feeder creeks or runs that convey run-off water from developments and undeveloped land into the larger systems that ultimately convey water out to the Atlantic Ocean. These creeks and their associated swamps, wetlands and low-lying vegetated land help to alleviate flood impact by storing water and recharging water back into the ground.

In the community of Longs/Red Bluff, some of the Florence flooding radiated from two tributaries that feed the Waccamaw River, Simpson Creek and Buck Creek. These man-made canals are characteristic of the infrastructure in the region and are appropriate candidates for regional creek storage improvements.

Detention basins could take the form of large storage lakes that could be drained in advance of flood events, or smaller dispersed detention ponds that could increase creek storage capacity. This strategy has been implemented for the Bayou system in Houston, Texas, a system that is being expanded based upon the extent of flooding that came from Hurricane Harvey. The larger systems are typically built and managed as government-owned property, often taking the form of passive recreational amenities, while serving as critical storage during storm events. Smaller detention structures could also be used by requiring new developments to meet



a higher standard for storage capacity in these areas. Many creek systems employ both strategies to optimize storage in areas where land development pressures exist.

Another alternative would be to provide floodplains along the banks of these canals. This would be accomplished by benching the sides of the canals to allow the water to come out of the bank and overflow into a man-made floodplain.

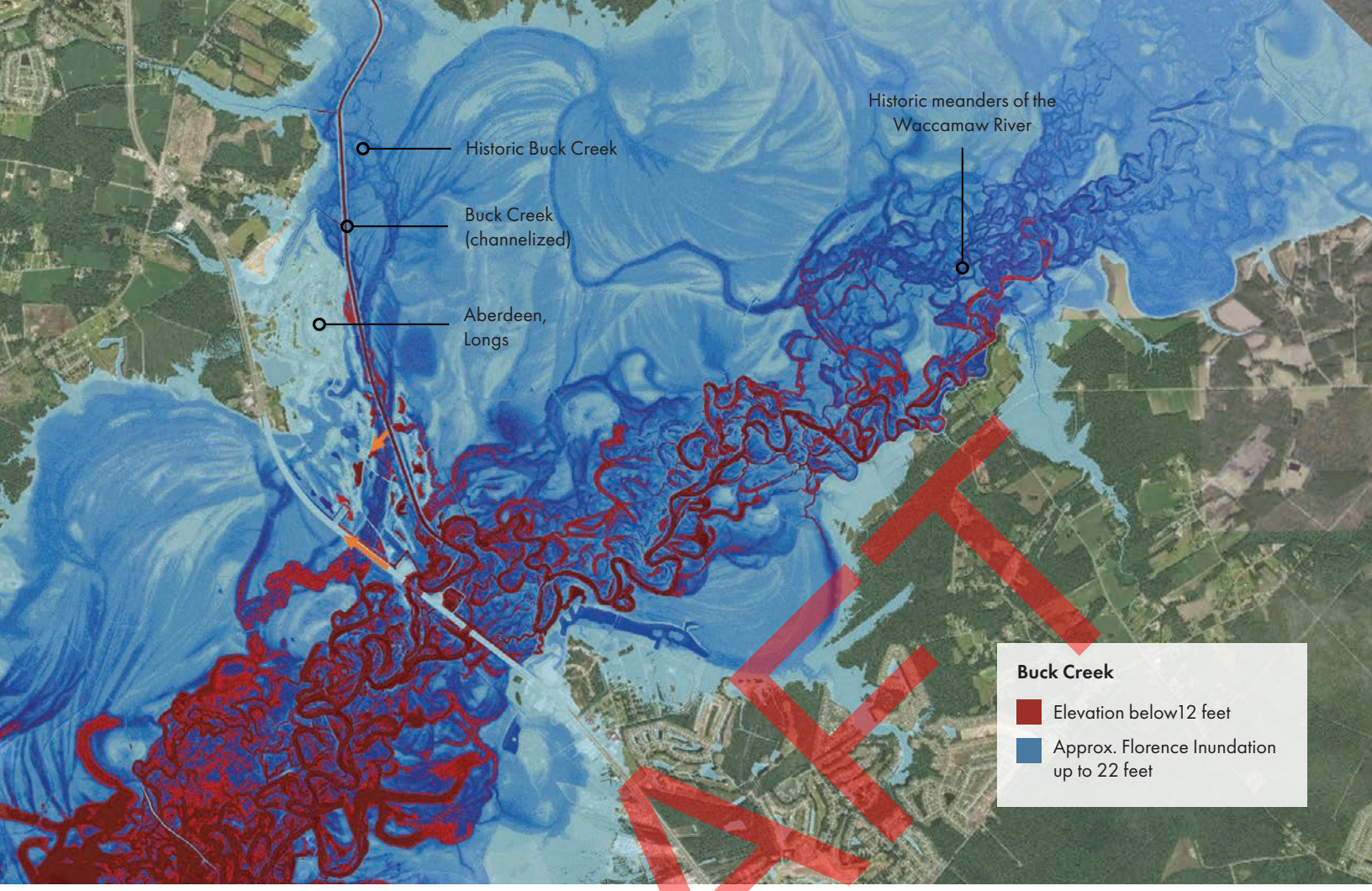
CONSIDERATIONS

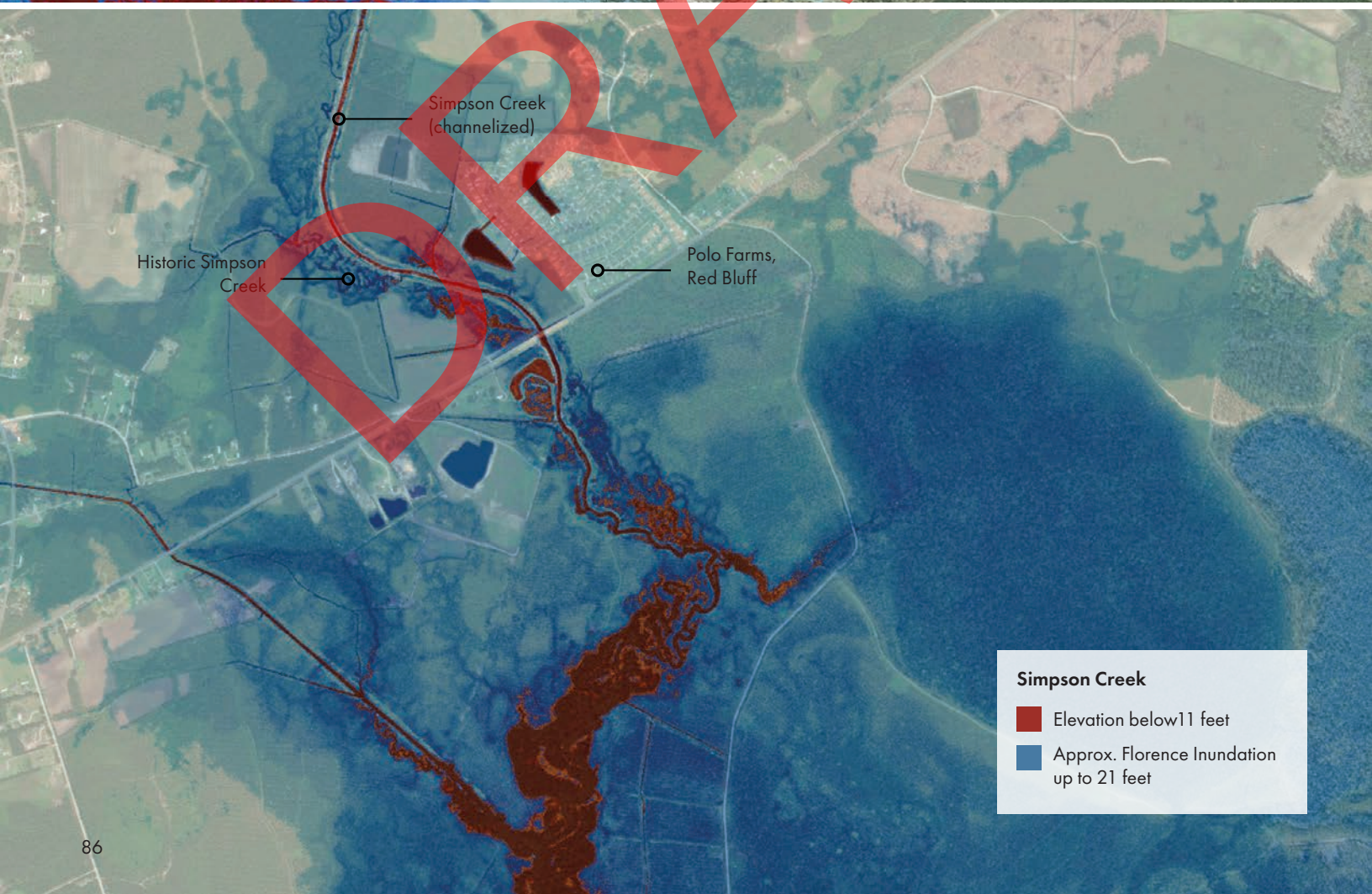
In Horry County there are several watershed canals like Buck Creek and Simpson Creek. The goal should be to systematically create additional storage, where possible, within the reaches and to consider all of the creeks as contributors to the larger network of streams and rivers. These storage systems would all participate in a regional stormwater management strategy as they come on-line, either as part of the normal course of private development or through targeted capital expenditures. Buck Creek and Simpson Creek storage improvements can serve as pilots for similar creek storage improvements throughout the County, creating a holistic storage network that works as a system to alleviate flood impacts from storms like Matthew and Florence.

The various storage areas should be placed strategically to maximize effectiveness. To optimize the efficiency of this plan, it is recommended that the County create a mechanism for developers to contribute into a stormwater system that is designed by the County. Through this approach, the County would incentivize developers to address the stormwater management aspect of their new developments, while still allowing the County to design the optimized stormwater system and identify larger storage locations that provide the main storage relief for each reach. Another option would be to determine specific areas that could be developed, requiring any new development to provide additional storage above the current Stormwater regulations. It is recommended that the storage points be placed near junctions of creek reaches, in areas where the natural soil drains well, or in undeveloped land parcels. Within undeveloped land parcels, optimal storage locations would be in between an area that would cause a large amount of runoff and where that runoff would drain into the creek/river system. Strategic placements of storage areas and additional storage requirements could be identified with a hydraulic model (i.e. HEC-RAS), to understand where pinch points occur. This information could then be layered into a Stormwater Management Model (SWMM) to identify where large amounts of runoff are accumulating throughout the watershed.

Jesrsey Meadows Detention Basin in Houston, Texas

In addition to the construction of detention basins, it is recommended that the larger stormwater system optimize the use of existing storage areas, such as ponds and lakes. In many cases, these systems can be part of an optimized system of water storage devices, lakes and ponds that drain water in advance of floods to optimize storage capacity. These water storage resources could be drawn down before anticipated back-ups of nearby water systems with structures that control the release of the stormwater through weirs and orifices (Outlet Control Structures). This approach would provide additional storage to slow down rising stage elevations in a riverine flood event. There are several methods for the placement of decentralized detention basins. If small, dispersed detention ponds were to be constructed throughout the region, the combined capacity of the basins could provide significant management of runoff during storm events. For example, if 10 detention ponds were constructed that were 10' in depth and spanned 100 acres, the constructed detention basins could completely manage the volumes of a 2-year storm, while reducing the water volumes of a 25-year storm, 100-year storm, and Florence-level storm by 58%, 40% and 16%, respectively. Additionally, existing storage points in the upstream portion of the basin (i.e. lakes, ponds, reservoirs, wetlands) can be optimized to hold an additional two feet of runoff before conveyance occurs, thereby managing 87 million cubic feet of storage. This amount of storage would reduce the water volumes for the 2-year storm, 25-year storm, 100-year storm, and Florence-level storms by 29%,


Historic Buck Creek
Buck Creek (channelized)
Aberdeen, Longs
Historic meanders of the Waccamaw River
Buck Creek
Elevation below12 feet
Approx. Florence Inundation up to 22 feet

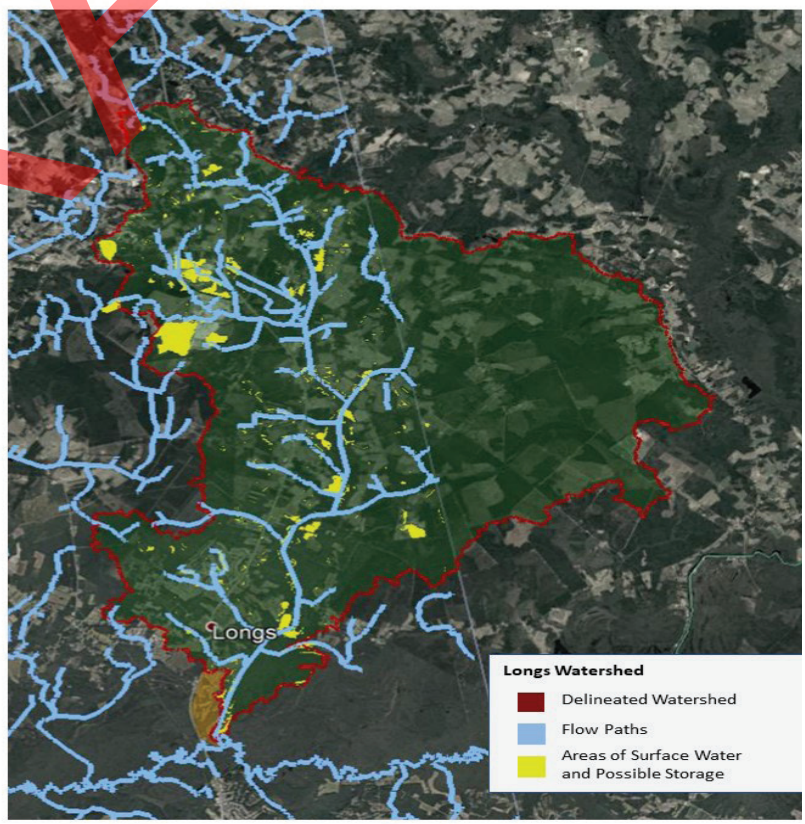

Simpson Creek (channelized)
Historic Simpson Creek
Polo Farms, Red Bluff
Simpson Creek
Elevation below11 feet
Approx. Florence Inundation up to 21 feet

12%, 8%, and 3%, respectively. Whereas the complete detention of Florence-level flooding (2.7 billion cubic feet of water) would require 6,200 acres of detention ponds, and is therefore largely unfeasible, the creation of detention basins is a viable strategy that could improve conditions in future events.

Another alternative is to create additional storage along these canals by creating a floodplain along the banks. This could be accomplished by creating a bench along the banks that would allow the water to come out of the channel and disperse into the floodplain. The County has currently utilized this practice on several other canals with success. The benching process creates a manmade floodplain that would provide storage as well as slowing down the velocity of the water in the canal. In addition to regional watershed storage areas, as well as improvements to creek storage or floodplain strategies, an upland strategy depends on treating runoff before it drains into the lowlands. Optimizing low-impact development (LID) and storage capacity in the top of the basin could allow the lower elevations of the basins to drain before they start to back up. Multiple strategies are needed to optimize creek storage and increase flood resilience. In developing this strategy, it is important to think of all of these creeks as contributors to a larger regional network, where capabilities to reduce localized flooding exist within each creek, and regional flooding can be mitigated by optimizing the entire regional network.

PROJECT BENEFITS

Piloting a comprehensive storage strategy would have a measurable impact within the watershed. A combination of larger-scale public storage devices and smaller-scale private resources could be implemented over time as funding becomes available and new development is envisioned within the areas of watershed within each reach. Through the consideration of a specific storage target and detention plan, the value of the effort will be optimized, and the comprehensive storage strategy will be more efficient.



Longs sits near the outlet of the Buck Creek watershed, where the creek drains into the Waccamaw River.

Improved Drainage for Localized and Riverine Flooding

PROJECT DESCRIPTION AND CONSIDERATIONS

Some of the recommendations for Bucksport and Socastee areas are aimed at reducing both local and riverine flood impacts. A two-stage flood relief strategy is proposed in Bucksport, solving for localized flooding through improvements to the local ditch system and providing "smart" relief to drain water in the opposite direction of flood waters during larger flood events.

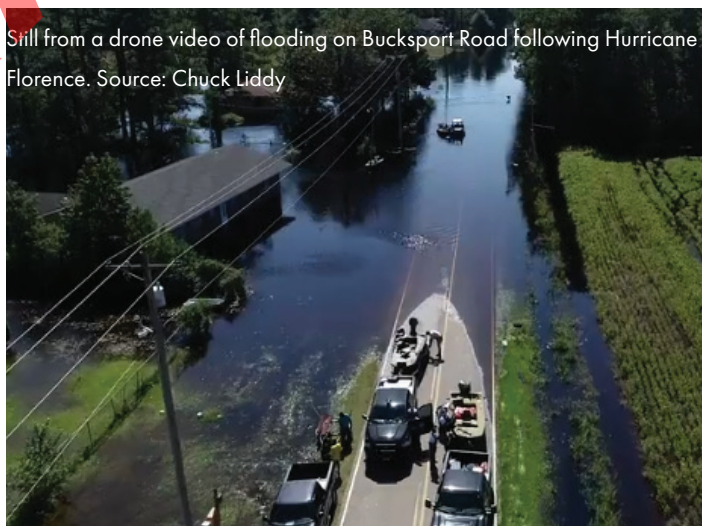
Neighborhood or localized flooding exacerbate the impacts of major flood events due to a lack of sufficient capacity in the local drainage ditches, driveway culverts, and storm drains. These drainage facilities may be filled with sediment or other debris, and may dead-end within the system, or may not have been recently maintained. These factors prevent the local drainage system from adequately conveying runoff. Additionally, the lack of gutters and underground storm drains, undersized and under maintained drainage facilities, and location of homes below the street grade have resulted in localized poor drainage and/or flooding around some residences, buildings, and roadways. An extensive drainage study to include survey data for the Bucksport area is necessary to determine the flow paths and areas that need to be upgraded or maintained. Obtaining easements has been an issue in the past and condemnation may be required if easements cannot be obtained. Similarly, some drainage systems dead-end when an easement cannot be obtained to connect the drainage conveyance to an outlet.

To allow the system to move water and maintain drainage from the wetland system, a relief channel/culvert system to the Waccamaw River should be studied. In the Bucksport Community, a pilot project is recommended entitled the Cowford Swamp Tributary Relief Channel Project. A relief channel would be constructed to divert the water from Cowferd Swamp (west of Big Bull Landing Road) to the Waccamaw River. East of Bucksport Road, a channel should be constructed from Bucksport Road to an elevation that would maintain positive flow to the Waccamaw River. The proposed channel section and culvert size would be determined through an H&H study.

Similar drainage impediments are apparent within areas of Socastee. The County should conduct a further technical analysis of Socastee area also include survey data to determine flow paths and areas that would need to be upgraded, improved or maintained. Obtaining easements has also been an issue in this area and condemnation may also need to be considered if improvements need to be made. It is important to note that there is a distinction between private drainage responsibilities and public drainage responsibilities. Private drainage easements do not convey water from a publicly maintained road, whereas public drainage easements do. There is a need to educate the public on this difference as well as the importance of the easements.

PROJECT BENEFITS

In a localized flooding scenario, a network of channels could detain, slow, and convey the flows effectively throughout the drainage system and mitigating flooding throughout these targeted neighborhoods.



Still from a drone video of flooding on Bucksport Road following Hurricane Florence. Source: Chuck Liddy

3.4
Community Engagement and Planning

3.4.1

Flood Education Plan and Communication Strategy

DESCRIPTION

Flooding is a persistent and significant threat to public safety and economic loss in Horry County. Well-informed citizens are able to make better decisions to protect themselves and their property against flooding. Horry County is prepared to tackle its flooding challenges on multiple fronts. Effective flood management policies, federal buyout relief dollars, federally-funded large-scale resilient infrastructure improvements, preservation of the flood plain, and protections at the local level to mitigate against acute flooding are all measures being advanced by the County. Effective management of flood risks is a community-wide endeavor that requires the support of citizens, businesses, government agencies, and other organizations. As such, a top priority is to develop a Flood Education Plan to enhance safety and reduce vulnerability to flood damage by improving the efficacy of public information programs.

Horry County wants everyone in the County to know their flood risk and understand the FEMA flood zone designations and their importance. Many community members admitted to not having flood insurance and many had not perceived that there was a need for insurance prior to Hurricane Florence. A better understanding of flood insurance programs and their availability is needed. Knowledge gaps may also exist within specific communities. Socastee experiences flooding on a regular basis from flash flood incidents as well as from larger-scale events that induce riverine flooding. Information on all types of flooding is important as many parts of the County experience flooding in different ways.

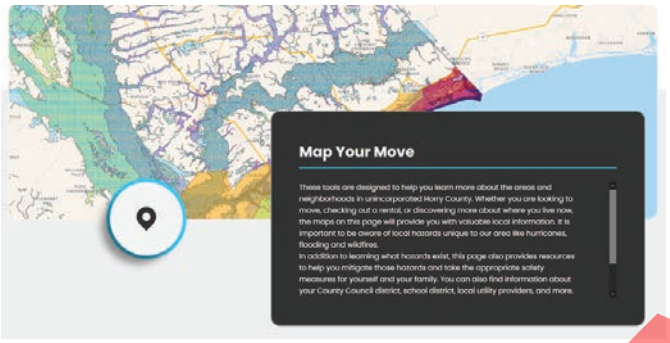
Bucksport community outreach event.

EXPANDING AWARENESS OF RISK THROUGH MAPPING

Many people who move to Horry County are not aware that their property may be near a flood zone or in an area that has the potential to be flooded, particularly if they are not located directly on the coast. The County is looking to make every effort to advise all potentially affected residents of their particular flood designation and what it means in practical terms for their property. The FEMA FIRM maps are being updated and the County has mapped the Florence-adjusted base flood elevation to document the extent of flooding from Hurricane Florence. As the County examines the proposed FEMA FIRM designations in comparison to the areas that experienced flooding from Hurricane Florence, information relating to risk of flooding beyond the FEMA flood zone can be made publicly available. Individuals can then consider flood insurance, make proper preparations for home repairs, and can make determinations about where to live in the County. This information can form the basis for a hazard risk reduction map that can be made available to residents. The County intends to use this information as part of an information campaign entitled "Map My Move," which can show anyone looking to move into or within the County

where flood waters have impacted properties.

Having this information readily available and providing a regular update is important to prepare against complacency, should there be a period of relatively minor flooding. Some form of recurring reminder can be disseminated on an annual basis, possibly as inserts to property tax bills or in a separate mailing at the start of hurricane season. Other forms of official media updates can be identified and adopted that provide information to Horry County communities on a regular basis. Maps could be posted at community centers and other locations where residents gather, made available online, and included in presentations to community groups at committee meetings.



Developing a Network for Communication

Horry County has a wealth of organizations that can jointly disseminate information and increase flood awareness. Partnerships could be explored with Volunteer Organizations Assisting in Disaster (VOAD) agencies, local environmental organizations, business groups, and community activists to better communicate the different types of flooding that affect Horry County. A knowledgeable source, perhaps someone from the state climatologist's office or a state water resource management official, could be engaged to communicate the types of flooding the County experiences and their relative impacts. Media resources, such as the "flood types" video produced by the consultant team or a FAQ list, can be developed and utilized in an effective fashion to make these distinctions. Once VOAD agencies, environmental organizations and community activists understand the differences in flood types, they can become partners in sharing that information with their members and with the public. This will provide multiple opportunities for residents to receive information. A regular campaign of information sessions will establish a recognized County authorized location for information and updates from the County.

Public outreach can include a forum for discussion of the likelihood of future flooding events impacting the neighborhood. To a degree this is inherently part of the flood zone designation, but effective communication must ensure that residents understand that a 100-year or even a 500-year storm event has the potential to occur more frequently than these statistical abbreviations might suggest.

The County is looking to construct a campaign to educate the community about flood risk. The focus will be on identifying the types of flooding to which the County is susceptible, where flooding is most likely to happen and why and the measures being undertaken to reduce flood risk and to move people out of harm's way. This program will focus on what to do when it floods and the outlets available within the County to assist people impacted by flood events. While much of this infrastructure is in place and has been active in response to recent floods, a plan to organize the flood management effort and a campaign for providing education through multiple outlets will help to increase awareness and build support for improved public policies that affect flood risks.

- Develop a Flood Education Plan for Horry County that Focuses on Public Messaging of Risks and Vulnerabilities
- Establish a multi-media platform to disseminate flood risk information
- Use mapping as a visual tool to illustrate risk
- Prioritize educating residents about funding resources

Door hangers placed in communities that may be impacted by flood map updates.

that are aimed at assisting individuals and households (Reference Appendix E for a comprehensive list)

PROJECT BENEFITS

Creating an education and communication campaign around flood resilience in Horry County will be beneficial on multiple levels. The dissemination of information will increase engagement, increase understanding, and help towards building consensus amongst community and government on needed actions. The community will thereby better understand their level of risk as well as be prepared for future storm events. Education and communication will help build trust on the part of the community, and improved awareness will enable the County to initiate future actions through a structured communication mechanism that is recognized by

3.4.2

Community-Based Mitigation Plans

PROJECT DESCRIPTION

Impacts have been felt differently in the many Horry County communities that have been impacted by flooding. Topography, elevation, proximity to the riverine system, housing typology and community infrastructure are just some of the unique characteristics that shape the nature of the impact to communities from flooding.

As the County looks to implement a series of initiatives to increase resilience, in some locations, infrastructure solutions alone are not going to be able to remove or significantly reduce flood risk. Future solutions in some communities may involve elevation of structures, property buyouts or some combination of interventions that have the potential to significantly impact community cohesion. In some communities, solutions could gravitate to discussions about communitywide relocation strategies.

Fundamentally, community-based resilience plans educate residents and community members on the risks being faced, the individual actions that can be undertaken to minimize risk and the options available for large-scale long-term resilience efforts begin with community engagement. Establishing a sense of trust with the community sets the foundation for neighborhood led decision making. The effort begins with community discussions regarding available options, the extent of risk, the challenges faced, and the possible avenues for resolution. More and more, as Counties look to build resilient futures, these large-scale engagement efforts are becoming part of the plan for long-term resilience. These efforts increase awareness while also allowing for civility in what is a challenging process. The County seeks to generate a resilience plan and the necessary steps that will be required to create a resilient future for a community that is at risk.

PROJECT BENEFITS

Community-based resilience planning efforts provide a forum for residents to voice their concerns, their fears, and their ideas about how they can combat disasters that impact their lives. These efforts can provide solutions that are place-based and appropriate for specific circumstances. A community-based planning approach may uncover additional fundamental challenges that can contribute to a larger resilient future where communities are not just protected, but can thrive as they build out solutions.

4.0
additional materials

Appendix A
Glossary of Critical Terms

AE Zone
Areas subject to inundation by the 1-percent-annual-chance flood event (often known as the 100-year flood zone or floodplain) determined by detailed methods by FEMA. Base Flood Elevations (BFEs) are shown. Mandatory flood insurance purchase requirements and floodplain management standards apply. (FEMA)

B or Shaded X Zone
FEMA's area of moderate flood hazard, usually the area between the limits of the 100- year and 500-year floods. B Zones are also used to designate base floodplains of lesser hazards, such as areas protected by levees from 100-year flood, or shallow flooding areas with average depths of less than one foot or drainage areas less than 1 square mile. In this report, this zone is referred to simply as the 500-year flood zone or floodplain. (FEMA)

Base Flood
A flood having a one percent chance of being equaled or exceeded in any given year, often referred to as the 100-year flood.The base flood is the national standard used by the National Flood Insurance Program (NFIP) and all Federal agencies for the purposes of requiring the purchase of flood insurance and regulating new development. Base Flood Elevations (BFEs) are typically shown on Flood Insurance Rate Maps. (FEMA)

Base Flood Elevation (BFE)
The elevation to which floodwater is anticipated to rise during the base flood. The BFE is the regulatory requirement for the elevation or floodproofing of structures. (FEMA)

Digital Elevation Model
A computer representation of the earth's terrain/topography, created from elevation data. (WCU)

Ditch
A narrow channel dug in the ground, typically used for drainage alongside a road or the edge of a field. (Oxford Languages Dictionary)

Federal Emergency Management Agency (FEMA)
FEMA is an agency of the U.S. Department of Homeland Security. Its mission is to ensure that the nation works to build, sustain, and improve capability to prepare for and respond to all hazards. FEMA was created in 1978 and implemented in 1979. (FEMA)

Flood Elevation
Water height during a particular storm, mostly commonly referenced to NAVD88. Most often measured by stream gages, rapid deployment gauges, or post-storm collected high water marks (i.e., mud lines on a building left by water). (WCU)

Flood Insurance Rate Maps (FIRMs)
The official map of a community on which FEMA has delineated both the special hazard areas and the risk premium zones applicable to the community, commonly called "flood maps." (FEMA)

Floodplain
A tract of land bordering a river, mainly in its lower reaches, and cosisting of alluvium deposited by the river. It is formed by the sweeping of the meander belts downstream, thus widening the valley. During floods, when the river overflows its banks, sediment is deposited along the valley banks and plains. (USACE)

Freeboard
The vertical distance between the water level and the bottom of a structure. For regulatory and design purposes, this is the additional height of a structure above the base flood elevation to prevent flooding. (USACE and NOAA)

Letter of Map Revision (LOMR)
An official amendment to the currently effective FEMA map. It is issued by FEMA and changes flood zones, delineations and elevations.

Levee
Earthen structure (also referred to as a dike or embankment) built to contain periodical floodwater from river systems within a specified area of the floodplain. (USACE)

Mean Higher High Water (MHHW)
The elevation of the highest predicted astronomical tide expected to occur at a specific tide station over the National Tidal Datum Epoch. (NOAA)

NAVD88
North American Vertical Datum of 1988. The official vertical datum in the National Spatial Reference System (NSRS) for the Conterminous United States and Alaska (definition from NOAA). A datum is a surface of zero elevation to which heights of various points are referenced. Elevation data, including flood heights, are often referenced to this datum. In Horry County, NAVD88 is within 0.5 feet of local mean sea level. (FEMA)

National Flood Insurance Program (NFIP)
NFIP is a program created by the U.S. Congress in 1968 through the National Flood Insurance Act of 1968. The program is administered by the federal government and enables property owners in participating communities to purchase insurance protection against losses from flooding. (FEMA)

National Oceanic and Atmospheric Administration (NOAA)
NOAA is an American scientific agency within the U.S. Department of Commerce that focuses on the conditions of the oceans and atmosphere. NOAA tracks dangerous weather patterns, charts seas, guides the use and protection of oceanic and coastal resources, and conducts research to improve stewardship and increase public understanding and awareness of the environment. (NOAA)

Outlet Control Structure
Hydraulic structures that are placed at the end of drainage lines that control the outflow of water through the use of orifices or weirs. (Sherwood Design Engineers)

Sea level rise
An increase in the volume of water in the world's oceans, resulting in an increase in global mean sea level. Sea level rise is attributed to thermal expansion caused by the warming of the water in oceans and increased melting of land-based ice including glaciers. (NOAA)

Special Flood Hazard Areas (SFHA)
The land area covered by the floodwaters of the base flood. The SFHA is the area where the NFIP's floodplain management regulations must be enforced and the area where the mandatory purchase of flood insurance applies. The SFHA includes Zones A, AO, AH, A1-30, AE, A99, AR, AR/A1-30, AR/AE, AR/AO, AR/AH, AR/A, VO, V1-30, VE, and V. (FEMA)

Tailwater
Waters located immediately downstream from a hydraulic structure, such as a dam, bridge or culvert. (Sherwood Design Engineers)

Topography
The measurements of the heights of the earth's terrain and relief surface above sea level. (NOAA)

U.S. Army Corps of Engineers (USACE)
USACE is a federal agency under the jurisdiction of the Department of Defense and one of the world's largest public engineering, design, and construction management agencies. Missions include civil engineering of locks, dams, maintenance dredging, and flood control as well as environmental regulation and ecosystem restoration. (USACE)

U.S. Geological Survey (USGS)
The USGS is a federal scientific agency under the jurisdiction of the U.S. Department of the Interior. The agency studies the nation's natural resources, natural hazards, ecosystems, and environmental health as well as the impacts of climate and land use change. (USGS)

Watershed
An area of land that drains all the streams and rainfall to a common outlet such as the outflow of a resrvoir, mouth of a

bay, or any point along a stream channel. (USGS)

Wetland

Land characterized by saturation with water, determining the nature of soil development and the types of plant and animal ecosystems that inhabit the soil and surface. In hydrologic terms, an area that is regularly wet or flooded and has a water table that stands at or above the land surface for at least part of the year. (USACE and NOAA)

Appendix B References

1.1

Planning Area

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- U.S. Census Bureau
- NC Department of Environmental Quality. 2018. *Yadkin-Pee Dee River Basin*. Office of Environmental Education and Public Affairs Brochure.
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1.2

Nature and Categorization of Storm Impacts

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2.1

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- Bamber, 2019, Proceedings of the National Academy of Sciences. PNAS | June 4, 2019 | vol. 116 | no. 23 | 11195–11200. www.pnas.org/cgi/doi/10.1073/pnas.1817205116. The estimate of 6.5 feet of sea level rise is "based on a worst-case emissions scenario in which little is done to rein in greenhouse gases and the planet warms as much as 5 degrees Celsius (9°F) above pre-industrial times."

2.3

Vulnerabilities in Target Communities

- Post-storm assessment damage data obtained from Horry County.
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Flood Ordinance Policy

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3.1.3
Comprehensive Buyout and Area Reuse Strategy

- Hazard Mitigation Assistance Guidance Addendum: Hazard Mitigation Grant Program, Pre-DisasterMitigation Program, and Flood Mitigation Assistance Program, FEMA, 2015.
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- *Stream Visual Assessment Manual.* U.S. Fish & Wildlife Service. https://www.fws.gov/southeast/pdf/manual/stream-visual-assessment-manual.pdf

3.2.2
Expanded Tree Preservation Standards

- https://www.epa.gov/sites/production/files/2016-11/documents/final_stormwater_trees_technical_memo_508.pdf
- https://cfpub.epa.gov/watertrain/moduleFrame.cfm?parent_object_id=170#
- https://www.state.sc.us/forest/gic-stormwatersummary12.pdf
- https://www.epa.gov/soakuptherain/soak-rain-trees-help-reduce-runoff

3.2.3
Resilient Neighborhood Design Standards

- https://dep.wv.gov/WWE/getinvolved/sos/Pages/RiparianMagic.aspx
- Article 4 Design Standards; Section 4 Flood prone areas of the Land Development Regulations.

3.3.1
County-Wide Watershed Hydrology Modeling

- https://www.sam.usace.army.mil/Missions/Planning-Environmental/Environment-Resources/Inland-Environment/Proctor-Creek-Feasibility-Study/
- https://fim.wim.usgs.gov/fim/

3.3.3
Watershed Management and Regional Storage Improvements

- Data Basin: https://www.usgs.gov/mission-areas/water-resources/science/streamstats-streamflow-statistics-and-spatial-analysis-tools

Appendix C

Horry County Supplemental Flood Zone Methodology
Western Carolina University
Program for the Study of Developed Shorelines

Purpose & Goals

The proposed Supplemental Flood Zone (SFZ) is a unique product that utilizes historic flood data to map estimated flooding during recent storms. This SFZ product and methodology is different than Federal Emergency Management Agency's (FEMA's) probability-based Flood Insurance Rate Maps (FIRMs). The Horry County SFZ is an estimation of flood level and extent during Florence using field data, while FEMA FIRMs represent a modeled probability of future flooding. The SFZ can be simply informational or can be used for planning, emergency management, and/or regulation. The SFZ was created by Western Carolina University (WCU) as a part of resilience planning for Horry County, South Carolina.

The primary objectives of this mapping exercise were to utilize field-collected, post-storm data of flood elevations from Hurricane Florence within Horry County to: 1) delineate a SFZ independent of the FEMA Special Flood Hazard Area, that approximates the actual extent of flooding during Florence (the storm of record); and 2) create subzones within the SFZ, each with an adjusted Base Flood Elevation (BFE) based on the flood elevations recorded during Florence.

Primary Data Utilized & Consulted

- *USGS Florence flood elevation data (sensor, HWM, and peak summary).* https://stn.wim.usgs.gov/FEV/#FlorenceSep2018. Most the flood elevation data used in this study are high water marks (HWMs), which are defined as post-flood evidence that marks the highest elevation of floodwaters (e.g., seed, mud, or debris lines stranded as water recedes).
- *2017 digital elevation model (DEM)*. These data were obtained from Horry County. The 2020 DEM was not available until after the digitization was complete, and therefore, the 2017 DEM served as the primary base map for the SFZ digitization and analysis. The 2017 DEM was the elevation dataset acquired closest to the date of Florence (2018), and therefore most closely represents the state of development and elevation of land surfaces at the time of the storm.
- *2019 preliminary FEMA data.* 2019 digital preliminary FEMA maps obtained from Horry County, including BFE transects.
- *Florence building flood damage data*. These data are from a rapid assessment of Florence damage percent for buildings in the county, commonly containing an estimate of water height within the structure (collected by Horry County).
- *Horry County reference data.* This includes roads, hydrology (rivers), buildings, communities, and the county boundary, obtained from Horry County.

General Methodology

Initially, USGS Florence flood elevations (HWMs) were used to create general "boundaries" between the different subzones (Figure 1). This process began in the east, where the Waccamaw River enters Horry County. HWMs were also used to assign each subzone a Florence-adjusted BFE (at one-foot intervals); these subzones approximate the Florence flood level and extent based. For example, BFE subzone 23 represents a Florence flood level and adjusted BFE of 23 feet (above NAVD88). The extent of each subzone (and associated BFE) is a relatively conservative estimate of inundation during Florence, as the HWM elevations were rounded down to the nearest whole number (e.g., the 22.9 HWM location is within the 22 subzone BFE; Figure 1).

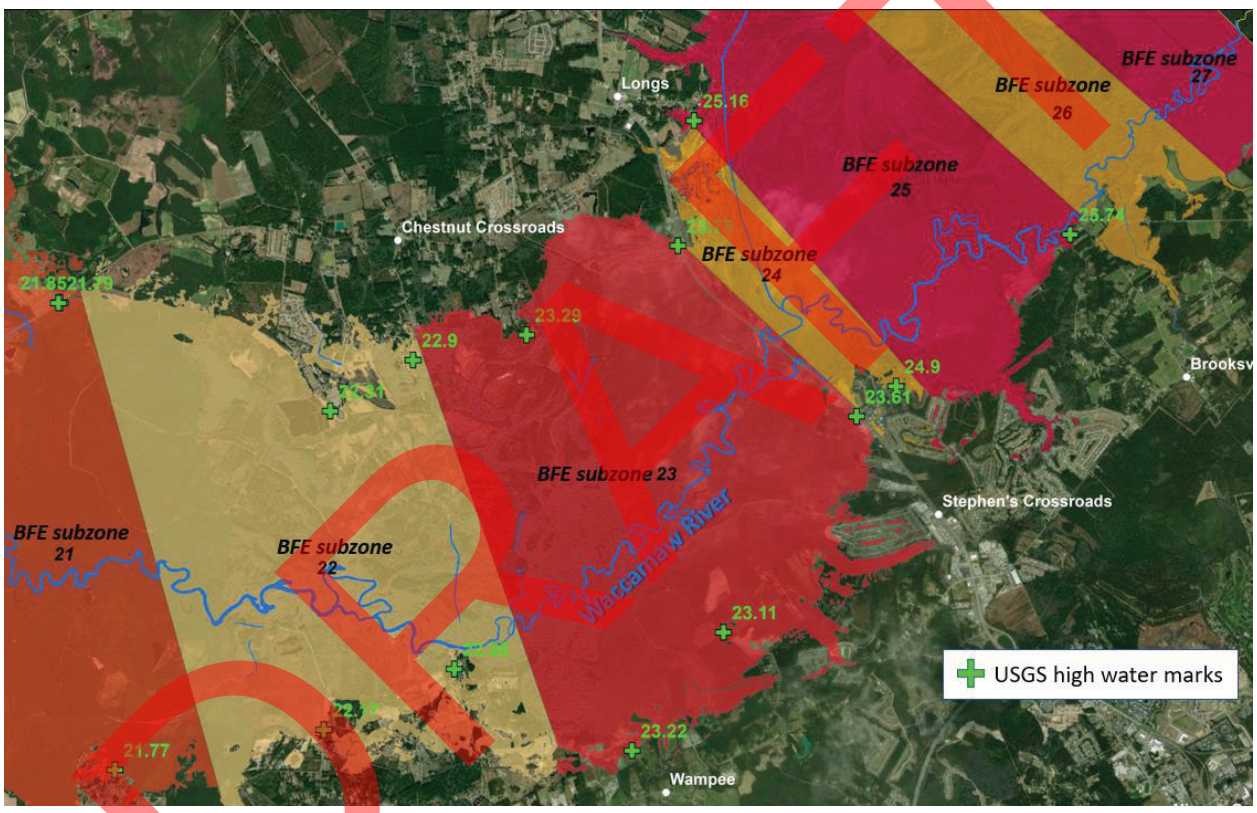

Figure 1. *Digitized SFZ with subzones (red/orange/yellow shaded areas) and USGS HWMs (green crosses), along the Waccamaw River in the eastern portion of Horry County. USGS HWM elevations in feet above NAVD88.*

In some locations along the Little Pee Dee River, HWMs immediately outside of Horry County were utilized to estimate the boundaries of SFZ subzones. However, the SFZ was only digitized within Horry County, even when the floodplain and flood elevations extended beyond the county line (Figure 2).

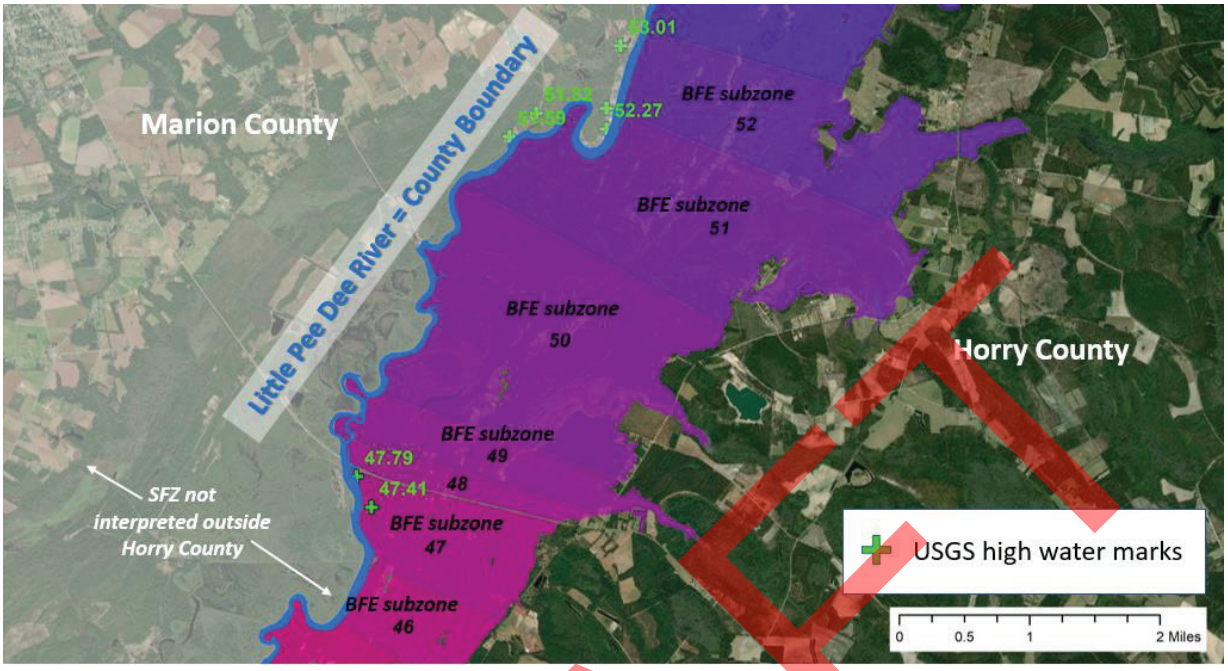

Figure 2. *Digitized SFZ and subzones (purple/blue shaded areas) along the Little Pee Dee River, with USGS HWMs (green crosses). Notice the location of several HWMs that were collected within the adjacent county (Marion) were utilized to delineate subzones 51-53, and that the SFZ does not extend outside of Horry County.*

For each BFE subzone, the approximate Florence flood elevation "contour" was visualized by color coding the DEM to the appropriate whole number elevation. For example, in BFE subzone 21, the DEM was color coded to highlight elevation values near 21 feet; the resulting shaded DEM was used to interpret (and digitize) an approximate 21-foot flood contour (Figure 3).

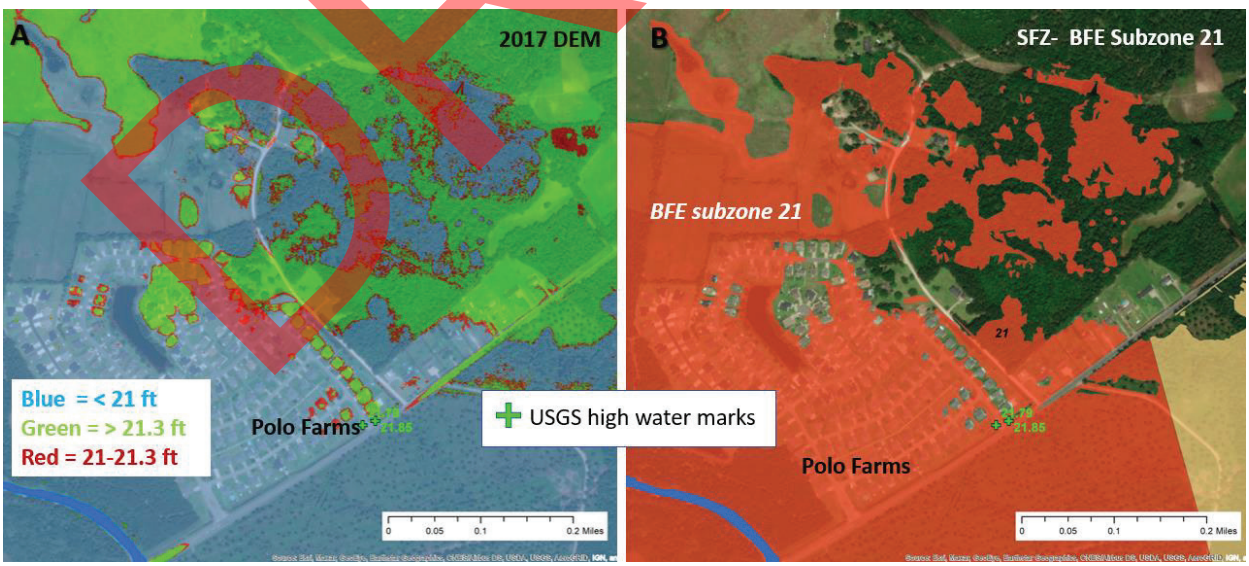

Figure 3. *DEM color coded and SFZ digitization in Polo Farms development near Red Bluff in Horry County. A) 2017 DEM color coded to highlight an elevation of approximately 21 feet (above NAVD88); the red shaded areas represent the values closest to 21 feet. B) SFZ interpreted using the 2017 DEM within BFE subzone 21.*

Each subzone was digitized using the polygon feature in ArcMap at 1-foot flood intervals, at a scale of approximately 1:800. The stepwise interpretation of subzones using flood contours continued for areas affected by Florence and where flood elevation data existed (downstream along the Waccamaw River and its major tributaries, into the Intracoastal Waterway near Socastee, and north along the Little Pee Dee River).

The SFZ is not continuously mapped within Horry County. In a few areas there is a lack of data control (no high-water marks exist nearby) and therefore the primary SFZ was not interpreted. This is true along the Waccamaw River near the southern boundary of Horry County (southern portions of subzones 11 and 15, near the confluence of Bull Creek and the Waccamaw), as well as several stretches along the Little Pee Dee River between Bucksport and Pee Dee Crossroads, Pee Dee Crossroads and Dog Bluff, Dog Bluff and Galivants Ferry, and north of Floyds Crossroad.

In some of locations along the Little Pee Dee River where the SFZ could not be interpreted (due to lack of HWMs), additional subzones were digitized using less reliable flood elevation data (Figure 4). This separate layer can be viewed in conjunction with the primary SFZ, but there is less confidence in the boundaries between these subzones due to the method of obtaining flood elevations. In these areas, flood elevations were estimated using the building damage data (rapid, post-storm, damage assessments obtained by Horry County, which estimate the amount of flooding in a building), the 2017 DEM (to get a ground elevation), and damage photos (to estimate building height above grade).

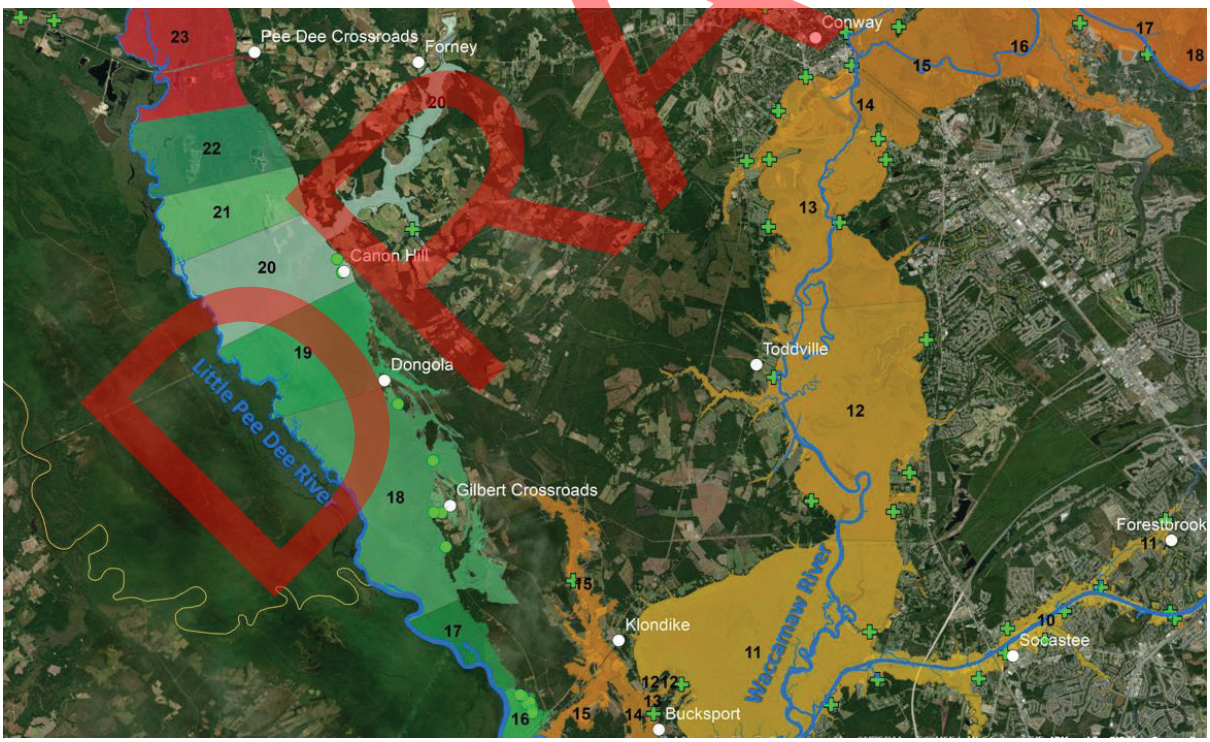

Figure 4. *SFZ in southern Horry County. Primary SFZ subzones are shaded in warm colors (oranges/reds) and the secondary SFZ (lower confidence) subzones are shown in shades of green. Notice the distribution of HWMs (green crosses) along the Waccamaw River between Conway and Bucksport, and the lack of these data along the Little Pee Dee River between Bucksport and Pee Dee Crossroads. When possible, the Florence damaged buildings data (green dots) were used to digitze additional subzones in locations where HWM data was lacking.*

Summary of SFZ Results

A total of 52 SFZ subzones were digitized across Horry County using this protocol. This includes 11 lower confidence secondary SFZ subzones (Figure 5). Over 185 square miles are included within the mapped SFZ subzones in Horry County. Approximately 12.5 square miles of land is included in the SFZ that is oustide the 2019 preliminary FEMA SFHA.

This SFZ (and associated subzones) represent the raw and highly detailed results of the digitization of flood-elevations, interpreted using Florence flood data and a DEM. The extent of the SFZ is limited by the location of flood elevation data collected from Florence, and is focused primarily along the riverine floodplains of the Waccamaw and Little Pee Dee Rivers (Figure 5). More practical generalized "zones" may need to be created for the regulation of development.

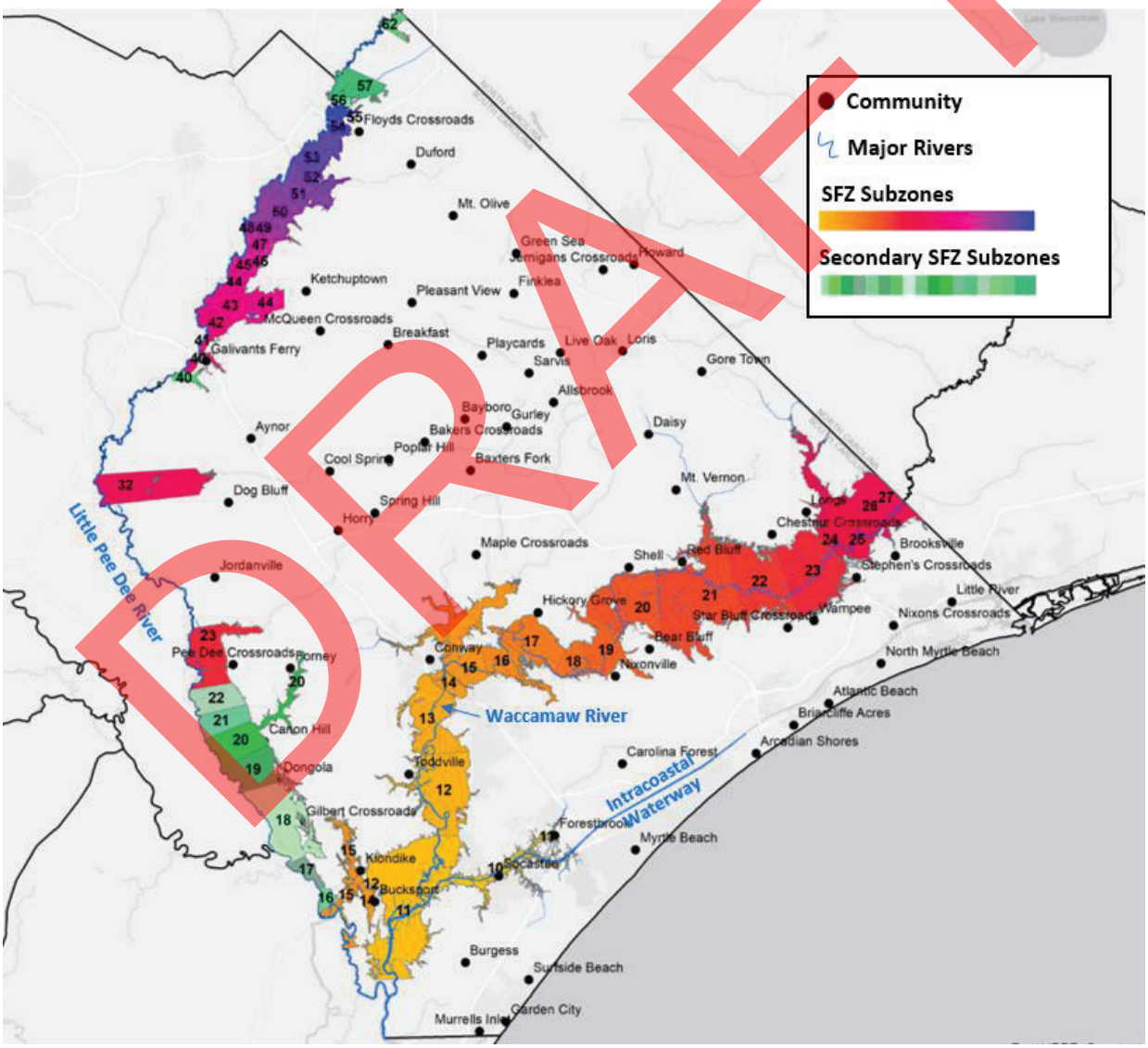

***Figure 5**. Digitized SFZ and subzones within Horry County.*

2017 vs 2020 DEM

The 2017 DEM was utilized in this analysis as it was the elevation dataset acquired closest to the date of Florence (2018). Thus, the landscape and development that is depicted in the 2017 DEM is most similar to pre-Florence conditions. After digitization of the SFZ was complete, the 2020 DEM was released and provided to WCU. This more recent DEM was compared to the 2017 DEM, but was not utilized for digitization. Even if the 2020 DEM had been available prior to digitization, the SFZ would not be drastically different, except in a few isolated locations where development has since occurred.

One method to highlight areas with landscape changes and development between 2017 and 2020, includes subtracting one DEM from the other, and noting areas with significant elevation changes (Figure 6). This subtraction was conducted by WCU and will be provided to Horry County as an additional dataset. It should be noted that water bodies in the 2017 DEM have inherent elevation errors, and therefore should be ignored in both the original 2017 DEM and the subtracted difference raster.

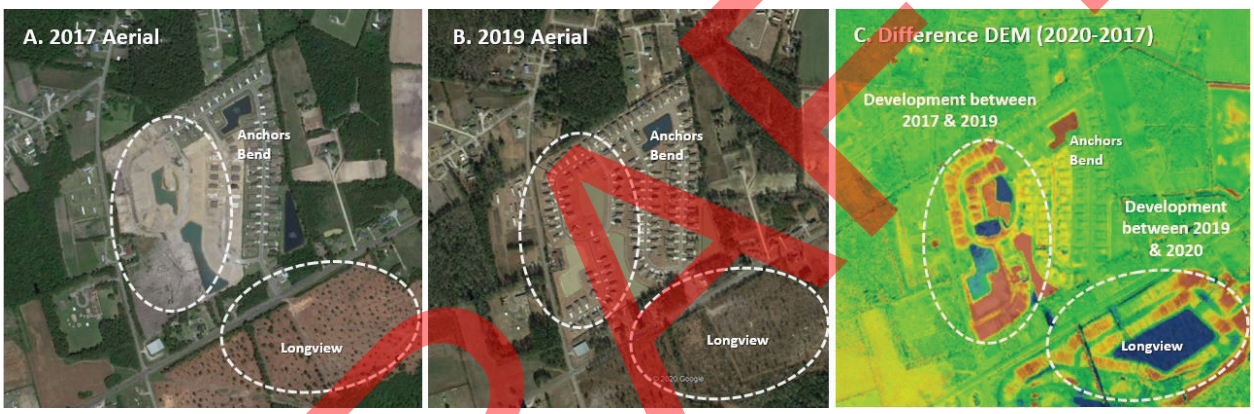

Figure 6*. Changes in development and elevation in the Anchors Bend and Longview subdivisions near Longs. A) 2017 Google Earth aerial imagery. B) 2019 Google Earth aerial imagery (most recent available). C) The subtracted difference DEM, highlighting changes in elevation from 2017 to 2020. Orange shades represent raised areas and blue shades represent lowered areas (darker shades signify greater elevation change).*

This document was compiled by Katie Peek, Blair Tormey, and Rob Young at the Program for the Study of Developed Shorelines at Western Carolina University.