Waccamaw River,
Horry County, South Carolina

Flood Risk Management Study
Draft Integrated Feasibility Report and
Environmental Assessment

Horry County, South Carolina

Charleston District, South Atlantic Division

September 2024

Executive Summary

This draft integrated Feasibility Report and Environmental Assessment (FR/EA) documents the planning process to address existing and future riverine flood and life safety risk to communities and transportation routes in the Waccamaw River Basin within Horry County, South Carolina. It also presents draft results of the study, including the Tentatively Selected Plan to reduce this risk. The U.S. Army Corps of Engineers (USACE) and Horry County are sponsoring this study. This integrated report meets the environmental review and disclosure requirements of the National Environmental Policy Act (NEPA). USACE is the lead agency under NEPA.

The Waccamaw River Basin covers a vast hydrologic drainage area that extends from North Carolina down through South Carolina before entering into the Atlantic Ocean at Winyah Bay, SC. The Waccamaw River receives tidal effect in its lower reaches and receives waters from the Pee Dee River and the Atlantic Intracoastal Waterway (AIWW). The Waccamaw River is fed by numerous small tributaries, including both channelized and natural creeks and swamps. It meanders through five counties, including Horry County in South Carolina. Horry County is characterized by low elevation and flat topography. These characteristics result in gradual decline in water levels during high water events, such as those caused by intense rainfall across the region. Flooding can persist for extended periods, ranging from several days to weeks, and typically features two distinct peaks, with the second peak larger than the first. The additional peak is often attributed to elevated water levels from flooding in North Carolina's Pee Dee River.

Horry County is also experiencing population growth, including in the City of Conway through which the Waccamaw River flows, and along the AIWW. This makes communities along the Waccamaw River and its tributaries vulnerable to the impacts of flooding. Horry County has experienced 36 flood events between 1950 and 2021. When flooding occurs, it is usually significant and costly – affecting homes, businesses, and major transportation routes, leaving densely populated areas in the county isolated, displaced, and unable to receive supplies. Flood events are expected to continue into the future, and more people are expected to be at risk of flooding impacts as Horry County continues to grow. Without this study and a recommended flood risk reduction plan for Federal investment, people and infrastructure may continue to experience economic losses and life safety implications now and into the future.

USACE and Horry County used an iterative and risk-informed plan formulation process to develop and evaluate alternative plans that could address the flood risks identified for communities in the study area. Foremost, this included a formulation strategy that narrowed Horry County into four primary flood impact areas based on the known extent of flooding and economic damages to population centers from past storm events. The flood impact areas that were identified for the study included: Longs & Red Bluff; City of Conway; Bucksport; and Socastee. The flood impacts in each of these areas were independent of each other so solutions could be evaluated independently, making any proposed alternative plans separable from each other. The study team brainstormed potential management measures, or solutions, to reduce flood risks including structural and nonstructural measures, and natural or nature-based solutions. Three public meetings were held during the summer of 2023 to better understand actual flooding impacts and solicit input on the potential measures to help define the scope of the study. The measures were also presented to Federal, state, and local resource agencies for their preliminary input. Based on this input and existing information about the study area and potential measures, additional measures were included while other measures were screened. The management measures were then organized or grouped into an initial array of alternative plans based on flood characteristics (source, direction, severity, topography, etc.) and means of management (water storage, water diversion, water conveyance, etc.), and different combinations of these. This resulted in an unwieldly and cost-prohibitive number of alternative plans to study for each flood impact area. Additional screening of plans was applied based on existing information and subject matter expertise to narrow down the initial array to a final array of alternative plans, which still resulted in 19 alternative plans in total for the study area. Alternative plans were evaluated in accordance with USACE guidance, the study objectives, social and environmental considerations, and other criteria described in this Draft FR/EA. Potential flood risk reduction of each plan was modeled and compared to the future without project conditions. Total costs for each of the plans, total net benefits for each, and environmental resource and social considerations for the plans were compared within each flood impact area to identify the Tentatively Selected Plan.

Based on the evaluation of the alternatives, the Tentatively Selected Plan in the Conway Flood Impact Area is Plan C3 for Relief Bridges (cross drains) and in the Socastee Flood Impact Area is Plan S3 for Barrier Removal. The Conway Relief Bridges (cross drains) have a benefit-to-cost ratio of 5.5. The Socastee Barrier Removal has a benefit-to-cost ratio of 10.7. These alternative plans best meet the planning criteria, reduce flood risk to nearby communities, and provide positive benefits to the communities. The Tentatively Selected Plan is also the National Economic Development Plan. For the Longs & Red Bluff and the Bucksport Flood Impact Areas, the No Action Alternative is tentatively selected.

USACE has conducted an environmental analysis of the final array of alternatives in accordance with the National Environmental Policy Act of 1969, as amended, which is presented in this Draft FR/EA. Potential effects on the environment were evaluated as applicable. For the Tentatively Selected Plan, less than significant effects have been determined based on the draft study results. A Draft Finding of No Significant Impact has been drafted and is included with this Draft FR/EA. Possible means for avoidance and minimization of impacts have been identified for eventual implementation. At the time of this Draft FR/EA, consultation for most environmental laws and regulations is still ongoing. However, pursuant to Section 7 of the Endangered Species Act of 1973, as amended, the U.S. Fish and Wildlife Service has concurred with USACE's determination that the Tentatively Selected Plan may affect but is not likely to adversely affect the federally listed species or the designated critical habitat of the Northern long-eared bat.

Views of the public, agencies, stakeholders, and tribes were shared during the early phase of this study when defining the scope of the study. This included input on the extent and nature of flooding and potential management measures to consider. Agencies and tribes have also had the opportunity to share their views during ongoing consultations. Input has helped to refine the study, but there has been no known opposition to conducting the study to date.

Written comments are being sought on this Draft FR/EA during the public review and comment period in accordance with NEPA. A quality control review was performed on this Draft FR/EA. Internal USACE policy and legal compliance review and Agency Technical Review on the Draft FR/EA will be conducted concurrent with the public review period, and results incorporated into the Final FR/EA. An independent external peer review for this study was not applicable.

Finally, this Draft FR/EA briefly acknowledges the major flood stage event that occurred in the Waccamaw River as a result of intense and extended rainfall associated with Hurricane Debby in August of 2024. However, since this just occurred only a few weeks prior to the release of this Draft FR/EA, the study team has not had time to assess the characteristics of this event and the resulting impacts of the flooding in relation to this study. This event provides a unique opportunity to consider real-time information that may further inform this study while results are still in draft format. USACE and Horry County will use this new information to supplement the study results as appropriate before the FR/EA is finalized.

APPENDICES

LIST OF ACRONYMS AND ABBREVIATIONS	
AEP	Annual Exceedance Probability
APE	Area of Potential Effects
ASA-CW	Assistant Secretary of the Army -Civil Works
ATR	Agency Technical Review
AIWW	Atlantic Intracoastal Waterway
BCR	Benefit-Cost Ratio
BiOp	Biological Opinion
BOEM	Bureau of Ocean Energy Management
CBRA	Coastal Barrier Resources Act
CBRS	Coastal Barrier Resources System
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
CWE	Current Working Estimate
DQC	District Quality Control
EA	Environmental Assessment
EAD	Expected Annual Damage
EC	Engineer Circular
EFH	Essential Fish Habitat
EJ	Environmental Justice
EO	Executive Order
EP	Engineer Pamphlet
EQ	Environmental Quality
EP	Engineer Pamphlet
ER	Engineer Regulation
ERDC	Engineer Research and Development Center
ESA	Endangered Species Act
FEMA	Federal Emergency Management Agency
FRM	Flood Risk Management
FRM-PCX	Flood Risk Management Center of Expertise
FWOP	Future Without Project
FWP	Future With Project
FY	Fiscal Year
GIS	Geographic Information System
HAZUS	Hazards United States, FEMA
HEC-FDA	Hydrologic Engineering Center-Flood Damage Analysis Model
HEC-HMS	Hydrologic Engineering Center-Hydrologic Modeling System Model
HEC-RAS	Hydrologic Engineering Center-River Analysis System Model
HTRW	Hazardous, Toxic and Radioactive Wastes
HUC	Hydrological Unit Codes
HCD	Habitat Conservation Division

HWY	Highway
IDC	Interest During Construction
IFR	Integrated Feasibility Report
LERRDs	Lands, Easements, Right-of-Ways, Relocations, and Disposal Areas
IPAC	Information for Planning and Consultation
LifeSim	Life Loss Simulation Model
LPP	Locally Preferred Plan
mg/l	Milligram Per Liter
MSA	Magnuson-Stevens Fishery Conservation and Management Act
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
NAVD88	North American Vertical Datum 1988
NED	National Economic Development
NEPA	National Environmental Policy Act of 1969, as amended
NFIP	National Flood Insurance Program
NFS	Non-Federal Sponsor
NHPA	National Historic Preservation Act
NMFS	National Marine Fisheries Service
NNBF	Natural and Nature-Based Features
NOAA	National Oceanic and Atmospheric Administration
NPL	National Priorities List
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NRI	National Rivers Inventory
NS	Nonstructural Measure
OMRR&R	Operation, Maintenance, Repair, Replacement, and Rehabilitation
OSE	Other Social Effects
P&G	Principles and Guidelines
PDT	Project Delivery Team
PED	Preconstruction Engineering and Design
RECONS	Regional Economic System Model, U.S. Corps of Engineers
RED	Regional Economic Development
ROM	Rough Order of Magnitude
S	Structural Measure
SLC	Sea Level Change
SLR	Sea Level Rise
SVI	Social Vulnerability Index
TES	Threatened, Endangered and Sensitive Species
TPCS	Total Project Cost Summary
TSP	Tentatively Selected Plan
USACE	United States Army Corps of Engineers
USACE-SAW	United States Army Corps of Engineers, Wilmington District
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency

USFWS	United States Fish and Wildlife Service
USGS	United States Geological Survey
VA	Vulnerability Assessment
WRDA	Water Resources Development Act
WRRDA	Water Resources and Recovery Development Act
WSEL	Water Surface Elevation

1.0 INTRODUCTION

The U.S. Army Corps of Engineers, Charleston District (USACE), in partnership with Horry County, has undertaken a feasibility study for the purposes of flood risk management on the Waccamaw River Basin within Horry County, South Carolina. The purpose of the Feasibility Report and Environmental Assessment (FR/EA) is to describe the outcome of the study and present a recommended plan appropriate for Federal investment and to comply with the National Environmental Policy Act (NEPA).

This FR/EA is prepared in accordance with the NEPA regulations that were in place at the inception of the study in August 2022 as codified at 40 C.F.R. §§ 1500-1508 (2022), rather than more recent regulatory amendments. Following public and agency review, comments will be considered and incorporated into the final FR/EA as appropriate. The Feasibility Phase is the first phase in the USACE Civil Works Project Development Process. The completion of the Feasibility Phase is marked by approval by the Chief of Engineers and signature of the Chief's Report, which is then submitted to Congress for consideration. If the project is authorized and funded by Congress, the next phase is Pre-Construction, Engineering, and Design (PED) followed by Construction of the project. After project implementation, operations and maintenance (O&M) are the responsibility of the non-Federal sponsor.

1.1 USACE PLANNING PROCESS

The USACE planning process follows six steps defined in the U.S. Water Resources Council's guidance document, *Economic and Environmental Principles & Guidelines for Water and Related Land Resources Implementation Studies* (P&G). This process is a structured approach to problem solving which provides a rational framework for sound decision making. The six-step process is used for all planning studies conducted by USACE. The six steps are:

- Identifying problems and opportunities
- Inventorying and forecasting conditions
- Formulating alternative plans
- Evaluating alternative plans
- Comparing alternative plans
- Selecting a plan

USACE decision making is generally based on the accomplishment and documentation of all these steps. As more information is acquired and developed, it may be necessary to reiterate some of the previous steps. While the six steps are presented and discussed in a sequential manner for ease of understanding, they occur iteratively, and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete, and acceptable plans (ER 1105-2-103, 2-2c). Those steps culminate in identification of the Tentatively Selected Plan (TSP) and are captured in the FR/EA.

1.2 Study Authority

The authority to investigate a flood control project for the Waccamaw River in Horry County, South Carolina was provided in Section 445 of WRDA 1999 (P.L. 106-53). Section 445 states:

The Secretary shall conduct a study to determine the feasibility of undertaking a flood control project for the Waccamaw River in Horry County, South Carolina.

There is a completed USACE navigation project that overlaps the study area. Section 445 necessarily includes the authority to recommend FRM measures including structures or changes to the river in the footprint of this completed USACE navigation project, which was originally authorized by the Rivers and Harbor Acts of June 14, 1880 -S. Ex. Doc. 117, 46th Cong., 2d session and Annual Report, 1880, p. 848, and of July 3, 1930 - H. Doc. 82, 70th Cong.

There are multiple completed USACE FRM projects within the Waccamaw River basin in Horry County, South Carolina. Section 216 of the Flood Control Act of 1970 (33 U.S.C. 549a) provides authority to review the operation of these FRM projects and recommend modifications. Section 216 states:

The Secretary of the Army, acting through the Chief of Engineers, is authorized to review the operation of projects the construction of which has been completed and which were constructed by the Corps of Engineers in the interest of navigation, flood control, water supply, and related purposes, when found advisable due the significantly changed physical or economic conditions, and to report thereon to Congress with recommendations on the advisability of modifying the structures or their operation, and for improving the quality of the environment in the overall public interest.

These completed FRM projects were originally authorized under the following Continuing Authorities Program authorities, Section 205 of the Flood Control Act of 1948 and Section 208 of the Flood Control Act of 1954.

1.3 Study Area

The Waccamaw River Basin is in North and South Carolina and covers 1,640 square miles. The Waccamaw River begins in Columbus County, North Carolina and flows approximately 140 miles southwest, roughly paralleling the coast of the Atlantic Ocean until joined by the Atlantic Intracoastal Waterway (AIWW) and the Great Pee Dee River before reaching the tidal Winyah Bay in Georgetown County, South Carolina. The Basin includes all or portions of five counties as shown below in Figure 1. Study authorization provided in Section 445 of WRDA 1999 focuses the study to Horry County, SC.

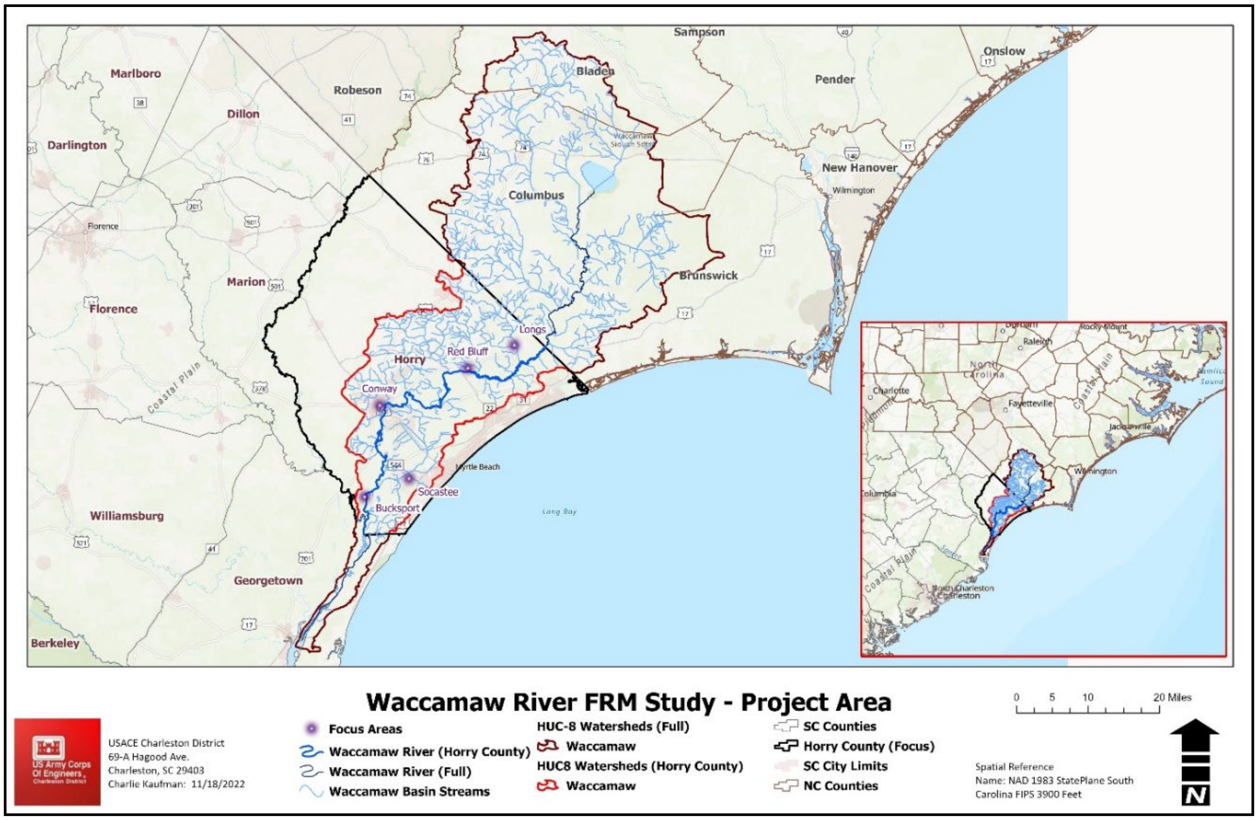

Figure 1: Waccamaw River Basin

Horry County is comprised of 1,255 square miles of mostly flat topography. This low-lying region is the middle ground between the inland river systems of South Carolina and waters exiting into the Atlantic Ocean through Winyah Bay. The confluence at Winyah Bay receives water from the Waccamaw River, the Pee Dee River, and the AIWW. Waters collected within the Basin come from almost 6,000 miles of streams across North and South Carolina and flow south along a gradual slope. Flat topography, low elevations, and tidal effects result in slow subsidence when high water events occur. Flooding is significant and affects major transportation routes, leaving densely populated communities along the coast isolated, displaced, and unable to receive supplies. Population centers within the study area and flood impact areas evaluated in this study include the following municipalities and incorporated areas: Longs, Red Bluff, Conway, Bucksport, and Socastee shown below in Figure 2.

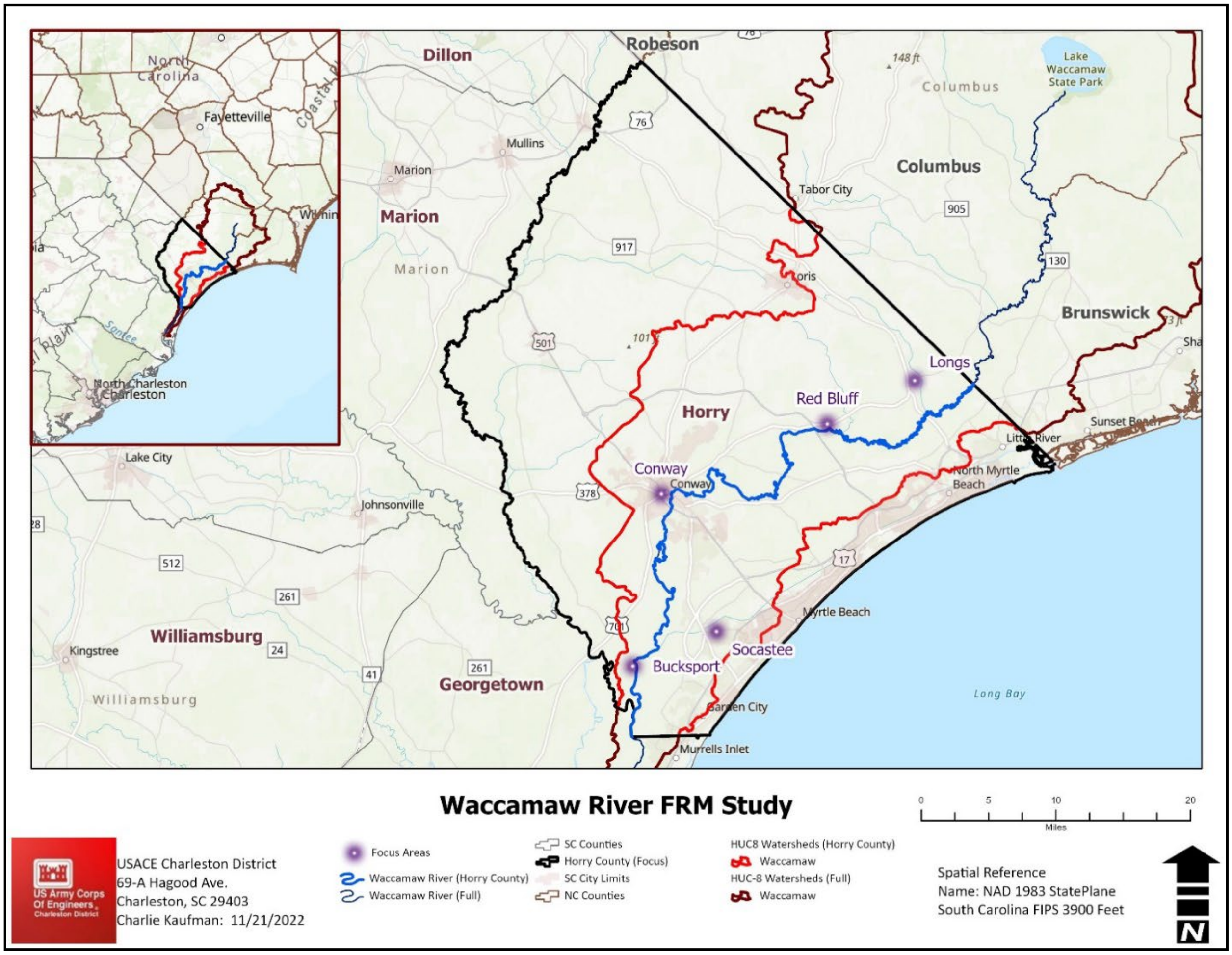

Figure 2: Waccamaw Population Centers

1.3.1 Longs and Red Bluff

Having shared hydraulic, social, and environmental characteristics, Longs and Red Bluff were investigated as a single flood impact area. These unincorporated areas are situated just north of the Waccamaw River. The Longs and Red Bluff area has approximately 9,550 residents according to the 2020 U.S. Census. Longs is expecting future population growth. According to county census estimates, it is anticipated to have over 30,000 residences by 2040. The primary tributaries of the Waccamaw River in this area are Buck Creek, Simpson Creek, and Todd Swamp. This area is predominately woody wetlands, evergreen forest, agricultural areas, and development scattered throughout. Development types range from open space, including agricultural land and maintained areas to dense clusters of impervious landscape, such as residential, commercial, and industrial structures. These communities are situated in the upper reach of the study area.

1.3.2 Conway

The Waccamaw River runs through the City of Conway, which serves as the county seat of Horry County. Located approximately 14 miles from the Atlantic Ocean, The City has approximately 46,200 residents according to the 2020 U.S. Census. The City anticipates a projected population increase of 60% by 2040. Crabtree Swamp (also known as Crabtree Canal), Kingston Lake, Stanley Creek, Tilly Swamp, Tilly Lake, Steritt Swamp, and Lake Busbee are the secondary drainage basins that impact the area of Conway. Much of the City of Conway is composed of residential and commercial development including many historical structures and places. Highways 501 and 501 Business are among the most heavily used roadways in Conway for local commute, but also by tourists visiting Myrtle Beach and surrounding tourist attractions.

1.3.3 Bucksport

Bucksport is a rural unincorporated community in southern Horry County with less than 2,000 people according to the 2020 U.S. Census. Bucksport lies on the western bank of the Waccamaw River. On the west side of the community is the Cowford Swamp, while Bull Creek, Collins Creek, and the Pee Dee River run through the flood impact area. Bucksport is composed mostly of waterways, marshes, wetlands, and residential neighborhoods that include historical structures and places.

1.3.4 Socastee

Socastee is a community located just seven miles from the Atlantic Ocean with a population of 22,213 (2020 U.S. Census). Socastee is a low-lying area with several waterways adjacent and running through the city, including the AIWW. Other drainage areas located in the community include Socastee Creek, Socastee Swamp, and the Waccamaw River. Development and land use in the area includes residential, commercial, recreational, and open water marsh lands.

1.4 Non-Federal Sponsor

Horry County, in collaboration with the City of Conway, is the non-Federal sponsor (NFS) for this study.

1.5 Project Background

1.5.1 Horry County Flooding History

According to Section 6 of the 2024 Comprehensive Emergency Management Plan, Horry County has experienced 36 flood events since 1950, with eight occurring between 2015 and 2021. Some of the most impactful flood events were following storms like Hurricanes Floyd, Joaquin, Matthew, and Florence. Generally, flooding in Horry County appears in three distinct phases following intense rainfall. The first phase of flooding occurs during a severe storm event where ponding occurs in low lying areas, parks, and intersections and cannot drain as quickly as it collects, commonly referred to as pluvial or flash flooding. The second phase typically occurs days following a storm event as smaller watersheds, like Crabtree Swamp, exceed capacity with runoff. As a result, nearby homes become inundated. The third phase generally begins a week after a storm event when drainage from the Waccamaw River basin causes the river to rise.

This is often referred to as fluvial or backwater flooding. The surrounding flat terrain and expansive floodplain play a contributing role in the dissipation of runoff and its conveyance through the river system out to Winyah Bay.

On September 16, 1999, Hurricane Floyd swept across the South Carolina coast as a category 4 storm, with up to 18-inches of rainfall recorded in parts of Horry County over several days of rain (https://www.weather.gov/ilm/Floyd). Hurricane Floyd was one of the most diverse events, with 3 distinct flood stage events in Horry County. Primarily attributed to intense rainfall that led to flash flooding across various portions of the county simultaneously. Days after the initial flooding subsided, backwater flooding crept into hundreds of homes. Ten days after Floyd's landfall, the Waccamaw River gauge reached a peak at 17.61 feet, over six feet above flood stage.

Sixteen years later, on October 1, 2015, Hurricane Joaquin struck the South Atlantic coast as a category 4 hurricane, bringing widespread rainfall ranging from 17 to 20 inches over the 5 days of rain in Horry County (https://www.weather.gov/chs/HistoricFlooding-Oct2015). Consequently, Horry County witnessed substantial flash flooding, affecting hundreds of homes throughout the flood impact areas. Additionally, the Waccamaw River reached its peak eight days later at 16.20 feet, marking the fifth-highest historical crest.

Just a year later, on October 8, 2016, Horry County suffered yet another severe storm event. Hurricane Matthew made landfall in Horry County as a category 1 hurricane. Horry County received between 12 to 14 inches of rain in a little over a 24-hour period causing flash flooding in low-lying areas, crossover flooding from the Pee Dee River, and backwater flooding in the Intracoastal Waterway and Waccamaw River. The peak crest was 17.89 feet, reached eight days after the hurricane made its initial landfall, making it the second highest historical crest on record.

When Hurricane Florence made landfall on September 18th, 2018, the Waccamaw and Pee Dee River basins received nearly 34 inches of rainfall. The rainfall resulted in a new record flood with the Waccamaw River cresting in Conway at 21.16 feet. Damage was reported to over 15,000 properties (firststreet.org).

In under 30 years, Horry County has faced 11 flood stage events. The threat of flooding persists days after the initial storm event. Coordination with the NFS and public meetings have shown, this pattern of flood risk is well understood by residents of Horry County, the City of Conway, and neighboring communities.

1.5.2 Recurring Community Costs

Flooding affects people and resources; however, emergency planning and management helps to alleviate some risks. Generally, the county has several days in advance of severe storm events to prepare and evacuate with forecasting from the National Oceanic and Atmospheric Administration (NOAA) and the National Weather Service (NWS). The ability to closely monitor stream gage heights along the Waccamaw and Pee Dee Rivers also supports the timely implementation of flood-fighting protocol described in Horry County's Comprehensive Emergency Management Plan (CEMP). However, while these protocols reduce life safety risks from flooding, other risks including structural, economic, social, and environmental remain.

Costs incurred by communities in Horry County are often the result of damages associated with long periods of inundation. Following previous severe storm events, floodwater has remained in or under buildings for up to 30 days causing significant damages and costs associated with repair and rebuilding. There have also been many instances of flooding in sewer lift stations, including those that serve the Horry County Emergency Operations Center and the County Dispatch Center. Lift station damage often leads to environmental contamination from sewage spills and leaks that contaminate soil, groundwater, and surface water. In addition to health concerns from harmful bacteria, viruses, and other pathogen exposure, property damage from sewage backups into homes and businesses is another potential issue.

Flooding associated with Hurricane Floyd caused significant structural damage to Downtown Conway and neighborhoods such as Jackson Bluff, Pitch Landing, Savannah Bluff, and Lees Landing. South Carolina Emergency Management reported over 11,000 homes damaged, 11 dams breached or failed, and 455,000 people evacuated (https://www.weather.gov/ilm/Floyd). Following Hurricane Joaquin, costs associated with damage to 410 residential structures (including damage to secondary structures such as appliances, crawlspaces, and garages) and public infrastructure exceeded $14M. Just a year later, Hurricane Matthew cost Horry County $46M in residential and public infrastructure losses from associated flood damages. The cost of damage from Hurricane Florence flooding was $41.5M stemming from impacts to 2,000 homes and numerous businesses and over 200 closed or damaged roadways and bridges that restricted movement after the storm passed (https://www.horrycountysc.gov/media/3rxjkrew/horry-county-resiliency-report-summary_07oct22.pdf, pg. 2).

Road closures pose a complex problem that result in a cascade of adverse impacts to response and recovery. While there may be ample warning time to evacuate, historic events have shown roads may remain flooded for extended periods. This means evacuated residents are temporarily displaced. During Hurricane Floyd, it would be weeks before businesses would resume operation due to the lack of staff, supplies, and customers. Many of the evacuated homes and commercial establishments were subject to looting and burglary in the absence of property owners and law enforcement. The Myrtle Beach Chamber of Commerce reported $45M in adverse impacts to businesses and regional commerce. Federal, State, and local assistance cannot be deployed until waters dissipate, residents return, and damage is assessed, which can be anywhere between 10–25 days.

Flash flooding endured during and after Hurricane Joaquin impacted Horry County's Emergency Operations Center by inundating all roads surrounding the building. Hurricane Florence caused significant impacts to essential transportation routes, from blocked or damaged roads, downed trees, and utility poles. The storm threatened to isolate the County from the rest of the region. Unprecedented steps had to be taken to ensure a lifeline was maintained into and through Horry County and ensure essential supplies and services were available for over 390,000 people (Horry County, 2023).

Federal Emergency Management Agency (FEMA) assistance was provided after each storm event. FEMA Individual Assistance Program funding exceeded $3M to over 4,000 applicants in Horry County during Hurricane Joaquin, 5,000 applicants affected by Hurricane Matthew, and 6,500 applicants affected by damages caused by Hurricane Florence.

1.5.3 Prior Reports and Existing Water Resource Projects

A variety of Federal and non-federal projects and activities are ongoing or have been completed in the Waccamaw River basin. While not an exhaustive list or part of this study, the scope and status of the efforts below have been tracked for consideration in the planning process, conceptual design development and impact analysis. Previous studies are used to characterize existing conditions and forecast future conditions for alternative evaluation.

<u>USACE Projects</u>

- Crabtree Swamp Sec. 206 Aquatic Ecosystem Restoration, 2020 (Completed)
- Socastee Creek Sec. 205 Flood Control, 2003 (Completed)
- Waccamaw River North and South Carolina Flood Control Report, 1951 (Completed) (USACE 1951)
- Atlantic Intracoastal Waterway,1930 (Completed)

<u>Horry County Projects</u>

- Comprehensive Emergency Management Plan (CEMP), 2024 (completed)
- Big Bull Landing Road Project (ongoing)
- Buck Creek Watershed Benching Project (ongoing)
- McCormick Bridge Supplemental Culvert Project (ongoing)
- Socastee Creek Upper Channel Benching Project (ongoing)

<u>City of Conway Projects</u>

- FEMA buyouts (completed)
- Acquisition of conservation property (ongoing)
- Chestnut Bay/Sherwood Forest (completed)
- Hawthorne Park (pending funding)
- Newcastle H&H Study (ongoing)
- Resiliency Plan (ongoing)
- Stormwater Master Plan (ongoing)
- Beaty and Pine Streets (pending funding)
- Carolina Bays (ongoing)

1.5.4 Horry County Flood Event Operational Plan

The Horry County CEMP published in 2024 describe the protocol and procedures specific to response operations during riverine and coastal flood events. Horry County uses flood stages for riverine and coastal waters as reference points for flood planning and the Operational Condition levels in the CEMP to respond, thus facilitating both emergency management and emergency response. These stages are summarized in Table 1.

Table 1: Waccamaw Flood Stage Impact

Flood Stage	Stream Depth	Flood Impact
Minor Flood Stage Rivers	Waccamaw River 11 feet; Little Pee Dee River 9 feet	Minor flooding is expected at this level, slightly above flood stage. Few, if any, buildings are expected to be inundated; however, roads may be covered with water, parklands, and lawns may be saturated, and water may go under buildings on stilts or higher elevations.
Minor Flood Coastline	1-2 feet above normal high tide	Water will usually run-up to the dune in waves during a minor flood. Overwash may occur on shoreline roads. Lifeguard structures and beach concession stands will usually be flooded and possibly damaged by the surf.
Moderate Flood Stage Rivers	Waccamaw River 12 Feet; Little Pee Dee River 11 feet	Inundation of buildings usually begins at this stage. Roads are likely to be closed, and some areas cut off. Some evacuations may be necessary.
Moderate Flood Coastline	2-4 Feet above normal high tide	At the moderate flood stage, usually, water overtops the natural dune and begins flooding coastal areas. Shoreline roadways and beaches will often be completely flooded out. High surf traditionally associated with this level of flooding may significantly impact some ocean side structures like piers, boardwalks, docks, and lifeguard stations. In addition, Beach houses may be damaged by water and surf, especially if lacking stilts.
Major Flood Rivers	Waccamaw River 14-16 feet, Little Pee Dee River 12 feet	Significant to catastrophic, life-threatening flooding is usually expected at this stage. Extensive flooding with some low-lying areas completely inundated is likely. Structures may be completely submerged. Large-scale evacuations may be necessary.
Major Flood Coastline	4-9 feet above normal high tide	Water surges over the dunes, man-made walls, and roads. Large and destructive waves pound weak structures to bits and severely damage well-built homes and businesses. Overwash occurs on high-level seawalls. If major flooding occurs at high tide, impacts may be felt well inland.
Record Flood Rivers	Waccamaw River above 17 feet; Little Pee Dee above 16 feet	These are the highest recorded on these rivers since the gauges have been in place
Record Flood Coastlines	Greater than 9 feet above normal high tide	Record flooding at the coast is associated with Tropical cyclones, but it may be associated with coastal storms or tsunamis. Destruction is often extensive and may extend a far distance inland.

1.5.5 Horry County Planning Future and Applicable Ordinances

Considering their rapid growth, Horry County is taking proactive steps to plan for the future. The IMAGINE 2040 Comprehensive Plan emphasizes the principles of sustainable development, focuses on community design and character, maximizes, and efficiently expands public infrastructure together with services, and brings people closer to job centers, while encouraging thoughtful development and redevelopment. Chapter 12 of the county plan discusses zoning and sustainability (https://www.horrycountysc.gov/departments/planning-and-zoning/imagine-2040/).

IMAGINE 2040 and pertinent local ordinances identified below are directly quoted from IMAGINE 2040.

- **Chapter 17, Article 1, Section 17.7 Stormwater Management**

This section contains numerous requirements for on-site stormwater systems, enforcement, and inspections.

- **Chapter 18, Article 1, Section 5. Suitability of the Land**

The Planning Department shall not approve the development of land if land intended for building sites can not be used safely for building purposes without being in danger of flood or other inundation or other menaces of the health, safety, or public welfare. Such decisions will be based on the Comprehensive Plan, related reports, and investigations conducted by other public or private entities.

- **Chapter 18, Article 5, Section 2-2 Stormwater**

All land development shall provide an adequate drainage system in accordance with the Horry County Storm Water Management and Sedimentation Control Ordinance.

1.5.6 Hurricane Evacuation Study (HES) Population Vulnerability Analysis

There is an ongoing South Carolina HES to serve as the root of state hurricane plans. This study replaces the previous 2012 study. These FEMA-funded Corps studies are funded by FEMA and assess the vulnerability of a population to hurricane threats and provide information and critical planning factors that guide state, local, tribal, and territorial governments in hurricane evacuation and response plans. The reports consist of five key components including: Hazard Analysis, Vulnerability Analysis, Behavioral Analysis, Shelter Analysis, and Transportation Analysis.

According to the 2023 census data, the project area added approximately 14,000 people (397,478 total) since 2022. The last hurricane landfall in Horry County was Matthew in 2016, but the County also took 3 other direct hits, along with two tropical storms since 2008. Preliminary results suggest that 35% of the county’s population does not know if they live in an evacuation zone. With regards to evacuations, 60% stated they would not leave for Category 1 or 2 storms. As such, some 239,000 people would weather out a Category 2 hurricane while 17% (67,000) would not leave regardless of category.

With regards to demographics, the project area is 83% white with an age distribution skewed towards age 55 and older (107,319 or 27%). The Black or African American population has steadily decreased since 1990 from 17% to 12%, while the Hispanic population has risen from 1% to 7.3% since 2015. Approximately 12.5% of residents in Horry County live in poverty or about 1.1% above the national average of 11.4%.

The reasoning behind individual decisions to evacuate are varied. Typically, if someone has stayed during a hurricane or is a transplant from another region that often experiences low category storms, they have the mindset that the next storm will present similar effects. Some municipalities offer evacuation transportation that do not allow pets. Most people will not leave a pet behind. For lower income individuals, leaving their home is often not possible unless the governor issues an evacuation. Without an official order, employees can be fired for not showing up to work. Regardless of the reasoning, the number of residents choosing to stay during a significant storm event, as identified in hurricane evacuation studies, pose a danger to themselves and civil servants who have a responsibility to protect citizens.

1.6 Purpose and Need

Within the last 75 years, residents of Horry County have suffered increasing structural and economic loss due to recurring exposure to flooding from the Waccamaw and Pee Dee Rivers. For example, Hurricane Florence flooded 2,000 homes in 2018, of which 90% did not have flood coverage, as many of the homes were not in a flood zone. Additionally, the storm damaged 250 roads (https://www.horrycountysc.gov/media/3rxjkrew/horry-county-resiliency-report-summary_07oct22.pdf, pg. 2). Intense rainfall from storm events in this region, and upstream reaches of the Waccamaw River and Pee Dee River, induce multi-phase flood events that have displaced communities for 10-30 days at a time. Flash, backwater, compounded by tidal flooding, pose a threat to structures (residential and commercial), local commerce, public infrastructure, critical facilities, and emergency services.

According to the 2023 U.S. Census Bureau (https://data.census.gov/profile/Horry_County,_South_Carolina?g=050XX00US45051), Horry County is the fourth most populated county in South Carolina and home to over 397,000 people. Between 2020 and 2023, the county added over 46,000 people growing the population 13.2% in three years. This region is a growing metropolitan area due to its proximity to popular tourist destinations like Myrtle Beach and has large potential for further development. The expected population and economic growth in Horry County create a need for improvements to existing projects and development of new infrastructure.

The purpose of the Waccamaw River, Horry County, South Carolina, Flood Risk Management (FRM) Study, herein referred to as the Waccamaw River FRM Study, is to address existing and future flood and life safety risk to communities and transportation routes within Horry County, South Carolina and to recommend a plan to reduce this risk. Tidal effects, flat topography and low elevations result in slow subsidence when high water events occur. Flooding is significant and affects major transportation routes, leaving densely populated communities along the coast isolated and unable to receive supplies.

Communities within the County are subject to flood risk stemming from more recent frequent riverine flooding and severe storm events. The physical and geographic conditions of the Waccamaw River Basin (the Basin), coupled with the frequency of severe storm events, justifies the need for flood risk management implementation. Horry County requested USACE assistance with flood damage reduction due to the scope of flooding, which has ranged from more frequent riverine flooding to severe and widespread impacts like those sustained during Hurricanes Joaquin (2015), Matthew (2016) and Florence (2018).

1.7 Problems, Opportunities, Objectives, and Constraints (POOCs)

POOCs are the foundation of the planning process. They direct and focus Corps studies both initially and throughout the study. The Corps develops them collaboratively with the non-federal sponsor, Federal, State, and local agencies, Tribes, environmental justice communities, non-governmental organizations, etc. The POOCs are continually reaffirmed as the study progresses towards completion.

1.7.1 Problems and Opportunities

A problem statement is the detailed description of a problem that helps guide the planning process. It informs identification of study goals and objectives and plan formulation, comparison, and selection. Opportunities are instances in which the implementation of a plan has the potential to create a desirable future condition and provides ways to address the specific problems within the study area.

1.7.2 Problem

- Horry County experiences frequent and prolonged flooding that causes inundation of private and public structures, roadways, and transportation routes leading to life safety concerns, economic loss, and community degradation.

1.7.3 Opportunities

The primary opportunities within Horry County include:

- Reduce flood risk to the communities of Horry County;
- Encourage social sustainability and community resilience;
- Protect against damage to cultural and historical resources;
- Increase flood risk awareness; and
- Improve environmental quality where compatible with flood risk management objectives.
- Investigate how shifting precipitation patterns due to climate change affect river flows and flood frequencies.

1.7.4 Objectives

Planning objectives outline the desired results to meet our planning goals based on problems and opportunities over the 50-year period of analysis. They reflect what the study should accomplish. Objectives identified for this study are:

- Reduce the likelihood and consequences of flooding on human life and safety;
- Reduce/mitigate flood damages to structures, critical infrastructure, and roads within the Basin; and;
- Increase accessibility and resiliency of ingress/egress and supply routes.

1.7.5 Constraints

Constraints are restrictions that limit the extent of the planning process and are identified to avoid undesirable changes between the with- and without-project conditions. They can be divided into universal constraints and study-specific constraints. Universal planning constraints are the legal and policy constraints to be included in every planning study. Study-specific planning constraints are scenarios unique to a specific planning study that alternative plans should avoid. The following have been identified as planning constraints for the study:

- Minimize risk transfer (marginal increases to offsite flood conditions)
- Measures must be consistent with AIWW purpose and function; and
- Measures must be consistent with SCDNR managed lands.

1.8 Study Scope

The scope of the study includes an analysis of existing and projected flooding issues and resultant damages, and the formulation of an array of alternatives from which a plan that reduces flood risk can be recommended for Federal investment.

USACE conducted this study in accordance with Engineer Regulation (ER) 1105-2-100, as updated in ER 1105-2-103, *Policy for Conducting Civil Works Planning Studies,* and the study is organized in the framework of the ER using the six-step planning process that originated in the P&G. This FR/EA includes a No Action alternative (NAA) as required by NEPA as well as alternatives consisting of both individual and combinations of structural and nonstructural measures. As required, the study identifies the National Economic Development (NED) plan which maximizes net benefits while safeguarding the nation's environment in accordance with applicable environmental laws, executive orders, and federal planning criteria. During the formulation of plans, consideration is given to the impact, whether positive or negative, on four key accounts: National Economic Development, Environmental Quality, Regional Economic Development, and Other Social Effects, as outlined in the P&G.

2.0 EXISTING CONDITION AND FUTURE WITHOUT PROJECT

Describing existing conditions of the study area primarily serves to establish a baseline for evaluating potential impacts associated with the alternatives considered for implementation. Affected resources included here are evaluated based on relevance to flood control actions or in keeping with requirements by relevant policies, laws, and executive orders. The following resources are described:

- Land Use
- Air Quality
- Climate
- Geologic Resources
- Water Resources
- Biological Resources
- Cultural Resources
- Recreation
- Transportation
- Socioeconomics and Environmental Justice
- Hazardous, Toxic, and Radioactive Waste
- Aesthetics

A forecast of a future without project (FWOP) scenario to which a future with project (FWP) scenario will be compared is also included here for each resource and is based on an assumed period of analysis. This FWOP scenario is equivalent to a "No Action Alternative". This interpretation of a NAA is equivalent to the Council on Environmental Quality's (CEQ) second interpretation of "no action" from its *Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations*, which "...*would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward.*" (46 Fed. Reg. 18026). An assumption of the FWOP condition is that project implementation would begin in the year 2030 and construction would occur from 2030 to 2035. This is referred to as the base year when benefits begin accruing. To evaluate performance of an alternative over a minimum of 50 years (see ER 1105-2-103, 2-4. (*b*)(4))*,* the period of analysis is therefore set to 2035 to 2085.

2.1 General Context for Existing Conditions and FWOP Conditions

Horry County is one of the fastest growing localities in the US and will continue to develop and reshape the landscape for decades to come. Much of the expected absolute population growth is anticipated east of the Waccamaw River along the coast and funneling up into the City of Conway. However, relative population growth in the Longs division is anticipated to be as high as 14.7% per year according to Horry County (2019). Seasonal populations within the county, particularly along the Grand Strand area are also expected to be higher than ever, with recent trends indicating more visitors with each passing year. Considering these trends, as population density increases in urban and suburban areas, services and facilities will need to expand to meet growing demands. Based on recent trends, much of the growing population is expected to be of a retirement age and to require more readily accessible recreational and human service facilities and will desire smaller housing units close to shopping and community services with fewer lawn maintenance needs (Horry County 2019). These changes are anticipated to be most observable in the Burgess, Forestbrook, Socastee, Carolina Forest, and Little River areas. Coinciding with these societal needs under FWOP conditions, improvements to development and zoning regulations are anticipated by the county. These would include regulations establishing the base flood elevation at which development would be permitted.

In the absence of implementation of the measures considered in this study, existing structures could remain susceptible to flood events and damages during high water events. Without Federal assistance, local and state resources may be limited in their abilities to implement similar measures to reduce impacts of flooding in the study area, making it more likely that potential impacts are not mitigated as much as possible and leading to potentially avoidable losses of life, infrastructure, economy, and other resources.

The study area boundary is divided among four flood impact areas: Longs/Red Bluff, Conway, Socastee, and Bucksport. These areas are based on jurisdictional boundaries but are also reflective of geographic and socioeconomic qualities unique to each. In recognition of both the context-dependent geographic similarities and differences across the study area, existing conditions and FWOP conditions for resources here are either described for the entire study area or as individual flood impact areas, consisting of Longs/Red Bluff, Conway, Socastee or Bucksport

2.2 Land Use

2.2.1 Existing Conditions

Land use in the study area was assessed using data from the U.S. Geological Survey (USGS) 2021 National Land Cover Database (NLCD) as well as at a county level with resources from Horry County (2019).

As most of the study area expands outward from the Waccamaw River, most of the study area (49%) consists of wetlands, with most of that being woody wetlands (46%) and the remainder being emergent herbaceous wetlands (2%). Woody wetlands are areas of forest or shrubland accounting for >20% of cover and soils which are periodically saturated or covered with water. These are often referred to as bottomland hardwoods. Emergent herbaceous wetlands are areas of perennials accounting for >80% of cover and where soil is periodically saturated or covered with water.

Ranging from low-lying areas near the Waccamaw River to areas of higher elevation, another 24% of land use consists of developed areas classified as open (9%) and low, medium, or high intensity (8%, 5%, and 1%, respectively). These land classes consist of primarily rural and suburban residential areas and recreational areas such as parks with gradually increasing levels of impervious covers. High intensity developed areas refers to areas where people reside or work in high numbers and includes apartment complexes, and commercial or industrial sites with 80-100% of cover being impervious. Generally, at greater elevations another 15% of land use consists of a mix of timberlands and unmanaged forested lands. Most of this class of land consists of evergreen forest (14%) while small pockets of mixed forest (0.3%) and deciduous forest (0.1%) exist in association. Evergreen forest is defined as areas of trees >5 meters tall which are >20% of cover and >75% of tree species being evergreens.

A relatively small proportion of land cover in the study area (<8%) is what may be associated with some form of agriculture. Cultivated crops, such as corn, soybeans, vegetables, tobacco, and cotton, as well as orchards and vineyards, are spread across about 5% of the study area, while another 3% consists of areas of herbaceous plants or hay/pasture.

At the broader county level, most land use (Table 2) is of rural land uses, such as farms, timberland and large single-family estates. Much of remaining residential areas are situated nearer beaches in the areas of Garden City, Burgess, Socastee, Forestbrook, Carolina Forest, and Little River. In total, residential land uses (including single-family, multi-family and transient lodging) occupied about 14% of land in Horry County in 2019. Industrial and commercial areas occupied about 3% more of land in the county. Like that of the study area, the county comprises about 21% agriculture and forestland, 8% conservation/preservation land and 41% vacant land.

Table 2: Current Land Use

Current Land Use	**Acres**	**% of County**
Single-Family Residential	98,249	13.46
Multi-family Residential	3,271	0.45
Transient Lodging	1,415	0.19
Business/Commercial	5,565	0.76
Industrial and Utility	17,119	2.35
Public or Institutional	7,797	1.07
Agricultural and Forestland	152,552	20.91
Conservation/Preservation	62,908	8.62
Golf Course	8,561	1.17
Vacant Land	296,679	40.66
Municipal Land Area	48,295	6.62
Other (Road Right of Way, Rivers, etc.)	27,267	3.74
Total	729,676	

2.2.1.1 Protected Lands

A protected land is similar in definition to that of a "natural area", which is defined under SC Code § 51-17-10.4. as:

"…*an area of land or water, or a combination thereof, generally, but not necessarily, large in size. Such an area may be in public or private ownership and shall contain relatively undisturbed ecosystems, landforms, threatened, endangered, or unique plant life or animal habitats, or other unusual or outstanding scientific, educational, aesthetic, or recreational characteristics.*"

According to data from the USGS GAP Analysis Project (USGS 2022), at least 26% of the study area overlaps with protected land (Figure 3). Protected lands are defined here as an "…*official national inventory of U.S. terrestrial and marine protected areas that are dedicated to the preservation of biological diversity and to other natural, recreation and cultural uses, managed for these purposes through legal or other effective means.*"

Broadly speaking, protected lands in the study area are predominately public lands (70%). Among the government or private entities which own or manage (some lands may be privately owned but exist as easements with private or government entities as well) protected lands in the study area, about 43% are state government, followed by private entities (30%), and Federal government (26%) (only about 0.6% are local government). Management of protected lands in the study area is largely carried out by the U.S. Fish and Wildlife Service (USFWS) (43%), the South Carolina Department of Natural Resources (SCDNR) (30%) and The Nature Conservancy (17%). Some other managers of protected lands include Ducks Unlimited, the North American Land Trust and Pee Dee Land Trust.

Among the most notable of protected lands are the Waccamaw National Wildlife Refuge (NWR), Waccamaw River Heritage Preserve (wildlife management area [WMA]), and the Sandy Island Preserve. The Waccamaw NWR makes up about 80% of the land in the Conway and Bucksport flood impact areas that meet the definition of protected lands. Approximately 10% more is protected as Waccamaw River Heritage Preserve in the Conway and Longs/Red Bluff flood impact areas. Sandy Island is just under 5% of the protected lands and is in the southern portion of the Bucksport flood impact location. Other lands considered protected areas can be broadly categorized as parks, gardens, recreation areas, and boat landings. Part of the Lewis Ocean Bay Heritage Preserve WMA also overlaps with the study area.

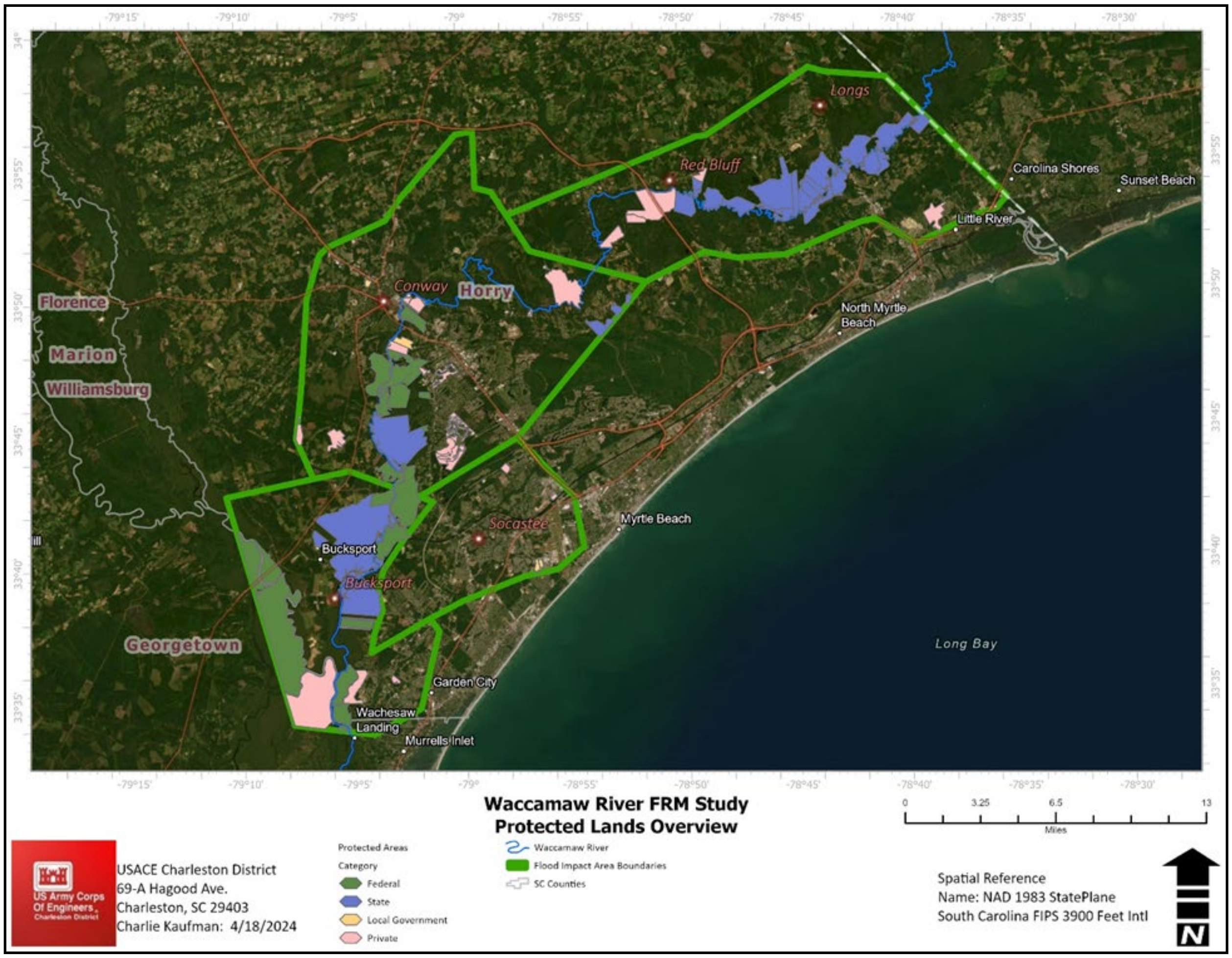

Figure 3: Project Area Protected Lands

2.2.2 FWOP Conditions

In South Carolina, recent land cover (Figure 4) trends may inform the course for the future. For instance, from 2001 to 2016, land in South Carolina underwent a general trend of urbanization and loss of “low disturbance” land covers (e.g., deciduous forest) and gain of developed land cover classes (e.g., open, low, medium, and high intensity) (Mikhailova et al. 2021). A similar trend occurred in Horry County from 1996 to 2016. For instance, total net developed land cover increased from 8.43% to 12.7% (50.6% increase) and impervious surfaces increased from 2.43% to 3.76% (54.7% increase). This is reflected in total net wetland cover decline of 2.2% (from 41.63% of total area to 39.42%) with associated conversion to developed land cover and a total net forested cover decline of 8.0% (from 51.6% of total area to 43.59%). However, forested cover changes are reflected in increases in both developed land covers and scrub/shrub. Very similar changes occurred in the Waccamaw River Watershed over the same period (NOAA Coastal Services Center C-CAP Landcover Atlas 2024). A similar trend is expected to continue into the FWOP conditions.

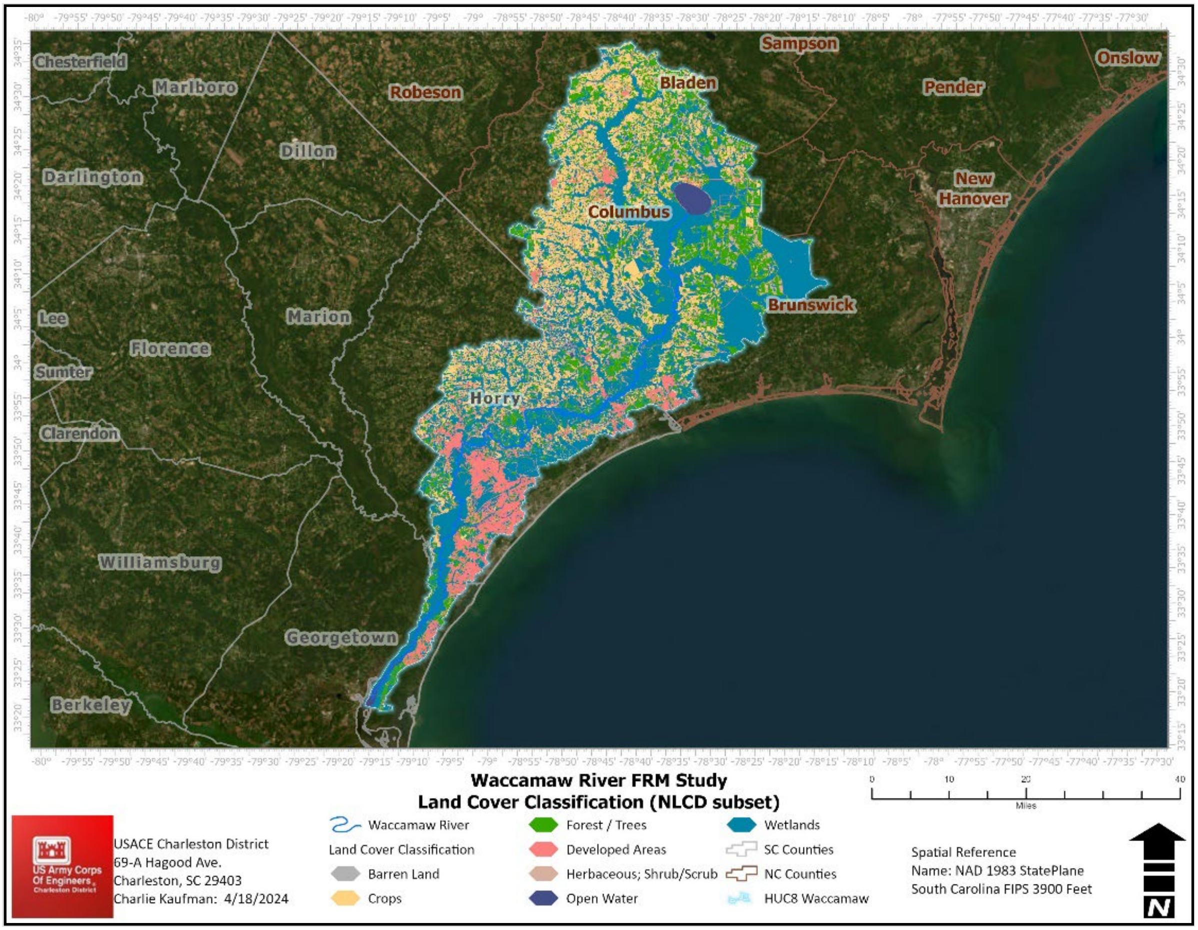

Figure 4: Waccamaw River Basin Land Cover

According to the Horry County IMAGINE 2040 Comprehensive Plan (Horry County 2019), Horry County's population and housing stock have more than doubled over the 30-year period between roughly the 1990s up to 2020. By 2040, the population is expected to nearly double again, and approximately 275,000 additional people are expected to make unincorporated Horry County home, creating a need for approximately 116,000 new housing units. According to Horry County (2019), current land use identified as single-family residential, multi-family residential, and transient lodging made up roughly 14% of land use in the county. In their plan, Horry County envisioned about 16-17% of land use would be for rural communities and suburban use, which are most closely associated with residential areas, indicating at least a 2-3% increase in development for these purposes over the next roughly 15-20 years. Other forms of developed land use, like industry and business centers are projected to occupy similar proportions of current land area. These trends are likely to continue into FWOP conditions.

In their IMAGINE 2040 Comprehensive Plan, the County identified approximately 40.66% of land use in the county as "vacant land," which they define as "land area not developed for a specific use or assigned a land use classification". Another 20.9% is considered agricultural and forestland and 8.6% is conservation/preservation. Future land use, as envisioned in the plan, is anticipated to become 38.9% scenic and conservation areas and 35.2% rural, collectively making up about 74% of land use. Based on the similarities in how the County defines each of these land use types, it is likely agricultural, and forestland (equivalent to rural) will increase by up to roughly 15%, and conservation/preservation will increase roughly 30% by 2040 while vacant land will no longer be considered "vacant." Given these assumptions alongside previous 20-year trends in changes in forested and wetland cover from 1996 to 2016, which saw roughly 10% decline in total area of these cover types, forested and wetland cover may continue to decline with expanding development into FWOP conditions.

The conversion of forested and wetland covers to developed and impervious land covers is expected to increase runoff rates and lead to greater peak discharges and frequency of floods (Konrad 2003). This is because the loss of vegetation, compaction of soils and filling of wetlands associated with land conversions reduce the porosity and storage capacity of a watershed. In addition, development is often coupled with changes to stream channels including channelization and reductions in surface area, which lead to less storage capacity. It is generally expected that FWOP conditions will include land use changes which reduce storage capacity of the watershed (i.e., development) based on trends and planning information described above, thus increasing need for effective flood risk management.

2.3 Air Quality

2.3.1 Existing Conditions

Air quality for a particular location may be described by the concentration of various pollutants in the atmosphere. Air quality is influenced by several factors such as type and level of pollutants released into the atmosphere, the size and topography of the air basin, and the prevailing meteorological conditions. The magnitude of the pollutant concentration is determined by comparing it to Federal and state ambient air quality standards. The Clean Air Act of 1963 (CAA), and its subsequent amendments enacted in 1990, established National Ambient Air Quality Standards (NAAQS) for six principal air pollutants, also known as "criteria air pollutants." The pollutants include sulfur dioxide (SO2), particulate matter (PM2.5 and PM10), carbon monoxide (CO), ozone (O3), nitrogen dioxide (NO2), and Lead (Pb).

A locality's air quality status and the stringency of air pollution standards and regulations depend on whether monitored pollutant concentrations attain levels defined in the NAAQS. To ensure NAAQS are achieved and/or maintained, the CAA requires each state to develop a State Implementation Plan (SIP). The South Carolina Department of Environmental Services (SCDES) (formerly known as the South Carolina Department of Health and Environmental Control or SCDHEC) – Bureau of Air Quality oversees the state's air agendas including the SIP. State and national ambient air quality standards represent the maximum allowable atmospheric concentrations that may occur while ensuring protection of public health and welfare, with a reasonable margin of safety. Primary standards are intended to protect the health of sensitive populations including children and the elderly, while secondary standards are established to protect the environment.

If the concentration of one or more criteria pollutants in a geographic area is found to exceed the regulated threshold level for one or more of NAAQS, the area may be classified as a non-attainment area. Areas with concentrations of criteria pollutants that are below the levels established by NAAQS are considered either in attainment or unclassifiable areas. All pollutants are currently classified as “in attainment” for Horry County, South Carolina (EPA 2024).

2.3.2 FWOP Conditions

FWOP air quality conditions in the study area are likely to reflect recent trends. The U.S. Environmental Protection Agency (EPA) maintains national and regional air quality data trends for concentrations of carbon monoxide, lead, nitrogen dioxide, ozone, PM_{10}, $PM_{2.5}$, and sulfur dioxide (https://www.epa.gov/air-trends). According to these data, average concentrations of CO, NO_2, O_3, PM_{10}, $PM_{2.5}$, and SO_2 have decreased by 67%, 44%, 25%, 31%, 48%, and 78% from 2000-2022 in the Southeast Region, and average concentrations of lead have decreased 88% from 2010-2022 nationally. According to Horry County (2019), on-road vehicles are likely the largest contributor to ozone emissions in the county, as well as of other pollutants like NO_2, SO_2, CO, and lead. Nevertheless, as national economic indicators including gross domestic product, vehicles miles traveled, population, and energy consumption have increased between 1970 and 2020, these six common pollutants have declined by 78% (EPA 2023).

2.4 Climate

2.4.1 Existing Conditions

The climate of the study area is “humid subtropical” characterized by long summers and relatively mild winters. According to data compiled by the South Carolina State Climatology Office, from 1991-2020, the mean temperature in Horry County was 64.5°F (mean min was 53.8°F, mean max was 75.3°F) and mean precipitation was 55.21” (SCDNR South Carolina State Climatology Office 2023). Across South Carolina, there is notable variability in the quantity of interannual rainfall which is correlated with that of Atlantic tropical storms and hurricanes. For instance, average fall season rainfall in the North Myrtle Beach area from 1991-2020 was 14.14”, while rainfall in 2006, 2009, and 2018 averaged 12.61”, 11.64”, and 23.32”, respectively (NWS 2023). The 2023 Atlantic Hurricane Season Outlook was 14-21 named storms, 6-11 hurricanes, and 2-5 major hurricanes which is considered above normal.

In the City of Conway, temperatures are relatively high, and precipitation occurs evenly throughout annual cycles. However, summers are generally wetter than winters, with convectional thunderstorm activity bringing much of the rainfall, while tropical cyclones can also bring large volumes of warm-season rainfall to the area. The warmest and wettest month is generally July, with an average temperature of 80.8°F and average rainfall of 6.8”. In the winters, the coolest month is generally January with an average temperature of 47.0°F, while the driest month is November with an average of only 2.5” of rainfall. Cooler months can bring an occasional frost and winter rainfall comes predominately in the form of frontal cyclones along the polar front. Some snow may also fall in winter months, with an annual average of 1.5” and most of that coming in February (Weatherbase 2023).

2.4.2 FWOP Conditions

2.4.2.1 Predicted Greenhouse Gas Emissions Changes

According to the Center for the New Energy Economy (CNEE) (2020), South Carolina cities and utilities are developing plans to limit or reduce the growth of greenhouse gas (GHG) emissions in the state. For instance, Columbia has set a goal to utilize 100% renewable energy by 2036 and the City of Charleston aims to reduce GHG emissions by 80% between 2002 and 2050. Local utility companies, Duke Energy and Dominion Energy, set a goal to meet net-zero carbon emissions by 2050.

In other economic sectors with influence on future GHG emissions, transportation is notable. M.J. Bradley and Associates (2020) estimate that if electric vehicle (EV) adoption reaches a “high” scenario (1.2 million vehicles by 2030, 5.5 million by 2050), South Carolina’s cumulative gasoline use would decline 15.4 billion gallons, and cumulative net GHG emissions would decline 294 million metric tons.

Similar scenarios are perceivable under FWOP conditions, including adoption of hydrogen-powered vehicles, increased public transportation options, improvements in energy efficiencies, innovations in new renewable energy sources, and several other ways of reducing GHG emissions from existing conditions.

2.4.2.2 Predicted Temperature Changes

According to the South Carolina Office of Resilience (SCOR) Strategic Statewide Resilience and Risk Reduction Plan (SCOR 2023), warming trends in the state of South Carolina accelerated in recent climatic periods. Since the turn of the 20th century, average annual temperatures have increased by about 1°F total, with the most recent 30-year period being warmer than any other consecutive 30-year period. These claims are supported by simulated analyses of historical data of the Waccamaw Watershed (all trend analyses herein are based on stream segment 03002010 for the purpose of simplicity) from 1951 to 2005 using the Climate Hydrology Assessment Tool (CHAT) which show statistically significant trends in annual minimum, mean, and maximum temperatures.

SCOR also reported that climate models project South Carolina temperature increases of 5° to 10°F by the year 2100, with the range of variability being at least partially dependent on future greenhouse gas emissions. The CHAT shows similar conclusions regarding temperature changes in the study area. For instance, simulations of climate change scenarios with varied levels of contributing emissions (based on the representative concentration pathway (RCP) 4.5 and RCP 8.5 scenarios identified by the International Panel on Climate Change (IPCC) indicate that statistically significant increasing trends in annual minimum (Table 3), mean and maximum temperature measures will continue from existing conditions into FWOP conditions (based on 2006 to 2099 period of analysis).

Table 3: Temperature Trends Existing Condition vs FWOP

Temperature Measure	2025		2085	
	RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Annual-Minimum 1-day Temperature (°F)	13.59	14.03	16.78	19.40
Annual-Mean 1-day Temperature (°F)	65.17	65.20	67.61	70.41
Annual-Maximum 1-day Temperature (°F)	100.71	100.66	103.31	106.78
All trends were statistically significant (p-value<0.05)				

2.4.2.3 Predicted Precipitation Changes

Patterns of precipitation in South Carolina have varied greatly since the turn of the 20th century, though data extrapolation indicates increases in precipitation extremes under FWOP conditions. According to SCOR (2023), there are little to no significant statewide trends in seasonal or annual total precipitation and particularly in Horry County. These findings are supported by analysis of simulated precipitation measures from 1951 to 2005 using CHAT, which depict no significant statistical trends in the Waccamaw Watershed. However, measures of precipitation including annual accumulated, maximum 1-day, maximum 3-day, and maximum number of consecutive dry days all show statistically significant increasing trends from existing conditions to the FWOP conditions under both RCP scenarios (Table 4). This is with one exception being that the annual-maximum 1-day precipitation trend over this period under the RCP 4.5 scenario is not statistically significant.

Table 4: Precipitation Trends Existing Conditions vs FWOP

Precipitation Measure	2025		2085	
	RCP 4.5	**RCP 8.5**	**RCP 4.5**	**RCP 8.5**
Annual-Accumulated Precipitation (inches)	52.02	52.02	53.53	53.32
Annual-Maximum 1-day Precipitation (inches)	2.34**	2.30	2.42**	2.55
Annual-Maximum 3-day Precipitation (inches)	4.24	4.22	4.42	4.61
Annual-Maximum of Number of Consecutive Dry Days	11.89	12.05	12.25	12.93
****indicates that trends from 2006 to 2099 were not statistically significant**				

2.4.2.4 Predicted Streamflow

Based on CHAT simulated future (2006 to 2099) modeling (USACE 2024), FWOP conditions streamflow measures throughout the Waccamaw Watershed (Hydrologic Unit Code [HUC]-8 03040206) are not projected to significantly differ from existing conditions with few exceptions. Virtually all stream segments in the watershed (includes downstream and upstream of study area) are projected to significantly increase annual maximum of mean monthly streamflow under the RCP 8.5 scenario. However, essentially no significant trend is projected under the 4.5 scenario or for any other measures (i.e., annual mean 1-day streamflow and annual streamflow volume) under either scenario. These findings suggest that most streamflow characteristics are unlikely to change under FWOP conditions, but under more dire climate change scenarios the intensity of streamflow during annual highpoints will be greater than currently experienced. This is particularly true for segments of the Pee Dee River (e.g., HUC-8 03002025) which are projected to experience significant increases in annual maximum of mean monthly streamflow under both RCP 4.5 and RCP 8.5 scenarios.

2.4.2.5 Predicted Sea Level Change

Recent research in the study area have indicated that rates of sea level rise (SLR) have averaged around one inch per year (Williams and O'Halloran 2023) and that water levels in the Waccamaw Watershed may outpace long-term projections. Analyses of water levels along the Waccamaw River have shown that although rapid changes in tidal range are not expected with current levels of SLR, mean low water is rising significantly faster than daily mean or high tide (Williams and O'Halloran 2023). The implication of these findings is likely to be increased periods of inundation in the tidal wetlands along the estuary and tidal river. As indicated by SCDNR (2021), despite uncertainty, most models project a rise of about two feet in South Carolina over the next century. Sea levels have already risen by approximately one foot in South Carolina and will most likely hit two feet by 2050. Projections for sea level rise by 2150 range from 2 to 16 feet (SCOR 2023).

The rise of two feet is expected to represent landward intrusion of 39-197 feet, affecting the boundaries between estuarine waters and tidal freshwater river and their associated habitats (e.g., tidal salt marsh) and wildlife. This estimate may, however, be an underestimation of SLR and intrusion into the watershed (Williams and O'Halloran 2023).

2.4.2.6 Extreme Weather Events

Patterns of extreme weather events under FWOP conditions are difficult to predict with precision, though broad patterns suggest higher frequency and intensity of such events commensurate with larger spatial extents. SCOR (2023) asserts data on precipitation extremes provide three generalities. The first of these is that interannual and interdecadal variability in heavy precipitation is substantial. The second is that while heavy precipitation since the mid-1900s has increased in parts of the southeastern U.S., most localities do not show a trend. Lastly, despite a lack of strong historical trends, the previous decade has exhibited the highest activity in historical record. Further, SCOR (2023) highlights Conway is among the few monitoring stations that shows a statistically significant increase in heavy precipitation, with a higher probability of occurrence for a given precipitation depth when considering 50-year periods after 1950 versus those in the 20th century. Projections from climate models show consistent increases in atmospheric moisture delivery to the Southeast with consequent increases in heavy precipitation at daily to hourly scales (Easterling et al. 2017; Prein et al. 2017).

2.4.2.7 Habitat Change

SCDNR (2013) have reflected on the potential effects of climate change to terrestrial and aquatic habitats throughout the state and highlighted habitat fragmentation, alteration and loss, and habitat impacts related to new and alternative energy as the greatest influences. Particularly in coastal areas, habitat fragmentation, alteration and loss are anticipated with changes in sea level rise, temperature extremes, and precipitation patterns. Climate change is most notable in its impacts on the ecology of plants due to their sessile nature and is of broader importance given the structural and functional influence of plants in both terrestrial and aquatic ecosystems.

Shifts in the range of average and extreme temperatures are likely to have consequences for plant community structure and functions as physiology of existing communities is under greater stress and better adapted species out-compete existing species. Similar impacts to plant communities are anticipated from changes in precipitation and where saltwater intrusion is expected, with better adapted plant communities replacing existing communities. Such changes may cause ecosystems to become fragmented, altered or ultimately collapse potentially leading to losses in biodiversity and ecosystem functions. This is particularly true where habitats are already fragmented or exist functionally in a closed system (i.e., limited or no migration in or out of a system) and climate-variable habitat components are depleted, precluding resource-dependent species and communities from geographic areas. The exacerbation of habitat fragmentation from climate change can have other indirect effects on biodiversity and species which are habitat specialists, such as increasing rates of inbreeding and reducing genetic variation in isolated populations (Leimu et al. 2010).

The effects of climate-related changes on ecosystems are likely to be measurable in most undeveloped terrestrial and aquatic habitats throughout the study area under FWOP conditions. Although it is not easy to predict precisely how the Waccamaw Watershed will change, it is relatively certain that species and habitats which already exist in fragmented or stressed conditions will become less represented in the watershed in the future, ultimately reducing biodiversity and ecosystem functions and potentially creating a more homogenous system.

2.5 Geologic Resources

2.5.1 Existing Conditions

Geologic resources consist of the topography, geology, mining, and soils of a given area. Topography describes the physical characteristics of the land such as slope, elevation, and general surface features. Geology includes bedrock materials and mineral deposits, and mining refers to the extraction of resources such as gravel or natural gas. The principal geologic factors influencing the stability of structures in the project area are soil stability, depth to bedrock, and seismic properties. Soil refers to unconsolidated earthen materials overlying bedrock or other parent material.

2.5.1.1 Geology

The study area lies entirely within the Coastal Plain of South Carolina which is divided among the marine coastal terraces or “low country” (<270 ft above sea level) and the Aiken Plateau, the High Hills of Santee, the Richland red hills, and the Congaree sand hills. Throughout the Coastal Plain is an underlying sedimentary deposit ranging in age from Upper Cretaceous to Recent and lies unconformably on ancient crystalline rocks. These deposits consist of three Upper Cretaceous formations including the Tuscaloosa formation (light-colored sand and clay), Black Creek formation (dark gray to black leafbearing laminated sand and clay), and the Peedee formation (gray sand and marl-stone) (Cooke 1936).

Beds along the Waccamaw are referred to as the Waccamaw formation and rest above the Upper Cretaceous Peedee formation as a Pliocene epoch layer. The Waccamaw formation is believed to be around 25 ft in thickness and to include several thin shell beds separated by sand. Shells of the Pleistocene Pamlico formation have been identified near the AIWW in Horry County and were underlain with irregularly indurated gray sandy marl and Pliocene mollusks (Cooke 1936). Upper sediments of the Pleistocene epoch were deposited or eroded with fluctuation and gradual overall lowering of sea level. The thickness of this Upper Pleistocene sediment has been estimated as deep as 65 feet in the Myrtle Beach area. Terrace soils of this layer consist of sands, silts, and clays with irregular deposits of shells. These soils are remnants of an archaic back barrier swamp at the backside of the barrier beach system at the seaward portion of the terrace (S&ME 2000).

2.5.1.2 Topography

The low country terraces are arranged in order by elevation, with the Pamlico (25 ft), Talbot (42 ft), Penholoway (70 ft), and Wicomico (100 ft) covering much of the study area extent (Cooke 1936). The Pamlico Terrace is a sandy Coastal Plain deposit characterized by gently undulating rolling topography characteristic of dune ridges of sand with low-lying swales of organic accumulation between (S&ME 2000). According to geographic information system (GIS) soil data compiled by the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS), elevations in the study area range from sea level to 40 ft (Pamlico and Talbot terrace), with most of the area ranging between 14 and 19 ft (Pamlico terrace).

2.5.1.3 Minerals

There are 57 actively permitted mines within Horry County according to SCDES. Of these, 13 overlap with the study area. Mineral mines in the study area consist mostly of sand and clay mining with at least one limestone mine. The material coming out of these mines is primarily used for road construction and development projects. Mining operations do not overlap with any areas identified within the study area for measures to be included as part of any alternatives.

Mining operation and activities are controlled by: (i) South Carolina Mining Act, S.C. Code Ann. §§ 48-20-10 el seq.; (ii) South Carolina Mining Compact, S.C. Code Ann.§§ 48-21-10 et seq.; (iii) Stormwater Management and Sediment Reduction Act §§48-14-10, et al., (iv) the Clean Water Act, 33 U.S.C. §§ 1251, et seq.; (v) South Carolina Pollution Control Act, S.C. Code Ann.§§ 48-1-10, et seq.; (vi) Clean Air Act, 42 U.S.C. 7401 et seq. and (vii) regulations promulgated thereto.

2.5.1.4 Soils

Pamlico terrace soils consist of gray or brown muddy sands and blue or gray clays. Several surface clays have been described in the study area. “Pine Island Clay” is characterized by a weathered gray or pink clayey sand and “Horry Clay” is a thick, black, peaty clay (S&ME 2000).

Broadly, the study area has a diverse array of soil types as characterized by the NRCS. Despite this, much of the soil textures consist of a mix of loams and fine sands ranging from moderately well drained to very poorly drained.

2.5.1.5 Prime Farmlands

Approximately 41,396 acres of land are considered prime farmland in the study area, and an additional 12,107 acres are prime farmland if drained. Of the remaining soils within the study area, 82,484 acres are considered farmland of statewide importance and 85,102 are considered not prime farmland.

2.5.2 FWOP Conditions

Geologic conditions of the study area are not expected to change notably under FWOP conditions other than those more surficial changes associated with land use changes described above. However, the U.S. Geological Survey (USGS) has documented land subsidence along the Coastal Plain of South Carolina with some areas sinking as much as -0.7 cm/year (Barnard et al. 2023). This has been associated with the compaction of sediment grains associated with the removal of large quantities of groundwater from underlying aquifers (Kemmer et al. 2023). In the study area, data from Garden City show the greatest amount of sinking at -0.25 cm/year. Much of the documented sinking is concentrated in the Bucksport flood impact area. Assuming no change in this rate, sinking could result in subsidence of some parts of the study area by up to about half a foot by the end of the period of analysis for this study. These changes could contribute to greater flood risk in affected areas.

2.6 Water Resources

Water resources include both surface water and groundwater; associated water quality; and floodplains. Surface water consists of lakes, ponds, rivers, streams, impoundments, and wetlands in a defined area or watershed. Subsurface water, commonly referred to as groundwater, is typically found in aquifers. Aquifers are areas with high porosity rock where water collects in pore spaces. Water quality describes the chemical and physical composition of water as affected by natural conditions and human activities. Floodplains are relatively flat areas adjacent to rivers, streams, watercourses, bays, or other bodies of water subject to inundations during flood events. A 100-year floodplain is an area that is subject to a one percent chance of flooding in any particular year, or on average once every 100 years.

The Waccamaw River is the primary focus of this FRM study, however, the Great Pee Dee River as well as several other large creeks and closely related waterbodies are also in the study area. Both the Waccamaw River and Pee Dee River are registered under the Nationwide Rivers Inventory (NRI) and receive additional protections under the Wild and Scenic Rivers Act of 1968 (Public Law 90-542;16 U.S.C. 1271 et seq.). This act was created to protect the free-flowing condition, water quality, and outstanding natural, cultural, and recreational values of rivers for the enjoyment of present and future generations.

2.6.1 Existing Conditions

2.6.1.1 Hydrology

The hydrology of the Waccamaw watershed has been highly modified over years of development resulting from direct structural changes like channel modifications, flood control levees, reservoirs, weirs, and dams. These modifications normally result in changes in the sinuosity of channels, flow velocities and connectivity of rivers to floodplains. Other less direct impacts to hydrology have included the contribution of sediment and runoff from surrounding land practices like timber production and development where bottomland hardwood previously existed. These changes have resulted in alterations of spatial and temporal patterns of flooding throughout the watershed. The movement of water throughout the watershed are also influenced by temporary changes and fluctuations which may include tidal effects, storm patterns and resulting effects to flood control structures, spread of invasive aquatic plants, forestry and agricultural practices and development patterns.

The Waccamaw River is classified as a blackwater river with its characteristic dark color coming from tannins drawn from neighboring vegetation. Typical conditions in the river are of an acidic nature and low in suspended sediments. The Great Pee Dee River at the western edge of the study area is considered an alluvial river originating in the Piedmont and has relatively high sediment loads. Both rivers generally have consistent seasonal flows patterns with lows often occurring from September through November and highs from February through April (USFWS 1997). Periods of high flow create networks of aquatic habitat throughout the floodplain with overbank flooding.

2.6.1.2 Surface Water

The extent of the study area overlaps five Hydrologic Unit Code (HUC) 10 watersheds: Buck Creek-Waccamaw River (0304020607), Kingston Lake (0304020608), Socastee Swamp-Waccamaw River (0304020609), Great Pee Dee River-Winyah Bay (0304020702), and Outlet Waccamaw River-Atlantic Intracoastal Waterway (0304020610). Four of these watersheds fall within the Waccamaw River Basin (03040206), while one is part of the neighboring Great Pee Dee River Basin (03040207). Collectively, these smaller watersheds are confined within the broader Lower Pee Dee (030402).

Overall, the Waccamaw River Watershed comprises 382,983 acres and is about 40% forested wetland, 22% forested land, 15% urban land, 15% agricultural land, and 5% or less of marsh, water, and barren land. The Waccamaw River flows from Waccamaw Lake in North Carolina through about 140 miles accepting drainage from Kingston Lake and the AIWW via Socastee Creek. The river then joins the Great Pee Dee River and drains into the Winyah Bay where it meets the Atlantic Ocean.

- **Buck Creek-Waccamaw River (east Longs/Red Bluff)**

This watershed spans the eastern portion of the Longs/Red Bluff flood impact location and is approximately 69,578 acres in size with tributaries from across the border of North Carolina downstream to Simpson Creek. Land use in the watershed is predominately forested wetland and forested land while about one-third is used for agriculture and urban developments. Although the watershed accepts drainage from about two dozen reaches, Buck Creek, Waccamaw River, and Simpson Creek are the greater surface water systems within the watershed. Collectively, the watershed concentrates 335 stream miles and 84 acres of lake water. All the surface water in the watershed is classified as “FW” (dissolved oxygen not less than 4.0 mg/l and pH between 5.0 and 8.5) (SCDHEC 2015).

Buck Creek is a blackwater system with naturally low dissolved oxygen (DO). Aquatic life and recreational uses are fully supported in the creek, although issues with oxygen demand, turbidity, nitrogen input, and pH have been trending unfavorably. The Waccamaw River is also a blackwater system and shares similarities with Buck Creek. However, nitrogen is less of a concern and both pH and turbidity have shown improving trends. Simpson Creek is fully supportive of aquatic life; however, it does show signs of increasing oxygen demand, and turbidity and recreational uses are partly limited from bouts of fecal coliform bacteria (SCDHEC 2015).

- **Kingston Lake (north of Conway)**

This watershed spans about 83,444 acres and consists of Kingston Lake and its tributaries north of Conway. Land use in the watershed is about half forested wetland and forested land, one-third agricultural, and the remaining land being predominately urban. Kingston Lake itself accepts drainage from Jacks Bay, Alligator Swamp and White Oak Swamp which in turn receive drainage from numerous swamps and creeks, all which finally feed into the Waccamaw River. Collectively, the watershed concentrates 184 stream miles and 162 acres of lake waters, all of which are classified as FW (SCDHEC 2015).

Kingston Lake does not support aquatic life uses due to issues with dissolved oxygen, which has been decreasing over years of monitoring. Additionally, recreational uses are not supported due to presence of fecal coliform bacteria. Upstream monitoring locations along Brown Swamp and Crabtree Swamp show similar issues with generally aquatic life or recreational uses being supported at the most upstream portions of the watershed (SCDHEC 2015).

- **Socastee Swamp-Waccamaw River (central study area)**

This watershed encloses the center of the study area and about 136,304 acres including primarily a lower stretch of the Waccamaw River and tributaries between Simpson Creek and Socastee Creek. Land use in the watershed consists of about half forested wetlands and forested land, a fifth urban areas, and some agricultural land. Upstream portions of the Waccamaw influence this area along with drainages from several creeks, swamps, bays, and lakes. Of particular interest in the study area is where Socastee Swamp and the AIWW merge near Socastee into Socastee Creek and meet the Waccamaw River. In total, the watershed comprises about 226 stream miles and 477 acres of lake waters, all of which is classified as FW (SCDHEC 2015).

As described earlier, Waccamaw River is a blackwater system, and its upstream portions of this watershed fully support aquatic life and recreational uses. However, downstream portions from near Tilly Swamp have had some DO excursions and there have been issues with turbidity in the recent past. Recreational uses are also only partially supported in this reach of the watershed (fecal coliform bacteria). These conditions improve around Conway and Lake Busbee and throughout the remainder of the Waccamaw River apart from a portion near Keys Field where aquatic life is partially supported and issues exist with DO and phosphorus inputs (SCDHEC 2015).

The Little River to Winyah Bay portion of the AIWW flows through this watershed and is tidally influenced from both ends. Due partly to limited flushing because of the tidal influences, and partly to a significant marsh drainage, DO and pH excursions are common here. Aquatic life and recreational uses are fully supported throughout this section of the watershed (SCDHEC 2015).

Despite aquatic life and recreational uses being supported throughout much of the watershed, a fish consumption advisory has been issued by SCDHEC for mercury in the Waccamaw River and AIWW.

- **Great Pee Dee River-Winyah Bay (west of Bucksport)**

This watershed originates west of the Bucksport flood impact area and is the final segment of the Great Pee Dee River from the Lynches River through Winyah Bay and their tributaries. The areal extent of this watershed is 223,613 acres and is about half forested wetland and forested land and about 1/7th agriculture and urban development. This low section of the Great Pee Dee River accepts drainage from its upper reaches consisting of innumerous lakes, swamps, creeks, and bays. All streams are classified as FW up until Thoroughfare Creek. Downstream of there, DO is below standard. The watershed contains 352 stream miles, 630 acres of lake waters, and 16,642 acres of estuarine areas.

Along the upper portions of the Great Pee Dee River near the City of Georgetown, aquatic life and recreational uses are fully supported, though increasing fecal coliform bacteria trends have been noted. Downstream portions of the river are largely supportive of aquatic life and recreation with some excursion in DO. Conditions in Winyah Bay are very similar (SCDHEC 2015).

Like in waters of the central study area, this watershed also has a fish consumption advisory for mercury.

- **Outlet Waccamaw River-Atlantic Intracoastal Waterway (south of Bucksport and Socastee)**

This watershed sits between Georgetown and Horry Counties and is part of the Waccamaw River that accepts drainage from the areas of Bucksport and Socastee. This watershed is of 55,599 acres in size and is composed of about half forested wetland and forested land, a fifth urban land, an eighth marsh, and a tenth or less of open water and agricultural land. This is the lowest section of the Waccamaw River, accepting drainage from all its upstream portions and surrounding creeks and swamps. The watershed spans about 117 stream miles, 582 acres of lake waters, and 3,494 acres of estuarine areas.

All of the watershed from the upstream portion to Thoroughfare Creek is considered FW while downstream portions that of a higher pH. Recreational uses and aquatic life are fully supported throughout the watershed though there are some variations in pH, turbidity, and oxygen demand in lower reaches (SCDHEC 2015).

A total maximum daily load for oxygen-demanding substances exists in this watershed to address issues measured at monitoring stations on the State's 1998 303(d) list of impaired waters (SCDHEC 2015).

- **Wetlands**

Wetlands are typically areas with frequent and prolonged standing water at or near the soil surface. Their presence drives the natural system including the types of soils (i.e., hydric soils) that form, the plants that grow and the fish and wildlife that use the habitat.

According to data obtained from the National Wetland Inventory (NWI), of the approximately 221,041 acres of area within the study area, about 116,576 acres (52.7%) are identified as a wetland. Of this, only about 0.01% is considered estuarine while the remainder is freshwater. The most common class of wetland in the study area is forested, composing 70% of wetland areas, followed by riverine (18.1%), scrub shrub (7.3%), freshwater ponds (2.2%), freshwater emergents (2.0%) and <1% lakes and estuarine emergents. Nevertheless, there are over two-hundred variations of wetland types in the study area that vary based on the origin of the water, physical features, plant types, water regimes, special modifiers (e.g., drained or ditched), water chemistry, and soil types.

There are 85,912 acres of the study area (40.4%) in the 500-year floodplain. The frequency of inundation in the study area contributes to the formation of hydric soils. This is further supported by NRCS Soil Survey mapping that indicates that most soils (57.6%) in the area are 90 to 100% hydric. Only about 31% of hydric soils are found outside of the 500-year floodplain.

2.6.1.2.1.1 Forested

Forested wetlands are defined by the Federal Geographic Data Committee (FGDC) (2013) as wetlands where trees (woody plants at least 20 ft in height) are the dominant life form and occupy at least 30% of land cover. This wetland class normally possesses an overstory of trees, an understory of young trees or shrubs, and an herbaceous layer. Forested wetlands in palustrine systems include cedar swamps and bottomland hardwoods.

In the study area, wetlands consist mostly of the broad-leaved deciduous subclass of forested wetlands (72% of all wetlands). Common dominant tree species include red maple (*Acer rubrum*), American elm (*Ulmus americana*), ashes (*Fraxinus pennsylvanica* and *F. nigra*), black gum (*Nyssa sylvatica*), tupelo gum (*N. aquatica*), swamp white oak (*Quercus bicolor*), overcup oak (*Q. lyrata*), and swamp chestnut oak (*Q. michauxii*). Soils generally consist of mineral soils or highly decomposed organic soils.

Needle-leaved evergreen wetlands are also common in the study area, making up 16% of all wetlands. Common dominant trees include Atlantic white cedar (C*hamaecyparis thyoides*) in organic soils and pond pine (*Pinus serotina*) among broad-leaved evergreens and deciduous shrubs.

2.6.1.2.1.2 Riverine

Riverine systems are defined as all wetlands and deepwater habitats contained within a channel with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergents, emergent mosses, or lichens, and (2) habitats with water containing ocean-derived salts of 0.5 parts per trillion (ppt) or greater. Most of the riverine system with the study area is unconsolidated bottom (>25% cover of particles smaller than stones and a vegetative cover <30%).

Unconsolidated bottom riverine wetlands are characterized by a lack of large stable surfaces for plant and animal attachment. These areas are unstable and have variable wave and current action, temperature, salinity, and light penetration conditions. These conditions affect the composition and distribution of organisms found in this wetland type.

In more coarse substrates, macroalgae may attach to surfaces, while in sands and muds, algae can establish below the substrate. Plants may also root where wave action and currents are not too strong. Most animals found in unconsolidated sediments of riverine systems live within the substrate, though more coarse variations may have animals which live on the surface as well.

In the riverine system, the substrate type is largely determined by current velocity, and plants and animals exhibit a high degree of morphologic and behavioral adaptation to flowing water. Certain species are confined to specific substrates, and some are at least more abundant in one type of substrate than in others. Substrates may include cobble-gravel, sand, mud and organic.

2.6.1.2.1.3 Scrub-shrub

Scrub-shrub wetlands are defined by FGDC (2013) as wetlands where woody plants <20 ft in height are the dominant life form and occupy at least 30% of land cover. This wetland class includes true shrubs (young specimens of tree species) and woody plants that are stunted. Shrub wetlands are broadly referred to as shrub swamp, shrub carr, bog, fen, and pocosin.

Among scrub shrub wetlands, the broad-leaved deciduous subclass is most common in the study area (5.1% of all wetlands). Common dominant plant species consist of alders (*Alnus* spp.), willows (*Salix* spp.), buttonbush (*Cephalanthus occidentalis*), red osier dogwood (*Cornus stolonifera*), honeycup (*Zenobia pulverulenta*), Douglas' meadowsweet (*Spiraea douglasii*), bog birch (*Betula pumila*), and young red maple (*Acer rubrum*). Needle-leaved evergreen scrub-shrub wetlands also occur in the study area (3.1% of all wetlands), and often include young or stunted tamarack (*Larix laricina*) and southern bald-cypress (*Taxodium distichum*).

2.6.1.3 Groundwater

Horry County is located within the Waccamaw Capacity Use Area (WCUA), an area where groundwater use is regulated under a groundwater management plan. The WCUA is one of six state-designated Capacity Use Areas in South Carolina and includes all of Georgetown County and Horry County. The WCUA was established in 1979. In areas designated as capacity use, groundwater withdrawals of 3 million gallons or more per month require a Groundwater Withdrawal Permit from SCDES. As of 2019, there were 39 active permits in the WCUA with 29 of these in Horry County.

The Waccamaw area is part of the Lower Coastal Plain physiographic province of South Carolina and has both groundwater and surface water sources. The stratigraphy is marked by alternating layers of aquifers and confining units. Aquifers in this area are typically comprised of crystalline carbonate rocks or water-bearing permeable sand with the confining layers comprised of silts, clays, and low-permeability carbonate rock.

Aquifers in the Waccamaw area were deposited during the Cretaceous to Tertiary periods. The Cretaceous aquifers include Crouch Branch (youngest) McQueen Branch, Charleston and the Gramling (oldest). Aquifers of the Tertiary period include Surficial, Floridian, and the Gordon. The Surficial is the only aquifer that receives direct recharge through infiltration of local precipitation while the deeper aquifers depend on infiltration from the Upper Coastal Plain. SCDNR maintains seven groundwater monitoring wells in the aquifers serving the WCUA: one well in the Surficial aquifer in Georgetown County, five wells in the Crouch Branch aquifer in Horry County, and one well in the McQueen Branch aquifer in Georgetown County. Data from these wells indicate the Crouch Branch water levels have been steadily declining over the past 50 years while the McQueen Branch water levels have increased approximately 10 feet since 1999. The Surficial aquifer is recharged through precipitation, so water levels fluctuate based on storm events and seasonal evapotranspiration.

Currently, there are 223 permitted Capacity Use wells permitted in the WCUA. Approximately 173 of these wells are in Horry County and are utilized for golf courses (78), industrial (3), agricultural irrigation (13), water supply (63) and other (16). The highest demand is for water supply at 2,386 million gallons (MG), or 78% of the total water use in Horry County for 2017 (SCDHEC 2019). Water supply needs are likely to increase with additional development; however, these needs would be managed under the WCUA.

2.6.1.4 Water Quality

Section 305(b) of the CWA requires states to assess the water quality of the waters of the state (both surface and groundwater) and prepare a comprehensive report documenting the water quality, which is submitted to the EPA every 2 years. In addition, Section 303(d) of the CWA requires states to prepare a list of impaired waters on which Total Maximum Daily Loads (TMDL) or other corrective actions must be implemented. SCDES is the state agency responsible for enforcing water quality standards and preparing the comprehensive report for submittal to EPA.

- **Surface Water**

In general, water quality depends on local point source discharges (e.g., wastewater facilities, industry, municipal storm sewer and wastewater systems, construction sites), non-point source runoff, and natural conditions. In Horry County, the majority of water quality issues stem from non-point sources with rain runoff transporting sediments, pesticides, and fertilizers from farms and lawns; motor oil and grease deposited on roads and parking lots; or bacteria containing waste from agricultural animal facilities, wildlife, domestic pet waste, malfunctioning septic systems or sanitary sewer system overflows (Horry County 2019). Much of the surface waters in the Waccamaw River and its tributaries have low dissolved oxygen levels and low pH. As of 2022, 23 waterways in the study area were listed on the CWA Section 303(d) list of impaired waters. Most of these waterways are listed as impaired based on high levels of mercury and are at monitoring stations located along the Waccamaw River and the small segment of the Pee Dee River which overlaps with the study area. Impairments from other water quality concerns include high levels of *E. coli* bacteria along Highway 905 monitoring locations. One of these monitoring locations is at the intersection of Simpson Creek and Highway 905, where a relief bridge (cross drain) is being considered as part of this study. Upstream of the Waccamaw River in Conway along tributaries of Kingston Lake such as Crabtree Swamp, impaired waters are affected by low dissolved oxygen and issues with *E. coli*. Lastly, downstream of Socastee Creek on the AIWW, water is impaired from acidic conditions and low dissolved oxygen.

Powerful hurricanes can lead to declines in water quality when extreme flooding occurs. For instance, Hurricane Joaquin in 2015 and Hurricane Matthew in 2016 contributed to three times higher mobilization of dissolved organic carbon and dissolved organic nitrogen (Majidzadeh et al. 2017). This issue is often compounded with the tendency for mercury to bind with organic matter (Ravichandran 2004), which is known to be present in the Waccamaw watershed as atmospherically deposited inorganic mercury and highly toxic methylmercury produced under reducing conditions in the Coastal Plain wetlands (Guentzel 2009).

- **Groundwater**

The Grand Strand Water and Sewer Authority (GSWSA) is the major supplier of water for Horry County and has two surface water treatment facilities. Most of Horry County is supplied by the Bull Creek Treatment Plant, supplemented by storage and recovery wells located throughout service areas. Untreated surface water is pulled from the Bull Creek which carries about 60% of the water flowing through the Great Pee Dee and Little Pee Dee Rivers. GSWSA has 8 groundwater wells withdrawing 6.7 million gallons per day. This native ground water is blended with treated surface water at major entry points to the distribution system. As water travels over the surface of the land or through the ground, it dissolves naturally occurring minerals and, in some cases, radioactive material, and can pick up substances resulting from the presence of animals or from human activity. Contaminants of concern which may occur in groundwater may include those resulting from a combination of contributing sources including sewage treatment plants, septic systems, agricultural livestock operations, wildlife, storm water runoff, industrial discharges, and more.

2.6.1.5 Floodplains

Approximately 24% of Horry County's total land area lies within the Federal Emergency Management Agency (FEMA) 100-year floodplain and is vulnerable to flooding (Horry County 2019). The flood zone is primarily situated along the major rivers of the county, with the Waccamaw River and Pee Dee River being significant to the study area (see Figure 5). Within the study area, about 36% of land falls within the FEMA 100-yr flood zone.

Figure 5: Study Area Floodplain Map

2.6.2 FWOP Conditions

2.6.2.1 Hydrology and Surface Water

Hydrology and surface waters of the study area under FWOP conditions will be affected by continued development as hardened structures and the filling of wetlands inevitably reduce natural storage capacities and influence the rate at which water moves through the watershed. Horry County has outlined several strategies for managing key issues associated with these changes as they pertain to flooding. Among these are the establishment of riparian and wetland buffers to preserve the landscape's natural flood storage capacity and minimize flood risks; better management and maintenance of ditches and stormwater management system; preservation of mature tree canopy stands through incentives and development requirements to promote flood storage and slow runoff; and establishment of resilient subdivision design standards to preserve open space for habitat, recreation, and flood attenuation. Implementation of these plans will provide means to counter changes to the watershed from anticipated development and to improve conditions which were already impacted.

In addition to the strategies for offsetting future changes in the county, strategies to re-use and re-purpose existing developed land are also being pursued and may provide some means for conserving or restoring existing and historical hydrological conditions. This would involve continued collaborations with private organizations like The Nature Conservancy and public agencies which manage existing conservation areas like USFWS and SCDNR to continue to identify and implement restoration projects that will protect and improve management of lower order streams connected to the Waccamaw River.

2.6.2.2 Groundwater

Challenges in managing groundwater will persist into the FWOP conditions. Groundwater use from the turn of the 21st century in the Waccamaw Area has fluctuated but has steadily increased since 2007 (Kemmer et al. 2023). This has been associated with period of drought which occurred half a dozen times between about 2002 and 2021. Since 2011, groundwater withdrawals for irrigation and water supply have remained constant or increased slightly while populations have continued to grow in Horry County. Some areas have observed declines in water levels, saltwater intrusion, and occurrences of dry wells, particularly in the Crouch Branch and Middendorf aquifers which are continuing to decline. Lowering of subsurface water pressure along the coast in conjunction with a growing population and continued use of groundwater resources can reduce freshwater flow toward coastal discharges and cause saltwater infiltration. Because of this, SCDES is encouraging the use of surface water as a source for future water demands and to discontinue use of wells which cross multiple aquifers. As discussed previously, more periods of heavy rainfall and longer dry periods are expected to increase alongside expected population growths in the study area into the FWOP conditions. These conditions are likely to create increased pressures on groundwater management as climate changes and increased impervious surfaces associated with expected development would increase rates at which surface runoff occur, thus impacting surface water resources and the rates of groundwater recharge. In addition, as discussed previously, continued depletion of groundwater aquifers has been linked to observed subsidence of surface level elevation, which may also contribute to increased need for effective flood risk management in the future.

2.6.2.3 Water Quality

Water quality of surface water declines with increased impervious cover in a watershed, with covers of more than 10% having measurable impacts (Schueler 1992; Holland and Sanger 2008). Given previously mentioned trends in increasing impervious surfaces which are expected to continue into the FWOP (see 2.2.2 above), it is expected that contributions to impacted surface water quality may increase as well. In addition, periods of drought and heavy rains also affect water quality conditions. For instance, with increased land use conversion for development and associated upstream withdrawals, and longer periods of dry days as is predicted (see 2.4.2.3 above), pollutants can become more concentrated on surfaces which can then be more impactful to water quality when heavy rain carries it into nearby waterways. Waterbodies which experience increasingly poor water quality conditions will be expected to be subject to development of a TMDL by SCDES as part of the regulatory framework of the CWA.

As described by Horry County (2019), future strategies to promote low impact development (LID) practices that use or mimic natural processes which promote infiltration, evapotranspiration and use of stormwater will be pursued from a local governing perspective. Examples of these practices include bioretention facilities, rain gardens, vegetated rooftops, rain barrels, and permeable pavements. Balancing water quality issues with improvements that would follow implementation of LID practices under the FWOP would depend greatly on economics and technological improvements of these strategies relative to traditional approaches and the willingness of private and public stakeholders to implement these practices. However, Horry County Stormwater has already updated its Stormwater Management Design Manual to include LID practices as well as improvements found in newer versions of the SCDES Municipal Separate Storm Sewer System (MS4) Permit and the Construction General Permit. It is anticipated these practices will be further innovated upon and help counter potential negative effects to water quality into the FWOP.

2.6.2.4 Floodplains

Conservation of land in the floodplain will remain a priority for Horry County moving towards FWOP conditions to limit the anticipated impacts of storms and heavy rainfall events to areas beyond the floodplain. This is because undeveloped forested land provides a way for slowing and absorbing the conveyance of floodwaters by providing a greater natural surface area with higher absorptive capacity. Working with local, state, and Federal partners to conserve, preserve and restore natural floodplain systems is a priority outlined by Horry County (2019) and will influence the floodplain under FWOP conditions. Thus, it is expected that floodplains in the study area will not notably change from existing conditions.

2.7 Biological Resources

Biological resources include plants, animals, and their habitats. Biological resources are important because they: (1) influence ecosystem functions and values; (2) have intrinsic value and contribute to the human environment; and (3) are subject to various laws and regulations that may affect project implementation.

2.7.1 Existing Conditions

The Waccamaw River and its floodplain ecosystem is very valuable due to its rich and diverse natural resources. Despite numerous projects constructed, the area still retains much of its original environmental characteristics and is among the richest freshwater wetland systems in North America. The Waccamaw River watershed extensive bottomland hardwoods provide habitat for hundreds of species of birds, mammals, reptiles and amphibians among other wildlife. It is also important wintering area for waterfowl. The Waccamaw River and adjacent floodplain aquatic habitats also provide for many species of fish, freshwater mussels and federally listed species.

2.7.1.1 Aquatic Habitat

Aquatic habitats in or downstream of the study area include the main stem of the Waccamaw River and its tributaries (including swamps, bays, creeks, lakes, etc.), adjacent waterbodies in the floodplain (e.g., swamps, ponds, impoundments), a small portion of the Great Pee Dee River and Bull Creek, the AIWW and Socastee Creek, and the confluence of rivers leading into Winyah Bay. These permanent and seasonal habitats available to wildlife in or downstream of the study area encompass a variety of riverine, estuarine, and floodplain habitat types including main channels, side channels, tributaries (i.e. creeks, bays, swamps), and inundated floodplains (i.e., bottomland hardwood forest), and abandoned channel segments (i.e., oxbow lakes) with varying degrees of connectivity to the main channel. Aspects of the aquatic habitats in the study area, including common plant species and habitat structure, have partly been described in the above section on wetlands (see Section 2.6.1.3)

2.7.1.2 Macroinvertebrates

Several insects, molluscs, and crustaceans within the Waccamaw River watershed are species of conservation need. Among the insects, the American bumble bee (*Bombus pensylvanicus*) is federally listed as an at-risk species and the monarch butterfly (*Danaus plexippus*) is a candidate for listing under the Endangered Species Act (ESA) under USFWS jurisdiction and is considered highest priority on the SCDNR State Wildlife Action Plan (SWAP). Bumble bees are often found in agricultural areas and open herbaceous environments which may be more common in upland portions of the study area. However, the monarch butterfly in the Coastal Plain is known for using inland swampy areas for breeding in spring, summer and fall seasons where aquatic milkweed may be abundant (Kendrick and McCord 2023).

Throughout the Waccamaw River NWR, several molluscs species are known to inhabit open waters, including several freshwater mussels ranging from moderate to highest SWAP priority as identified by SCDNR. These include Eastern elliptio (*Elliptio complanata*), Carolina slabshell (*E. congaraea*), pod lance (*E. folliculata*), Atlantic spike (*E. producta*), yellow lampmussel (*Lampsilis cariosa*), rayed pink fatmucket (*L. splendida*), Savannah lilliput (*Toxolasma pullus*), and Eastern creekshell (*Villosa* *delumbis*). Among the broader study area, SCDNR (2023) has also documented mussels like the Eastern pondhorn (*Uniomerus carolinanus*) and variable spike (*Elliptio icterina*) and freshwater snails including ridged lioplax (*Lioplax subcarinata*). Mussels vary considerably between species in habitat types which are occupied but can generally be found inhabiting a range of conditions including temporary bodies of water such as sloughs and oxbow lakes, streams which may experience durations of dry conditions, and impoundments; however, many are adapted to free-flowing rivers and streams and may be unable to survive in stagnant waters. Mussels are generally impacted by habitat degradation through sedimentation and runoff contaminants in waterways and through significant alterations of local hydrology (Bogan et al. 2008)

Among the crustaceans, numerous crayfish are of moderate to high SWAP priority by SCDNR. These include coastal plain crayfish (*Procambarus ancylus*), Santee crayfish (*P. blandingii*), Waccamaw crayfish (*P. braswelli*), cedar creek crayfish (*P. chacei*), and Carolina sandhills crayfish (*P. pearsei*). Among the broader study area, SCDNR (2023) has also documented the digger crayfish (*Creaserinus fodiens*). Species like the Waccamaw crayfish tend to inhabit clear, sand-bottomed streams which flow through swampy areas (NCWRC 2024).

Further downstream near Winyah Bay, the Chesapeake blue crab (*Callinectes sapidus*) is a common crustacean in the estuary (SCDNR 2023). From the mouth of Winyah Bay at the Atlantic Ocean to just north of Butler Island in the Waccamaw River is designated by NOAA Fisheries as Essential Fish Habitat (EFH) Habitat of Particular Concern (HAPC) for penaeid shrimp.

2.7.1.3 Fish

Both the Waccamaw River and Great Pee Dee River provide nursery areas for freshwater and estuarine species of fish, such as red drum (*Sciaenops ocellatus*), tarpon (*Megalops* spp.), striped mullet (*Mugil cephalus*), and flounder. The rivers provide corridors for a multitude of related habitat types in oxbows, creeks, and small tributary streams throughout the floodplains and forested wetlands. These conditions support populations of shad (*Alosa sapidissima*) and catfish species which provide recreation and economical resources to local communities (USFWS 2008). Around 70 species of fish are known to occur within the boundaries of Waccamaw River NWR, including freshwater, anadromous, catadromous, estuarine-dependent, and marine fish (USFWS 2008). Among these, 23 species are listed on the SCDNR SWAP as species of greatest conservation need. Anadromous fish include the striped bass (*Morone saxatilis*), American shad, hickory shad (*Alosa mediocris*), blueback herring (*A. aestivalis*); catadromous fish species include the American eel (*Anguilla rostrata*); and freshwater fish include largemouth bass (*Micropterus salmoides*), redbreast sunfish (*Lepomis auritus*), bluegill (*L. macrochirus*), redear sunfish (*L. microlophus*), warmouth (*L. gulosus*), pumpkinseed (*L. gibbosus*), black crappie (*Pomoxis nigromaculatus*), chain pickerel (*Esox niger*), redfin pickerel (*E. americanus*), bowfin (*Amia calva*), and numerous species of native catfish. Among the broader study area, SCDNR (2023) has also documented the banded killfish (*Fundulus diaphanus*), banded sunfish

(*Enneacanthus obesus*), Carolina pygmy sunfish (*Elassoma boehlkei*), fieryblack shiner (*Cyprinella pyrrhomelas*), flat bullhead (*Ameiurus platycephalus*), sawcheek darter (*Etheostoma serrifer*), snail bullhead (*Ameiurus brunneus*), swampfish (*Chologaster cornuta*) and white catfish (*Ameiurus catus*). Further downstream, sampling sites in the estuarine portions of the lower Waccamaw River have found common nekton to include Atlantic croaker (*Micropogonias undulatus*), star drum (*Stellifer lanceolatus*), longnose gar (*Lepisosteus osseus*), American silver perch (*Bairdiella chrysoura*) and Atlantic menhaden (*Brevoortia tyrannus*) (SCDNR 2023).

From downstream of the study area, coastal, estuarine, and riverine waters that include all of Winyah Bay, to the Waccamaw River at a junction with the AIWW is designated as EFH for snapper grouper and spiny lobster. In waters downstream of the study area, cartilaginous fishes, such as sandbar sharks (*Carcharhinus plumbeus*), finetooth sharks (*C. isodon*), blacktip sharks (*C. limbatus*), spinner sharks (*C. brevipinna*), bull sharks (*C. leucas*), lemon sharks (*Negaprion brevirostris*) and Atlantic sharpnose sharks (*Rhizoprionodon terraenovae*) can be found in middle and lower portions of the Winyah Bay (Collatos et al. 2020). Winyah Bay to Georgetown is designated as EFH for neonate, juvenile and adult sand tiger sharks (*Carcharias taurus*); neonate spinner and blacktip sharks; and juvenile sandbar sharks. Winyah Bay through the Waccamaw River up to Bull Creek is designated EFH for juvenile and adult tiger and blacktip sharks. Many species of shark in the bay become increasingly limited as salinity levels decline in the middle portions of the bay (around 25 ppt: Collatos et al. 2020), particularly during low tides (around 15 ppt: Collatos et al. 2020). Nevertheless, the bay may serve as secondary nursery grounds (Collatos et al. 2020) where juveniles mature and contribute to population growth, such as in species recovering from overfishing (SEDAR 2011).

2.7.1.4 Essential Fish Habitat

The 1996 Congressional amendments to the Magnuson-Stevens Fishery Conservation and Management Act (MSA) (PL 94-265) set forth requirements for the National Marine Fisheries Service (NMFS), regional fishery management councils (FMC), and other Federal agencies to identify and protect important marine and anadromous fish habitat. These amendments established procedures for the identification of EFH and a requirement for interagency coordination to further the conservation of federally managed fisheries.

EFH is defined in the MSA as "…*those waters and substrate necessary to fish for spawning, breeding, feeding, or growth to maturity*" (16 U.S.C. § 1802(10)). The definition for EFH may include habitat for an individual species or an assemblage of species, whichever is appropriate within each Fisheries Management Plan (FMP). Designated EFH for the project area may include aquatic beds, estuarine emergent wetlands, estuarine water column, intertidal flats, oyster reefs and shell banks, palustrine emergent and forested wetlands, or submerged aquatic vegetation. Federally managed species known to occur within the project area are provided in Table 5 below. The project area may include HAPC for summer flounder.

Table 5: Federally managed species for the South Atlantic that may occur within the project area.

Common Name	Species Name	Jurisdiction[1]	FMP[1]
Blacktip Shark	*Carcharhinus limbatus*	NMFS	HMS
Bluefish	*Pomatomus saltatrix*	MAFMC	Bluefish
Slipper Lobster	*Scyllaridae*	SAFMC	Spiny Lobster
Snapper Grouper	*Serranidae*	SAFMC	Snapper Grouper
Spiny Lobster	*Palinuridae*	SAFMC	Spiny Lobster
Summer Flounder	*Paralichthys dentatus*	MAFMC	Summer Flounder
Tiger Shark	*Galeocerdo cuvier*	NMFS	HMS
[1]Definitions for acronyms used include: SAFMC = South Atlantic Fishery Management Council, MAFMC = Mid-Atlantic Fishery Management Council, and FMP = Fishery Management Plan			

2.7.1.5 Marine Mammals

While bottlenose dolphins (*Tursiops truncatus*) can be found in nearshore coastal waters and estuaries of the Atlantic Coast from New York to Florida, bottlenose dolphins have been documented in numbers in Winyah Bay (Brusa 2012, Silva et al. 2019). Anecdotes in media stories have also provided some evidence of bottlenose dolphins in the Waccamaw River as far upstream as Conway, but often these stories involve rescue or mortality that follow these sightings. These individuals of the Northern South Carolina Estuarine System Stock (NSCESS) are described as dolphins that inhabit estuarine and coastal waters within 1 km of the shoreline form Murrells Inlet to Price Inlet (NOAA 2022). West Indian manatee have also been sighted over the past five to eight years between Winyah Bay and the Waccamaw River up to about Conway (J. Lemeris, SCDNR, email comm. 2023), as well as throughout the AIWW. Information on manatees is described further in Section 2.7.1.5 below.

- **Marine Mammal Protection Act**

Bottlenose dolphins and other marine mammals that may occur in the study area are afforded protection under the Marine Mammal Protection Act (MMPA) (16 U.S.C. § 1361). The MMPA is designed to protect marine mammal species and their habitats in U.S. waters by prohibiting the taking—such as hunting or harassment—of these animals, with specific exceptions for scientific research and public display. The Act's regulations, found in 50 CFR Part 216, ensure that incidental takes during activities like commercial fishing and military exercises are minimized and mitigated. Additionally, the MMPA requires the development of conservation plans and periodic assessments to monitor and maintain the health and stability of marine mammal populations and their ecosystems.

2.7.1.6 Terrestrial Habitat

Most of the study area consists of waterways, aquatic habitat and wetlands which have been described in previous sections. However, intermediate habitats and upland habitats also occur in the study area and broadly include two categories which may be described as (1) evergreen forested and shrub wetlands and (2) upland forests.

Evergreen forested and shrub wetlands rarely experience inundation from flooding but periodically retain soil moisture at the surface. This habitat is often at high elevations in the floodplain and results from poorly drained soils or pockets in surface topography.

Common species include loblolly pine (*Pinus taeda*), spruce pine (*Pinus glabra*), live oak (*Quercus virginiana*), and American holly (*Ilex opaca*). Beyond the floodplain, habitats matching this definition may include bay swamps, pine savannahs, or wet pine flatwoods and are dominated by pond pine, loblolly bay (*Gordonia lasianthus*), sweet bay (*Laurus nobilis*), red bay (*Persea borbonia*), titi (*Cyrilla racemiflora*), fetter-bush (*Lyonia lucida*), wax myrtle (*Myrica cerifera*), honeycup, and sweet gallberry (*Ilex coriacea*).

Upland forests include any area that does not meet the definition of wetland or deepwater habitat. Upland plant communities are highly diverse and include maritime sandhill community, longleaf pine savannahs, and flatwoods with intermittent inclusions of small evergreen and deciduous depressions, pocosins, freshwater depression meadows, broad-leafed deciduous swamps, and pond pine woodlands.

2.7.1.7 Birds

Most North American birds are protected under the Migratory Bird Treaty Act, which prohibits activities that result in taking of migratory birds unless authorized by USFWS. USFWS most recently published the Birds of Conservation Concern (BCC) in 2021 (USFWS 2021b) that identifies migratory and non-migratory bird species, beyond those already protected under ESA, with the highest conservation priorities. Bird species considered for listing as BCC include nongame birds, gamebirds without hunting seasons, ESA candidates, proposed endangered or threatened species, and recently delisted species. The study area is in the Southeast Coastal Plain Region 27.

Across the study area, at least 12 eBird hotspots are registered and serve as survey points which may be considered representative of the broader study area. There are eight hotspots in Conway, two in Bucksport, and two in Socastee. As of October 2023, 264 species of bird have been documented in the study area within the Waccamaw River NWR, approximately 200 species of bird had been known to occur as of 2008 (USFWS 2008), of which 100 or more are listed in the SCDNR 2015 State Wildlife Action Plan (SWAP) as Species of Greatest Conservation Need (SGCN) (SCNDR 2014). As of 2023, up to 225 bird species have been observed in the NWR (eBird 2023). At various other hotspots and individual observation locations throughout the study area, several BCC have been identified. Out of the 39 BCC species listed in the Southeastern Coastal Plain, or Bird Conservation Region 27, 31 have been observed in the study area (Table 6). Some of these BCC species are ubiquitous in the study area, while others have only been recorded on very few occasions.

Table 6: Birds of Conservation Concern listed for Bird Conservation Region 27 as determined by USFWS (2021b).

Common Name	Scientific Name	Status[1]	Presence in Study Area[2]	Locality
Chuck-will's Widow	*Antrostomus carolinensis*	B	Y[3]	Throughout study area
Eastern Whip-poor-will	*Antrostomus vociferus*	B	Y[3]	Throughout study area
Chimney Swift	*Chaetura pelagica*	B	Y[3]	Throughout study area

King Rail	*Rallus elegans*	B	Y[3]	Lake Busbee, Waccamaw NWR
Yellow Rail	*Coturnicops noveboracensis*	NB	N	-
American Oystercatcher	*Haematopus palliatus*	B	Y[3]	Waccamaw NWR
Wilson's Plover	*Charadrius wilsonia*	B	Y[3]	Lake Busbee
Snowy Plover	*Charadrius nivosus*	B	N	-
Whimbrel	*Numenius phaeopus*	NB	Y[3]	Highway 501, Myrtle Beach Airport
Marbled Godwit	*Limosa fedoa*	NB	Rare[4]	-
Ruddy Turnstone	*Arenaria interpres*	NB	Y[3]	Myrtle Beach Airport
Dunlin	*Calidris alpina*	NB	Y[3]	Bucksport Sod Farm
Purple Sandpiper	*Calidris maritima*	NB	Rare[4]	-
Pectoral Sandpiper	*Calidris melanotos*	NB	Y[3]	Bucksport Sod Farm, Conway
Semipalmated Sandpiper	*Calidris pusilla*	NB	Y[3]	Lake Busbee, sewage plants (Conway)
Short-billed Dowitcher	*Limnodromus griseus*	NB	Y[3]	Cox Ferry (Waccamaw NWR)
Lesser Yellowlegs	*Tringa flavipes*	NB	Y[3]	Bucksport Sod Farm, Conway
Willet	*Tringa semipalmata*	B	Y[3]	Bucksport, Socastee, Conway
Least Tern	*Sternula antillarum*	B	Y[3]	Bucksport, Socastee, Conway
Gull-billed Tern	*Gelochelidon nilotica*	B	Rare[4]	-
Black Skimmer	*Rynchops niger*	B	Rare[4]	-
Swallow-tailed Kite	*Elanoides forficatus*	B	Y[3]	Throughout study area
Red-headed Woodpecker	*Melanerpes erythrocephalus*	B	Y[3]	Throughout study area
American Kestrel	*Falco sparverius*	B	Y[3]	Throughout study area
Brown-headed Nuthatch	*Sitta pusilla*	B	Y[3]	Throughout study area
Wood Thrush	*Hylocichla mustelina*	B	Y[3]	Throughout study area
Bachman's Sparrow	*Peucaea aestivalis*	B	Y[3]	Conway
Grasshopper Sparrow	*Ammodramus savannarum*	B	Y[3]	Conway
LeConte's Sparrow	*Ammodramus leconteii*	NB	N	-
Seaside Sparrow	*Ammodramus maritimus*	B	Y[5]	Waccamaw NWR
Saltmarsh Sparrow	*Ammodramus caudacutus*	NB	Y[5]	Waccamaw NWR
Henslow's Sparrow	*Ammodramus henslowii*	NB	Y[5]	Waccamaw NWR
Rusty Blackbird	*Euphagus carolinus*	NB	Y[3]	Throughout study area
Prothonotary Warbler	*Protonotaria citrea*	B	Y[3]	Throughout study area
Kentucky Warbler	*Geothlypis formosa*	B	Y[3]	Waccamaw NWR
Cerulean Warbler	*Setophaga cerulea*	B	Rare[4]	-
Prairie Warbler	*Setophaga discolor*	B	Y[3]	Throughout study area
Black-throated Green Warbler	*Setophaga virens*	B	Y[3]	Waccamaw NWR (Conway)

Painted Bunting	*Passerina ciris*	B	Y[3]	Throughout study area
[1]Status of either breeding (B) or non-breeding (NB) based on whether species utilize the study area for breeding purposes or not. **[2]Presence is either identified as documented as present (Y); rare, in isolated or remote areas, or poorly documented (Rare); or as being not documented in the study area (N)** **[3]Occurence information derived from eBird (2023)** **[4]Occurence data derived from USFWS (2023)** **[5]Occurence data derived from USFWS (2008)**				

Contiguous forested wetland ecosystems within the Waccamaw watershed serve as important habitat for transient neotropical migratory species, as well as feeding, foraging, and nesting habitat for other temperate migratory and resident species (USWFS 2008). Many SGCN require bottomland hardwood habitat, including colonial nesting birds (e.g. wood stork), raptors, woodpeckers, shorebirds, and passerine birds. Examples of bottomland hardwood birds of SGCN include barred owl (*Strix varia*), red-shouldered hawk (*Buteo lineatus*), wood duck (*Aix sponsa*), yellow-crowned night heron (*Nyctanassa violacea*), yellow-billed cuckoo (*Coccyzus americanus*), Acadian flycatcher (*Empidonax virescens*), prothonotary warbler, Swainson's warbler (*Limnothlypis swainsonii*) and Northern parula (*Setophaga americana*). Swallow-tailed kites have their highest nesting density in South Carolina (USFWS 2008) within the NWR and represents some of their northern-most nesting habitat (Carpenter and Allen 2013). Wood stork (*Mycteria americana*), a federally endangered species, have also had rookeries documented in the study area.

Also, within the NWR are southern pine forests, which are valued by vulnerable species like Northern bobwhite (*Colinus virginianus*), Bachman's sparrow, wintering Henslow's sparrow, southeastern American kestrel, brown-headed nuthatch and prairie warbler. The endangered red-cockaded woodpecker (*Leuconotopicus borealis*) is known to nest within the NWR in mature pine forest of Sandy Island.

Downstream of the study area are coastal wetlands near the Winyah Bay drainage area, which serve as wintering and staging areas for migratory waterfowl. The area also serves as wintering habitat for more ducks than any comparable habitat in South Carolina, and the river system provides a flight corridor for birds migrating between coastal wetlands. Forested floodplains also provide resting and feeding areas for waterfowl during stopovers. These include SGCN such as green-winged teal (*Anas carolinensis*), mallards (*Anas platyrhynchos*), and Northern pintails (*Anas acuta*). Wood ducks also nest and produce offspring year-round in the NWR. Also downstream of the study area are tidal marshes which serve as habitat for marsh and wading birds. These include many SGCN such as American bittern (*Botaurus lentiginosus*), pied-billed grebe (*Podilymbus podiceps*), American coot (*Fulica americana*), king rail, least bittern (*Ixobrychus exilis*), and purple gallinule (*Porphyrio martinicus*). Nearby, shorebird habitats along the coastal plain may provide for more SGCN such as greater yellowlegs (*Tringa melanoleuca*) and lesser yellowlegs, spotted sandpiper (*Actitis macularius*), and American woodcock (*Scolopax minor*).

- **Bald and Golden Eagle Protection Act**

The Bald and Golden Eagle Protection Act (BGEPA) (16 U.S.C. § 668-668d**)** protects bald eagles and golden eagles by prohibiting the taking, possession, sale, or transport of these birds, their parts, nests (including those previously used), or eggs without authorization. "Taking" under the act is broadly defined to include actions such as killing, capturing, disturbing, or molesting the eagles, as well as activities that interfere with their normal breeding, feeding, or sheltering behavior. This includes significant habitat alteration that could disrupt an eagle's access to vital resources or its use of a nest site.

According to eBird (2023), bald eagles are observed throughout the study area with most in urban areas near the Conway and Socastee areas. According to data from the South Carolina Natural Heritage Trust, there are at least five known breeding locations for bald eagles in the study area with one in the Longs/Red Bluff flood impact area, three in the Conway flood impact area, and one in the Bucksport flood impact area.

2.7.1.8 Mammals

Within the Waccamaw River NWR, bottomland hardwood forests provide habitat for about 40 species of mammals (USFWS 2008). This includes black bear (*Ursus americanus*), bats, white-tailed deer (*Odocoileus virginianus*), bobcat (*Lynx rufus*), raccoon (*Procyon lotor*), beaver (*Castor canadensis*), mink (*Neovison vison*), river otter (*Lontra canadensis*), marsh rabbit (*Sylvilagus palustris*), and gray squirrels (*Sciurus carolinensis*). Among these, SGCN include 8 species of bat, mink, Eastern woodrat (*Neotoma floridana*), meadow vole (*Microtus pennsylvanicus*), and black bear.

2.7.1.9 Reptiles and Amphibians

Within the Waccamaw River basin, over 100 species of amphibians and reptiles are likely to occur (USFWS 2008). Documented within the Waccamaw River NWR, aquatic salamanders include the greater siren (*Siren lacertina*), Eastern lesser siren (*Siren intermedia intermedia*), two-toed amphiuma (*Amphiuma means*), dwarf water dog (*Necturus punctatus*), and broken-striped newt (*Notophthalmus viridescens* ssp. *dorsalis*). Common terrestrial salamanders within the NWR are the marbled salamander (*Ambystoma opacum*) and South Carolina slimy salamander (*Plethodon variolatus*). Among frogs, the most encountered are the bull frog (*Rana catesbeiana*), Southern leopard frog (*Rana utricularia*), and green tree frog (*Hyla cinerea*). Among snakes, the most widespread species are the brown water snake (*Natrix taxispilota*) and Eastern cottonmouth (*Agkistrodon piscivorus piscivorus*). Lastly, among turtles, the most common are the Florida cooter (*Chrysemys floridana*) and yellowbelly sliders (*Trachemys scripta scripta*). Over 20 SGCN may occupy varied habitats in the NWR including American alligator (*Alligator mississippiensis*), common snapping turtle (*Chelydra serpentina serpentina*), Carolina diamondback terrapin (*Malaclemys terrapin centrata*), southern hognose snake (*Heterodon simus*), flatwoods salamander (*Ambystoma cingulatum*), and pickerel frog (*Rana palustris*) among others.

2.7.1.10 Threatened and Endangered Species

The ESA of 1973, as amended (16 USC § 1531), provides for the conservation of species that are endangered or threatened throughout all or a significant portion of their range and the conservation of habitats upon which they depend. The law also prohibits any action that causes a "*taking*" of any listed species of endangered fish or wildlife unless otherwise authorized by USFWS or NOAA. The term "*take*" per the ESA means to "*harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct*." Section 7 of the ESA requires that Federal agencies consult with USFWS and NOAA to ensure that their actions do not jeopardize the existence of any listed species. The ESA also designates "*critical habitat*" (per 50 CFR parts 17 or 226) and defines those habitats that are essential for the conservation of a federally threatened or endangered species, and that may require special management and protection.

There are a variety of habitat types in the study area that ESA species (Table 7) may rely on, including but not limited to: open water (including freshwater and estuarine), freshwater marsh, managed wetlands, deciduous forested and shrub wetlands of varied flooding regimes, evergreen forested and shrub wetlands, and upland forest.

Table 7: Federally listed threatened and endangered species under jurisdiction of the Services in the study area.

Common Name	Scientific Name	Status[1]	Presence in Study Area[2]	Jurisdiction
Atlantic sturgeon	*Acipenser oxyrinchus*	E, CH	Y	NMFS
Shortnose sturgeon	*Acipenser brevirostrum*	E	Y	NMFS
Wood stork	*Mycteria americana*	T	Y	USFWS
Eastern black rail	*Laterallus jamaicensis jamaicensis*	T	U	USFWS
Red-cockaded woodpecker	*Picoides borealis*	E	Y	USFWS
Piping plover	*Charadrius melodus*	T	N	USFWS
Red knot	*Calidris canutus rufa*	T	R	USFWS
Northern long-eared bat	*Myotis septentrionalis*	E	U	USFWS
Tricolored bat	*Perimyotis subflavus*	PE	U	USFWS
West Indian manatee	*Trichechus manatus*	E	Y	USFWS
Green sea turtle	*Chelonia mydas*	T	N	USFWS/NMFS
Kemp's ridley sea turtle	*Lepidochelys kempii*	E	N	USFWS/NMFS
Leatherback sea turtle	*Dermochelys coriacea*	E	N	USFWS/NMFS
Loggerhead sea turtle	*Caretta caretta*	T	N	USFWS/NMFS
American Alligator	*Alligator mississippiensis*	SAT	Y	USFWS
Magnificent Ramshorn	*Planorbella magnifica*	E	N	USFWS
Monarch butterfly	*Danaus plexippus*	C	Y	USFWS
American chaffseed	*Schwalbea americana*	E	U	USFWS
Pondberry	*Lindera melissifolia*	E	U	USFWS
Cooley's Meadowrue	*Thalictrum cooleyi*	E	N	USFWS
Rough-leaved Loosestrife	*Lysimachia asperulaefolia*	E	N	USFWS

Canby's dropwort	*Oxypolis canbyi*	E	U	USFWS
[1]Status designations are abbreviated as follows: E - Endangered PE - Proposed Endangered T - Threatened C - Candidate CH - Critical Habitat, SAT – Similarity of Appearance (Threatened) [2]Presence indicators are abbreviated as follows: documented in study area (Y), presence possible, but not well documented in study area (U), presence is rare (R), no presence documented in study area (N)				

2.7.1.11 Fish

Two federally protected fish species commonly occur in the Winyah Bay and up the Great Pee Dee and Waccamaw Rivers. As noted in Table 7, they include the shortnose sturgeon (*Acipenser brevirostrum*) and the Atlantic sturgeon (*Acipenser oxyrhynchus*). Shortnose sturgeon spend most of their time as adults in fresh and brackish water but do venture into lower coastal reaches and the ocean on rare occasions. Atlantic sturgeon is a subtropical, anadromous species that typically migrates up rivers in the spring and fall in this region to spawn. Both are bottom feeders. Historically, overfishing affected sturgeon populations. Current prominent threats to these species include habitat loss or fragmentation, dredging, migration/passage barriers, decreased water quality, and entanglement in fishing gear, as well as vessel strikes for Atlantic sturgeon. Shortnose sturgeons are currently found in downstream portions of the Waccamaw River, and the Carolina Distinct Population of Atlantic sturgeon is found throughout portions of the Great Pee Dee River and in the Waccamaw River up to Bull Creek which is designated as Critical Habitat for the Atlantic sturgeon.

Carolina Unit 5 is designated as critical habitat for the Carolina and South Atlantic DPS of Atlantic sturgeon. However, the Waccamaw River is believed to not support spawning and juvenile recruitment or to contain suitable habitat features to support spawning (above its confluence with Bull Creek which links it to the Pee Dee River). Post et al. (2014) also found Atlantic sturgeon only use the portion of the Waccamaw River downstream of Bull Creek. For this reason, only the portion of the Waccamaw River downstream of Bull Creek is designated as critical habitat for Atlantic sturgeon. Based on preliminary analyses of sturgeon detections during their study, Post et al. (2014) concluded the Pee Dee River system appears to be used by Atlantic sturgeon for summer/winter seasonal habitat as well as for spawning.

2.7.1.12 Marine Mammals

Marine mammals protected under the ESA and MMPA which may occur in the study area includes the West Indian manatee (*Trichechus manatus*). Manatees can inhabit both salt and fresh waters and are found at shallow depths (5-20'). In the waters of the continental US, they are most abundant in the warm waters of peninsular Florida. During the summer months, manatees on the eastern coast of Florida have been reported to travel as far north as Cape Cod, Massachusetts (USFWS 2008). Manatees that inhabit and travel through South Carolina waters during the warmer months will feed on salt marsh grasses at high tide and submerged algae beds at low tide. Manatees have been sighted over the past five to eight years between Winyah Bay and the Waccamaw River up to about Conway (J. Lemeris, SCDNR, email comm. 2023), as well as throughout the Atlantic Intracoastal Waterway (AIWW).

2.7.1.13 Birds

According to the USFWS web-based tool Information for Planning and Consultation (IPaC), there are five avian species listed under the ESA (see Table 7) that are of interest for this study: wood stork, Eastern black rail, red-cockaded woodpecker, piping plover and red knot. According to citizen science database, eBird (2023), the wood stork is documented throughout the study area, while other species identified by IPaC such as the red-cockaded woodpecker and red knot have been documented in some locations in Bucksport and Conway. USFWS (2008) does list the black rail, red-cockaded woodpecker, and wood stork as existing in the Waccamaw River NWR. In addition, the South Carolina Natural Heritage Species Reviewer (SCNHSR) tool provides data on locations of viable habitat for ESA species. According to the SCNHSR tool, viable breeding habitat for Eastern black rail is adjacent to the Waccamaw River from Sandy Island downstream to Georgetown (just outside study area limits). Wood stork also have seven known breeding areas throughout the extent of the study area. The Red-cockaded woodpecker is prominent throughout Horry County and have many known nesting areas at Sandy Island north up to Bucksport. Several nesting locations are also known throughout Lewis Ocean Bay and a location north of Chestnut Crossroads. Piping plover and red knot are not well-documented anywhere aside from shorelines outside of the study area and one location inland in Bucksport.

- **Wood Stork**

The wood stork is a long-legged water bird species that uses freshwater and estuarine wetlands as feeding, nesting, and roosting sites. The stork constructs nests in trees, usually in gregarious colonies (called rookeries). Often the rookeries and roosting areas are in association with herons, egrets, and other species. Stork feeding behavior is typically along the marsh vegetation and open water interface seeking small fish and macroinvertebrates (Ogden 1990).

Wood storks are sighted throughout the study area in small numbers, however, a handful of locations in the Conway area provide habitat for sometimes large numbers of Wood Stork. For instance, several dozen wood storks have been reported at the Cox Ferry Lake Recreation Area in Waccamaw River NWR, and over one hundred have been documented at Lake Busbee (eBird 2023). Not far from these locations, two known nesting locations exist in the Conway area floodplain along the Waccamaw River. Four others are located along the 100-year floodplain of the Waccamaw River in the Longs/Red Bluff area, as well as one outside the 500-yr floodplain near Chestnut Crossroads.

While wood storks are habitat generalists, foraging and reproductive grounds are decreasing due to encroaching development. Additionally, storks are especially sensitive to environmental conditions at breeding sites and may fly relatively long distances either daily or between regions annually seeking adequate food resources (Ogden 1990).

- **Eastern Black Rail**

The Eastern black rail is a wetland-dependent bird found in a variety of salt, brackish, and freshwater wetland habitats that can be tidally or non-tidally influenced requiring dense overhead cover and soils that are moist to saturated (occasionally dry) and interspersed with or adjacent to very shallow water. The black rail nests within dense clumps of vegetation over moist soil or shallow water to provide shelter from the elements and protection from predators. The primary threats to the eastern black rail include habitat degradation through marsh draining and ditching as well as fragmentation from conversion of habitat to agricultural lands or urban areas (USFWS 2019).

- **Red-cockaded Woodpecker**

The red-cockaded woodpecker is a relatively small woodpecker. Both male and female adult red-cockaded woodpeckers are black and white with a ladder back and large white cheek patches. This woodpecker relies on mature pine forests in the southeastern U.S. throughout their life history, including all aspects of foraging, roosting, and breeding. This species was common when open, old-growth pine–particularly longleaf pine–forests were maintained by natural wildfires.

As mentioned above, several dozen nesting locations for red-cockaded woodpecker have been documented in the study area, as well as species sightings at several hotspots. Sandy Island in the southern portions of the Bucksport flood impact area is perhaps the best documented area for the species to nest in evergreen forests above the floodplains. Several other nesting locations are known east of Bull Island in the higher elevation timberlands and evergreen forests, of which one location overlaps with a proposed location for water farming. A singular nesting location is also known near Little Town in the Cowpen Mitigation Bank. Some sightings have also occurred around the Conway area, particularly at locations where lower elevations border higher elevations.

Currently, the greatest threat to red-cockaded woodpecker continues to be habitat loss and/or a lack of unfragmented connected suitable habitats. Availability of key habitat features limits opportunities for population growth. In pines (softwoods), resin in outer sapwood layers make inner heartwood layers the only suitable substrate for nesting and roosting, thus requiring heartwood of trees to be of sufficient size (i.e., age) (Conner et al. 2001). Furthermore, older stands of pine have higher incidences of heartwood decay which facilitates excavation. Throughout their previous range, remaining forest habitat is consistently young, dense, and composed of loblolly pine, with substantially more hardwood and little to no herbaceous groundcover (Noel et al. 1998; Frost 2006). Suitable foraging habitat generally consists of mature pines with an open canopy, low densities of small pines, a sparse hardwood or pine midstory, few or no overstory hardwoods, and abundant native bunchgrass and forb groundcovers (USFWS 2020).

Lack of suitable roosting, nesting and foraging habitat is largely attributable to legacy effects from historical logging, incompatible forest management, and conversion of forests to urban and agricultural uses (USFWS 2020). Except in rare instances, extent populations remain dependent on conservation actions, such as prescribed fire, forest management with compatible silviculture, placement, and maintenance of artificial cavities within existing clusters, creation of new recruitment clusters using artificial cavities and translocation and monitoring of population and habitat conditions.

- **Red Knot**

The *rufa* red knot breeds in the Canadian Arctic; winters in parts of the Southeastern U.S., the Caribbean, and South America; and uses many well-known spring and fall stopover areas[1] on the Atlantic coast of the U.S. Red knot are dependent on easily digested food at wintering and stopover locations to achieve adequate weight gain for successful migration (Piersma et al. 1999; van Gils et al. 2005*a*, 2005*b*; Niles et al. 2008). In addition to energetic needs for migration, food stores are utilized for body transformation to breeding conditions (Morrison 2006). These needs coupled with the species' tendency to form congregations representing large proportions of a range-wide population at singular sites makes the species vulnerable (Harrington 2001).

Red knots, generally, overwinter and stopover at coastal marine and estuarine habitats with large areas of exposed intertidal sediments. Preferred microhabitats are muddy or sandy coastal areas, particularly at the mouths of bays and estuaries, tidal flats, and tidal inlets (Harrington 2001; Niles et al. 2008; Lott et al. 2009). In some localized areas, *rufa* red knots use artificial habitats that mimic natural conditions, such as nourished beaches, dredge spoil sites, elevated road causeways, or rock structures (e.g. jetties, breakwaters). Some information suggests small numbers of red knots sometimes use inland manmade freshwater habitats (e.g. impoundments) along migration routes (USFWS 2023*a*). At least one record exists (eBird 2023) of red knots utilizing the Bucksport Sod Farm during a wintering period (record from February). It is not uncommon for some shorebird species to forage in agricultural fields when a sheet of water is present, and The Carolina Bird Club (2005) reports several shorebird species at sod farms across North Carolina and South Carolina, as well as reports of red knots along low-water areas of Falls Lake far inland near Durham, NC.

Threats to the *rufa* red knot include habitat loss, reduced food availability, asynchronies in the annual cycle, competition with gulls, and human disturbance. Habitat destruction and modification are occurring throughout the subspecies' range; affected by climate change, shoreline stabilization, and coastal development, in addition to smaller scale

[1] Stopover sites are defined here as places for birds to rest, refuel, and seek shelter during their bi-annual migration.

impacts like beach cleaning, invasive vegetation, agriculture, and aquaculture. Habitat changes may be compounded in effect by included disturbances from recreational and other human activities.

2.7.1.14 Mammals

The Northern long-eared bat and tricolored bat are colonial cavity roosting species of bats that primarily occupy the forested coastal plains during the warmer breeding season and overwinter in cavernous structures. These species of bats are nocturnal and feed on insects in groups and rest during daylight hours in maternity colonies consisting of females and young and of numbers around 30-60 (Whitaker and Mumford 2009), or singly or small groups in the case of males and non-reproductive females (Nagorsen and Brigham 1993). This often takes place in tree cavities and under bark of trees (Mumford and Cope 1964; Menzel et al. 2002; Briggler and Prather 2003). The greatest threat currently to these species is a fungus, *Pseudogymnoascus destructans*, which causes disease called white-nose syndrome. This disease is most closely associated with species of bat that hibernate (or undergo torpor) in caves during the winter where the fungus may be prevalent. This disease has been responsible for the listing of numerous bat species under the ESA in recent years as it has led to declines of >90% of species populations in some cases (Blehert et al. 2009).

The Northern long-eared bat is found throughout much of the eastern and north-central U.S., and all Canadian provinces west to the southern Yukon Territory and eastern British Columbia (Nagorsen and Brigham 1993; Caceres and Pybus 1997; Environment Yukon 2011). During the summer, the species may roost singly or in maternity colonies within both live trees and snags (Perry and Thill 2007; Timpone et al. 2010), although cooler locations such as caves and mines have also been documented (Amelon and Burhans 2006). Of particular importance to summer habitat selection and use are forest successional patterns, stands and tree structure (Silvis et al. 2012). Mature forests and mixed forests with small gaps provide optimal foraging habitat for the species, where foraging takes place above the understory (Nagorsen and Brigham 1993; USFWS 2015; White et al. 2017).

The tricolored bat is found throughout eastern Canada south along the eastern US and into Mexico, and then west to the Great Lakes and Texas. The species is found statewide in South Carolina (Menzel et al. 2003). Like Northern long-eared bats, the species uses open woods where there is sparse vegetation (Nowak 1999; Loeb and O'Keefe 2006). Carter et al. (1999) found the species used cavities of bottomland hardwood tree species including swamp chestnut oak (*Quercus michauxii*), sweetgum, and laurel oak (*Q. laurifolia*), and they have been documented using Spanish moss in understory trees on exposed high-marsh hammocks (Menzel et al. 1999). While foraging, tricolored bats tend to forage over riparian areas, lakes and ponds, and grass-brush habitats (Menzel et al. 2005).

Although only one record of tricolored bat has been documented in the study area (near floodplain forests of the Waccamaw in Longs/Red Bluff) as of August 2024 (SCDNR 2023), the species is known throughout Horry County. On the other hand, no Northern long-eared bats have been documented in the study area but are well known on Sandy Island just outside the study area (SCDNR 2023). The two species share considerable similarities in their ecological needs and thus would be expected to be affected similarly from actions. Primary stressors for the species include white-nose syndrome, wind energy mortality, effects from climate change and habitat loss (USFWS 2021*a*; USFWS 2022).

2.7.1.15 Plants

Three listed plants may exist in the study area: pondberry, Canby's dropwort, and American chaffseed. Pondberry inhabits seasonally flooded wetlands, sandy sinks, pond margins, and swampy depressions (USFWS 2008). Canby's dropwort inhabits natural ponds primarily composed of pond cypress, grass-sedge dominated bays, wet pine savannahs, shallow pineland ponds, and cypress-pine swamps (USFWS 2008). American chaffseed inhabits pine flatwoods and savannahs with a history of frequent burning (USFWS 2008). Potential habitat for all three of these species has been identified on Sandy Island within the Waccamaw River NWR (USFWS 2008), and historical records of American chaffseed exist near Bucksport and Conway in areas that are now developed (SCDNR 2023).

2.7.1.16 Invasive Species

Executive Order 13112, *Invasive Species*, dated February 3, 1999, directs Federal agencies to expand and coordinate their efforts to combat the introduction and spread of invasive species. Not all invasive species are non-native (i.e., originating outside of North America), but are considered invasive purely from their ability to spread quickly and become abundant, to the detriment of native flora and fauna and indigenous biodiversity. Invasive species capable of spreading and invading into new areas are typically generalists that can easily adapt to new environments and are highly prolific and superior competitors and predators. Some are very specialized and more efficient and effective than their native competitors at filling a particular niche. They compete for resources, alter community structure, displace native species, and may cause extirpations or extinctions. Invasive species often benefit from altered and declining natural ecosystems by filling niches of more specialized and displaced species with limited adaptability to changing environments.

According to the University of Georgia Center for Invasive Species and Ecosystem Health, there are over 232 invasive species recorded in Horry County. Most common among them are plant species, which make up 89% of the invasive species in the county (UGA 2023). Other groups of invasive species include insects, fungi, and animals.

- **Terrestrial Species**

Over 200 invasive plant species are known to occur in Horry County (UGA 2023). The most frequently recorded among these are Japanese honeysuckle (*Lonicera japonica*) and privet (*Ligustrum* spp.). Japanese honeysuckle can be a shrub or vine that often grows up and over other plants (i.e., trees), blocking access to sunlight and killing the parasitized plant. Additionally, kudzu (*Pueraria montana*) is recognized as one of the most important invasive plants at Waccamaw NWR, and, similar to Japanese honeysuckle, is a fast-growing vine that spreads into disturbed areas, fields, and edges of forests (USFWS 2008). Privet is a shrub used primarily as an ornamental hedge and is spread laterally or through bird excretions. The plant can form dense thickets and blanket across damp wetlands. If not managed, privet can lead to forests of shrubbery throughout floodplains.

A number of invasive introduced bird species are known throughout the study area, particularly in urban areas. These include European starling (*Sturnus vulgaris*), rock pigeon (*Columbia livia*), house finch (*Haemorhous mexicanus*) mute swan (*Cygnus olor*), house sparrow (*Passer domesticus*) and Eurasian collared dove (*Streptopelia decaocto*). By far, one of the most common areas to find large numbers of invasive species of birds is at landfills like the Horry County landfill in the Conway area, where several thousand starlings and hundreds of rock pigeons may be at any given time. Other common places to find numbers of invasive bird species include agricultural areas (e.g., Bucksport sod farm), parks and recreation areas (e.g., Grand Park Recreational Complex, Coastal Carolina University Campus, Waccamaw River Park), and industrial facilities (e.g., Grand Strand Water & Sewage) (eBird 2023).

One of the most important invasive animals in the Waccamaw NWR is the feral hog. Rooting and wallowing activities of this animal leads to erosion of riverbanks and areas along streams and wetlands. They are also vectors for disease and compete for resources with native wildlife. They are also predators of reptiles, small mammals, and deer fawns, as well as ground-nesting birds, such as turkeys (USFWS 2007).

- **Aquatic Species**

Among the invasive plant species in the county, USFWS (2008) identified alligator weed (*Alternanthera philoxeroides*) and water hyacinth (*Eichhornia crassipes*) among some of the highest priorities in the Waccamaw NWR. The proliferation of these species is thought to be influenced by static water levels caused by a lack of annual flooding and reduced water depths resulting from excessive sedimentation. The spread of these species further chokes waterways, restricting light and depleting dissolved oxygen levels. *Phragmites* (spp.) is another common aquatic invasive plant in brackish and freshwater marshes that can form dense clones that are capable of altering structure and function of marsh ecosystems. *Phragmites* are capable of changing species compositions, nutrient cycling, and hydrological regimes having impacts across trophic levels and throughout the ecosystem.

Aquatic invasive fauna in the study area may include flathead catfish (*Pylodictis olivaris*), blue catfish (*Ictalurus furcatus*) and Asian clam (*Corbicula fluminea*). Flathead and blue catfish were first documented in the Waccamaw River in the period around 1999 and impact a variety of native fish species including catfish, sunfish and even Atlantic sturgeon through predation (NCWRC 2019) Asian clams have spread in the US since the 1930s through activities like bait bucket dumping, aquaria releases into streams and canals, and intentional release of specimens from food markets. Ecological impacts include changing benthic substrata and competition with native species in riverine habitat and more temporary bodies like sloughs and oxbow lakes (Bogan et al. 2008).

2.7.2 FWOP Conditions

Alongside the previously discussed effects of a changing climate on terrestrial and aquatic habitats, anticipated development and land use changes are also expected to play a role, perhaps even larger than that of climate change (Sala et al. 2000), in shaping biological resource communities in the FWOP conditions. Developed land covers and impervious surfaces increased by roughly 50% over a recent 20-yr period, occurring alongside a doubling of housing stock throughout the county. This phase of development was accompanied by declines in the covers of wetlands and forest of 5% and 15%, respectively. Horry County (2019) anticipated another period leading into 2040 of housing stock doubling again. This may be in many forms and may not have the same consequences for habitat covers which include wetlands and forests, among others. However, assuming a similar trend, wetland and forest covers, and their respective biological resources are likely to see further declines in abundance, diversity, or both under FWOP conditions as the county continues to develop. This assumption is based on a previous finding that habitat destruction in the U.S. has impacted over 92% of imperiled mammals, birds, reptiles, amphibians, and fish (Wilcove et al. 1998).

Horry County (2019) acknowledges the value of nature-based solutions to development including conservation subdivisions and interconnected open space. These solutions to enhancing both economic and conservation values are based on smart planning of developments which include setting aside major portions of subdivisions as undeveloped tracts and linking parks, greenways, river corridors, and other natural or restored lands together to create interconnected green space. Horry County (2019) also acknowledges the effects of poor development planning practices including suburban sprawls and the impacts of resulting fragmentation on wildlife habitat, corridors, and communities. Horry County also developed a few environmental sustainability objectives to avoid flood and wildlife hazards and minimize adverse impacts to water quality, flooding, habitat, and wildlife. Through these planning objectives and through actions of local, state, and Federal regulatory bodies, the impacts to biological resources from continued development of the county and thus, the study area, can be ameliorated.

2.8 Cultural Resources

2.8.1 Existing Conditions

Historic structures and archaeological sites in the study area were identified utilizing existing survey data and through initial coordination with cultural resource agencies. These agencies include Catawba Indian Nation, the Chickasaw Nation, Horry County Historical Society, Horry County Museum, Horry County Historic Preservation Commission (HPC), Alabama Quassarte, Horry County Archives Center, Eastern Shawnee Tribe of Oklahoma, South Carolina Department of Archives and History (SCDAH), Thlopthlocco Tribal Town, Shawnee Tribe, Poarch Band of Creek Indians, Kialegee Tribal Town, Eastern Band of Cherokee, Delaware Tribe, Absentee Shawnee.

A brief analysis of the existing conditions and future without project is provided below; however, please see Appendix D Section 1.1 for more detailed analysis.

There are a total of 37 historic structures and 14 archaeological sites within the Longs/Red Bluff project area. Resources in the area include the Watson-Richard House, Redbluff Landing, in addition to undocumented structures with limited available data. Archaeological sites in the area consist of prehistoric and historic artifact scatters, and the historic Bellamy Cemetery.

The Bucksport project area has at least nine historic structures and six archaeological sites. Many of the resources in the area are associated with the town's founder, Henry Buck, who established a plantation and lumber mill in the area in the 1820s. The area consists of vast sources of cypress, pine, and hardwood trees, which was seen as an attractive location for lumber production. In addition to historic nineteenth century resources, prehistoric resources are also prevalent in the area.

The Conway project area has 38 historic areas and 151 significant historic structures. Many of these resources are located within downtown Conway, including the Conway Downtown Historic District, and the Waccamaw River Warehouse Historic District. The Conway Downtown Historic District is significant as the focal public commercial and social center of the city of Conway. Additionally, the district is significant as a collection of buildings associated with the commercial and governmental growth and development of Conway from circa 1824 to 1950. The Waccamaw River Warehouse Historic District illustrates the evolution of utilitarian structures at the end of the nineteenth century. These warehouses are significant both architecturally and as the last extant warehouses in Conway associated with the commercial trade on the Waccamaw River, as well as with the impact of the railroad on that trade, which was vital to the local economy and was in large part responsible for the boom years from 1890 to 1930. The Waccamaw River Memorial Bridge is a historically significant National Register of Historic Places (NRHP) listed bridge that is associated with the Downtown Conway Historic District.

The Socastee project area has two historic areas and 38 historic structures. Resources in the area include the Socastee Historic District, the Socastee Bridge (contributes to Socastee Historic District), and the Central Hall House from circa 1870.

2.8.2 FWOP Conditions

Flooding under the existing and FWOP conditions have impacts on identified cultural resources. Flooding along the coast and reaching up rivers into low lying areas causes flooding within/near historic properties and damages buildings. Damage may include, but is not limited to, structural damage and destruction of historic materials (e.g., furniture, textiles, archives, etc.). Erosion poses threats to historic properties and both terrestrial and submerged archaeological sites. Erosion can eliminate surface evidence of archaeological sites, wear away site layers, and displace materials from various cultural layers making recovery and interpretation challenging, if not impossible. Erosion will impact features more severely due to the disturbed nature of the soil, while leaving intact topographic layers less damaged.

2.9 Recreation

2.9.1 Existing Conditions

According to the Myrtle Beach Area Chamber of Commerce, a large seasonal tourist population is attracted to the Grand Strand's extensive beaches and over 90 golf courses. In 2003, an estimated 13 million tourists visited the Grand Strand area (USFWS 2005). Most visitors to the Grand Strand area are from out-of-state and typically visit for a period of four to seven days. Over 50 percent of the area's tourists make return visits. Although most visitors concentrate on beach activities, many seek a diverse recreational experience. The basic appeal of the Grand Strand is its family-oriented recreational activities, including beaches, water parks, golf courses, fishing, historical sites, cultural events, hiking, and tennis/sports. As more people are attracted to the area, visitor activities that are not related to water have also grown in importance.

Several rural agricultural communities' stem from Highways 905 and 701 through much of the Longs/Red Bluff flood impact area and portions of Conway. Family farming communities in these areas and throughout the county have maintained farming practices for more than 100 years (a.k.a. "century farms") and a vastly different traditional and cultural aesthetic from more developed parts of the study area and county (Horry County 2019). Some of these agricultural areas provide for an agritourism industry with activities like you-pick, farm-to-table, and special events hosted on farms. For example, Freewoods Farm in the Socastee flood impact area is a 40-acre living farm museum providing educational and tourism opportunities for locals and visitors.

Rural and undeveloped parts of the study area also provide recreation qualities through preservation of open natural spaces, clean and accessible waterways, conservation areas, and wildlife management areas for wildlife viewing, boating, swimming, hunting and fishing. These include prominent features in the study area such as the along the Waccamaw River and the Waccamaw River NWR. According to the 2022 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation (USFWS 2022b), inhabitants of the South Atlantic are avid anglers, hunters, and wildlife watchers, and both those in the South Atlantic and Americans in general are avid users of wildlife resources. Out of 53 million individuals in the South Atlantic, 16%, 4%, and 60% of people enjoyed fishing, hunting, and wildlife watching, respectively. Effectively, at least 32 million people in the South Atlantic enjoy at least one of the recreation activities. The

Waccamaw River NWR provides for opportunities in hunting, fishing, wildlife observation, wildlife photography, environmental education and interpretation, hiking, biking, horseback riding, recreational boating, waterskiing, canoeing, kayaking, and swimming. Hunting for white-tailed deer, waterfowl, and small game is very popular. Hunting opportunities also include turkey, feral hog, and squirrel among others. Methods like still hunting and dog drives have been traditionally used on private lands, though many of the forested wetlands throughout the NWR are accessible seasonally through vehicles and are used by hunting clubs with organized dog drives. Freshwater commercial fishing within the refuge has been a traditional livelihood for many native South Carolinians as well. Recreational fishing is primarily limited to the main river systems and smaller tributaries that are not blocked and not considered private property. Boat accesses are publicly available within and adjacent to the refuge. Nearby the refuge are similar nature-based tourist attractions like Conway Riverwalk, Lewis Ocean Bay Heritage Preserve, Sandy Island and Waccamaw River Heritage Preserve. Fishing and recreational boating are also widely available along the AIWW which runs through Bucksport and Socastee.

2.9.2 FWOP Conditions

In their Parks and Open Space plan, Horry County (2022) calls for development of 3 new Greenway parks, 2 new neighborhood parks, 3 new community parks, 2 new major county parks, 1 new regional recreation facility, 2 new specialized recreation facilities, and 2 new recreation centers. The plan also identifies a need for expansion and upgrading of existing recreation facilities. These plans reflect upwards of $161 million invested in recreation and aesthetics at a county scale up until 2040 and beyond. In addition, the plan details ambitions to preserve an effective green infrastructure network which involves “*(1) conserving large areas of significant habitat and areas adjacent to existing conservation lands; (2) siting future parks along waterways, beaches, and other natural areas; (3) protecting wetlands, floodplains, and woodlands within neighborhood open space; and (4) establishing linear connections between conservation areas, parks and neighborhoods.*” Priority areas for implementation of these aspirations include green infrastructure along the Highway 90 Corridor, Lake Busbee, and the City of Conway to Coastal Carolina University and Cox Ferry Lake Recreation Area; habitat corridors along the Socastee Greenway and Waccamaw River; improvements and expansions of conservation hubs at Lewis Ocean Bay Heritage Preserve, Waccamaw River NWR, and Waccamaw River Heritage Preserve; addressing conservation gaps along the Middle Waccamaw; and conserving or improving habitat links along Bull Creek and Kingston Lake. Successful implementation of these ambitions will require cooperation among local jurisdictions, grant providers, local partners, and private enterprise. Thus, with successful implementation of these plans, recreation qualities of the study area are expected to be similar or improved under FWOP conditions.

2.10 Transportation

Transportation refers to the movement of people, goods, and/or equipment on a surface transportation network that can include many different types of facilities serving a variety of transportation modes, such as vehicular traffic, public transit, and non-motorized travel (e.g., pedestrians and bicycles). The relative importance of various transportation modes is influenced by development patterns and the characteristics of transportation facilities. In general, urban areas tend to encourage greater use of public transit and/or non-motorized modes of transportation, especially if pedestrian, bicycle, and transit facilities provide desired connections and are well operated and well maintained. More dispersed and rural areas tend to encourage greater use of passenger cars and other vehicles, particularly if extensive parking is provided and/or transit systems are unavailable.

2.10.1 Existing Conditions

Several important Federal and state highways, roadways, and railways occur entirely within or intersect the study area. Some important modes of ingress and egress are considered under alternatives herein for modifications designed to limit the impacts of flooding. In the Longs/Red Bluff impact area, Highways 9 and 905 provide the major transportation routes to and from Longs. Highway 905 continues into the Conway impact area where it intersects the Carolina Southern Railroad prior to meeting Main St and 4th Ave. The Carolina Southern Railroad runs from the border with North Carolina near Howard, SC and runs parallel along much of Highway 701 to its terminus in Conway where the railway has several spurs before following Highway 501 south down to Myrtle Beach. Highways 701, 501 and 378 are also important roadways which converge broadly in the City of Conway near Lake Busbee. Highway 501 serves as a major transportation between Conway and the Grand Strand area, including Socastee, from many other parts of the county. Socastee is home to the Myrtle Beach International Airport with coastal Highway 17 running through the area. Other highways in the Socastee area include 31, 544 and 707. Highway 707 continues into the southern portions of the Bucksport impact area, but Highway 701 is the major highway in the Bucksport area and crosses the Great Pee Dee River. The Pee Dee Highway is another important roadway for communities to gain access to 701 from areas upstream of the river.

2.10.2 FWOP Conditions

Several transportation projects are in a planning and design phase at the county level in Horry. Some planned projects are spanning multiple decades while some are still in need of permitting and funding. Nevertheless, FWOP conditions may be partially inferred from some projects already planned.

Several regional transportation initiatives are likely to change the landscape of FWOP conditions, allowing for more efficient transportation, accommodation of a larger population, and alternative modes of egress and ingress in the region. The Intermodal Surface Transportation Efficiency Act of 1991 designated the I-73/74 North-South Corridor as a “High Priority Corridor” and connects Charleston, SC to Winston-Salem, NC and will continue through Virginia and West Virginia and beyond. Another high priority route identified as the “Southern Project” would run as Interstate 73 from Interstate 95 to State Route 22 in the Myrtle Beach/Conway area. This route would serve to connect Myrtle Beach to I-95 and improve national/regional connectivity and hurricane evacuations. To achieve similar connectivity of the Grand Strand area between US 17 and US 501, the Southern Evacuation Lifeline (SELL) is another proposed multi-lane highway to stretch from Garden City to US 501 at the SC 22 interchange. Another project is the extension of Carolina Bays Parkway SC 31. The goal of these projects is ultimately to alleviate traffic on currently congested highways throughout the region. In addition to these regional projects, Horry County is also continuing their Road Improvement and Development Effort (RIDE) program which is in its 3rd iteration. RIDE 3 consists of five paving projects including paving one hundred miles of dirt roads and resurfacing many others.

Horry County (2019) also outlined several roadway and other transportation projects included in various other planning documents and projects with future growth in mind. These include construction of bridges, road extensions, road widenings and realignments, highway elevations, safety improvements and more. For a complete list of planned transportation projects in the study area, see Horry County's IMAGINE 2040 Plan (Horry County 2019). Aside from major motor vehicle transportation plans, Horry County (2019) has also outlined projects involving bicycle and pedestrian transportation, public transportation, railroads, and airports. Nevertheless, most of these are focused around improving existing infrastructure to promote greater efficiency and to support higher demands.

As the county and areas of the study area continue to develop into FWOP conditions, transportation needs will inevitably require investment in local and regional infrastructure. Innovation in transportation technology and culture is likely to change quickly over the 50-yr period between 2035 and 2085, and under some models for the future, transportation demands may decrease despite population growth predicted for some areas. Zhu et al. (2016) modeled a system which may reduce public vehicle needs by up to 90% and total travel distances by over 30%. Projects which are planned now may develop through time at various scales and require continual re-evaluation to remain relevant and feasible.

2.11 Socioeconomics and Environmental Justice

Environmental justice is the fair treatment and meaningful involvement of all people regardless of income, race, color, national origin, Tribal affiliation, or disability in agency decision-making and other Federal activities that affect human health and the environment. Section 112(b)(1) of WRDA 2020 requires that "*In the formulation of water development resources projects, the Secretary shall comply with any existing Executive order regarding environmental justice in effect as of the date of enactment of this Act to address any disproportionate and adverse human health or environmental effects on minority communities, low-income communities, and Indian Tribes.*" The Executive Order (EO) in place at the time of the enactment of WRDA 2020 was EO 12898 (1994), Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations, which directs each federal agency to assess whether disproportionately high and adverse effects would be imposed on minority or low-income areas by federal actions. Subsequent EOs include: EO 14008 (2021), Tackling the Climate Crisis at Home and Abroad, which in Section 219 directs federal agencies to "*[develop] programs, policies, and activities to address the disproportionately high and adverse human health, environmental, climate-related and other cumulative impacts on disadvantaged communities;*" and, EO 14096 (2023), Executive Order on Revitalizing Our Nation's Commitment to Environmental Justice for All, which directs federal agencies to pursue the protection of environmental justice communities (including underserved and disadvantaged communities) "*from disproportionate and adverse human health and environmental effects (including risks) and hazards,*" and to "*provide opportunities for the meaningful engagement of persons and communities with environmental justice concerns who are potentially affected by Federal activities.*"

2.11.1 Existing Conditions

According to data from the EPA's Environmental Justice and Screening Tool (EJST), the study area generally scores better on socioeconomic indicators and environmental burden indicators than the rest of South Carolina and the broader U.S. However, despite being lower than the state percentile (36%), the socioeconomic indicator of low income in the study area is 33% and is slightly higher than the national level of 30% (Table 8). The flood impact area of Conway has the highest proportion of individuals considered to be low income and is slightly higher than both state and national levels at 37%. This disparity between Conway and the state and national averages is also reflective in the unemployment rate. The percentage of individuals over age 64 is also greater in the study area (26%) than both the state (20%) and national levels (18%). The flood impact area with the largest proportion of individuals over age 64 is Bucksport. Among the flood impact areas, Conway represents the most vulnerable demographics, exceeding state and national averages for low income, unemployment, people with disabilities and individuals aged >64.

Table 8: Project Area Socioeconomics Indicators

	Longs/Red Bluff	Conway	Socastee	Bucksport	Study Area	State	Nation
Population	24,292	64,208	65,050	19,831	173,380	-	-
% Low Income	*35*	***37***	*32*	24	*33*	36	30
% People of Color	24	31	22	11	24	39	40
% <High School Ed.	9	9	8	5	8	12	11
% Limited English Household	1	*2*	1	0	1	1	5
% Unemployment	4	***7***	5	4	6	6	6
% People with Disabilities	***18***	***19***	***17***	***21***	***19***	15	14
% Aged <5	5	5	5	4	5	5	5
% Aged >64	***33***	***21***	***23***	***40***	***26***	20	18

Numbers in *italics* indicate value is higher than either the state or national average, while values in *bold italics* are higher than both the state and national averages

Other data from the EJST includes climate indicators of social vulnerability. Among these is flood risk. Relative to the state and national average flood risk value (12% for both), the study area and all flood impact areas, except for Longs/Red Bluff, had higher flood risk values. The areas of greatest flood risk, in order of increasing value, are Socastee (14%), the broader study area (16%), Conway (18%) and Bucksport (22%). These data, when considered with the distribution of traditionally vulnerable social demographics, such as those of low income and minority populations, do not show a clear relationship.

According to data amassed through the Council on Environmental Quality's (CEQ) Climate and Environmental Justice Screening Tool (CEJST) (which uses 2010 U.S. Census Bureau census tract boundaries), 16 of the 43 census tracts overlapping the study area are identified as disadvantaged (only 15 are within Horry County). According to the CEJST, to be identified as disadvantaged, a census tract must meet at least one burden threshold (e.g., climate change, health, transportation, housing, energy, legacy pollution, water and wastewater, or workforce development) and the associated socioeconomic threshold (e.g., low income or less than a high school education). An example of a burden threshold for climate change is if a census tract is at or above the 90^{th} percentile for expected agriculture loss rate, expected building loss rate, expected population loss rate, projected flood risk, or projected wildfire risk.

Census tracts in Longs/Red Bluff and Conway are among the most overburdened in the study area according to data aggregated by CJEST (Table 9). For instance, Census Tract 30.103, including the communities of Longs, Little Town, and surrounding communities, exceeds thresholds for the climate change, health, transportation, and workforce development categories. Thresholds exceeded within these categories include expected agriculture loss rate (climate change); diabetes, heart disease and low life expectancy (health); transportation barriers (transportation); unemployment (workforce development); and socioeconomic threshold including low income and percent of people without a high school diploma. In Conway, Census Tract 70.500, including neighborhoods in South Conway, is overburdened based on several categories which differ from that of Longs, but also shares health thresholds exceeded. For instance, thresholds exceeded here include projected wildfire risk (climate change); diabetes, heart disease and low life expectancy (health) and wastewater discharge (water and wastewater); and the socioeconomic threshold for low income. In addition, the neighboring Census Tract of 70.400 in Conway also is among the most overburdened in the study area sharing thresholds exceeded including those for asthma and diabetes (health) and wastewater discharge (water and wastewater). Among these most disadvantaged census tracts, Longs includes vulnerable demographics, including greater proportions of elderly individuals (% age >64), and the areas of Conway also include vulnerable demographics, including greater proportions of people of color and elderly (only in Census Tract 70.500), relative to the rest of the study area and state and national averages.

Table 9: Overburdened Census Tracts in the Project Area

Flood Impact Area[1]	Census Tract	% Black or African American alone	% White	% Hispanic or Latino	% other races	% age over 64	Thresholds exceeded	Share of properties at risk of flood in 30 years (percentile)
L	45051030103	22%	76%	0%	0%	32%	6	88
C	45051070500	42%	54%	5%	0%	23%	5	57
C	45051070400	54%	42%	1%	0%	18%	3	54
C	45051070702	21%	62%	13%	10%	13%	3	75
L	45051040101	29%	63%	7%	0%	29%	2	68
S	45051051501	7%	70%	19%	3%	20%	2	79
L/C	45051060301	28%	69%	1%	0%	21%	2	93
C	45051070300	39%	53%	3%	1%	17%	2	83
C	45051070601	7%	84%	3%	0%	14%	2	85
L	45051030102	23%	69%	5%	2%	22%	1	76
S	45051050900	20%	42%	29%	6%	10%	1	70
S	45051051502	11%	73%	9%	4%	15%	1	62
C/B	45051060101	17%	69%	8%	4%	5%	1	86
C/B/S	45051060102	5%	72%	19%	11%	15%	1	43
S	45051060208	7%	83%	4%	0%	15%	1	81

[1]Abbreviated versions of flood impact areas are as follows: L = Longs/Red Bluff, C = Conway, S = Socastee, and B = Bucksport
NOTE: Racial and ethnic groups which consist of <5% of census tracts are excluded to reduce table size

Disadvantaged communities in the study area are generally not disproportionately represented by any demographic, and these overburdened communities show no relationship with the risk of flooding according to the CJEST.

2.11.2 FWOP Conditions

The projected annual growth rate from 1970-2040 for Horry County is projected to total 89% and the projected population is expected to near 584,500 by 2040. This figure includes a projected growth of 63% in Conway, 130% in Conway East and 367% in Longs.

According to Horry County (2019), the age group distribution of Horry County grew relatively evenly from 2009-2016, with the greatest growth in people aged >55, surpassing the previously most abundant age group of 30-54. However, individuals aged 20-29 showed little to no growth in the county. Horry County is expected to remain a desirable location for retirees into the future, and trends in age distribution are not expected to significantly change under FWOP conditions.

From 1990 to 2015, racial composition of Horry County changed by declines in individuals who identified as white from 81% to 77% and as black or African American from 17.5% to 13.7%, while other individuals who identified as Hispanic or Latino increased (0.9% to 6.1%), and individuals who identified as other or two or more races saw little change. The geographic distribution of minorities throughout the county generally follows patterns for all races, with Conway and the Grand Strand areas representing most density of minority populations. These trends are expected to continue or stabilize under FWOP conditions.

From 1989 to 2015, Horry County retained among the highest per capita incomes in the six-county area of northeastern South Carolina. This is also reflected in trends in poverty in Horry County relative to South Carolina and the U.S. between 1989 and 2015. Many of those below poverty in the county are in rural areas including Longs and in highly developed urban areas of Socastee and Conway. The geographic distribution of those experiencing poverty in the county will likely continue to reflect areas where fewer jobs exist in more rural and undeveloped areas. Despite this, the FWOP conditions for income and poverty are expected to improve as these areas with rural communities like Longs are expected to have significant population growth (leading to greater tax revenues) and through the development of opportunity zones in Longs and Conway areas that will incentivize private investment in low-income areas.

2.12 Hazardous, Toxic, and Radioactive Waste

Hazardous, toxic, and radioactive waste (HTRW) includes any material listed as a "*hazardous substance*" under the Comprehensive Environmental Response, Compensation and Liability Act, 42 U.S.C. 9601 et seq (CERCLA) (See 42 U.S.C. 9601(14)). Hazardous substances regulated under CERCLA include "hazardous wastes" under Sec. 3001 of the Resource Conservation and Recovery Act, 42 U.S.C. 6921 et seq; "*hazardous substances*" identified under Section 311 of the Clean Air Act, 33 U.S.C. 1321, "*toxic pollutants*" designated under Section 307 of the Clean Water Act, 33 U.S.C. 1317, "*hazardous air pollutants*" designated under Section 112 of the Clean Air Act, 42 U.S.C. 7412; and "*imminently hazardous chemical substances or mixtures*" on which EPA has taken action under Section 7 of the Toxic Substance Control Act, 15 U.S.C. 2606; these do not include petroleum or natural gas unless already included in the above categories (See 42 U.S.C. 9601(14)).

2.12.1 Existing Conditions

An assessment of HTRW in the study area was performed to determine the type and extent of HTRW contamination, if any, and how HTRW considerations will impact alternative project plans. A desktop review of geospatial information from all publicly available EPA databases which maintain HTRW data (including RCRAInfo, ICIS-AIR, NPDES, TRI, NPL and ACRES) was performed and information of facilities registered to the EPA's Facility Registry Service (FRS) was used to identify facilities and HTRW which may overlap with areas of proposed measures in the study area.

In the Conway flood impact area, a mining operation recorded in the Resource Conservation and Recovery Act (RCRA) information system (FRS ID: 110070516353) is adjacent to the US 501 Business Highway and within roughly half a mile from a structural measure proposed. The facility also shares part of the floodplain with a proposed structural measure. This facility has had one occurrence of non-compliance on record, but this referred to a lapse in record-keeping.

In the Socastee flood impact area, eight facilities registered as producers of hazardous waste under RCRA exist within a half mile of a proposed structural measure. Of these eight facilities, one (FRS ID: 110013197824) has been cited for violations in the previous 5 years pertaining to labeling of hazardous wastes and the proper treatment and disposal of wastes at disposal facilities. However, none of these facilities are known to share a drainage or floodplain with the proposed measure and do not physically overlap with the extent of the proposed measure.

In all flood impact areas, all areas being considered for any construction-related activities should include the appropriate level of review of real estate records for further information on HTRW and a site inspection where appropriate to gather additional information prior to any action being taken.

2.12.2 FWOP Conditions

No new HTRW sites relevant to the focus areas (locations where measures are proposed) within the study area are anticipated under FWOP conditions which are not captured in the existing conditions. However, approval of National Pollutant Discharge Elimination System (NPDES) permits and increases in the presence of point source and non-point source pollutants would be expected with increased development which is anticipated into FWOP conditions.

2.13 Aesthetics

2.13.1 Existing Conditions

Aesthetics of the study area were assessed using an abbreviated General Visual Impact Assessment (VIA) Procedure described in the WES Instructional Report EL-88-1. This approach was used given the relative weight of economics on plan evaluation and the number of alternatives being considered across a very large study area. Given the size and geographic diversity of the study area, visual resource summaries where measures are being evaluated were performed.

- **Longs/Red Bluff**

Measures being evaluated herein are set in two separate areas which are considered individual similarity zones for these purposes:

Between Highway 9E and Buck Creek

Much of the visual resources nearby the measure considered here consists of residential homes in a suburban layout, stretches of rural highway, golf course and integrated artificial ponds of the neighboring country club, and an extensive backdrop of dense woody wetland forest where Buck Creek is channeled through. The topography is very flat and does not provide for visibility beyond any ground-level obstructions such as large trees and shrubs.

Along Simpson Creek from S Highway 905

This zone consists of a mix of woody wetlands following adjacent a narrow, murky, and channelized creek which is flanked by a maintenance road and dense herbaceous and shrub vegetation. Other parts of the creek are bordered by reaches of evergreen forest and a stretch of woody wetland developed into open space for a private ranch. Like many parts of the study area, the topography is very flat, and visibility is limited to viewpoints absent of trees and tall vegetation.

- **Conway**

Measures being evaluated herein are set in one similarity zone, which is along short stretches of E Highway 501, Highway 501 Business, and Highway 905.

Visual resources relevant to the areas of Highways 905 and 501 Business are both limited to those visible directly from these 2-lane highways—being obstructed by dense tree line and possessing flat topography. Both reaches of highway are flanked by dense, mature, woody wetlands with water flows which are present for portions of the year. On Highway 501 Business the roadside is flanked by guard rails.

On the relevant stretch of the 4-lane E Highway 501, visual resources include stretches of woody wetland to the north, commercial development eastbound of the highway, the historic 501 bridge westbound and a mix of commercial property and detention waters to the south. As is the case with most of the study area, the topography is flat and visibility is limited to nearby stretches of woody wetlands and the rising bridge structures. A series of billboards and transportation infrastructure (e.g., guard rails and light posts and nearby dirt roadways) flank the highway in the area. From the area of the proposed measure, the historic bridge is beyond the point of visibility and appears as a raised roadway flanked by guard rails and trees.

- **Socastee**

Measures being evaluated herein are set in one similarity zone.

The visual resources in this zone are primarily along a long stretch of the channelized, murky and relatively shallow Socastee Swamp and are bound by Highway 501 to the north, the suburban developments along Forestbrook Rd to the west, the AIWW to the south, and dense suburban developments interspersed with golf courses and detention ponds to the east with industrial and commercial development beyond there. The measures considered herein, however, would only affect visual resources flanking along the creek and flooded portions of the landscapes described above. The creek is flanked by dense, mature woody wetlands with two breaks—one perpendicular to Limerick Rd and another on McCormick Rd. Like much of the study area, the topography is flat and visibility is limited by common obstructions such as mature vegetation.

- **Bucksport**

Measures being evaluated herein are set in two similarity zones.

One measure consists of alteration of the 2-lane Pee Dee Hwy extending from Highway 701 near Klondike, SC northbound to the community of Dongola. The majority of this highway is flanked by a mix of woody wetlands, evergreen forest, and agricultural properties. The roadway is very flat and visibility is limited to common obstructions like mature vegetation.

Another measure would be situated off Old Pee Dee Rd where it intersects the 2-lane Cowford Swamp bridge. The bridge is mostly concrete and has concrete barriers flanking it throughout its length. On either side are mature woody wetlands and water associated with Cowford Swamp. Visibility is limited to the tree line on either side of the bridge.

2.13.2 FWOP Conditions

Horry County (2019) recognizes the value of preserving and enhancing the aesthetics of the study area in their outlined goals and strategies. The county has laid out a community character strategy which set several objectives to preserve and cultivate community character and promote a sense of place. Some of the objectives identified include:

- Develop and implement a community beautification and branding program.
- Develop and amend regulations that contribute towards distinct community character.
- Develop, update and implement plans to ensure the character and form of communities are preserved and enhanced.
- Revise and simplify Horry County's sign regulations.
- Increase the number of designated historic properties in Horry County.
- Expand efforts to educate residents and visitors about Horry County's history.

Other strategies identified by the county which are relevant to preserving and enhancing the aesthetic qualities of the region include those on rural preservation; revitalization, redevelopment, and infill; healthy, livable communities; safe communities; community facilities and services; environmental sustainability; economic growth; and community engagement. Collectively, the priorities outlined by the county provide a vision for the future which includes allocation of resources to improve conditions as they relate to aesthetics.

In the areas described in the existing conditions above, it is unlikely that the aesthetic qualities of these areas will change to any relevant degree given the proximity to undeveloped natural features and the tendency for flooding. Therefore, it is expected that although developed community areas, urban environments, and new development outside the floodplain are likely to experience changes in aesthetic qualities, those areas relevant to the measures considered herein are not.

In conclusion, aesthetic qualities of the areas considered here are unlikely to meaningfully change. However, flooding will likely continue to affect these areas and the ability for individuals to experience the aesthetic qualities.

3.0 PLAN FORMULATION AND EVALUATION

This section provides a roadmap explaining the planning framework that outlines and explains the Corps' logic and reasoning used to build alternative plans. It describes each step of the planning process, including data sources, considerations, and assumptions that informed identification of the TSP. A management measure is a feature or an activity that can be implemented at a specific site to address one or more planning objectives. Management measures are the building blocks of alternative plans and can be structural and/or nonstructural (Figure 6). A plan is formulated using structural and nonstructural management measures to meet, fully or partially, identified study planning objectives subject to planning constraints. An alternative plan (Figure 7) is one or more management measures functioning together to address one or more objectives.

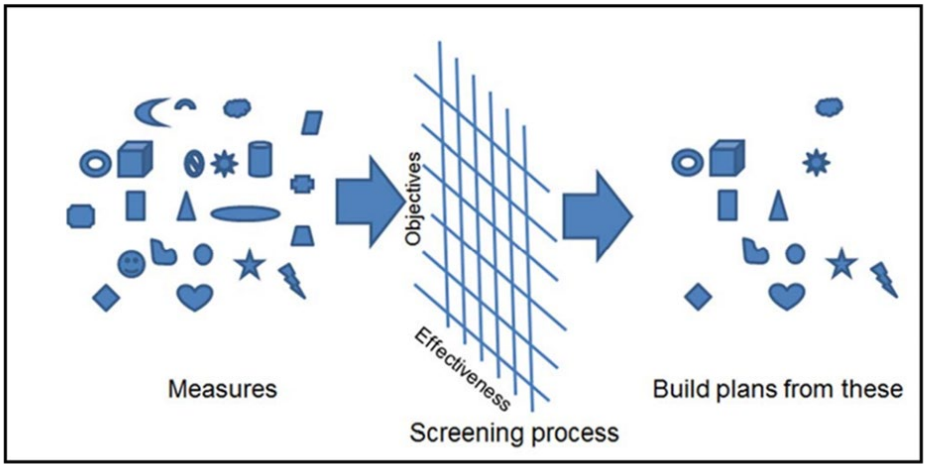

Figure 6: Stylized summary of management measure and alternative plans screening process.

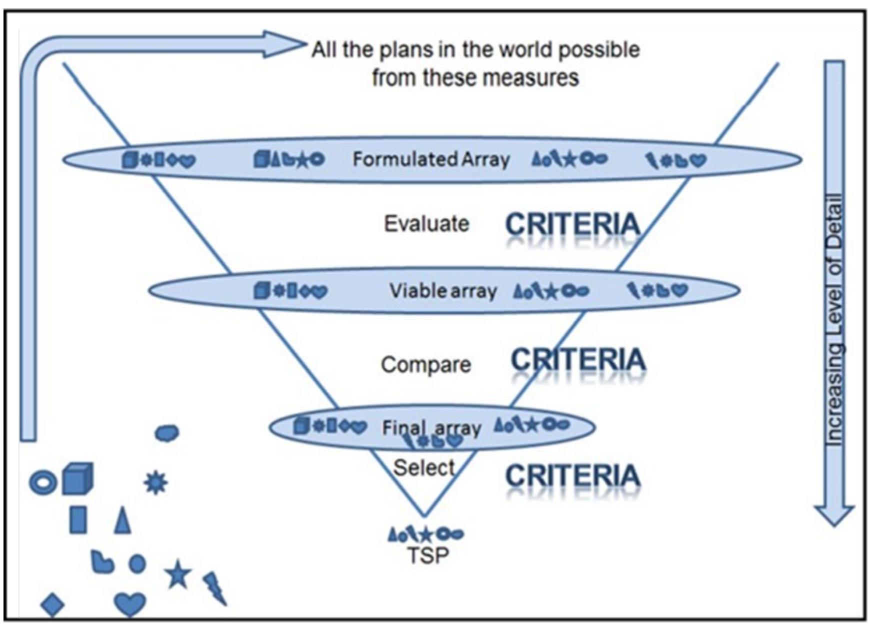

Figure 7: Stylized summary of the alternative screening process.

3.1 Study Strategy

The study strategy consisted of a multi-phased approach. Flood risk reduction requires a distinct investigative strategy using documented flood experience and social vulnerabilities within each impact area. Residents of Horry County experience flooding differently in the upper reaches of the Basin than those in the southern reaches. The framework for plan formulation concentrated on the flood characteristics such as source, direction, severity, and surrounding topography to inventory and position management measures within each impact area.

- **Management Measure Identification:** With input from the non-Federal Sponsor, the affected public, and the study team, measures were developed to target flooding issues for each of the flood impact areas. The study team assessed the potential for each management measure to meet study objectives within each flood impact area.
- **Management Measure Screening:** Screening determined which management measures should be included in the initial array based on their completeness, effectiveness, efficiency, and acceptability, as outlined in the PR&G (USACE, 2013). Additional considerations for screening included technical feasibility, study authority, and other social and environmental considerations.
- **Initial Array Formulation and Evaluation:** The remaining measures were combined into an array of alternatives—combinations of management measures that aim to reduce risk throughout the flood impact areas. The initial array was evaluated based on the following evaluation criteria: effectiveness, efficiency, completeness, acceptability, constructability, environmental effects, real estate impacts, operations and maintenance, estimate cost, and social considerations. As outlined in the PR&G, alternatives were evaluated with respect to the four accounts, the four accounts are NED, Regional Economic Development (RED), Other Social Effects (OSE) and Environmental Quality (EQ). Alternatives in the initial array were screened based on project problems, objectives, opportunities, and constraints. Those measures meeting the criteria were retained for further analysis and comparison.
- **Final Array Formulation and Comparison:** Alternatives retained for further consideration were reformulated into the final array of alternatives. Alternatives within the final array were then evaluated and compared using the same criteria and accounts as discussed above under step 3. The final array was also evaluated and compared with respect to the extent they met the study objectives and to what extent they met the PR&G criteria.

3.2 Screening Criteria

Screening of management measures was conducted iteratively with input from external partners to identify and limit potential concerns and maximize overall efficiency. The first iteration of screening was conducted using existing data and previous study information for the Waccamaw River basin (Section 1.5.3). The second iteration of screening was conducting while developing the measures into the initial array of alternatives.

3.3 Identifying Management Measures Based on Flooding Category

Inundation in upper reaches like Longs and Red Bluff can be categorized as flashy, fluvial tributary flooding. Socastee is subject to inundation for weeks at a time because of the tidal and backwater effects from the Waccamaw, AIWW and Socastee Creek. Meanwhile, the Pee Dee River is a major contributor to flooding in Bucksport. In some cases, measures for Longs and Red Bluff, Conway, Bucksport, and Socastee are independent of one another.

3.4 Management Measures

Identifying plans that meet the study objectives begins with a broad examination of all possible actions. Management measure development relied on an understanding of the problem to determine suitability. Understanding the operational and topographic limitations, public receptivity, and the diversity of flood experiences within Horry County were fundamental for identification of management measures. Knowledge of the area and reliance on past studies were also used to determine what measures should be considered or studied again. As a result, two actions were not carried forward in the study: dredging of the Atlantic Intracoastal Waterway and construction of a channel from the Waccamaw River to the Atlantic Ocean. Implementation of a channel from the mainstem to the ocean was studied previously by USACE and was not recommended to be undertaken by the Federal Government due to additional flooding that would be incurred where the proposed channel would go through (see Appendix A1). Dredging of the Atlantic Intracoastal Waterway (AIWW) would not be effective at considerably reducing riverine flooding. Deepening or widening of a tidally-influenced channel, such as the AIWW, would increase the tidal prism but not increase storage capacity for rainfall and overland flow of water.

Management measures were conceived to function independently. Once all potential management measures were identified, the measures were developed into alternatives.

During the scoping phase of the study, the management measures underwent the first screening exercise using screening criteria developed. The first level of screening the measures revolved around the POOCs. Any measure that did not address the problem or meet the objectives was dropped from further analysis.

3.4.1 Structural

Structural measures are constructed to redirect or impede flood water to reduce the hazard or probability of flooding. This includes structures like gates, levees, floodwalls, channel modifications, or detention ponds.

3.4.2 Nonstructural

Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. Relocation, acquisition, floodproofing, home elevation, and flood warning systems are examples of nonstructural measures.

3.4.3 Natural and Nature Based Features

Natural and nature-based features (NNBF) are landscape features that provide engineering function or restore natural processes to achieve flood risk reduction. Conceptualizing feasible NNBF measures was a challenge for the study area given the hydrologic nature of flooding, low topography, and sweeping floodplain. Those considered included land conservation, wetland restoration, and watershed storage in the form of water farming. Some structural measures that were considered can also be regarded as nature-based solutions. For example, removing flow barriers to restore natural hydrologic flow and construction of river/stream benching.

3.4.4 Measure Applications by Location

In addition to the initial retention of measures based around the POOCs, measures for each location were further refined. The screening rationale was based around constructability, effectiveness as reducing flood risk, environmental impacts, real estate impacts, acceptability (legally acceptable), cost range, and operation and maintenance burden. The subsequent sections outline the area-specific qualities and attributes that informed management measure retention and application.

3.4.4.1 Longs and Red Bluff Measures

For this study, the impact area influenced by riverine flooding near the communities of Longs and Red Bluff in South Carolina is shown in Figure 8.

Figure 8: Longs and Red Bluff Impact Area

Homes and businesses in this flood impact area are spread out among diverse and independent community sectors primarily along HWY 905, HWY 9, HWY 90, Red Bluff Road (also referred to as HWY 31E), Old Reaves Ferry Road, and Lee's Landing Circle. Inundation from flooding disrupts transportation along these roadways which creates evacuation challenges along with accessibility issues which can result in long-term displacement. A large percentage of residents in this community exhibit social vulnerabilities such as age, income, and limited education that place a disproportionate recovery burden post disaster. See management measures in Table 10.

Table 10: Longs/Red Bluff Initial Management Measures

Measure Type	Measure Description	Screening Rationale
Structural		
Levees/Floodwalls	Barriers between the river and vulnerable structures. Levee or floodwall along Buck Creek adjacent to the	Retained.

	Aberdeen community. Levee or floodwall near Rolling Ridge Drive.	
Diversion	Diverts flow from a river, around an area, then back into the river in a controlled manner. Detention and diversion in open placement area near NC/SC border.	Screened out. Significant environmental impacts. Wetland impacts. Significant agency opposition. May impact existing mitigation bank. High cost and high O&M burden.
Channel Modification	River and stream channel engineering (straightening, widening, deepening, or relocating existing stream channels). Channelize the stream from NC/SC border to Veterans Hwy. Modify existing drainage along the power line easement to Tributary 33. Modify Tributary 1 to Cold Water Branch and along Simpson Creek.	Retained.
Benching	Modification to the streambanks to create a benching effect on both sides of the river to connect the river to the floodplain. Low-lying ground adjacent to a river or stream, constructed to allow out of bank flows in areas with limited, non-existing, or disconnected floodplain. Streambank benching along Buck Creek upstream of HWY 905, Tributary 1 to Cold Water Branch, and Simpson Creek.	Retained.
Bank Stabilization	Erosion control features. Streambank stabilization along Buck Creek and Simpson Creek.	Screened out. Ineffective at reducing flood damage. Does not address the problem.
Relief Bridges (Cross Drains)	Installation of culverts or bridges along Highways 501, 501 Business, and 905.	Retained.
Road Elevation	Elevate HWY 9 including connections. Additional culverts to HWY 905 between Todd Swamp and Simpson Creek needed to reduce bottleneck effect.	Screened out. Bridge is high enough to pass the 500-year flood. Not effective at further reducing flood damages. Does not address the problem.
Nonstructural		
Buyouts/Acquisition	Purchase and elimination of flood-prone structures. Acquire property exhibiting the greatest flood risk or within 100-yr floodplain.	Retained.
Elevation	Raising structures for reduction in frequency and/or depth of flooding during high-water events. Elevate homes in low-lying regions such as those along Crystal Lane.	Retained.
Wet Floodproofing	Allowing floodwater to enter the structure by removing vulnerable components from the flood path. Retrofit residential, public, and commercial structures with water-resistant materials in low-lying areas or those subject to frequent flooding.	Screened out. Only recommended for commercial facilities, which are limited within the flood impact area. Ineffective at flood reduction.

Dry Floodproofing	Sealing building walls with waterproofing compounds, impermeable sheeting, or other materials to prevent the entry of floodwaters into damageable structures.	Screened out. Only recommended for commercial facilities, which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Flood Warning Systems	Optimization of the existing flood warning system. Through community flood preparedness planning, evacuation planning, zoning, and land use regulation.	Retained.
Nature-Based		
Natural Material	Use of natural materials to stabilize streambank and retain stormwater along tributaries like Buck Creek, Todd Swamp, and Simpson Creek.	Screened out. Ineffective at reducing flood risk. Does not address the problem.
Watershed Storage	Restricting land usage in low-lying, undeveloped tracts to temporarily store runoff and control dissipation when storm events are expected. Conserve unoccupied land to store water. Also known as water farming, water to be stored in agricultural area near Waccamaw Lane.	Screened out. Limited effective locations identified due to project constraints.

3.4.4.2 City of Conway Measures

For this study, the impact area influenced by riverine flooding near the City of Conway, South Carolina is shown in Figure 9.

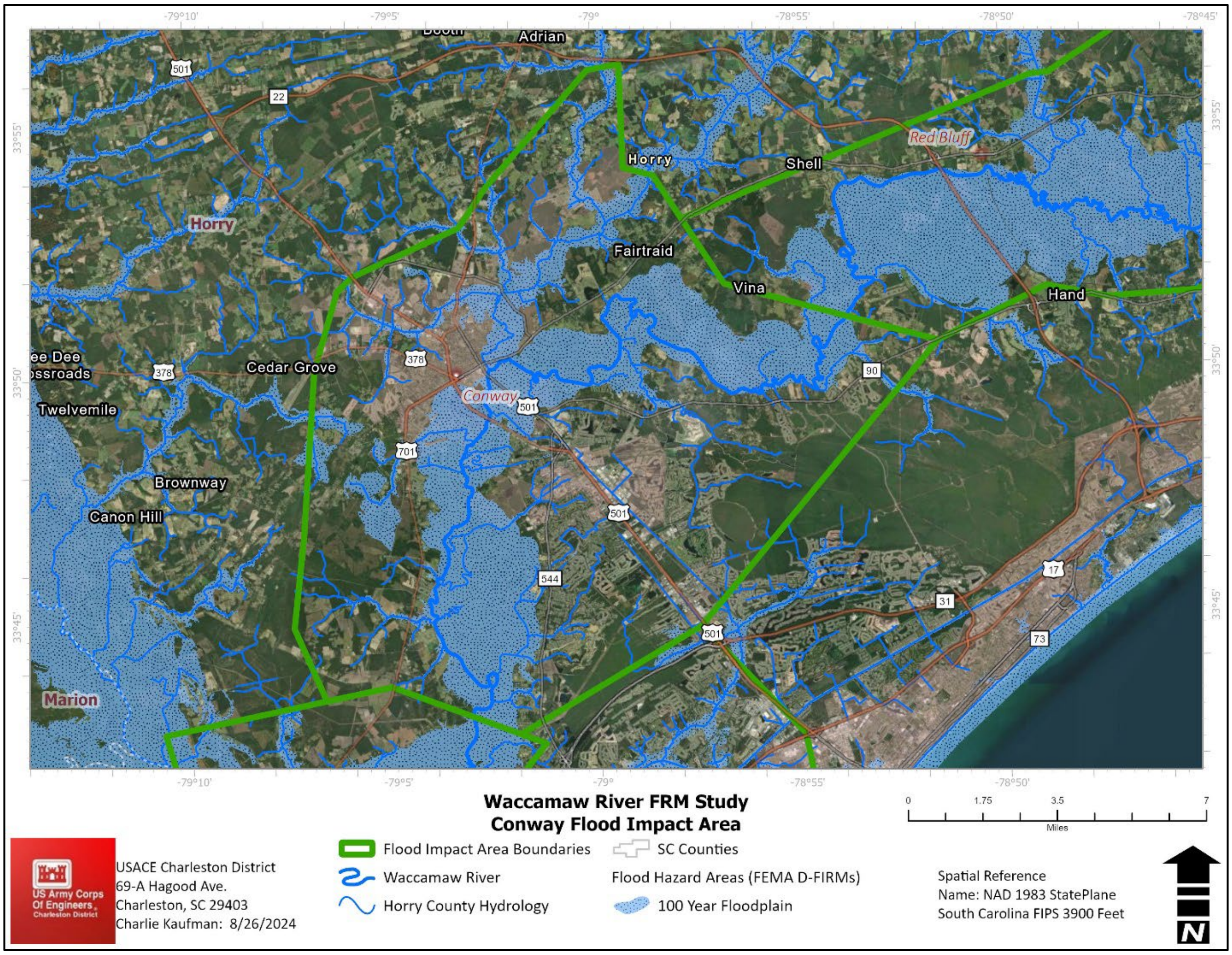

Figure 9: Conway Impact Area

Residences and commercial establishments within this flood impact area scattered across various distinct community sectors, primarily situated along, or in the immediate vicinity of, Historic HWY 501, HWY 501 Business, HWY 905, Mill Pond Road, Sherwood Drive, E Country Club, and the Waccamaw National Wildlife Refuge (NWR). Flooding not only affects the integrity of the natural and built environments, but it reduces reliability of these routes during emergency response, evacuation, and upon return following disaster. Many of Horry County's essential services are stationed in Conway, including Conway Medical Center, Horry County Police Department, Emergency Operating Center, and Emergency Management Office, delaying emergency services for residents in Conway, Socastee, Bucksport, and Mrytle Beach. The infrastructure within the city continues to see economic damages during each storm event. A significant portion of the population in this community faces social vulnerabilities, including factors such as age, income, and limited education, which magnify the challenges of response and recovery following a disaster. Measures identified for the Conway area are identified in Table 11.

Table 11: Conway Initial Management Measures

Measure Type	Measure Description	Screening Rationale
Structural		
Levees/Floodwalls	Barriers between the Waccamaw river and vulnerable structures. Floodwall along Gray Oaks Dr. Ring Levee around 6194 Bear Bluff Rd. Floodwall on outer bend downstream of oxbow on Lees Landing Cir. Floodwall in Riverside drive area on the outer bend. Floodwall along Waccamaw drive.	Screened out. Low efficiency, constructability issues with proximity to high ground.
Dams/Retention	Diverts flow from a river, around an area, then back into the river in a controlled manner. Retention at Lake Busbee. Dam and retention on Thorofare Island. Adding retention to two areas south of Conway near Riverfront Park, and Landing Rd at the oxbow.	Screened out. High cost.
Clear and Snag	Removal of debris and sedimentation to reduce constriction points and return channel to more natural conditions.	Screened out. Ineffective at reducing flood risk. Does not address the problem.
Channel Modification	River and stream channel engineering (straightening, widening, deepening, or relocating existing stream channels). Clear and snag oxbow near Lees Landing. Channelize Steritt Swamp and Steamer Trace Road areas.	Screened out. Low effectiveness at reducing flood risk. Does not address the problem.
Benching	Modification to the streambanks to create a benching effect on both sides of the river to connect the river to the floodplain. Low-lying ground adjacent to a river or stream, constructed to allow out-of-bank flows in areas with limited, non-existing, or disconnected floodplain. Streambank benching along the outer bend of the Waccamaw River near Inman Circle and Crabtree Swamp.	Retained.
Relief Bridges (Cross Drains)	Installation of culverts or bridges along Highways 501, 501 Business, and 905.	Retained.
Bank Stabilization	Erosion control features. Stabilize channelization on Steritt Swamp and Stamer Trace Rd. areas.	Screened out. Not effective at reducing flood risk. Does not address the problem.
Nonstructural		
Buyouts/acquisition	Acquire property exhibiting the greatest flood risk or within 100-yr floodplain, adjacent to Crabtree Swamp, Kingston Lake, and Waccamaw River.	Retained.
Elevation	Elevate homes in floodplains such as those along Waccamaw Circle, Gray Oaks Drive, Busbee Street, Longs Avenue, Chelsea Drive, Murrell's	Retained.

	Landing, Riverfront St, Pitch Landing, Sasser Lane, and Bradford Circle.	
Wet Floodproofing	Allowing floodwater to enter the structure by removing vulnerable components. Retrofit residential, public, and commercial structures with water-resistant materials in low-lying areas or those subject to frequent flooding.	Screened out. Only recommended for commercial facilities, which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Dry Floodproofing	Sealing building walls with waterproofing compounds, impermeable sheeting, or other materials to prevent the entry of floodwaters into vulnerable structures.	Screened out. Only recommended for commercial facilities which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Flood Warning Systems	Optimization of the existing flood warning system. Through community flood preparedness planning, evacuation planning, zoning, and land use regulation.	Retained.
	Nature-Based	
Watershed Storage	Restricting land usage in low-lying, undeveloped tracts to temporarily store runoff and control dissipation when storm events are expected. Water farming along upper Mill Road in agricultural area.	Retained.

3.4.4.3 Bucksport Measures

For this study, the impact area influenced by riverine flooding near the community of Bucksport in South Carolina is shown in Figure 10.

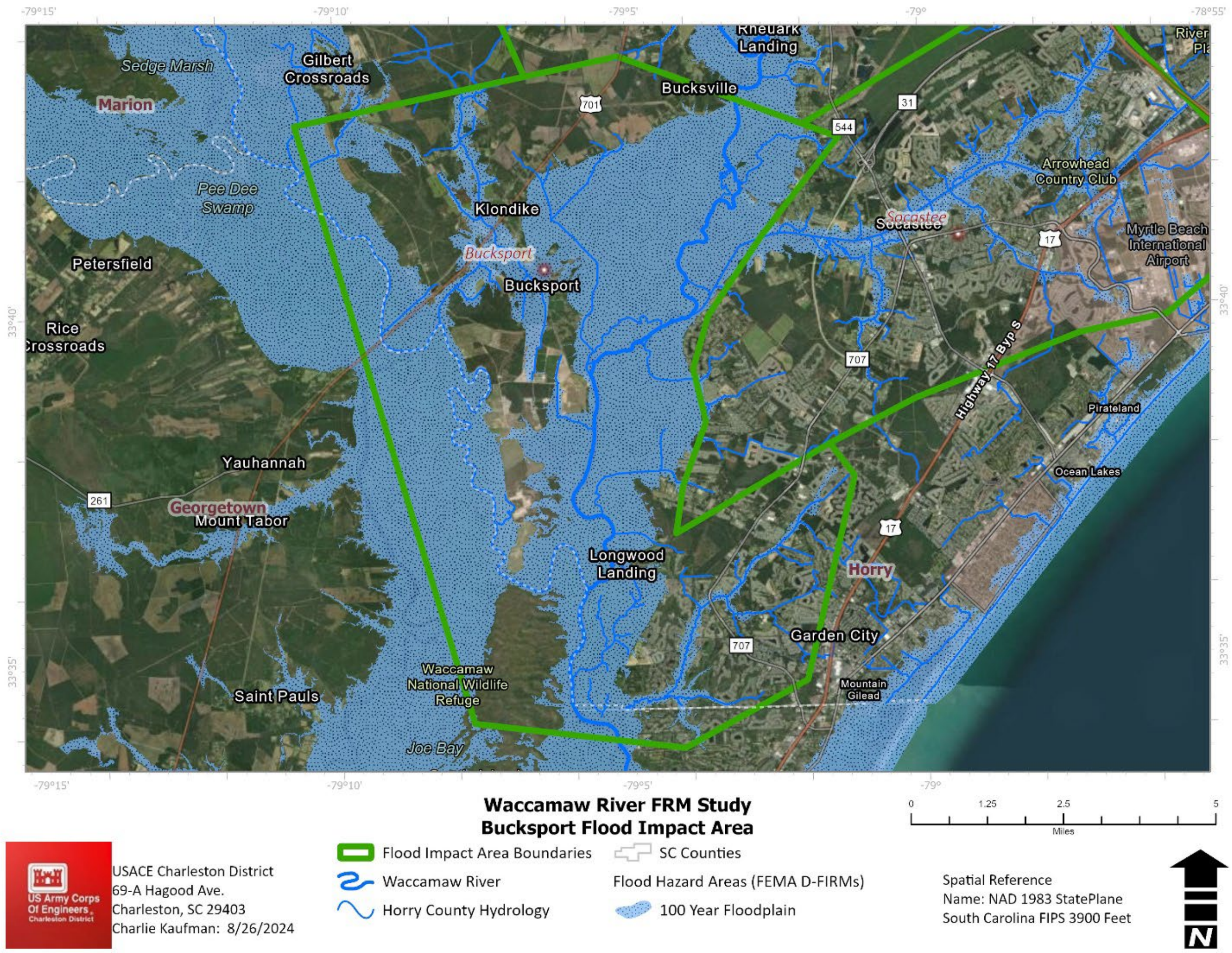

Figure 10: Bucksport Impact Area

Management measures retained for the Bucksport flood impact area (Table 12) relied on the anticipated performance of the Big Bull Landing Project (BBLP). The BBLP is a local effort expected to manage the impacts of flooding from the Pee Dee River by elevating Big Bull Landing Road. Residences and commercial establishments within this area branch off into distinct community sectors almost exclusively from HWY 701, Bucksport Road and the Pee Dee HWY. Flooding affects transportation along these routes, causing evacuation difficulties and accessibility issues after the storm event that can lead to prolonged displacement. However, the BBLP is expected to alleviate those issues. A considerable segment of the community contends with social vulnerabilities, stemming from historical underinvestment and limited economic opportunities.

Table 12: Bucksport Initial Management Measures

Measure Type	Measure Description	Screening Rationale
	Structural	

Levees/Floodwalls	Barriers between the river and vulnerable structures. Levee or floodwall from HWY 701 along Bucksport Road. Flood barrier placed along outer bend of the Pee Dee River where water flows towards the Basin and would tie into the Floodgate.	Screened out due to project constraints. Likely significant environmental impacts. Significant mitigation requirements. Significant resource agency opposition. Critical habitat impacts. Acceptability issues. Moderate O&M burden. Expensive. Public opposition.
Floodgate	Floodgate system to hold flows from the Pee Dee River by restricting backflow through Cowford Swamp. Its function would permit flow from Cowford Swamp to the Pee Dee River, in anticipation of high-water levels, the gate would be closed.	Retained.
Dams/Retention	Diverts flow from a river, around an area, then back into the river in a controlled manner. A capping apparatus on Cowford Swamp to reduce backwater effects from the Pee Dee River. Flood gate to minimize Pee Dee River backwater south of HWY 701.	Screened out. Effectiveness concerns regarding the local topography limitations in the area.
Channel Modification/ Diversion	River and stream channel engineering (straightening, widening, deepening, or relocating existing stream channels). Channelize stream diversion from sandy island to ocean *(*restore the canals that were on the rice plantations*).	Screened out due to project constraints. Significant environmental impacts could impact DOT mitigation bank at Sandy Island. Significant mitigation requirements. Cultural resources impacts to rice plantation features. Critical habitat impacts. Acceptability issues. High O&M. Potential for T&E impacts. High cost.
Road Elevation	Manage cross drainage and backwater from the Pee Dee River by elevating the Pee Dee HWY. Intersecting with the Big Bull Landing Project, as proposed, at Marine Park Road and Port Harrelson Road (Big Bull Landing).	Retained.
	Nonstructural	
Buyouts/acquisition	Acquire property exhibiting the greatest flood risk or within 100-yr floodplain adjacent to Cowford Swamp and Bucksport Road.	Retained.
Elevation	Elevate homes in floodplains along Cowford Swamp and Bucksport Road.	Retained.
Wet Floodproofing	Allowing floodwater to enter the structure by removing vulnerable components. Retrofit residential, public, and commercial structures with water-resistant materials in areas north of Big Bull Landing Road.	Screened out. Only recommended for commercial facilities which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.

Dry Floodproofing	Sealing building walls with waterproofing compounds, impermeable sheeting, or other materials to prevent the entry of floodwaters. Implemented in areas north Big Bull Landing Road subject to less than 3 ft of inundation.	Screened out. Only recommended for commercial facilities which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Flood Warning Systems	Optimization of the existing flood warning system. Through community flood preparedness planning, evacuation planning, zoning and land use regulation.	Retained.
	Nature-Based	
Watershed Storage	Restricting land usage in low-lying, undeveloped tracts to temporarily store runoff and control dissipation when storm events are expected. Water farming adjacent to the water treatment facility in unoccupied agriculture area. Agricultural area currently used for a sod farm.	Retained.

3.4.4.4 Socastee Measures

For this study, the impact area influenced by riverine flooding near the community of Socastee in South Carolina is shown in Figure 11.

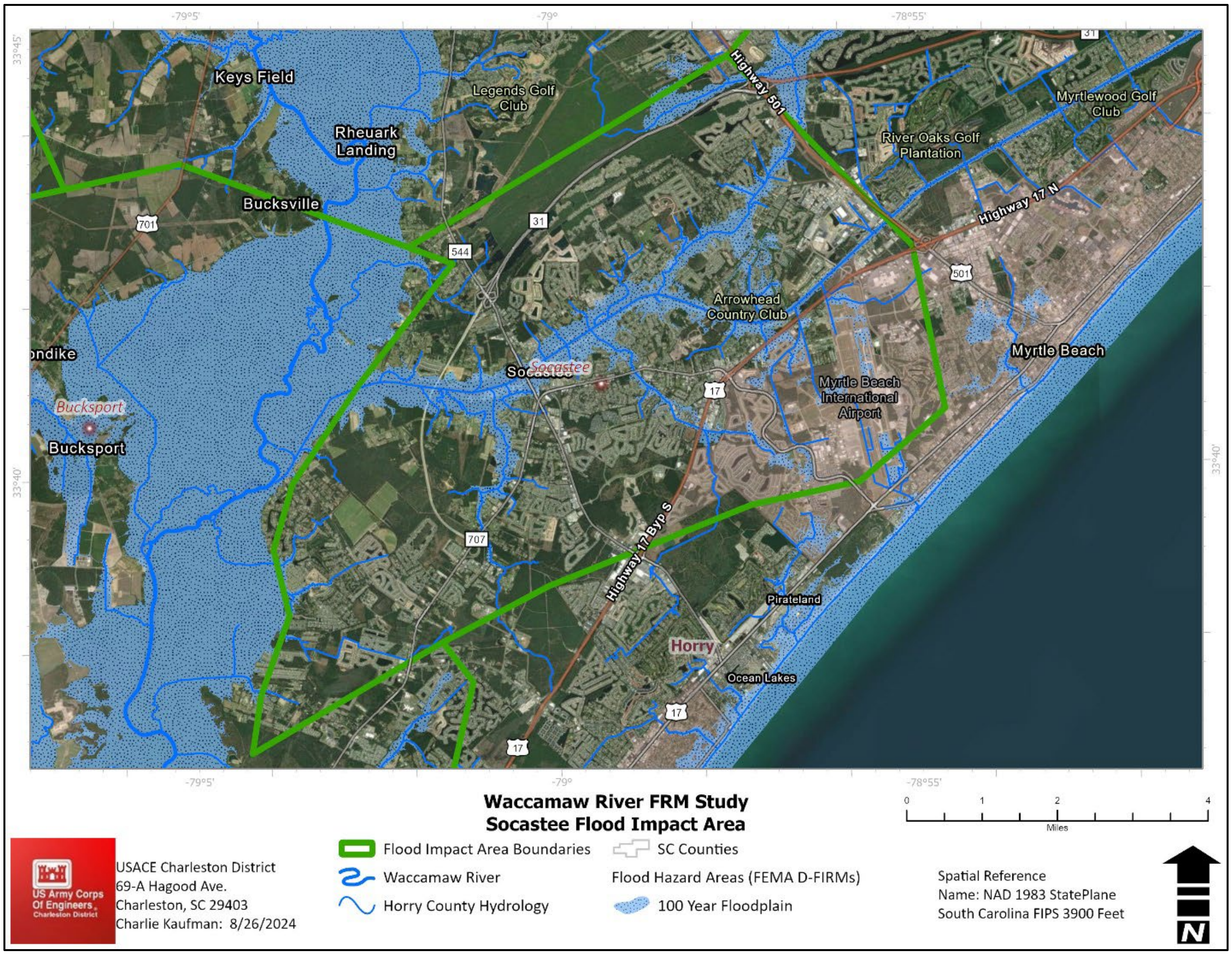

Figure 11: Socastee Impact Area

The Waccamaw River borders Socastee to the Northwest, including Carolina Bays and major tributaries like Socastee Creek. South of Socastee is where Mrytle Beach abuts the Atlantic Ocean. The AIWW runs through Socastee and differentiates coastal and inland waters. This area is heavily populated with residential communities and commercial properties. Management measures (Table 13) in this flood impact area focused on reducing the flooding along the bridge crossings on HWY 544 and HWY 501, which results in accessibility challenges with returning after the storm event and recovery. Residential and commercial infrastructure continues to see economic damages and loss with each storm event.

Table 13: Socastee Initial Management Measures

Measure Type	Measure Description	Screening Rationale
Structural		
Levees/Floodwalls	Barriers between the river/creek and vulnerable structures. Floodwall along the outer bend of Socastee Creek near Forestbrook to HWY 501. Sheet pile wall along the river/creek bend near	Retained.

	Paw Paw Lane and Brook Gate Drive to the powerline easement. A parallel barrier on the east side from HWY 501 to AIWW. Floodwall on both banks of Socastee Creek.	
Diversion	Diverts flow from a river/creek, around an area, then back into the river in a controlled manner. Utilizing land south of the HWY 501 bridge to serve as a detention pond encapsulated by a berm on Burcale Road.	Retained.
Channel Modification	River and stream channel engineering (Straightening, widening, deepening, or relocating existing stream channels). Deepening or dredging the AIWW to carry additional water. Modify tributaries from Racoon Run to Coventry Boulevard.	Retained.
Bank Stabilization	Erosion control features. Streambank stabilization along the AIWW.	Screened out. Existing ICW project on Socastee Creek.
Barrier Removal	Removal of two weir structures currently maintaining water levels.	Retained.
	Nonstructural	
Buyouts/Acquisition	Acquire property exhibiting the greatest flood risk or within 100-yr floodplain like those in Rosewood and Forestbrook.	Retained.
Elevation	Raising structures in place for reduction in frequency and/or depth of flooding during high-water events. Elevate homes in low-lying regions such as those along Crystal Lane.	Retained.
Wet Floodproofing	Allowing floodwater to enter the structure by removing vulnerable components. Retrofit residential, public, and commercial structures with water-resistant materials in low-lying areas or those subject to frequent flooding.	Screened out. Only recommended for commercial facilities which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Dry Floodproofing	Sealing building walls with waterproofing compounds, impermeable sheeting, or other materials to prevent the entry of floodwaters into vulnerable structures.	Screened out. Only recommended for commercial facilities which are limited within the flood impact area. Ineffective at flood reduction. Does not address the problem.
Flood Warning Systems	Optimization of the existing flood warning system. Through community flood preparedness planning, evacuation planning, zoning, and land use regulation.	Retained.

3.4.5 Agency and Public Input

Three public meetings were held early in the study to facilitate external input on the scope of the study. Identical meetings were repeated in locations of the communities affected by riverine flooding, including one in Longs and Red Bluff, one in Bucksport, and one in the City of Conway that was also attended by the Socastee community. Attendees were introduced to the study and engaged with the study team through conversations and participatory mapping to help verify the extent and impacts of flooding, and to provide input on initial measures being considered to reduce flood risks. Attendees were also able to submit input following the meetings through an online form. The input was used to focus the final array of alternatives. Discussions held during public events also established a community baseline from which the Other Social Effects and Environmental Quality accounts were used to evaluate plans.

Federal, state, and local resource agencies provided input on the impacts of each retained management measure. Several considerations like hydraulic changes to habitat, substantial displacement, controlled water-release, and structural development changes stem from these early discussions. See Appendix H for a detailed account of stakeholder engagement.

3.5 Array of Alternatives

An alternative is formulated using structural and nonstructural management measures to meet, fully or partially, identified study planning objectives subject to planning constraints. An alternative plan is one or more management measures functioning together to address one or more objectives. To further refine the potential alternatives, the Corps used factors like constructability, acceptability, and public receptivity to help determine the effectiveness of each alternative. Also, considering the influence of other local flood reduction efforts in the region, best professional judgment was used to screen less-effective components of each alternative to prepare the final array of alternatives. The array continued to be evaluated and adjusted as design parameters began to take form. Each alternative was then evaluated against FWOP conditions, using the four accounts (NED, RED, OSE, EQ).

Full consideration and reporting on nonstructural alternatives are integral to the evaluation of federal investments in water resources. These alternatives are typically the most cost-effective and environmentally friendly options as they alter the use of existing infrastructure or human activities to avoid or minimize adverse changes to existing hydrologic, geomorphic, and ecological processes. These measures can be stand-alone or incorporated with structural measures to create alternatives that achieve the planning objective. The nonstructural measures evaluated for each impact area were elevation, acquisition, dry floodproofing, and wet floodproofing, with some additional based on impact area, as shown above. The effectiveness of a nonstructural measure was determined based on flood depth, flood frequency, structural foundation type, and community vulnerability.

3.5.1 Initial Array of Alternatives

Screening of measures occurred based on the initial qualitative assumptions regarding constructability, effectiveness, environmental impacts, real estate impacts, acceptability (legally acceptable), cost range, and operation and maintenance burden. The remaining measures were combined into an initial array of alternatives for evaluation.

3.5.1.1 Longs and Red Bluff Initial Array of Alternatives

The initial array of alternatives is discussed below in Table 14.

Table 14: Longs and Red Bluff Initial Array of Alternatives

Plans	Plan Type	General Plan Description
LR 1	Flood Barriers	Levee/Floodwall along Buck Creek to protect Aberdeen + Levee/Floodwall near Rolling Ridge Drive
LR 2	Diversion	Channel modification + bank stabilization + wet/dry floodproofing
LR 3	Floodplain Relief and Proofing	Benching upstream of 905, add benching to Trib 1 to Cold Water Branch + wet/dry floodproofing
LR 4	Floodplain Relief and Proofing	Drainage improvements + bank stabilization + benching + wet/dry floodproofing
LR 5	Nonstructural Plan	Elevation + Wet/Dry Floodproofing
LR 6	Comprehensive Plan	Levee/Floodwall along Buck Creek to protect Aberdeen + Levee/Floodwall near Rolling Ridge Drive + Drainage improvements + bank stabilization + benching + wet/dry floodproofing
LRBNS1	Nonstructural	Wet Flood Proofing
LRBNS2	Nonstructural	Dry Flood Proofing
LRBNS3	Nonstructural	Elevation
LRBNS4	Nonstructural	Acquisition
LRBNS5	Nonstructural	Flood warning systems
LRBNS6	Nonstructural	Wet or Dry Floodproofing for the WWTP

3.5.1.2 Conway Initial Array of Alternatives

The initial array of alternatives is discussed below in Table 15.

Table 15: Conway Initial Array of Alternatives

Plans	Plan Type	General Plan Description

C1	Flood Barrier	Floodwall along Grey Oaks + floodwall in Riverdale Drive area + Floodwall along Waccamaw Drive + Floodwall along Lee's Land (these are independent of each other)
C2	Detention and Diversion	Dams/Retention + Elevation + Wet/Dry Floodproofing (Lake Busbee alt)
C3	Floodplain Relief	Clear and Snag + Relief Bridges
C4	Nonstructural Plan	NS only - Elevation + Wet/Dry Floodproofing
C5	Comprehensive Structural and Nonstructural Plan	Clear and Snag + Relief Bridges + Elevation + Wet/Dry Floodproofing + Benching near Inman Circle
CNS-1	Nonstructural	Acquisition
CNS-2	Nonstructural	Structure Elevation

3.5.1.3 Bucksport Initial Array of Alternatives

The initial array of alternatives is discussed below in Table 16.

Table 16: Bucksport Initial Array of Alternatives

Plans	Plan Type	General Plan Description
B1	Flood Barrier	Floodgate
B2	Flood Barrier	Road elevation – PeeDee HWY
B3	Nonstructural Plan	NS only - Elevation + Wet/Dry Floodproofing
BNS1	Nonstructural	Wet Flood Proofing
BNS2	Nonstructural	Elevation
BNS3	Nonstructural	Acquisition
BNS4	Nonstructural	Flood warning systems
BNS5	Nonstructural	Dry Flood Proofing

3.5.1.4 Socastee Initial Array of Alternatives

The initial array of alternatives is discussed below in Table 17.

Table 17: Socastee Initial Array of Alternatives

Plans	Plan Type	General Plan Description

S1	Flood Barriers	Floodwall along Forestbrook + sheet pile wall near the bend of Paw Paw Lane + barrier removal
S2	Diversion and Detention	Detention south of 501 + diversion channel + Elevation + Wet/Dry Floodproofing + barrier removal
S3	Floodplain Relief and Proofing	Barrier removal + expanded benching + Elevation + Wet/Dry Floodproofing + Weir Removal
S4	Comprehensive Structural Nonstructural Plan	Floodwall along Forestbrook + sheet pile wall near the bend of Paw Paw Lane + Detention south of 501 + diversion channel + Barrier removal + expanded benching
S5	Nonstructural Plan	NS only - Elevation + Wet/Dry Floodproofing
SNS – 1	Nonstructural	Wet Flood Proofing
SNS-2	Nonstructural	Dry Flood Proofing
SNS-3	Nonstructural	Structural Elevation
SNS-4	Nonstructural	Acquisition
SNS-5	Nonstructural	Early Flood Warning

The Corps continued to evaluate the array of alternatives for each location as design parameters began to take form. Criteria developed for evaluation of the initial array included constructability, effectiveness, environmental, real estate impacts, cost efficiency, and O&M burden. Each plan in the initial array was assessed under the criteria using a ranking system 1 to 3 and noting additional assumptions of impacts or uncertainties with implementation of the alternative.

3.6 Hydrology and Hydraulics (H&H) Model

To identify and corroborate flooding concerns in the project area, models were developed to better understand how rainfall events impacted the flow of water through the Waccamaw River watershed, including potential flooding risks and the effectiveness of mitigation measures. With hydrological modeling, insights into watershed dynamics allowed the Corps to identify locations that would most benefit from the study. Additionally, the model informed decision-making for water resource management, flood forecasting, and infrastructure planning.

A hydrologic model was developed to assess existing conditions in the Waccamaw River basin, using the USACE Hydrologic Engineering Center Hydrologic Modeling

System (HEC-HMS) software, version 4.10. Given the Waccamaw River basin's large size and number of tributaries, as well as variety in urban landscape, it was decided that the rain-on grid feature in the USACE HEC-HMS software, version 4.10 would best serve the intent in formulating local flood risk management measures. A hydrologic sensitivity analysis was conducted to see which hydrologic model would replicate the hydrologic features of the Waccamaw River Watershed. One comprehensive basin model was developed for hydrologic assessment along the mainstem of the Waccamaw River as well as the following headwaters and major tributaries: Pee Dee River, Little Pee Dee River, Buck Creek, Socastee Creek, Simpson Creek, Crabtree Swamp, and Atlantic Intracoastal Water Way. The large footprint of this model would provide the ability to evaluate basin-wide flooding concerns and associated opportunities. Its development priority would also help direct future modeling needs as plan formulation progressed through the feasibility process.

Based on sponsor and community input at the onset of this feasibility study, as well as recently completed/ongoing related basin studies, several specific locations within the study area were highlighted. The availability of existing subbasin modeling also provided either a good starting point or in one instance, a significant modeling effort that already detailed existing and future without project conditions. Furthermore, the highly urban characteristics of some of these subbasins created inconsistencies in the modeling approach assumed for the larger basin-wide model. Complex watersheds such as Crabtree Swamp required much smaller subbasin delineations in the area to account for the high density of streams, impoundments, and confluences. A basin wide HEC-HMS model was developed in parallel with the rain on grid approach encompassing the four areas of interest: Socastee, Longs/ Red Bluff, Conway, and Bucksport.

The Rain on Grid approach, also known as the Rainfall-Runoff Grid approach, is a method used in hydrological modeling to simulate rainfall and its resulting runoff within a specific area. This approach is often implemented using HEC-RAS. In the Rain on Grid approach, the study area is divided into a grid of smaller cells, with each cell representing a portion of the watershed. Rainfall data, typically obtained from rain gauges or radar, is applied to each grid cell individually. This allows for spatially distributed rainfall inputs, accounting for variations in precipitation across the watershed.

HEC-RAS utilizes the Rain on Grid approach to simulate how rainfall is transformed into runoff, considering factors such as infiltration, surface runoff, and channel flow. The software calculates runoff volumes and flow rates for each grid cell, accounting for factors such as land use, soil type, topography, and vegetation cover. By simulating rainfall and runoff at a high spatial resolution, the Rain on Grid approach provides more detailed and accurate representations of hydrological processes compared to traditional lumped models.

A H&H analysis was developed for each of the final alternatives in Section 3.7. See Appendix A for detailed analysis on modeling calibration and validation.

3.7 Final Array of Alternatives

This section details the final array of alternatives, including the NAA, for each location within the project area.

3.7.1 No Action Alternative

NEPA requires agencies to always describe and analyze a "No Action" alternative (NAA) in as part of the alternatives analysis in NEPA documents. In the context of this study, the interpretation of a NAA is equivalent to the Council on Environmental Quality's (CEQ) second interpretation of "no action" from its *Forty Most Asked Questions Concerning CEQ's National Environmental Policy Act Regulations*, which "...*would mean the proposed activity would not take place, and the resulting environmental effects from taking no action would be compared with the effects of permitting the proposed activity or an alternative activity to go forward.*" (46 Fed. Reg. 18026). The NAA analysis provides a benchmark to allow decision makers and the public to compare the levels of environmental effects of the alternatives.

Under the NAA, communities of Horry County, South Carolina, would continue to suffer flood losses and experience life safety risk to residents, businesses, and transportation routes. Tidal effects, flat topography and low elevations result in slow subsidence when high water events occur. As such the NAA would not equip communities to better address frequent riverine and storm event flooding and continue to isolate densely populated communities along the coast.

3.7.2 Longs and Red Bluff Final Array of Alternatives

Table 18 and Figure 12 indicate the final array of alternatives for this location.

Table 18: Longs/Red Bluff Array of Alternatives

Plans	**Plan type**	**Brief Plan Description**
LR-NA	No Action	No Action
LR-1	Flood Barriers	Levee/Floodwall along Buck Creek at Rolling Ridge and Cox Lane
LR-3	Floodplain Relief	Simpson Creek Benching, Relief Bridges
LR-6	Comprehensive	Levee/Floodwall along Buck Creek and Rolling Ridge, Benching, Relief Bridges
LRBNS-3	Nonstructural	Structure Elevation
LRBNS-4	Nonstructural	Acquisition

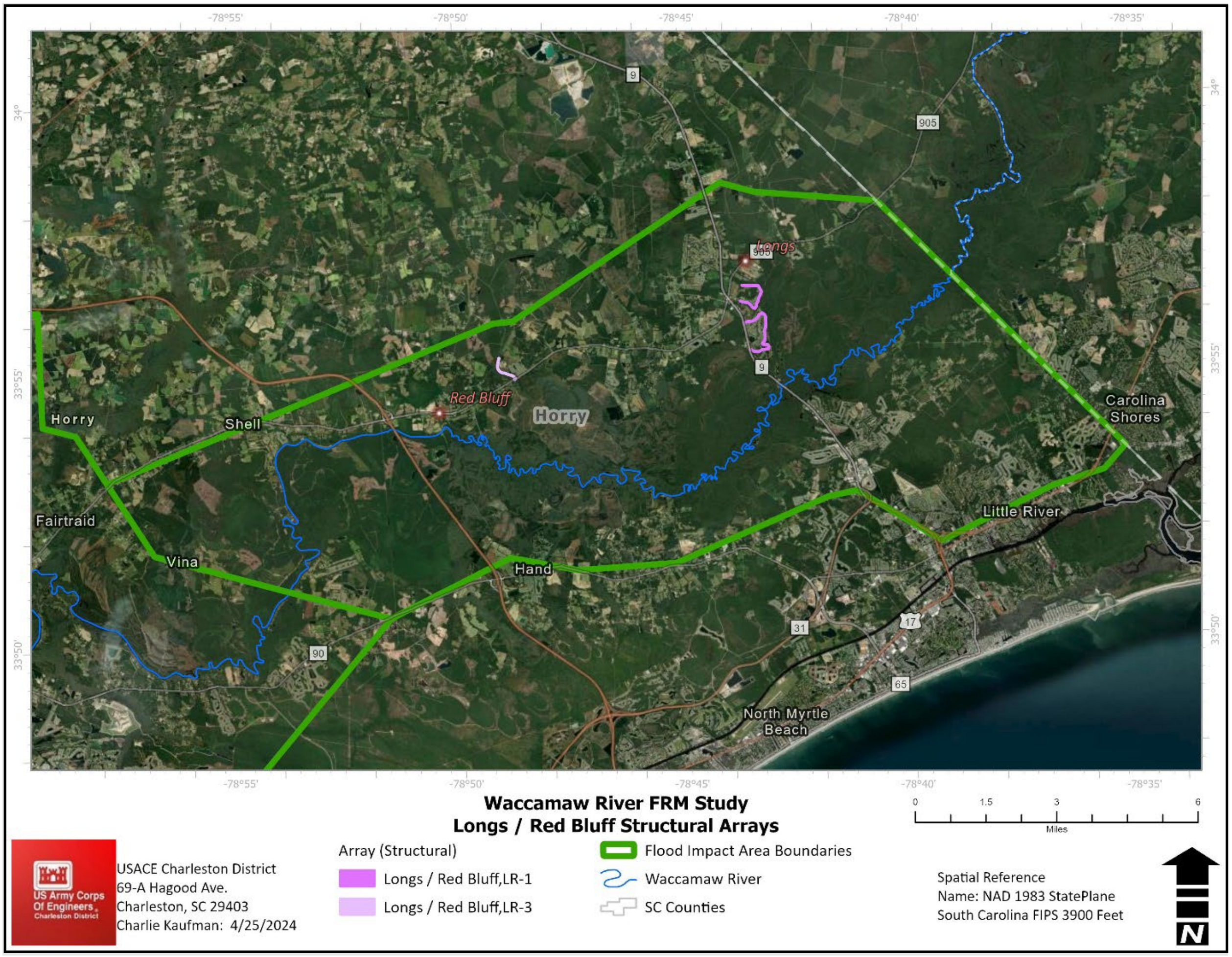

Figure 12: Longs/Red Bluff Structural Array of Alternatives

- **LR-1 Flood Barrier**

A Flood Barrier would be either a sheet pile floodwall or earthen levee, along the right bank of Buck Creek, running from the Aberdeen community northward to Rolling Ridge Drive. The estimated height of the floodwall or levee would range from 5 to 11 feet and span approximately 2 miles in length. For maintenance purposes, a perpetual 25-foot-wide easement is required on each side of the wall from the centerline, along with a temporary 10-foot-wide easement during construction, totaling 70 feet in width. In areas where the wall runs parallel to a waterway, the entire 70-foot width will be allocated on one side for construction purposes. Additionally, drainage components such as culverts, gates, and pumps will be integrated with the floodwall or levee to mitigate internal flooding issues, such as scouring.

- **LR-3 Floodplain Relief**

Streambank benching using excavation methods upstream of HWY 905 along Simpson Creek would open the channel and allow stream connection back to the floodplain surrounding Simpson Creek. Benching extent would be determined if the measure was included in the final array.

Relief Bridges are proposed culverts/water connections in areas where conveyance is restricted by roadways, bridges, or similar abutments. These drainage improvements will be placed along the Hwy 905 and Simpson Creek crossing. Improvement activities include clearing streambanks of debris, woody vegetation, downed trees, etc., under the bridge and installing culverts in the stream and within the abutments.

- **LR-6 Comprehensive**

This alternative was formulated to be comprehensive, containing the structural components of both LR-1 and LR-3 along with LRBNS-3, nonstructural plan. In summary this comprehensive alternative includes sheet pile floodwall or earthen levee along Buck Creek, streambank benching along Simpson Creek, relief bridges at the HWY 905 and Simpson Creek crossing, and elevation and acquisition of eligible structures.

- **LRBNS-3 Nonstructural Structural Elevation**

Residential structures within the 2% AEP (50-yr) floodplain subject to 1-3ft of structural damage from first floor elevation are eligible for elevation. This would apply to numerous structures that could be elevated above the 100-yr Base Flood Elevation (BFE) plus 2ft based on local building ordinance . This plan excludes communities where flood risk reduction would already occur through structural means such as Aberdeen Country Club and Buck Creek area where a flood barrier would provide this. Eligible structures include, but are not limited to (subject to FWOP flood depths) the residences around the Dusty Lane to Loop Circle and south around Star Bluff Crossroads.

- **LRBNS-4 Nonstructural Acquisition**

Structures which are either subject to flood events more frequent than 2% AEP flooding (50-yr events), lack structural suitability for elevation, or are subject to greater than 4 ft of flooding during a 100-yr event are eligible for acquisition. This may apply to at least 43 structures. This plan excludes communities subject to flood risk reduction through structural means such as Aberdeen Country Club and Buck Creek.

3.7.3 Conway Final Array of Alternatives

Table 19 and Figure 13 indicate the final array of alternatives for this location.

Table 19: Conway Array of Alternatives

Plans	Plan Type	Brief Plan Description
C-NA	No Action	No Action
C-3	Structural	Relief Bridges
C-5	Comprehensive	Relief Bridges, Structure Elevation, and Acquisition
CNS-1	Nonstructural	Acquisition
CNS-2	Nonstructural	Structure Elevation

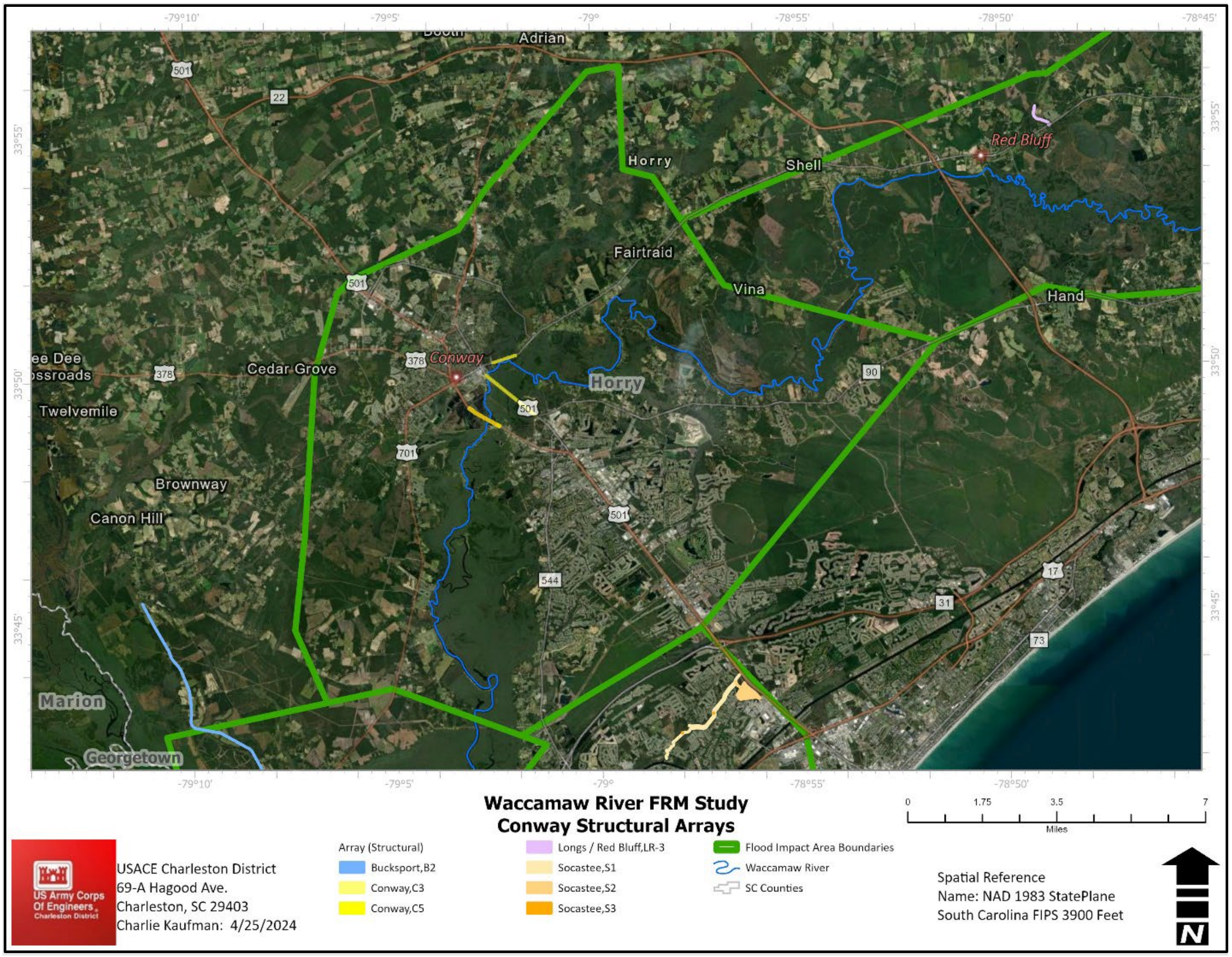

Figure 13: Conway Structural Array of Alternatives

- **C-3 Relief Bridges**

Relief bridges/ cross drain culverts at 501 Business, 501 Bypass, and 905 to increase conveyance through these areas where potential bottlenecking is occurring. Edward E. Burroughs relief bridges would most likely consist of culverts due to the proximity of the existing bridge. The proposed protections include decreasing the flood depths and size of the floodplain upstream of the Edward E. Burroughs highway along the Waccamaw River. This relief bridge would convey more water away from the inundated zone. It is expected to decrease the water depths and possibly decrease the size of the floodplain upstream of Highway 501 Business that crosses the Waccamaw River. Potential interference with a railroad crossing at 905 would require mitigation. Installation of drainage infrastructure on Hwy 501 is proposed, which would consist of a new bridge and culverts to allow more flow and will be dependent on space and SCDOT requirements. Environmental impacts associated with stream encroachment and removing fill from the streambanks apply.

- **C5 – Comprehensive Plan**

This alternative was formulated to be comprehensive, containing the structural components of C-3 and the nonstructural retained measures in CNS1 and CNS2. In summary, this alternative includes relief bridges installed at three locations around the City of Conway, elevation of eligible residential structures, and acquisition of eligible residential structures.

- **CNS1 – Acquisition**

Structures subject to more frequent flooding (50-yr events), that lack structural suitability for elevation, or flood greater than 4ft during a 50-yr event are eligible for acquisition. This alternative could apply to at least 210 structures. Structures eligible for acquisition are on or near Gray Oaks Drive, Wildhorse Drive, Pitch Landing Drive, Lees Landing Circle, Jackson Bluff Road, Bradford Circle, Riverside Drive, Riverfront N and S, and Sasser Ln. This alternative would Provide flood risk reduction to smaller residential communities throughout Conway.

- **CNS2 - Elevation**

Structures and utilities within the 50-yr floodplain subject to 1-3ft of structural damage are eligible for elevation. This alternative could apply to at least 191 structures. Structures eligible for elevation are on or near Gray Oaks Drive, Wildhorse Drive, Pitch Landing Drive, Lees Landing Circle, Jackson Bluff Road, Bradford Circle, Riverside Drive, Riverfront N and S, and Sasser Ln. Structures will be elevated above the 100-yr BFE including 2ft of additional height per county ordinance. This plan excludes communities subject to flood risk reduction through structural means. Residential structures already elevated to the appropriate height or to be acquired through FEMA buyouts will not be eligible for nonstructural measures under this plan. This alternative would provide flood risk reduction to smaller residential communities throughout Conway.

3.7.4 Bucksport Final Array of Alternatives

Table 20 and Figure 14 indicate the final array of alternatives for this location.

Table 20: Bucksport Array of Alternatives

Plans	Plan Type	Brief Plan Description
B-NA	No Action	No Action
B-1	Structural	Floodgate
B-2	Structural	Pee Dee Hwy Elevation
BNS-2	Nonstructural	Structure Elevation
BNS-3	Nonstructural	Acquisition

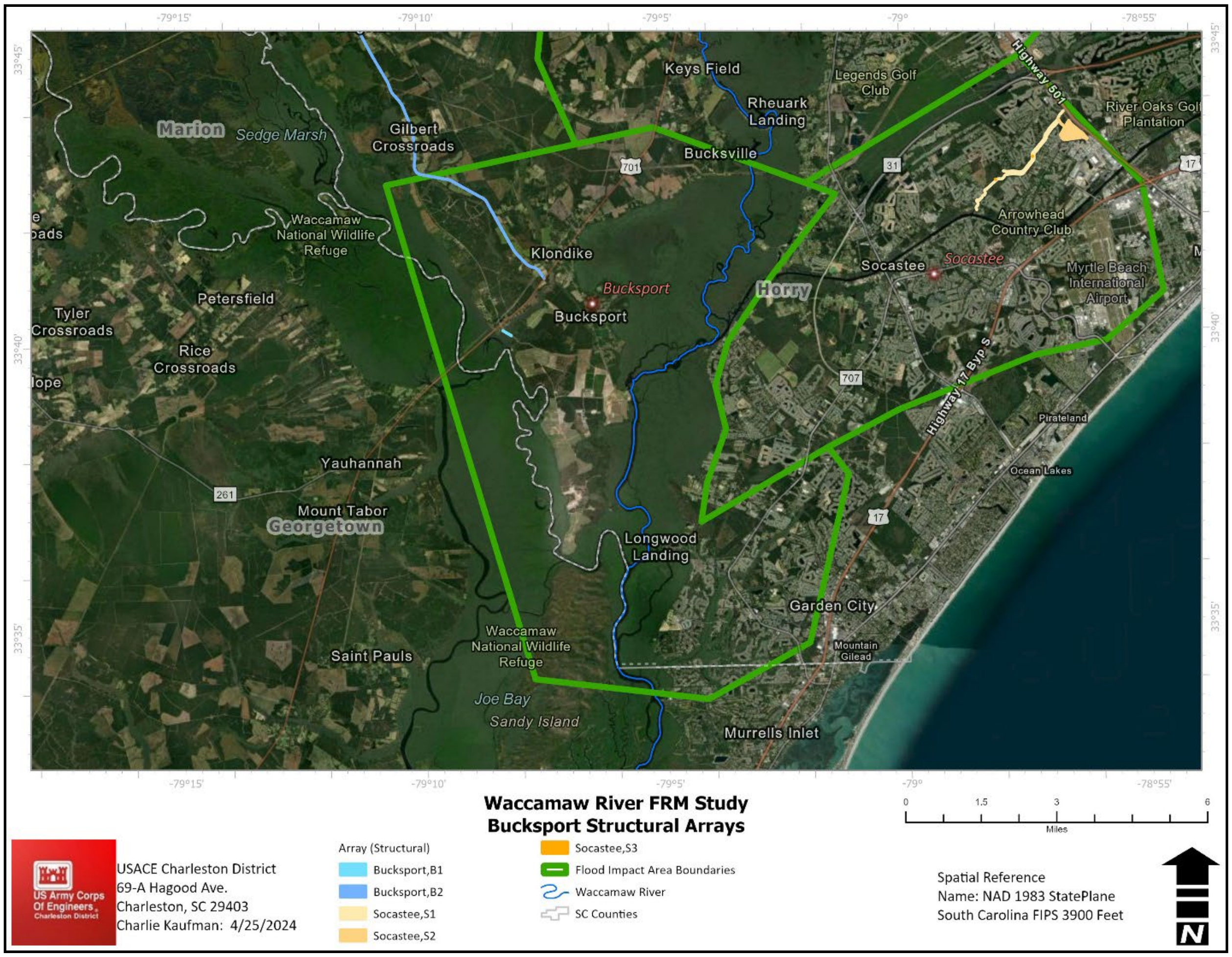

Figure 14: Bucksport Structural Array of Alternatives

- **B1 - Floodgate**

This plan involves installation of a floodgate system parallel to the confluence of Cowford Swamp and Bull Creek. A floodgate is expected to slow backwater to the Pee Dee River by restricting backflow through Cowford Swamp. Its function would permit flow from Cowford Swamp to the Pee Dee River, but in anticipation of high-water levels, the gate would be closed. Under normal conditions the flap gate would remain open. Situated between 701 HWY and Big Bull Landing on Marine Park Road, this structure is estimated to be 0.6 miles in length and 13ft above surface water levels. This alternative provides flood risk reduction to residential communities on or near Frazier Road, Bucksport Road, and Railroad Drive.

- **B2 – Pee Dee Hwy Elevation**

Elevating the Pee Dee Hwy provides reliable access to residents during flooding events and minimizes overflow from the Pee Dee River. Currently the Pee Dee Hwy has significant low points that allow flood water to overflow and cover the road, preventing ingress and egress during flood events. This plan involves elevating approximately 7 miles of the Pee Dee Hwy, starting at US 701 Hwy, and terminating at Pauley Swamp Road. To reduce flood risk for a 1% AEP event the Pee Dee Hwy would need to be raised by 3-7ft (existing road elevation varies). Auxiliary drainage features to minimize pooling east of the roadway may be required.

- **BSN-2 Elevation**

Structures and utilities within the 50-yr floodplain subject to 1-3ft of structural damage are eligible for elevation. This alternative could apply to approximately 10 structures. Structures eligible for elevation are located throughout the community and rural areas of Bucksport. Structures will be elevated above the 100-yr BFE including 2ft of additional height per county ordinance. This plan excludes communities subject to flood risk reduction through structural means. Residential structures already elevated to the appropriate height or to be acquired through FEMA buyouts will not be eligible for nonstructural measures under this plan. This alternative would provide flood risk reduction to smaller residential communities throughout Bucksport.

- **BSN-3 Acquisition**

Structures subject to more frequent flooding (50-yr events), that lack structural suitability for elevation, or flood greater than 4ft during a 50-yr event are eligible for acquisition. This alternative could apply to at least 10 structures. Structures eligible for acquisition are on or near Mill Pond Road, Chamberlin Road, Marine Park Road, Henrietta Bluffs, and Shadow Moss Place. Providing flood risk reduction to smaller residential communities throughout Bucksport.

3.7.5 Socastee Final Array of Alternatives

Table 21 and Figure 15 indicate the final array of alternatives for this location.

Table 21: Socastee Array of Alternatives

Plans	Plan Type	Brief Plan Description
S-NA	No Action	No Action
S-1	Structural	Floodwall and Barrier Removal
S-2	Structural	Detention Pond with Channel to Socastee Creek
S-3	Structural	Barrier Removal
S-4	Comprehensive	Floodwall, Barrier Removal, Detention Pond with Channel to Socastee Creek, and Structure Elevation
SNS-3	Nonstructural	Structure Elevation
SNS-4	Nonstructural	Acquisition

Figure 15: Socastee Structural Array of Alternatives

- **S1 – Floodwall and Barrier Removal**

Two sheet pile floodwalls along the outer banks of Socastee Creek. Perpendicular to Edwards Burrough Hwy these floodwalls are estimated to be 5-9ft in height; with the right bank extending ~2.3 miles and the left bank extending ~3 miles. From the center line of the wall on each side, a perpetual 25-foot-wide easement is required for maintenance, plus a 10-foot-wide temporary easement during construction, totaling 70 feet. Pump stations would be required in conjunction with the flood wall/levee to alleviate interior flooding. These features are positioned, either permanently or temporarily, at the low points along the structure.

Barrier removal involves the removal of the two existing weirs on the Socastee Creek Federal Project. Water currently flows around the weirs, eroding the area and causing damage to the weir structures. This measure would increase conveyance in the adjacent flood impact area.

- **S2 – Detention Pond with Channel to Socastee Creek**

On the left bank of Socastee Creek, immediately south of Edward E Burroughs Hwy, a detention pond impounded by levees/flood barriers is proposed. This plan involves occupying up to 55-acres. An existing tributary will be channelized to act as a diversion channel for a passively controlled release into Socastee Creek. Depth of the detention pond is unknown currently. Given the existing stream and lower topography, this plan may include pumps and or gates features to prevent backwater spillage.

- **S3 – Barrier Removal**

This alternative involves removing the two existing weirs on the Socastee Creek Federal Project. Weirs were originally constructed to maintain a certain ground water level to mitigate loss of wetland area. With increased development in this area, weirs may not be needed to maintain water level. Water currently flows around the weirs, eroding the area and causing damage to the weir structures. This measure would increase conveyance in the adjacent flood impact area.

- **S4 – Comprehensive Plan**

This alternative was formulated to be comprehensive, containing the structural components of S1, S2, and S3 along with the nonstructural retained measures in SNS3 and SNS4. In summary this includes a floodwall, detention pond with channel to Socastee Creek, barrier removal, elevation, and acquisition of eligible residential structures.

- **SNS3 – Elevation**

Structures and utilities within the 50-yr floodplain subject to 1-3ft of structural damage are eligible for elevation. This may apply to up to 275 structures. Structures will be elevated above the 100-yr BFE including 2ft of additional height per county ordinance. Nonstructural elevation is proposed along the intracoastal waterway, on the south side of the waterway. Nonstructural elevation is proposed from Malibu Lane on the east side to Carolina Bays Pkwy on the west, extending south to Socastee Blvd. On the northern side of the intracoastal water way nonstructural elevation is proposed to start at Riverside Drive to the east and ending at Carolina Bays Pkway on the west end of the project, extending north to Peachtree Road. This plan excludes communities subject to flood risk reduction through structural means proposed above.

- **SNS4 – Acquisition**

Structures subject to more frequent flooding (50-yr events), that lack structural suitability for elevation, or flood greater than 4ft during a 100-yr event are eligible for acquisition. This alternative may apply to 121 structures. This plan excludes communities subject to flood risk reduction through structural means.

3.8 Plan Evaluation

This section will include a display of costs and benefits for National Economic Development (NED) or National Ecosystem Restoration (NER) plan evaluation.

3.8.1 Principles, Requirements, and Guidelines Criteria

In addition to previously discussed environmental justice and environmental effects, alternatives were also evaluated based on the four evaluation criteria outlined in the PR&G (USACE, 2013) and described below:

- **Completeness:** The extent to which the measure provides and accounts for all necessary investments or other actions to ensure the realization of the planned effects. Alternatives being evaluated represent complete alternatives in that they account for all necessary investments and actions required to ensure realization of the planned effects. However, structure elevation is voluntary and participation rate could affect overall benefit accrued by each action alternative.
- **Effectiveness:** The extent to which each measure would contribute to planning objectives. Effectiveness does not mean all objectives need to be addressed. Any recommended plan, in this case, reduces flood damages and increases evacuation route reliability within the project area.
- **Efficiency:** The extent to which each alternative is a cost-effective means of alleviating the specified problems and realizing the specified opportunities, consistent with protecting the Nation's environment. The environmental effects of each alternative are presented in detail in Section 4 of this report. The net annual economic benefits and benefit to cost ratios (BCR)s for all the final array of alternatives were developed and discussed further in Section 5.1. The NAA would not be efficient, while no federal dollars would be spent, the problem would not be solved.
- **Acceptability:** The workability and viability of the measure with respect to acceptance by state and local entities and the public and compatibility with existing laws, regulations, and public policies. The alternatives are compatible with existing laws, regulations, and policies. The nonstructural alternatives of elevation and/or acquisition would not be supported by the non-federal sponsor. These plans were carried forward through evaluation and comparison to ensure full formulation. The NAA would be considered acceptable.

3.8.2 Documentation of Benefits

In accordance with USACE Policy Directive, Comprehensive Documentation of Benefits in Decision Document, dated January 5, 2021, the remaining alternatives were evaluated and further refined. This refinement identified the plan that maximizes net NED benefits and a comprehensive benefits understanding for the final array of alternatives that identifies the plans that maximize total benefits across all benefits categories (i.e., NED, RED, OSE, and EQ). A summary of comprehensive benefits for the final array of alternatives is documented in Section 5.1.

3.8.3 Environmental Justice

In addition to the four criteria outlined in the PR&G (USACE, 2013), the study team identified three additional evaluation criteria, including Environmental Justice (Resilience), Environmental Justice (Community Cohesion), and Environmental Effects.

3.8.4 System of Accounts

Alternatives were assessed and compared using the four accounts established in the PR&G (USACE, 2013), which are described below in Table 22.

Table 22: USACE Four Accounts

Account	Definition	Analysis/Metrics
National Economic	The NED account represents the change in the economic	The NED account was assessed using the Hydrologic Engineering Center's

Development (NED)	value of the national output of goods and services that result from each alternative.	Flood Damage Reduction Analysis (HEC-FDA) software 4.10. Metrics include net annual economic benefits and BCR.
Regional Economic Development (RED)	The RED account characterizes changes in the distribution of regional economic activity that result from each alternative.	The USACE Regional Economic System (RECONS) was used to estimate regional economic impacts and contributions associated with the various alternatives. Metrics include increases in employment and labor income.
Other Social Effects (OSE)	The OSE account characterizes effects that are relevant to the planning process but not reflected in the other three accounts.	Qualitative/semi-quantitative assessment of effects on life safety risk. Semi-quantitative assessment of benefits to resiliency and community cohesion within reaches identified as socially vulnerable using the EJScreen and CEJST Tools.
Environmental Quality (EQ)	The EQ account characterizes non-monetary effects (positive or negative) on important natural and cultural resources that result from each alternative.	Qualitative analysis that considers benefits and impacts to aquatic and terrestrial resources.

A detailed analysis of how each alternative met the four accounts is found in Section 5.1.6.

3.8.5 Risk and Uncertainty

Alternatives were also evaluated with respect to remaining risk and uncertainty. The following sections detailed residual risk and uncertainty associated with the final array of alternatives.

3.8.5.1 Residual Risk

Residual risk represents existing, future, or historical risk that remains or might remain after an alternative has been implemented. Each alternative provided potential benefits to specific areas within the project location; however, no one alternative could address flooding throughout the entire study area.

Additionally, accelerated rates of sea level rise are anticipated to impact the study area in the future. This increase in sea level rise could further increase water surface elevations under the full range of flood events and result in additional residual risk.

3.8.5.2 Uncertainty

Identifying and managing risk is critical to making informed planning decisions in the face of uncertainty. However, some level of uncertainty will remain following any decision. Understanding and characterizing this remaining uncertainty is also critical as it can affect the outcome of any decision.

4.0 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

The purpose of this section is to describe the future condition forecasted with implementation of evaluated alternatives. As in section 2, these analyses will be described in terms of the following:

- Land Use
- Air Quality
- Climate
- Geologic Resources
- Water Resources
- Biological Resources
- Cultural Resources
- Recreation
- Transportation
- Socioeconomics and Environmental Justice
- Hazardous, Toxic, and Radioactive Waste
- Aesthetics

Since some alternatives include a single measure, while others considered include a combination of measures, environmental consequences related to individual measures are described below while combinatorial alternatives are assumed to be cumulative in nature in each flood impact area.

Any structural measures which are intended to influence hydrology could have unintended site-specific impacts such as increased flood durations and/or extents and would require further investigation once all other considerations have been made. Likewise, implementation of some alternatives may require mitigation and adaptive management plans while others would not. These impacts are generally discussed here but would be evaluated in greater detail upon selection of an alternative.

4.1 Land Use

4.1.1 No Action

It is expected that over the period of analysis the NFS and other governing bodies (e.g., State of South Carolina), government agencies (e.g., USFWS, SCDNR) and organizations (e.g., The Nature Conservancy, Ducks Unlimited) will address flood risks throughout Horry County where resources allow outside Federal assistance by USACE on this project. These potential flood risk management actions (e.g., conversion of flood-prone residences to conservation tracts or NWR lands, construction of flood-abatement structures) are expected to result in similar impacts to land use as would alternatives considered here (i.e. direct effects of construction footprints, changes in land covers flooded), but on a scale relative to that allowed by resources available.

4.1.2 Longs/Red Bluff

4.1.2.1 LR1

Construction of floodwalls around the Aberdeen Country Club and suburban residences near Cox Ln in the Longs/Red Bluff flood impact area would directly impact about 27 acres overlapping with the construction footprint. Land covers impacted would include predominately developed open space (11 acres) and woody wetlands (10 acres) but would also include some evergreen forest and low intensity development. Some reduction of landscape structure and function would also be expected within construction and maintenance easements along floodwall corridors. Doing so would also functionally disconnect floodplain habitats connected to Big Branch and Buck Creek. This is expected to indirectly contribute to loss of woody wetlands inside floodwalls and corresponding shifts to more upland habitat types including variations of scrub/shrub, mixed forest, herbaceous, evergreen forest, and deciduous forest. However, the magnitude of this change may be affected by other local hydrology factors like water inputs from connected tributaries and precipitation (Park and Latrubesse 2017), groundwater inflow (Burt 1996), and subsurface connection to the channel (Kupfer et al. 2015).

Some downstream impacts may also occur, as flood waters would be conveyed downstream over shorter durations than under FWOP conditions and floodplain disconnection would allow for less floodplain storage of flood waters. This may include altered hydrology where Buck Creek meets the Waccamaw River. Determination of the degree to which these impacts would affect land use downstream would require further investigation as noted above.

4.1.2.2 LR3

Construction of floodplain benching along Simpson Creek would directly impact about 6 acres overlapping with the construction footprint. Land covers within the footprint are almost entirely wetlands of woody or emergent herbaceous types.

Floodplain benching is anticipated to increase channel capacity for conveyance during flood events but decrease water velocity and height during periodic high water in the creek by expanding above the bankfull width. An immediate impact of construction is that it would require excavation of the channel bank and some clearing of existing bankside vegetation. Increasing conveyance of the waterway from benching would also decrease durations of floodplain inundation, disrupting the disturbance regime to local floodplain forest. Potential impacts may include encroachment of more flood-intolerant plant species and reduced exchange of sediment and nutrients between the channel and floodplain forest. This could result in impacts like those on reduced floodplain connectivity discussed for floodwalls above (i.e., shifts to characteristics more similar of upland habitats). However, some changes in downstream hydrology may result and have varied and contrasting effects on wetlands depending on site-specific hydrological changes.

Construction of relief bridges (cross drains) are anticipated to have few consequences related to construction footprints on land use. Increases in the size of culverts or addition of culverts may require some resurfacing of existing right-of-way (ROW) or extension of the ROW laterally, resulting in some loss of adjacent land uses, but this extent would be limited to a very narrow area. Relief bridges would restore some connectivity of waterways which are otherwise obstructed by the roadway, leading to some increased conveyance downstream in the watershed. This would be expected to affect some wetlands in addition to developed areas which experience flooding by allowing for additional drainage. As is the case with other structural measures, hydrological changes would require further site-specific investigation to rule out potential additional impacts. In Longs/Red Bluff, this would likely involve predominately downstream changes.

4.1.2.3 LR6

The combination of floodwalls along Buck Creek, benching and relief bridges (cross drains) along Simpson Creek and elevation and acquisition of flood prone properties would likely be additive in effects to land use. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here are geographically and hydrologically disjunct based on modeling, therefore largely eliminating potential to have synergistic effects on flooding and indirect effects to land use.

4.1.2.4 LRNS3

Elevation of properties would have no net effect to land use. Utility of the land would be maintained outside flood periods but would still be impacted during flood periods.

4.1.2.5 LRNS4

Acquisition of properties would have no net effect to land use. The type of small-scale land use may change, but more broadly likely would remain largely unchanged. For example, change may involve removal of structures on the land, but the same environmental factors which affect land use (e.g., flooding, soil type, topography, vegetation management) would be expected to largely remain.

4.1.3 Conway

4.1.3.1 C3

Impacts to land use in this flood impact area would be very similar to those described for Longs/Red Bluff above. To reiterate, this would be expected to affect some wetlands in addition to developed areas which experience flooding by allowing for additional drainage. As is the case with other structural measures, hydrological changes would require further site-specific investigation to rule out potential additional impacts. In Conway both downstream and upstream changes would likely occur.

4.1.3.2 C5

The combination of relief bridges (cross drains) and elevation and acquisition of flood prone properties would be additive in effects to land use. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) there is only one type of structural measure considered here.

4.1.3.3 CNS1

Effects would be the same as described in Section 4.1.2.4 above.

4.1.3.4 CNS2
Effects would be the same as described in Section 4.1.2.5 above.

4.1.4 Socastee
4.1.4.1 S1
Construction of floodwalls around the Forestbrook communities in the Socastee flood impact area would impact about 39 acres overlapping with the construction footprint. This would include predominately woody wetlands (33 acres) and some developed open space (4 acres) and emergent herbaceous wetlands (1 acre). The construction would result in similar impacts to the landscape as discussed above; however, unlike the proposed floodwalls in Longs, the floodwalls proposed in Socastee would run parallel for approximately two miles, confining Socastee Creek between them. This is expected to lead to a woody wetland land cover remaining within the confines of the parallel walls and to contribute to greater creek depths as well as potentially greater flood pulses on the north side of the creek beyond the terminus of the parallel floodwalls. Similarly, land behind the walls which is currently woody wetlands is expected to shift to more upland land cover.

Like the Longs/Red Bluff floodwall, some downstream impacts may also occur, as flood waters would be conveyed downstream over shorter durations than under FWOP conditions and floodplain disconnection would allow for less floodplain storage of flood waters where Socastee Creek meets the AIWW. Determination of the degree to which these impacts would affect land use downstream would require further investigation as noted above.

Construction of floodplain benching along Simpson Creek would directly impact about 6 acres overlapping with the construction footprint. Land covers within the footprint are almost entirely wetlands of woody or emergent herbaceous types.

Floodplain benching is anticipated to increase channel capacity for conveyance during flood events but decrease water velocity and height during periodic high water in the creek by expanding above the bankfull width. An immediate impact of construction is that it would require excavation of the channel bank and some clearing of existing bankside vegetation. Increasing conveyance of the waterway from benching would also decrease durations of floodplain inundation, disrupting the disturbance regime to local floodplain forest. Potential impacts may include encroachment of more flood-intolerant plant species and reduced exchange of sediment and nutrients between the channel and floodplain forest. This could result in impacts like those on reduced floodplain connectivity discussed for floodwalls above (i.e., shifts to characteristics more similar of upland habitats). However, some changes in downstream hydrology may result and have varied and contrasting effects on wetlands depending on site-specific hydrological changes.

4.1.4.2 S2
The area of the proposed detention pond is currently a roughly even mix of woody wetlands and evergreen forest. The area of woody wetlands is at least periodically

flooded during heavy precipitation events. This measure would involve conversion of existing habitats to open water and developed open area, with some areas of potentially intact habitat remaining, albeit with altered hydrology. In the unaffected areas surrounding the constructed detention pond, altered hydrology would have similar impacts to the landscape as are anticipated with floodwalls discussed above resulting from disconnection of nutrient cycling, sediment transport, and hydric conditions.

4.1.4.3 S3

This alternative would include removal of existing weir (barrier) removals located within Socastee Creek. This measure would directly result in decreased water depth and an increase in relative flow velocity upstream (Im et al. 2011) and allow for greater conveyance of flood waters downstream. This alternative would allow for restoration of natural flow conditions in the creek and remove barriers to flow which result in local inundation to both nearby woody wetlands and residential developed lands. However, despite disruptions to wetland conditions which may have developed following construction of the weirs, restoration of more natural geomorphological conditions within the creek are expected and contribute to restoring floodplain connectivity and creating more storage which can be important from a flood risk perspective and in restoring bankside and floodplain wetland habitat and functions. Thus, it is expected that this alternative would alleviate developed areas of flood damages while having net benefits to wetlands in the area. However, like other alternatives which alter hydrology, some downstream impacts may occur and require further investigation.

4.1.4.4 S4

The combination of floodwalls, a detention pond and removal of barriers along Socastee Creek, and elevation and acquisition of flood prone properties would likely be additive in effects to land use. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here all unilaterally affect the same waterway (Socastee Creek).

4.1.4.5 SNS3

Effects would be the same as described in Section 4.1.2.4 above.

4.1.4.6 SNS4

Effects would be the same as described in Section 4.1.2.5 above.

4.1.5 Buckport

4.1.5.1 B1

The floodgate is expected to slow backwater from the Pee Dee River by restricting backflow through Cowford Swamp. Construction of this structure would occur largely along existing roadside ROWs and would require conversion of some developed open space, open water, and woody wetlands to a similar order of magnitude as the bridge which would be just upstream. The structure would permit flow below the 2-yr or 5-yr floodplain level from Cowford Swamp to the Pee Dee River; but provide protection above these levels to provide a barrier for waters associated with more severe flood events. Inherent to the additional surface area of impervious structure to be constructed for this measure are changes to water velocity and depth, scouring of sediment upstream and downstream, and the potential for debris to further impact flow and act as a physical barrier. These effects are of more concern when high water levels or flow rates increase output demands through the obstruction created by a floodgate. The intended reduction in flooding would likely contribute to some lateral reduction in the extent or duration of flooding experienced in nearby floodplain forest along Cowford Swamp and Bull Creek. However, it is unlikely this would result in any significant shifts in the extent of woody wetlands in the area.

4.1.5.2 B2

Raising the Pee Dee Highway would inevitably result in some tree clearing and permanent loss of land use and filling of wetlands as the roadside embankment would need to be extended laterally from the existing road. Raising the highway would also result in loss of lateral connectivity of floodplains which currently flow over the highway during high water events. Impacts would be similar to those discussed with regards to lateral disconnection by floodwalls above. However, these impacts could be minimized through adequate maintenance of waterways through addition of culverts and bridges.

4.1.5.3 BNS2

Effects would be the same as described in Section 4.1.2.4 above.

4.1.5.4 BNS4

Effects would be the same as described in Section 4.1.2.5 above.

4.2 Air Quality

4.2.1 No Action

In this context, the No Action alternative for each flood impact area is considered the same: If the proposed alternatives are not implemented, Horry County may pursue other flood management actions that could involve similar construction-related impacts on air quality.

4.2.2 Alternatives Evaluated

The following tables outline the anticipated impacts on air quality for alternatives across the flood impact areas. The assessments consider the scale and type of construction activities, including land-clearing, excavation, grading, and the operation of heavy machinery. These activities can affect air quality by generating dust and particulate matter, and by emitting pollutants such as nitrogen oxides (NOx), carbon monoxide (CO), and volatile organic compounds (VOCs). The impact ratings are categorized into minor, moderate, or major, reflecting the extent of the air quality effects relative to those expected from the No Action alternative.

4.2.3 Longs/Red Bluff

Table 23 Impacts to Air Quality from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate	Construction of about 3-mile floodwall involves land-clearing, excavation, and heavy machinery operation, leading to substantial dust, particulate matter, and emissions of NOx, CO, and VOCs.
LR3	Minor to Moderate	Similar impacts to LR1 due to land-clearing and excavation. Emissions from equipment and dust generation are notable, though on a smaller scale.
LR6	Moderate	The additive effects of floodwalls, benching, and relief bridges increase the overall impact on air quality due to combined construction activities.
LRNS3	Minor	Potentially involves excavation and grading with minor dust and emissions compared to larger-scale projects.
LRNS4	Minor	Limited to demolition and site preparation, resulting in minor dust and emissions. The conversion to green space may have long-term positive effects.

4.2.4 Conway

Table 24 Impacts to Air Quality from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	Similar to LR3, with dust and emissions from construction activities. Improvements in traffic flow could have positive long-term effects.
C5	Minor	Combines the effects of relief bridges, elevation, and acquisition, leading to small-scale, short-term impacts on air quality due to construction activities.
CNS1	Minor	Limited scope of potential excavation and grading results in minor air quality impacts.
CNS2	Minor	Similar to LRNS4, with minor impacts from demolition and site preparation, and potential long-term benefits from converted green space.

4.2.5 Socastee

Table 25 Impacts to Air Quality from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate to Major	Larger-scale floodwalls result in substantial dust, particulate matter, and emissions due to extensive construction and equipment use.
S2	Moderate to Major	Large-scale clearing and excavation for the pond will generate notable dust and emissions, though less extensive than floodwall construction.
S3	Minor	Limited to equipment use for weir removal, resulting in minor dust and emissions compared to larger construction projects.

Alternative	Impact Relative to NAA	Details
S4	Major	The combined effects of floodwalls, detention pond construction, and barrier removal result in substantial impacts on air quality.
SNS3	Minor	Similar to CNS1, involving minor dust and emissions from potential excavation and grading.
SNS4	Minor	Minor dust and emissions from demolition, with potential long-term benefits from green space conversion.

4.2.6 Bucksport

Table 26 Impacts to Air Quality from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor	Smaller scale construction involving excavation and grading, resulting in minor dust and emissions compared to larger projects.
B2	Moderate	Extensive earth-moving activities will produce moderate dust and emissions, though improvements in traffic flow could benefit air quality long-term.
BNS2	Minor	Limited scope results in minor impacts from excavation and grading activities.
BNS4	Minor	Minor dust and emissions from demolition, with potential long-term benefits from green space conversion.

4.3 Climate

4.3.1 No Action

In this context, the No Action alternative for each flood impact area is considered the same: If the proposed alternatives are not implemented, Horry County may pursue other flood management actions that could involve similar construction-related impacts on climate.

4.3.2 Alternatives Evaluated

The following tables summarize the anticipated impacts on climate change for various construction alternatives. The analysis focuses on greenhouse gas (GHG) emissions, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), which are affected by construction activities such as land-clearing, excavation, grading, and machinery operation. The impact ratings are categorized into minor, moderate, or major, reflecting the extent of contributions to climate change relative to those expected from the No Action alternative.

4.3.3 Longs/Red Bluff

Table 27 Impacts to Climate from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate	Construction of floodwalls involves notable land-clearing and use of heavy machinery, leading to substantial CO_2 emissions from vegetation removal and machinery operation.
LR3	Minor to Moderate	Similar to LR1, with notable CO_2 emissions from land-clearing and excavation, though on a smaller scale.
LR6	Moderate	The combined effects of floodwalls, benching, and relief bridges result in notable GHG emissions due to extensive construction activities.
LRNS3	Minor	Smaller scale excavation and grading activities result in relatively minor CO_2 emissions compared to larger projects.
LRNS4	Minor	Minor CO_2 emissions from demolition and site preparation, with potential long-term climate benefits from increased green space.

4.3.4 Conway

Table 28 Impacts to Climate from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	Similar to LR3, with CO_2 emissions from construction activities, but with potential long-term climate benefits from improved traffic flow.
C5	Minor	Combines the effects of relief bridges, elevation, and acquisition.
CNS1	Minor	Limited scope of excavation and grading results in minor CO_2 emissions.
CNS2	Minor	Similar to LRNS4, with minor CO_2 emissions from demolition and potential long-term climate benefits from green space conversion.

4.3.5 Socastee

Table 29 Impacts to Climate from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate	Large-scale floodwalls contribute to notable CO_2 emissions from extensive construction and machinery use.
S2	Moderate	Large-scale clearing and excavation for the pond generate notable CO_2 emissions, though likely less than floodwall construction.
S3	Minor	Limited CO_2 emissions from weir removal and equipment use, compared to larger projects.
S4	Moderate to Major	The combined effects of floodwalls, pond construction, and barrier removal result in substantial CO_2 emissions.
SNS3	Minor	Similar to CNS1, with minor CO_2 emissions from excavation and grading.
SNS4	Minor	Minor CO_2 emissions from demolition and potential long-term climate benefits from green space conversion.

4.3.6 Bucksport

Table 30 Impacts to Climate from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor	Small-scale construction activities lead to minor CO_2 emissions compared to larger projects.
B2	Moderate	Extensive earth-moving activities produce moderate CO_2 emissions, though improvements in traffic flow could have long-term climate benefits.
BNS2	Minor	Minor CO_2 emissions from excavation and grading activities.

Alternative	Impact Relative to NAA	Details
BNS4	Minor	Minor CO_2 emissions from demolition, with potential long-term climate benefits from green space conversion.

4.4 Geologic Resources

4.4.1 No Action

In this context, the No Action alternative for each flood impact area is considered the same: If the proposed alternatives are not implemented, Horry County may pursue other flood management actions that could involve similar construction-related impacts on geologic resources.

4.4.2 Alternatives Evaluated

The following tables outline the anticipated impacts on geologic resources from the evaluated alternatives. The analysis considers direct impacts such as soil erosion, compaction, and conversion to impervious surfaces, as well as indirect effects on farmland and other geological resources. Nonstructural measures are expected to have no direct impacts on soils, while structural measures may result in temporary or permanent soil disturbances. The impact ratings are categorized into minor, moderate, or major, reflecting the extent of contributions to geologic resources relative to those expected from the NAA.

4.4.3 Longs/Red Bluff

Table 31 Impacts to Geologic Resources from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate	Floodwalls require easements and construction that lead to soil erosion, compaction, and permanent conversion to impervious surfaces. Some prime farmland may be affected but is currently in use for the country club.
LR3	Minor	Construction around Simpson Creek and Highway 905 involves compacted and disturbed soils. Some prime farmland or farmland of statewide importance may be directly impacted.
LR6	Moderate	The combination of floodwalls, benching, relief bridges, and property elevation and acquisition results in cumulative impacts, including soil disturbances and conversion to impervious surfaces.
LRNS3	Minor	Elevation of properties involves minimal soil disturbance, with no direct impact on geological resources.
LRNS4	Minor	Property acquisitions do not directly impact geological resources, though potential future uses of acquired lands may involve farmland.

4.4.4 Conway

Table 32 Impacts to Geologic Resources from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	Construction largely within existing DOT ROW involves minimal new soil disturbance, but some prime farmland and farmland of statewide importance may be impacted.
C5	Minor	The combination of relief bridges, elevation, and acquisition results in cumulative impacts, including soil disturbances and conversion to impervious surfaces.
CNS1	Minor	No direct impact to geological resources, similar to LRNS3.
CNS2	Minor	No direct impact to geological resources, similar to LRNS4.

4.4.5 Socastee

Table 33 Impacts to Geologic Resources from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate	Similar to LR1, with some impacts to farmland of statewide importance, though most of the area is not used for agriculture.
S2	Moderate	Conversion of land to a detention pond and associated infrastructure impacts farmland of statewide importance, though the area is currently undeveloped.
S3	Minor	No direct impact to geological resources, similar to LRNS3.
S4	Moderate	The combination of floodwalls, a detention pond, and property acquisition results in cumulative impacts, including soil disturbances and conversion to impervious surfaces.
SNS3	Minor	No direct impact to geological resources, similar to CNS1.
SNS4	Minor	No direct impact to geological resources, similar to CNS2.

4.4.6 Bucksport

Table 34 Impacts to Geologic Resources from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor	Construction largely within existing DOT ROW involves minimal new soil disturbance, but some prime farmland and farmland of statewide importance may be impacted.
B2	Moderate	Although construction would occur along mostly existing DOT ROW, the distance of highway to be raised and extension of slopes would require substantial soil disturbance which would include some prime farmland and farmland of statewide importance.
BNS2	Minor	No direct impact to geological resources, similar to CNS1.
BNS4	Minor	No direct impact to geological resources, similar to CNS2.

4.5 Water Resources

4.5.1 No Action

Some changes in surface water, groundwater, water quality, wetlands and floodplains are likely to occur as development continues in the study area. However, it is also likely that the NFS, stakeholders (i.e., landowners, conservation organizations), and regulatory agencies (i.e., SCDES, USACE) will work to ensure that these resources are also protected from degradation and depletion. It is also assumed that these groups will pursue flood risk management measures in absence of Federal action by USACE, albeit limited to those resources which are available to do so. Reduction of flood risk under FWOP conditions or by the alternatives considered herein is expected to have both positive and negative effects to water resources depending on the measures pursued. For instance, reduction of flooding itself may improve water quality conditions as fewer contaminants from damaged infrastructure and properties, as well as sediment and runoff, would enter into floodwater. Alternatively, alternatives composed of measures which would require wetland filling or floodplain disconnection (e.g., floodwalls) would likely have net negative impacts to water resources like wetlands, surface water, and groundwater. Thus, it is likely that FWOP conditions would be similar to that of those with implementation of the alternatives herein.

4.5.2 Longs/Red Bluff

4.5.2.1 LR1

Floodwalls inherently confine the flow of water within a hardened channel boundary. This change has the potential to increase the velocity of water flow in the waterway and induce erosion of streambanks and streambeds. Floodwalls also create a lateral flow barrier which can change patterns of sediment transport, erosion, and suspension and deposition of solutes and debris. These changes can have secondary effects to hydrology along with destabilization of surrounding habitat features and infrastructure. Additional changes can include formation of new channels, widening of channels, lengthening of meander bends, and slope flattening by upstream degradation and downstream aggradation.

Just as floodwalls can serve as a barrier between channels and floodplains, floodwalls can also affect the exchange of surface water and groundwater aquifers. Floodwaters which may otherwise be stored on or within the substrate of floodplains, may instead be conveyed downstream. Some floodwalls may also create a backwater effect upstream and expand the connected floodplain.

Floodwalls are designed to reduce flooding in sensitive and developed areas, which, despite potential impacts to the waterway, have the potential to reduce impacts to waterways from leaching and contamination of the waterway associated with flooding events. Flooding of developed areas may damage structures and carry solutes from these areas back into the waterway, affecting water quality. Floodwalls can also facilitate the implementation of water treatment measures, leading to improved water quality downstream. Floodwalls can be integrated into comprehensive water management systems, allowing for better regulation of water levels and can help mitigate the impact of both floods and droughts, ensuring a more reliable water supply for various uses.

- **Clean Water Act Compliance**

This alternative would require dredging and/or filling of wetlands which are actions regulated under Sections 401 and 404 of the CWA. Section 401 water quality certifications (WQC) are issued by SCDES Bureau of Water, while Section 404 permitting is issued by USACE. Per ER 1105-2-103, "*For USACE's Civil Works projects that involve discharges of dredged or fill material into waters of the United States, USACE authorizes its own discharges by applying all applicable substantive legal requirements, in accordance with 33 CFR Part 336, allowing a federally permitted release*." Implementation of this alternative would require issuance of a 401 WQC by SCDES and adherence to applicable conditions to the extent practicable and would require a 404(b)(1) analysis to be completed.

- **Wild and Scenic Rivers Act Compliance**

Section 5(d)(1) of the Wild and Scenic Rivers Act requires Federal agencies to avoid or mitigate actions that could negatively impact river segments that are part of the Nationwide Rivers Inventory (NRI). Both the Waccamaw River and Pee Dee River are included on this list. These rivers are recognized for "outstandingly remarkable values" including those related to cultural, fish, geologic, historic, recreational, scenic, and wildlife resources. This alternative would likely have some indirect adverse effects to values of the Waccamaw River including those related to fish and wildlife resources in particular. More specifically, this alternative may have some indirect impacts to water quality and aquatic wildlife which are connected to this river. However, the alternative is not expected to foreclose options to classify any portion of the NRI segment as wild, scenic or recreational river areas.

4.5.2.2 LR3

- **Benching**

Benching is a form of channel enlargement which results in a two-stage channel. This measure is used to increase hydraulic capacity to carry a more infrequent flood event (e.g., 100-year flood). Such a measure can create stream impacts, which may vary in magnitude depending on design. For instance, if the channel carries substantial sediment loads and the resulting cross-section is too large, the section may slow water velocities and partially infill with sediment deposits. However, if higher velocities are maintained at moderate discharges, resulting conveyance of bed material is more effective. Under intended conditions, higher discharges would be better conveyed downstream with a higher capacity channel. This may also affect channel morphology downstream where water is again confined into a narrower channel.

A few secondary impacts from benching of streamside banks can occur. Benching is designed to reduce flooding in nearby residential areas, which inherently also limits lateral connectivity between the channel and floodplain. Floodplain disconnection alters the exchange of surface water, groundwater, and sediment and debris, affecting hydrological patterns in both the channel and floodplain. Benching can also change the surfaces of the channel. Creation of a two-stage channel can slow water velocities during moderate to high discharges and create pools, riffles, and shallow areas as changes in channel bed morphology and sediment sorting occur. Benching also directly results in the loss of supportive bankside vegetation. Loss of the structural support to soils from plant root networks can increase erosion and widening of the banks, redistributing sediment downstream and further altering hydrology and degrading water quality. The removal of vegetation and finer-grained sediments (e.g., sand, organic matter, silt, and clay) from the bank can also impact infiltration rates and water storage capacity as coarser material increases downstream conveyance. In contrast, benches can also contribute to stabilization of banks within the channel by reducing forces on the bank and by increasing surface area for new vegetation to establish. This can lead to reduced sedimentation of the waterway and improved water quality.

Impacts of benching on hydrology are context-specific and depend on factors such as site conditions, project objectives, and stakeholder priorities. Careful planning, site assessment, and implementation are essential to maximize the potential benefits of benching while minimizing negative consequences on stream hydrology. Additionally, thorough monitoring and adaptive management are necessary to evaluate the effectiveness of benching projects over time and make any necessary adjustments to optimize outcomes.

- **Relief Bridge (Cross Drain)**

The design of a relief bridge (cross drain) can create both improvements and complications in the flow of waterways. The intention of relief bridges (cross drains) is to allow a greater volume of water to move more freely through the intersection of a roadway and waterway. This leads to a redistribution of the force with which water moves through the original intersection and can lead to stabilization of the channel. This effect is also attributable to prevention of erosion and sediment build-up in the channel and along the banks. However, relief bridges (cross drains) may also create individual outflows with a high-water velocity and lead to erosion of the channel and banks downstream. Likewise, sediment can accumulate in front of and behind relief bridges (cross drains) and further affect hydrology at the intersection.

Overall, while relief bridges (cross drains) offer significant benefits in terms of traffic efficiency and safety, their construction and presence can have notable hydrologic and hydraulic effects on surrounding waterways. Proper design, mitigation measures, and ongoing maintenance are essential to minimize negative impacts and maximize the positive contributions of relief bridges to both transportation networks and hydrological systems.

- **Combined Effects**

Benching considered here would occur along about 0.7 miles of bankside on Simpson Creek upstream of Highway 905. Design evaluated consisted of a 140-ft width with a 1:1 slope and max width of 200 ft and was intended to increase conveyance by reducing flood elevations and backwater effects. Some increased water velocity is expected to result in stream scouring and erosion. The addition of a relief bridge (cross drain) at the Highway 905 intersection would also provide drainage improvements including clearing streambanks under the bridge and installing culverts in the stream and within the abutments.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.2.3 LR6

The combination of floodwalls along Buck Creek, benching and relief bridges (cross drains) along Simpson Creek and elevation and acquisition of flood prone properties would likely be additive in effects to water resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here are geographically and hydrologically disjunct based on modeling, therefore largely eliminating potential to have synergistic effects on flooding and indirect effects to water resources.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would have the same compliance needs as identified in Section 4.5.2.1 (under Wild and Scenic Rivers Act Compliance).

4.5.2.4 LRNS3

Elevation of structures would have few consequences for water resources. When home elevation occurs, stormwater no longer reaches the same capacity for destruction and suspension of contaminants and debris. This could improve downstream water quality following storm events.

Elevation of properties would have no effect or minor benefits to water resources such as water quality. When home elevation occurs, stormwater no longer reaches the same capacity for destruction and suspension of contaminants and debris. This could improve downstream water quality following storm events.

- **Clean Water Act Compliance**

This alternative would not have any compliance requirements under the CWA.

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.2.5 LRNS4

Acquisition of properties would have no net effect or minor benefits to water resources such as water quality and wetlands. Properties identified for acquisition could have varied impacts to water resources depending on whether any sources of contamination or pollution would need to be removed. Whereby deconstruction would need to be achieved, the effective implementation of construction BMPs would limit any potential impacts to nearby waterbodies that may occur from nonpoint sources of sediment or pollution. Where acquisition properties are restored with natural features in the floodplain, improvements to nearby water resources would be expected as natural flooding regimes would be restored as well and reestablish continuity in surface water and groundwater exchange, provide sediment storage, and promote growth of vegetation that serves to stabilize sediment and store and filter water.

- **Clean Water Act Compliance**

This alternative would not have any compliance requirements under the CWA.

- **Wild and Scenic Rivers Act Compliance**

Some properties identified for acquisition would be located along the Waccamaw River.

4.5.3 Conway

4.5.3.1 C3

Effects would be relatively the same as described in Section 4.5.2.2 (under “Relief Bridge (Cross Drain)” above. The proposed protections include decreasing the flood depths and size of the floodplain upstream of Highway 905, Highway 501 Business and E Highway 501 along the Waccamaw River. These relief bridges (cross drains) would convey more water away from the inundated zone and reduce the water surface elevation through reduction of bottlenecking occurring along highways.

- **Clean Water Act Compliance**

Based on initial designs, construction of relief bridges would result in three independent and fully functioning structures which would require <0.01 acres of wetland impacts. These types of actions are generally authorized under Nationwide Permit 14 – Linear Transportation Projects. The issuance of NWPs involves a programmatic review rather than a project-specific 404(b)(1) analysis. While a project-specific 404(b)(1) analysis is not required for NWPs, individual projects must still comply with the general and regional conditions specified in the NWP. In order to comply with Section 401, USACE would submit a pre-filing meeting request and certification request under General State Certification to SCDES.

- **Wild and Scenic Rivers Act Compliance**

This alternative would not result in adverse effects (e.g., deterioration of water quality) to the natural, cultural, and recreational values of the Waccamaw River or foreclose options to classify any portion of the river as wild, scenic, or recreational river areas.

4.5.3.2 C5
The combination of relief bridges (cross drains) and elevation and acquisition of flood prone properties would be additive in effects to water resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) there is only one type of structural measure considered here.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.3.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would have the same compliance needs as identified in Section 4.5.3.1 (under Wild and Scenic Rivers Act Compliance).

4.5.3.3 CNS1
Effects would be the same as described in Section 4.5.2.4 above.

4.5.3.4 CNS2
Effects would be the same as described in Section 4.5.2.5 above.

4.5.4 Socastee
4.5.4.1 S1
Effects to water resources from construction of floodwalls would be relatively the same as those described in Section 4.5.2.1 above.

The removal of weirs contributes to the restoration of a natural flow regime. Immediate effects include a reduction in water levels upstream of the weir and mobilization of built-up sediment behind the weir. This leads to a less segmented hydrological regime in the creek and restores natural sinuosity of the channel. This can also contribute to the restoration of wetland vegetation along channel banks and stabilization of soils as well as uniform connectivity between surface waters and groundwater in the basin.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.4.2 S2
Detention ponds can mitigate impacts from flooding by temporarily diverting and storing excess stormwater. Through the control of rates of storage, peak flows can be managed and allow for modification of the magnitudes in which sediment and debris are taken into the waterway during storms. This can aid in managing impacts to water quality and damages to infrastructure and help to stabilize channels. Controlled flow of sediment and pollutants in the waterway also allows for storage in the detention basin where

transformation of suspended solids and pollutants can occur through natural processes, while promoting infiltration rates and groundwater storage.

Overall, detention ponds play a crucial role in managing stormwater runoff, improving water quality, and contributing to the sustainable management of water resources in urban and suburban areas. Effective planning, design, and maintenance are essential to maximize the positive impacts of detention ponds on hydrology while minimizing potential adverse effects.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance). In addition, it is expected that a detention pond and diversion canal would also require a National Pollution Discharge Elimination System (NPDES) permit under CWA Section 402.

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.4.3 S3

Effects of weir removal would be the same as described in Section 4.5.4.1 above.

- **Clean Water Act Compliance**

This type of action is generally authorized under Nationwide Permit 53 – Removal of Low-Head Dams. As stated above, the issuance of NWPs involves a programmatic review rather than a project-specific 404(b)(1) analysis. While a project-specific 404(b)(1) analysis is not required for NWPs, individual projects must still comply with the general and regional conditions specified in the NWP. In order to comply with Section 401, USACE would submit a pre-filing meeting request and certification request under General State Certification to SCDES.

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.4.4 S4

The combination of floodwalls, a detention pond and removal of barriers along Socastee Creek, and elevation and acquisition of flood prone properties would likely be additive in effects to water resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here all unilaterally affect the same waterway (Socastee Creek).

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.4.2 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.4.5 SNS3

Effects would be the same as described in Section 4.5.2.4 above.

4.5.4.6 SNS4

Effects would be the same as described in Section 4.5.2.5 above.

4.5.5 Bucksport

4.5.5.1 B1

Floodgates are used to regulate the flow of water, particularly during periods of high-water levels or flooding. By opening or closing the gates, water managers can control the discharge rates, thereby mitigating flood risks downstream. The operation of floodgates can alter the natural flow patterns of rivers and water bodies, leading to changes in water levels, flow velocities, and sediment transport processes.

Floodgates may influence sediment dynamics and water quality in rivers and estuaries by trapping or releasing sediment particles during their operation. When floodgates are closed, sediment deposition can occur upstream, leading to channel aggradation and potential impacts on flood conveyance capacity. Conversely, when floodgates are opened, sediment can be flushed downstream, affecting sedimentation patterns, erosion rates, and navigation channels.

The operation of floodgates can influence water quality parameters such as temperature, dissolved oxygen levels, nutrient concentrations, and pollutant transport. Changes in flow patterns, residence times, and mixing dynamics resulting from floodgate operation can impact the distribution and fate of contaminants, algae blooms, and other water quality indicators.

Overall, floodgates can have significant hydrologic impacts, influencing flow regimes, sediment dynamics, water quality, and water supply management. It's important to consider these impacts in floodgate design, operation, and management to minimize adverse effects on water resources, and communities downstream. Additionally, ongoing monitoring and adaptive management are essential to assess and mitigate the hydrological impacts of floodgate operations over time.

Based on initial designs, the floodgate here would permit flow from Cowford Swamp to the Pee Dee River, but in anticipation of high-water levels, the gate would be closed. Under normal conditions the gate would remain open. The floodgate would be located between Highway 701 and Big Bull Landing on Marine Park Road, and 0.6 miles in length and 13ft above surface water levels. The exact location and footprint remain undefined. Some pooling north of the Big Bull Landing is anticipated when the flood gate is closed and some stream and floodplain impacts to Cowford Swamp and Bull Creek are expected.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would have the same compliance needs as identified in Section 4.5.2.1 (under Wild and Scenic Rivers Act Compliance).

4.5.5.2 B2

The intention of raising the Pee Dee Highway is to provide modes of ingress or egress during storm events for connected communities. Doing so would have few consequences for hydrology of the area aside from prevention of stormwater from spilling over the highway. Where improvements may be needed to existing culverts and drainages, there would be additional opportunity to restore flow and connectivity to existing waterways and waterbodies. This could lead to improvements in the exchange between surface water and groundwater aquifers as well.

- **Clean Water Act Compliance**

This alternative would require CWA compliance as is described above in Section 4.5.2.1 (under Clean Water Act Compliance).

- **Wild and Scenic Rivers Act Compliance**

This alternative would not affect any rivers listed on the NRI, study rivers designated by Congress or any designated Wild and Scenic Rivers.

4.5.5.3 BNS2

Effects would be the same as described in Section 4.5.2.4 above.

4.5.5.4 BNS4

Effects would be the same as described in Section 4.5.2.5 above.

4.6 Biological Resources

4.6.1 No Action

It is expected that under FWOP conditions similar actions to reduce flood risk will be undertaken by the NFS and other stakeholders in the study area and have similar impacts to biological resources as any of the alternatives considered herein. However, it is likely that these actions may occur over a longer period or at a smaller scale as resources associated with the Federal actions for this project would not be available. The degree to which these two scenarios would affect biological resources differently would depend entirely on the actions pursued. Nevertheless, it is expected that measures to reduce flood risks which are less impactful to biological resources (i.e., relief bridges, NNBF) would potentially improve conditions for biological resources under either the FWOP or under those alternatives considered herein.

4.6.2 General Study Area

Aside from the broader ecological impacts associated with individual alternatives discussed below, impacts to individual species or wildlife would likely include those to any non-mobile species (e.g., plants, fungi) and more basic lifeforms such as invertebrates which would be directly lost as a result of construction-related activities. Other impacts include those to more complex lifeforms (e.g., mammals, birds, amphibians, reptiles, etc.) through construction-related disturbance and displacement, and the potential loss of critical habitat features for reproduction (e.g., bird nests). Under any of the alternatives considered, development of avoidance and minimization measures would be necessary to ensure no more than minor impacts.

4.6.3 Longs/Red Bluff

4.6.3.1 LR1

Levees and floodwalls innately disconnect floodplains from waterways and result in simple floodplain disconnection, lateral flowline alteration, or both (Knox et al. 2022a). Floodplain disconnection directly reduces the area of active floodplain. Lateral flowline alteration describes adjustment of the direction of flood waters and shifting of the locations of flooding. Floodplain disconnection leads to shifts away from biological community types specialized for flooded environments to those which are less tolerant of those conditions (Yin 1998; Gergel et al. 2002). Lateral flowline alteration contributes to the redistribution of floodwaters to neighboring floodplain habitats, which may contribute to longer duration and greater depths of water in habitats which would otherwise not experience those conditions. This can also cause a biological community shift to one more tolerant of anaerobic conditions. Apart from the impacts to hydrology from presence of floodwalls, a reduction in habitat diversity and complexity may occur within the construction corridor as soils may be compacted and vegetation removed by structural components and vehicular traffic during maintenance.

Floodwalls also impact biological resources by severing hydrogeomorphic pathways (i.e., flow of nutrients, sediments, debris, etc.). This disruption in the exchange of resources and disturbance patterns between habitats leads to decreased habitat diversity and complexity within both habitats (Naiman et al.1993; Jenkins and Boulton 2003; Knox et al. 2022*b*). Movement of nutrients, like organic matter, between these habitats contributes to a high biodiversity of fish invertebrates, microbes, and more (Opperman et al. 2017). Dead biomass in the form of large wood, can come from overbank flows and creates physical and ecological functions on floodplains (Wohl et al. 2019; Wohl 2020). Many aquatic species in riverine systems undergo life history stages which require specific nursery habitat that are spatially and temporally variable, predominately in the form of branching shallow water habitats from a connected floodplain (Schiemer 2000; Amoros and Bornette 2002).

- **Essential Fish Habitat and Threatened and Endangered Species**

There is no EFH that would be affected by this alternative.

Broadly, the Northern long-eared bat and tricolored bat can occupy forested habitats and neighboring areas at any given time of year in South Carolina, using trees, culverts, caves, and even homes or human structures for roosting or even hibernacula. Although according to IPaC and data from SCDNR (2023), only tricolored bat have been documented in the Longs/Red Bluff area, given their considerable overlap in habitat requirements, any actions which would alter, damage, destroy or create a disturbance near potential habitat features could have at least some potential to affect these species.

As noted in Section 4.1.2.1, this alternative would require impacts to 11 acres of woody wetland and some evergreen forest. Avoidance and minimization measures, such as tree cutting windows could be utilized here to avoid adverse effects to these species. However, informal consultation with USFWS would be required before any conclusions could be made.

4.6.3.2 LR3

- **Benching**

This measure is anticipated to increase conveyance in Simpson Creek and reduce flood elevations around the adjacent damage areas that include residential homes and would result in some impacts to floodplain habitats and changes to aquatic habitats. An immediate impact of construction is that it would require excavation of the channel bank and some clearing of existing vegetation. Increasing conveyance of the waterway would also decrease durations of floodplain inundation, disrupting the disturbance regime to local floodplain forest. This could result in impacts like those on reduced floodplain connectivity. Despite this, benching may allow for formation of new ecological niches in depositional formations on the resulting 2-tier channel (Vietz et al. 2004) providing benefits to fish and plant assemblages in the creek (Junk et al. 1989; Burke et al. 2003). Benching can also contribute to modulating flood frequency and intensity and improve system productivity and species richness (Pollock et al. 1998). Nevertheless, reduced exchange of floodplain resources with the channel could contribute to some loss of important habitat features (e.g., sediment and nutrients, woody debris) (Malanson and Butler 1990; Burke et al. 2003).

- **Relief Bridge (Cross Drain)**

Relief bridges (cross drains) would consist primarily of installation of culverts to improve water flow and conveyance in the surrounding floodplain. Depending on the design of the culverts, impacts can be varied for associated aquatic organisms and habitats. For example, as culvert size decreases, water pressure within the culvert increases and the structure becomes more prone to obstructions. In addition, the internal texture of the structure and relative position of the structure can have a varied effect on the movement of organisms and the degree to which scouring, pooling, and accumulation of fine sediments occurs downstream (Harper and Quigley 2000; Wellman et al. 2000). Previous studies have demonstrated the restriction on movement by aquatic organisms at high velocity culverts (Mahlum et al. 2014), culverts with high hanging heights (Burford et al. 2009), and culverts obstructed by debris (Wellman et al. 2000). All these factors can contribute to changes in the biodiversity and community compositions of streams intersected by culverts and relief bridges.

Although there is some potential for habitat changes around and immediately downstream, the relief bridge proposed at Simpson Creek would likely improve longitudinal connectivity of the creek by improving conveyance otherwise impeded by the existing bridge infrastructure during high water periods. As mentioned, issues with culverts include sediment build-up, scouring, and increased flow velocity which can all affect stream habitat for fish and invertebrates; however, Simpson Creek is already impacted by an existing bridge and these effects to stream physics are generally the result of narrowing a stream through a hard structure, while this measure would widen the area for water to flow through. For this reason, there are lower impacts relative to construction of culverts where infrastructure does not already exist. There may also be some benefits where these issues common to culverts are relieved by improving conveyance.

- **Essential Fish Habitat and Threatened and Endangered Species**

The same type and relative scale of impacts to the EFH and ESA species identified in Section 4.6.3.1 would occur under this alternative.

4.6.3.3 LR6

The combination of floodwalls along Buck Creek, benching and relief bridges (cross drains) along Simpson Creek and elevation and acquisition of flood prone properties would likely be additive in effects to biological resources given their degree of geographic separation.

- **Essential Fish Habitat and Threatened and Endangered Species**

There is no EFH that would be affected by this alternative.

Impacts to ESA species would be limited to any effects which could occur to Northern long-eared bat or tricolored bat where structures are affected that could be utilized as potential habitat. However, implementation of appropriate avoidance and minimization measures, such as preconstruction surveys, could reduce these effects to none.

4.6.3.4 LRNS3

Elevation of flooded structures would have little to no effects on biological resources. There could be the potential for indirect impacts to biological resources from nonpoint discharges and elevated noise during construction. Nonpoint discharges could temporarily alter water quality conditions that aquatic resources depend on. However, the potential for this would be offset through construction-related practices that comply with the Clean Water Act. Elevated noise would be a temporary disturbance to nearby wildlife and of minor duration and intensity.

Despite some potential for minor impacts to nearby biological resources, elevating structures could also provide opportunity for some beneficial effects. For instance, elevating structures removes many objects (e.g., appliances, food waste, industrial solvents, etc.) from the flood zone which may otherwise create sources of contamination and debris when flood events occur, protecting nearby waterways from deposition of these objects.

- **Essential Fish Habitat and Threatened and Endangered Species**

There is no EFH that would be affected by this alternative.

Impacts to ESA species would be limited to any effects which could occur to Northern long-eared bat or tricolored bat where structures are affected that could be utilized as potential habitat. However, implementation of appropriate avoidance and minimization measures, such as preconstruction surveys, could reduce these effects to none.

4.6.3.5 LRNS4

Acquisition of flooded properties would have little to no effects on biological resources. Like elevation, noise and potential runoff issues would be addressed with appropriate avoidance and minimization measures. However, acquisition may also allow for opportunities to restore floodplain habitat where structures are removed and provide a benefit to floodplain habitat and wildlife.

- **Essential Fish Habitat and Threatened and Endangered Species**

Impacts under this alternative would be the same as in Section 4.6.3.4 (under Essential Fish Habitat and Threatened and Endangered Species).

4.6.4 Conway

4.6.4.1 C3

Impacts to biological resources from construction of relief bridges (cross drains) has largely already been discussed and would apply similarly here (see Section 4.6.3.2 under Relief Bridge [Cross Drain]).

Installation of a relief bridge along Highway 905 in Conway would also likely be a net benefit to the environment following construction as it would enhance connectivity of floodplain habitat which is currently intersected by elevated roadways and bridges. Increasing downstream conveyance of floodwaters may reduce some of the areal extent of the floodplain but would allow for more natural movement of floodwaters throughout the system of floodplains. Relief at Highway 905 may also restore floodplain connectivity between the Waccamaw River and Kingston Lake which is currently reduced by the roadway.

- **Essential Fish Habitat and Threatened and Endangered Species**

The same type and relative scale of impacts to the EFH and ESA species identified in Section 4.6.3.1 would occur under this alternative.

4.6.4.2 C5

The combination of relief bridges (cross drains) and elevation and acquisition of flood prone properties would be additive in effects to biological resources.

4.6.4.3 CNS1

Effects would be the same as described in Section 4.6.3.4 above.

4.6.4.4 CNS2

Effects would be the same as described in Section 4.6.3.5 above.

4.6.5 Socastee

4.6.5.1 S1

Impacts to biological resources would principally be the same as described in Section 4.6.3.1.

- **Essential Fish Habitat and Threatened and Endangered Species**

Floodwalls along Socastee Creek may affect hydrology of the area and could have effects to EFH along the AIWW. Potentially affected EFH here includes that for snapper/grouper species which includes areas inshore of the 100-foot contour, such as estuarine emergent vegetated wetlands (saltmarshes, brackish marsh), tidal creeks, oyster reefs and shell banks, and unconsolidated bottom; and EFH for spiny lobster which includes shallow subtidal bottom and unconsolidated bottom.

Offset floodwalls would be designed to reduce flooding from storm events, influencing aquatic conditions of Socastee Creek particularly during those events. Under normal conditions, these measures would have little to no immediate effect on hydrological conditions of the creek. Floodwalls would likely contribute to greater freshwater and suspended sediment inflow into the AIWW, given its proximity to the AIWW and the potential to induce erosion along banks, likely having some adverse impacts to EFH. However, these processes would likely carry out over long durations and would not be likely to create permanent perturbations in the water quality, hydrography, or habitat features of the AIWW and its EFH.

Effects to ESA species would include those described in Section 4.6.3.1 above as they pertain to Northern long-eared bat and tricolored bat. In addition, impacts to West Indian manatee are possible given their documented use of the AIWW. For instance, greater freshwater and suspended sediment inflow into the AIWW during flood events would expose manatees to diminished water quality. However, this species is also only present in isolated accounts and infrequently and the action would likely have no effect on manatee.

4.6.5.2 S2

The purpose of the detention pond would be to allow for storage of stormwater and reduction in flood pulses along connected waterways like Socastee Creek. Independent of measures under other alternatives, this would limit to some degree the extent and volume of overbank flooding along the main channel into the floodplain. The direct effect of this is the reduced duration and extent of hydric conditions experienced at the outer extents of the floodplain along Socastee Creek and nearby tributaries, which can lead to shifts in the composition of biological communities and reductions in the biodiversity and complexity of those habitats as described in relation to impacts from floodwalls above.

The area proposed for construction of the detention pond overlaps with about 65 acres of existing woody wetlands and evergreen forest. The area is partially flooded at least periodically following heavy precipitation events. Construction of the detention pond would require a substantial portion of this area to be cleared and excavated, converting existing habitats to a mix of open water, emergent herbaceous wetland and developed open area. Doing so would also indirectly alter the surface and sub-surface hydrology to connected habitats nearby the detention pond. This would have similar impacts as would be expected for floodplain disconnection from floodwalls mentioned above (i.e., changes in exchange of sediment, nutrients, surface water).

Direct loss of woody wetland and evergreen forest habitats where the footprint of the detention pond would occur would be in place of some gain of other wetland habitat features and functions. This would be dependent upon several design features of the pond as they relate to the amount of impervious surface, incorporation of habitat buffers, use of pumps and gates, and the rate of active or passive storage and discharge of water among other important features. The dynamics of stormwater storage and discharge influence the flow of water, total suspended solids (TSS), and potential contaminants into and out of the connected Socastee Creek (Nix 1985; Stanley 1996). Whereby the detention pond serves as a sink for TSS and contaminants, the measure could contribute to improvements in downstream habitat quality in Socastee Creek reducing impacts to dissolved oxygen and reducing turbidity and contamination (Bilotta and Brazier 2008). Incorporation of practices related to streamside buffers around the detention pond and diversion canal would also protect physical, chemical, and biological components of the stream (Sweeney and Newbold 2014). Practices of establishing and maintaining native aquatic plants in the pond could also contribute to improving water quality in the system, supplying food for herbivores, and providing habitat (Bornette and Puijalon 2011; de Winton et al. 2013). In contrast, unchecked establishment of invasive aquatic plants could have further impacts on the system biodiversity (Villamagna and Murphy 2010; Stiers et al. 2011; Hussner et al. 2017), light penetration in the pond (Schefer et al. 2003), and dissolved oxygen levels (Perna and Burrows 2005). Other important features which would limit impacts of the measure could include maintaining adequate water depths to support a variety of organisms and incorporating complexity in shoreline morphology (Hamar et al. 2012). When monitored for effectiveness, hydroperiods in detention ponds can support development of early life stages of aquatic organisms which may otherwise be truncated by natural ephemeral wetlands (Brand and Snodgrass 2010). Detention ponds can also support a variety of bird species with design features that optimize ratios of surface to volume and open water to aquatic plant cover (Blackwell et al. 2008).

- **Essential Fish Habitat and Threatened and Endangered Species**

Impacts to EFH would be very similar to those described in Section 4.6.5.1.

ESA species would be very similar to those described in Section 4.6.5.1. However, it is anticipated potential impacts to bat species could be slightly more elevated given the scale of tree removal being proposed. In addition, there is a habitat patch of evergreen forest which would need to be removed which could serve as potential habitat for red-cockaded woodpecker. This action would require further habitat site evaluation and formal consultation with USFWS under Section 7 of the ESA.

4.6.5.3 S3

Weir removal in Socastee Creek would directly result in a reduction in the floodplain extent and volume, while restoring natural flow conditions. The effects to nearby wetlands from functional disconnection of floodplains were discussed in detail in Section 4.1. Direct effects to aquatic habitat from weir removal would include induced erosion upstream and downstream, sedimentation of fine grains downstream (Thomas et al. 2014), and an increase in flow velocity upstream (Im et al. 2011). These effects, however, would effectively restore natural flow conditions in the creek and improve habitat diversity as the channelizing effect of the weirs would be remediated (Im et al. 2011; Thomas et al. 2014; Kim and Choi 2019). The potential for adverse downstream effects may also be more limited than the potential for beneficial upstream effects as habitat suitability may be improved for a broader diversity of native lotic fish and invertebrate species (Im et al. 2011; Im et al. 2018; Kim and Choi 2019). Similarly, restoration of natural flow conditions has been shown to lead to increased fish abundance systemwide (Im et al. 2018) and improved capacity for bi-directional movement of aquatic organisms (Birnie-Gauvin et al. 2018). All these effects would be expected to have wider beneficial ecosystem effects (Lefcheck et al. 2015; Thompson et al. 2017).

- **Essential Fish Habitat and Threatened and Endangered Species**

Long term effects of removal of existing weirs in Socastee Creek would likely include restoration of natural flow and sinuosity, promoting growth of bankside vegetation, and increasing capacity for movement of aquatic organisms upstream. Dispersion of built-up sediment downstream would be a limited, temporary impact in Socastee Creek and would be minimized through use of turbidity curtains. This action would be unlikely to have any measurable effects on the water quality (i.e., through increased turbidity or sedimentation) of the AIWW given the distance between the weirs and the waterway and the use of avoidance and minimization measures like turbidity curtains. No adverse effects to EFH are expected.

No impacts to ESA species are expected from implementation of this alternative. Similar to other alternatives in Socastee, impacts to West Indian manatee are possible given their documented use of the AIWW and the potential for some changes in upstream hydrology and sedimentation. However, this species is present in low numbers and infrequently and the action would likely have no effect on manatee.

4.6.5.4 S4

The combination of floodwalls, a detention pond and removal of barriers along Socastee Creek, and elevation and acquisition of flood prone properties would likely be additive in effects to biological resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here all unilaterally affect the same waterway (Socastee Creek).

4.6.5.5 SNS3

Effects would be the same as described in Section 4.6.3.4 above.

4.6.5.6 SNS4

Effects would be the same as described in Section 4.6.3.5 above.

4.6.6 Bucksport

4.6.6.1 B1

Like other flood reduction methods described above, adverse effects would occur to connected floodplain habitats with construction of a floodgate. Although this measure is intended to only limit flooding from events above the 5-year AEP, effects may be experienced by floodplain assemblages up to 50-year and 100-year flood events (Junk et al. 1989; Stromberg et al. 1993; Burke et al. 2003). There may be a threshold below which disturbances from more infrequent flood events leads to a substantial shift in floodplain biological communities (Graf 1983; Stromberg et al. 1993).

Inherent to the additional surface area of impervious structure to be constructed for this measure are changes to water velocity and depth, scouring of sediment upstream and downstream, and the potential for debris to further impact flow and act as a physical barrier to the movement of aquatic organisms. These effects are of more concern when high water levels or flow rates increase output demands through the obstruction created by a floodgate of the nature proposed here. During high water events, the floodgate would expose aquatic organisms to large differences in head pressures between waterways, elevated shear stresses and decompression levels. These physical effects can limit the exchange of aquatic organisms between Cowford Swamp and Bull Creek as organisms which cannot overcome the directional flow velocity moving under the gate would be restricted from passing (Beach 1984) and potentially affecting important migration periods (Halls et al. 1998), restricting access to valuable resources, and increasing vulnerability to predation; as well as directly contributing to mortality of organisms in vulnerable life stages such as larval forms (Martin and de Graaf 2002) and small-bodied fish (Pflugrath et al. 2019). Some of these impacts could be offset depending on design considerations such as the inclusion of stilling basins to diffuse energy flow under the gate (Beach 1984).

Auxiliary equipment to support functional operation of a floodgate could have additional impacts to aquatic organisms in the affected waterways. For instance, operation of pumping systems behind the floodgate can lead to an increased risk of entrainment and indirect effects on aquatic organism movement (Norman et al. 2023).

Use of the connected Bull Creek by ESA-species such as Atlantic sturgeon, shortnose sturgeon and West Indian manatee as well as species of conservation concern in Cowford Swamp raises additional concerns for impacts from construction of the floodgate. Particularly during construction, any in-water work could have direct impacts on sensitive aquatic organisms from potential for collisions, entanglement, entrainment, habitat obstruction and noise (Hieb et al. 2021). These potential impacts from construction-related disturbance may also affect nearby state-listed species such as the Swallow-tailed Kite (*Elanoides forficatus*) (Cely and Meyer 2015) which is known for nesting along Cowford Swamp in the late summer (M. Sasser, Email comm., 2024).

- **Essential Fish Habitat and Threatened and Endangered Species**

The sturgeon species which may occur in the study area (i.e., shortnose and Atlantic) occupy reaches of the Pee Dee River, Waccamaw River and Bull Creek. These reaches are designated as critical habitat for the Carolina and South Atlantic DPS of Atlantic sturgeon. As is discussed above, impacts to sturgeon species could occur from implementation of this alternative.

Manatees are known to occur in Bull Creek upstream of its junction with the Waccamaw River. Impacts from structural measures associated with altered hydrology and obstruction of waterways could have some adverse effects on manatees.

4.6.6.2 B2

Raising the Pee Dee Highway is expected to improve modes of egress and ingress for surrounding communities following flood events. This measure would require some expansion of the ROW area to accommodate additional structural support needed for the roadway and would reduce the amount of floodwater that flows over the roadway. This would innately contribute to some disconnection of nearby wetland habitats from floodwaters which may contribute to hydric conditions. However, this effect is expected to be minimal. Expansion of the ROW area would potentially require clearing of some trees and fill of some wetland, resulting in direct loss of these habitat types and impacts to associated species of plants and wildlife. Depending on the design feature, there is opportunity to maintain or improve connectivity of nearby wetlands through upfitting existing culverts or installation of new culverts where the highway bisects wetlands. This opportunity could improve habitat conditions already impacted by the existing highway and offset some impacts from expansion of the footprint laterally.

- **Essential Fish Habitat and Threatened and Endangered Species**

There is no EFH that would be affected by this alternative.

Impacts to ESA species would include any effects which could occur to Northern long-eared bat or tricolored bat where trees or structures are affected that could be utilized as potential habitat. Similarly, impacts to red-cockaded woodpecker are possible where suitable evergreen forest would be impacted. Given the scale of this action, formal consultation with USFWS would likely be required under Section 7 of the ESA.

4.6.6.3 BNS2

Effects would be the same as described in Section 4.6.3.4 above.

4.6.6.4 BNS4

Effects would be the same as described in Section 4.6.3.5 above.

4.7 Cultural Resources

The management of cultural resources is regulated under Federal laws such as the National Historic Preservation Act (NHPA) of 1966 (54 U.S.C. § 300101, et seq.), the Archaeological and Historic Preservation Act of 1974 (54 U.S.C. §§ 312501- 312508), the American Indian Religious Freedom Act of 1978 (42 U.S.C. §§ 1996 and 1996a), the Archeological Resources Protection Act of 1979 (16 U.S.C. §§ 470aa-470mm), NEPA (42 U.S.C. § 4321, et seq.), the Native American Graves Protection and Repatriation Act of 1990 (25 U.S.C. § 3001, et seq.), the Abandoned Shipwreck Act of 1987 (43 U.S.C. §§ 2101-2106, et seq.), and the Sunken Military Craft Act of 2004 (10 U.S.C. § 113, et seq.).

Cultural resources considered in this study are those defined by the NHPA as properties listed, or eligible for listing, on the National Register of Historic Places (NRHP) and are referred to as historic properties. Historic properties include buildings, structures, sites, districts, objects, cultural items, Indian sacred sites, archaeological artifact collections, and archaeological resources (36 CFR 800.16(l)(1)). Cultural resources also include resources with unknown NRHP eligibility status. A brief synopsis of potential effects to cultural resources is provided below, and a detailed evaluation of effects of the alternatives to cultural resources and historic properties is provided in Appendix D.

4.7.1 No Action

It is expected that the NFS and other governing bodies, government agencies and organizations will address flood risks where resources allow outside Federal assistance by USACE. These potential flood risk management actions are expected to result in similar impacts to cultural resources as would alternatives considered here, but on a scale relative to that allowed by resources available.

4.7.2 Longs/Red Bluff

4.7.2.1 LR1

Construction of floodwalls can disturb unknown archaeological sites, as well as cover archaeological sites to the point that they are no longer accessible for documentation/scientific research. Floodwalls can protect historic structures by reducing flooding and minimizing erosion that could impact structural integrity, but it can also impact viewsheds and change the feel of the environment, which pose adverse effects. Cultural resources surveys may be necessary for unsurveyed areas. Buffer zones can also be implemented for the immediate project area, as well as any staging areas and/or access roads, if there are known cultural sites that could potentially be impacted.

4.7.2.2 LR3

- **Benching**

Benching can disturb unknown archaeological sites, as well as cover archaeological sites to the point that they are no longer accessible for documentation/scientific research. Flood relief from benching can protect historic structures by reducing flooding and minimizing erosion that could impact structural integrity, but it can also impact viewsheds and change the feel of the environment, which pose adverse effects. Cultural resources surveys may be necessary for unsurveyed areas. Buffer zones can also be implemented for the immediate project area, as well as any staging areas and/or access roads, if there are known cultural sites that could potentially be impacted.

- **Relief Bridge (Cross Drain)**

Relief bridges typically have little to no impact on cultural resources. There are two caveats to this, however, which include when the current bridge is historic in nature and if there are cultural resources within the construction footprint that could be impacted. Replacement of historic bridges poses potential adverse effects to the bridge as a historic property, as well as any associated historic districts for which the bridge is a contributing structure. Additional potential adverse effects have to be investigated for nearby underwater archaeological sites. When these situations are present, they require more in-depth assessments and consultation under Section 106 of the NHPA. This could include the development of a programmatic agreement and further consultation to identify and mitigate for potential adverse effects. A programmatic agreement would necessitate consultation with the SHPO, appropriate federally recognized tribes, and the Advisory Council on Historic Preservation.

In terms of minimizing effects, as much of the historic bridge's integrity would need to be maintained. If the project is determined to adversely affect the historic bridge's integrity, examples of potential mitigation measure include a HAER (Historic American Engineering Record), educational signage, and/or other documentation or reporting determined through consultation. If the historic nature of the bridge and/or the presence of cultural resources are unknown, cultural surveys may be required to identify or better refine data associated with unknown or known cultural resources/historic structures. Buffer zones can also be implemented for the immediate project area, as well as any staging areas and/or access roads, if there are known cultural sites that could potentially be impacted.

4.7.2.3 LR6

The combination of floodwalls along Buck Creek, benching and relief bridges (cross drains) along Simpson Creek and elevation and acquisition of flood prone properties would likely be additive in effects to cultural resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here are geographically and hydrologically disjunct based on modeling, therefore largely eliminating potential to have synergistic effects on flooding and indirect effects to cultural resources.

4.7.2.4 LRNS3

Per the 2023 Department of Defense's Climate Adaptation Guide for Cultural Resources, structure elevation is an acceptable adaptation to climate change (DOD 2023). Surveys may be required to identify and/or better assess the historic properties that may be located within potential areas. Structure elevation may be a viable way to protect historic structures, but these structures may need to be assessed/documented in their original condition prior to modifications being implemented.

4.7.2.5 LRNS4

Acquisition does not typically have an impact unless the structure itself is historic; however, the presence of historic properties that may be eligible or do not have an eligibility determination will mean that a higher level of analysis may be required for a determination of effects. For example, a historic structures survey may be required to identify any previously unknown historic properties and/or make an eligibility determination. Indirect impacts of acquisitions may also need to be assessed to determine if there could be future adverse effects to any eligible historic properties after the acquisition process is complete. Purchase of properties by a local entity can aid in their preservation. If the structure can be characterized as a historic property and the known intent is eventual demolition, then this can pose an indirect effect that is adverse in nature. This would need to be considered in the cumulative impacts should this scenario fit any of the alternatives. To minimize potential impacts, a historic structures survey may be required to identify any previously unidentified historic properties. If historic structures are identified, then these structures may need to be assessed/documented in their original condition prior to transfer to this new entity, and a covenant or some other level of jurisdictional control (e.g., easement) may be required to ensure future protections. This may provide a higher level of protection for any historic properties than if the acquisition does not occur.

4.7.3 Conway

4.7.3.1 C3

Effects would be relatively the same as described in Section 4..2.2 (under "Relief Bridge (Cross Drain)" above.

4.7.3.2 C5

The combination of relief bridges (cross drains) and elevation and acquisition of flood prone properties would be additive in effects to cultural resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) there is only one type of structural measure considered here.

4.7.3.3 CNS1

Effects would be the same as described in Section 4..2.4 above.

4.7.3.4 CNS2

Effects would be the same as described in Section 4..2.5 above.

4.7.4 Socastee

4.7.4.1 S1

Effects to cultural resources from construction of floodwalls would be relatively the same as those described in Section 4..2.1 above.

Barrier removal can disturb and expose unknown archaeological sites. Flood relief from barrier removal can protect sites and historical structures by reducing damage and erosion during flood events with increased water flow. Cultural resources surveys may be necessary for unsurveyed areas. Buffer zones can also be implemented for the immediate project area, as well as any staging areas and/or access roads, if there are known cultural sites that could potentially be impacted.

4.7.4.2 S2

Implementing a detention pond can help reduce flood risk to cultural resources surrounding the pond. Channeling flood water in a detention pond can have beneficial effects to reducing erosion of archaeological sites and historic structures. Constructing a detention pond could lead to inadvertent discoveries of cultural resources and may require cultural resources surveys for any unsurveyed areas.

4.7.4.3 S3

Effects of weir removal would be the same as described in Section 4..4.1 above.

4.7.4.4 S4

The combination of floodwalls, a detention pond and removal of barriers along Socastee Creek, and elevation and acquisition of flood prone properties would likely be additive in effects to cultural resources. This is because (1) nonstructural measures are additive by nature and do not have the potential to increment, and (2) the structural measures considered here all unilaterally affect the same waterway (Socastee Creek).

4.7.4.5 SNS3

Effects would be the same as described in Section 4..2.4 above.

4.7.4.6 SNS4

Effects would be the same as described in Section 4..2.5 above.

4.7.5 Bucksport

4.7.5.1 B1

Constructing a floodgate can reduce flood risk to historic structures and archaeological sites. Implementing a floodgate helps to regulate storm water downstream, which can reduce erosion of archaeological sites during flood events. The construction footprint of the floodgate could pose risk to any unknown archaeological resources. A cultural resource survey would be necessary to document any potential sites prior to the construction of a floodgate.

4.7.5.2 B2

Highway elevation can have adverse effects to cultural resources near the construction footprint. Based on the presence of nearby historic structures, a survey would be necessary to determine NRHP eligibility based on an assessment of potential impacts. Road elevations can have an impact to viewsheds and potentially change the feel of the surrounding environment. Implementing buffer zones within the immediate project area, including staging areas and/or access roads, could help reduce adverse impacts to any cultural resources near the highway elevation.

4.7.5.3 BNS2

Effects would be the same as described in Section 4..2.4 above.

4.7.5.4 BNS4

Effects would be the same as described in Section 4..2.5 above.

4.8 Recreation

4.8.1 No Action

Under any of the alternatives, recreation impacts would be very similar to the FWOP condition. All the alternatives considered involve some form of construction which would lead to a temporary reduction in recreational opportunities in the immediate vicinity of the construction footprint. It is likely that under FWOP conditions, the NFS and other agencies would pursue similar means to reduce flood risk and would likely include several structural and non-structural measures that have very similar construction-related impacts to recreation. Thus, impacts to recreation under any of the alternatives are likely to be minor to moderate. Any impacts to recreation that might occur as an indirect result (i.e., changes in hydrology) of any of the alternatives considered are anticipated to be of minor to moderate consequence for these resources.

4.8.2 Alternatives Evaluated

The following tables outline the anticipated impacts on recreation resources from the evaluated alternatives. The impact ratings are categorized into minor, moderate, or major, reflecting the extent of contributions to climate change relative to those expected from the No Action alternative.

4.8.3 Longs/Red Bluff

Table 35 Impacts to Recreation from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate	- Construction of floodwalls may alter the landscape, affecting views and access to recreational areas. - Temporary disruptions due to construction activities. - Potential long-term impacts on water-based activities.
LR3	Minor	-- Relief bridge construction might temporarily impact access due to construction activities and traffic disruptions. - Potential long-term benefits from improved access.
LR6	Moderate	- Combination of floodwalls, benching, and relief bridges may cause cumulative disruptions to recreational areas. - Temporary construction impacts such as access disruptions and noise. - Long-term changes to water flow may affect activities.
LRNS3	Minor	- Elevation of homes may cause temporary disruptions such as road closures or noise. - Minimal long-term effects on recreational activities.
LRNS4	Minor	- Acquisition of flood-prone properties generally has minimal direct impacts. - Temporary disruptions during demolition. - Long-term benefits from converting properties to green spaces or parks.

4.8.4 Conway

Table 36 Impacts to Recreation from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	- Construction of a relief bridge may cause temporary disruptions to recreational access due to construction activities. - Possible long-term improvements in access.
C5	Minor	- Combination of relief bridges, elevation, and acquisition of flood-prone properties may have cumulative impacts on recreational areas. - Temporary disruptions due to construction activities and access changes. - Long-term benefits from improved infrastructure.
CNS1	Minor	- Acquisition of flood-prone properties typically results in minimal direct impacts. - Temporary disturbances during construction.
CNS2	Minor	- Similar to CNS1, with minor temporary impacts from construction. - Long-term recreational benefits from new green spaces or parks. - Overall, minimal direct impacts on recreational use.

4.8.5 Socastee

Table 37 Impacts to Recreation from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate	- Construction of floodwalls and removal of weirs may alter landscapes and obstruct views. - Temporary disruptions due to construction activities. - Potential long-term effects on water-based recreational activities.
S2	Moderate	- Creation of a detention pond and diversion canal involves extensive land-clearing, which could disrupt existing recreational areas. - Substantial changes in landscape and water flow could impact recreational activities like fishing or boating. - Long-term benefits from improved flood management.
S3	Minor	- Temporary disruptions and long-term changes to recreational access or water-based activities.
S4	Moderate	- Combination of floodwalls, detention pond, diversion canal, and property acquisitions could have cumulative impacts on recreational areas. - Extensive land-clearing and construction activities may cause substantial short-term disruptions. - Long-term benefits from improved flood management and new green spaces.
SNS3	Minor	- Similar to CNS1 and CNS2, with minimal direct impacts.
SNS4	Minor	- Similar to SNS3, with minor temporary impacts from demolition. - Potential for new green spaces or parks that could enhance recreational opportunities. - Overall, minimal direct impacts on recreational use.

4.8.6 Bucksport

Table 38 Impacts to Recreation from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor	- Construction of a floodgate may cause temporary disruptions to recreational access due to construction activities. - Long-term improvements in water management may benefit recreational access.
B2	Moderate	- Raising approximately 7 miles of highway involves substantial earth-moving activities, which could disrupt access to recreational areas. - Temporary construction impacts, including road closures and noise. - Long-term benefits from improved traffic flow and reduced congestion.
BNS2	Minor	- Similar to CNS1, with minimal direct impacts on recreation. - Temporary disturbances during construction.
BNS4	Minor	- Temporary disruptions from construction activities. - Long-term benefits from improved infrastructure and creation of new green spaces.

4.9 Transportation

4.9.1 No Action

As transportation infrastructure changes into FWOP conditions, existing flood risks in some areas may be addressed as new bridges, highway elevations and other structural measures continue to be pursued by the NFS and other local entities. However, development of more impervious surfaces and any associated filling of wetlands to accommodate construction of transportation projects may lead to new or exacerbated flood risk in some areas. Nevertheless, alternatives considered here are intended to improve flood risks and transportation from both existing conditions and FWOP conditions modeled with planned and permitted transportation projects.

4.9.2 Alternatives Evaluated

Throughout the study area, some structural impacts which overlap with modes of transportation (i.e., roads and bridges) may have direct impacts to transportation during the duration of construction. Temporary detours may be required during construction, however, there are no alternatives which would temporarily close transportation routes entirely between municipalities as alternative routes would be available within reasonable distance. In general, flood risk reduction measures are designed to reduce the extent and duration of flooding in developed areas, and thus, relative to FWOP conditions, would affect transportation positively once construction has ceased. Thus, net positive outcomes on transportation are expected over time.

All the flood impact areas in the study have associated non-structural plans as independent or combined alternatives. There are no direct or indirect impacts expected to occur from implementation of non-structural measures other than minimal impacts of increased construction-related vehicular traffic and movement.

The following tables outline the anticipated impacts on transportation resources from the evaluated alternatives.

4.9.3 Longs/Red Bluff

Table 39 Impacts to Transportation from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Minor	- Construction of floodwalls may cause temporary road closures or detours. - Disruptions during construction could affect local traffic flow. - Long-term improvements in flood management could reduce road damage and improve safety.
LR3	Minor to Moderate	- Benching and relief bridge construction may lead to temporary road closures or detours. - Short-term disruptions to traffic during construction. - Long-term benefits include improved infrastructure for water flow and potentially less congestion.
LR6	Minor to Moderate	- Combination of floodwalls, benching, and relief bridges could result in road closures or detours. - Temporary impacts on traffic flow and access. - Long-term improvements in flood management could enhance road safety and reduce delays.
LRNS3	Minor	- Elevation of homes may cause minimal disruptions to local roads. - Short-term construction impacts with potential minor traffic delays. - Long-term benefits include reduced flood risk that could prevent future road damage.
LRNS4	Minor	- Acquisition of flood-prone properties may involve temporary road disruptions during demolition. - Possible short-term impacts on local transportation. - Long-term benefits from reduced flood risk and improved infrastructure.

4.9.4 Conway

Table 40 Impacts to Transportation from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor to Moderate	- Relief bridge construction may cause temporary road closures or detours. - Short-term impacts on local traffic during construction. - Long-term improvements in infrastructure may enhance traffic flow and reduce congestion.
C5	Minor to Moderate	- Combination of relief bridges, elevation, and acquisition of flood-prone properties may have cumulative impacts on transportation.
CNS1	Minor	- Elevation of homes may cause minimal disruptions to local roads. - Short-term construction impacts with potential minor traffic delays. - Long-term benefits include reduced flood risk that could prevent future road damage.
CNS2	Minor	- Acquisition of flood-prone properties may involve temporary road disruptions during demolition. - Possible short-term impacts on local transportation. - Long-term benefits from reduced flood risk and improved infrastructure.

4.9.5 Socastee

Table 41 Impacts to Transportation from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Minor	- Floodwall construction and weir removal may cause temporary road disruptions. - Short-term impacts on local traffic and access. - Long-term benefits from improved flood management could enhance road safety and reduce future disruptions.
S2	Minor	- Extensive land-clearing for a detention pond and diversion canal may lead to some traffic disruptions. - Long-term improvements in flood management could reduce future traffic-related issues.
S3	Minor	-- Little or no disruptions to local roads and traffic flow. - Long-term benefits from improved flood management and infrastructure.
S4	Minor	- Cumulative impacts from floodwalls, detention pond, diversion canal, and property acquisitions. - Substantial short-term traffic disruptions and potential road closures. - Long-term benefits from enhanced infrastructure and reduced flood risk.
SNS3	Minor	- Elevation of homes may cause minimal disruptions to local roads. - Short-term construction impacts with potential minor traffic delays. - Long-term benefits include reduced flood risk that could prevent future road damage.
SNS4	Minor	- Acquisition of flood-prone properties may involve temporary road disruptions during demolition. - Possible short-term impacts on local transportation. - Long-term benefits from reduced flood risk and improved infrastructure.

4.9.6 Bucksport

Table 42 Impacts to Transportation from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor to Moderate	- Floodgate construction may cause temporary disruptions to local roads and bridge. - Short-term impacts on traffic flow and access. - Long-term improvements in flood management could enhance road safety and reduce future disruptions.
B2	Moderate	- Raising 7 miles of highway involves extensive construction activities. - Substantial short-term impacts on traffic flow, including detours and road closures. - Long-term benefits from improved road conditions and reduced congestion.
BNS2	Minor	- Elevation of homes may cause minimal disruptions to local roads. - Short-term construction impacts with potential minor traffic delays. - Long-term benefits include reduced flood risk that could prevent future road damage.
BNS4	Minor	- Acquisition of flood-prone properties may involve temporary road disruptions during demolition.

Alternative	Impact Relative to NAA	Details
		- Possible short-term impacts on local transportation. - Long-term benefits from reduced flood risk and improved infrastructure.

4.10 Socioeconomics and Environmental Justice

4.10.1 No Action

Under FWOP conditions, the study area is expected to continue to increase racial diversity and expand economically, thus improving socioeconomic and environmental justice conditions from existing conditions. These conditions, particularly those related to economy and vulnerable populations (e.g., large cohort of age >55 individuals), are likely to further improve with increased action addressing flood risk. It is expected that the NFS and other governing bodies, government agencies and organizations will address flood risks where resources allow outside Federal assistance by USACE. These potential flood risk management actions are expected to result in similar impacts to socioeconomics and environmental justice as would alternatives considered here, but on a scale relative to that allowed by resources available.

4.10.2 Alternatives Evaluated

- **Socioeconomics**

Socioeconomic impacts are assessed in terms of direct effects on the local economy and population, and related indirect effects on other socioeconomic resources within the study area or adjacent to the study area, in this case, Horry County.

Construction activities associated with any of the alternatives would be expected to directly affect the local economy through a temporary increase in economic activity in the construction sector. Temporary increases in employment, income, business activity, and local tax revenues would be anticipated in years in which construction of the structures are implemented. No permanent change in population or demand on local public services would be expected.

Under all of the alternatives considered, an indirect effect of flood reduction on socioeconomics would include the alleviation of flood impacts on local economies. For example, anywhere flooding no longer affects the ability for transportation, an exchange of goods, or operation of a business occurs, a socioeconomic benefit would be gained, and vise-versa where any flooding remains or is worsened by measures. However, these effects are not expected to be significant with respect to influence on socioeconomics of the area.

- **Environmental Justice**

Environmental justice impacts are assessed in terms of direct effects on overburdened populations (i.e., minorities, Indian tribes, low-income residents, and children) within or adjacent to the study area.

Locations where structural measures are proposed under alternatives considered overlap with communities which are and are not identified as disadvantaged by the EPA in Conway and Longs/Red Bluff. Structural measures proposed in these areas are proposed to reduce flood damages to surrounding infrastructure and residences and would not have adverse or disproportionate impacts. Construction footprints would not overlap with properties in a way that would have any adverse impacts to individuals or contribute to any negative environmental effects (e.g., air pollution, noise pollution, etc.). Structural measures are anticipated to have net benefits to surrounding communities.

Properties identified for acquisition or elevation may fall within areas identified as disadvantaged or overburdened by the EPA. However, these properties are identified for acquisition or elevation because they are repetitively inundated with substantial depths and durations of flood waters. Acquisition or elevation of these properties would serve to enhance the life quality of these individuals relative to FWOP conditions. Furthermore, elevation of properties is voluntary. These FWP conditions do not represent disproportionate or adverse impacts to disadvantaged communities.

The following tables outline the anticipated impacts on socioeconomics and environmental justice resources from the evaluated alternatives.

4.10.3 Longs/Red Bluff

Table 43 Impacts to Socioeconomics and Environmental Justice from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate	- Construction of floodwalls may lead to displacement of communities or changes in property values. - Potential impacts on local businesses and recreational areas. - Communities with limited resources may experience more pronounced effects.
LR3	Minor to Moderate	- Benching and relief bridges might cause temporary disruptions to local businesses and residences. - Possible changes in property values. - Long-term benefits include improved infrastructure that could enhance access and community resilience.
LR6	Moderate	- Combination of floodwalls, benching, and relief bridges may have cumulative effects on local communities. - Potential displacement or property value changes. - More pronounced effects on lower-income or marginalized communities due to concentrated impacts.
LRNS3	Minor	- Elevation of homes might lead to temporary disruptions but generally has minimal direct impacts on socioeconomic factors. - Long-term benefits include reduced flood risk and potential improvement in property values.
LRNS4	Minor to Moderate	- Acquisition of flood-prone properties may temporarily disrupt local economies. - Long-term benefits from creating new green spaces or parks can enhance community well-being. - Disproportionate impacts might be felt by lower-income or minority communities.

4.10.4 Conway

Table 44 Impacts to Socioeconomics and Environmental Justice from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	- Construction of relief bridges might cause temporary disruptions to local businesses and residents. - Long-term improvements in infrastructure could benefit community resilience and access.
C5	Minor	- Combination of relief bridges, elevation, and acquisition of flood-prone properties may have cumulative socioeconomic impacts. - Potential for displacement or changes in local property values. - Disproportionate effects on lower-income or marginalized communities.
CNS1	Minor	- Elevation of homes might lead to temporary disruptions but generally has minimal direct impacts on socioeconomic factors. - Long-term benefits include reduced flood risk and potential improvement in property values.
CNS2	Minor to Moderate	- Acquisition of flood-prone properties may temporarily disrupt local economies. - Long-term benefits from creating new green spaces or parks can enhance community well-being. - Disproportionate impacts might be felt by lower-income or minority communities.

4.10.5 Socastee

Table 45 Impacts to Socioeconomics and Environmental Justice from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate	- Construction of floodwalls and removal of weirs may cause temporary disruptions to local businesses and residences. - Potential changes in property values. - Long-term benefits could include reduced flood risk and improved community resilience.
S2	Moderate	- Extensive land-clearing for a detention pond and diversion canal may disrupt local economies and lead to temporary displacements. - Long-term benefits from improved flood management could enhance community resilience, but impacts may be more pronounced on lower-income or marginalized groups.
S3	Minor	- Temporary disruptions and potential changes in property values. - Long-term improvements in flood management and community resilience.
S4	Moderate	- Combination of floodwalls, a detention pond, diversion canal, and property acquisitions may have cumulative impacts. - Potential for displacement and changes in local economies. - Long-term benefits from improved infrastructure and new green spaces.
SNS3	Minor	- Elevation of homes might lead to temporary disruptions but generally has minimal direct impacts on socioeconomic factors.

Alternative	Impact Relative to NAA	Details
		- Long-term benefits include reduced flood risk and potential improvement in property values.
SNS4	Minor to Moderate	- Acquisition of flood-prone properties may temporarily disrupt local economies. - Long-term benefits from creating new green spaces or parks can enhance community well-being. - Disproportionate impacts might be felt by lower-income or minority communities.

4.10.6 Bucksport

Table 46 Impacts to Socioeconomics and Environmental Justice from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor to Moderate	- Construction of a floodgate may cause temporary disruptions to local businesses and residents. - Potential changes in property values. - Long-term benefits from improved flood management may enhance community resilience.
B2	Moderate	- Raising approximately 7 miles of highway involves extensive construction activities. - Temporary disruptions to local access and potential impacts on businesses. - Long-term benefits include improved traffic flow, which could positively impact local economies.
BNS2	Minor	- Elevation of homes might lead to temporary disruptions but generally has minimal direct impacts on socioeconomic factors. - Long-term benefits include reduced flood risk and potential improvement in property values.
BNS4	Minor to Moderate	- Acquisition of flood-prone properties may temporarily disrupt local economies. - Long-term benefits from creating new green spaces or parks can enhance community well-being. - Disproportionate impacts might be felt by lower-income or minority communities.

4.11 Hazardous, Toxic and Radioactive Waste

4.11.1 No Action

It is expected that impacts related to HTRW as they pertain to flood risk will remain roughly the same or slightly more adverse under FWOP conditions. Actions to address flood risk are expected to occur with or without Federal action by USACE on this project, although are likely to be more limited in scale due to less resources being available. Some unabated and increased flooding depths, duration, or intensity could result in greater degrees of HTRW exposure to the environment.

4.11.2 Alternatives Evaluated

There are no active HTRW sites which would directly overlap with and be affected by structural measures in the study area. There is some potential for properties identified for elevation or acquisition to harbor HTRW. These properties would be evaluated for such substances or exposures prior to the real estate easement acquisition process.

Any HTRW would be the responsibility of the NFS to remove from potential effects associated with elevations or acquisition before easements to those properties can be executed.

The following tables outline the anticipated impacts on HTRW resources from the evaluated alternatives.

4.11.3 Longs/Red Bluff

Table 47 Impacts to HTRW from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Minor	- Construction of floodwalls involves land-clearing and excavation which could disturb any existing contaminated soils. - Measures should be in place to handle and dispose of any HTRW encountered.
LR3	Minor	- Benching and relief bridge construction might involve excavation and disturbance of soils that could contain HTRW. - Proper handling and disposal procedures are essential to manage any potential contamination.
LR6	Minor	- Combination of floodwalls, benching, and relief bridges increases the likelihood of encountering and handling HTRW. - Comprehensive site assessments and management plans are necessary to address potential contamination issues.
LRNS3	Minor	- Elevation of homes generally involves minimal excavation and disturbance of soils, reducing the likelihood of encountering HTRW. - Effective handling and disposal practices are still required if contamination is found.
LRNS4	Minor to Moderate	- Property acquisition and demolition activities might reveal HTRW, particularly in older or industrial areas. - Site assessments and safe handling protocols are important to manage any discovered waste.

4.11.4 Conway

Table 48 Impacts to HTRW from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	- Relief bridge construction could involve excavation that might uncover HTRW. - Proper site assessments and waste management plans should be in place to address any potential issues.
C5	Minor to Moderate	- Relief bridge construction could involve excavation that might uncover HTRW. - Detailed HTRW assessments and handling procedures are required to reduce potential risks.
CNS1	Minor	- Elevation of homes generally involves minimal excavation and disturbance of soils, reducing the likelihood of encountering HTRW. - Effective handling and disposal practices are still required if contamination is found.

Alternative	Impact Relative to NAA	Details
CNS2	Minor to Moderate	- Similar to CNS1, with minimal risks associated with property acquisition and demolition. - Effective waste management practices are needed to handle any HTRW found during the process.

4.11.5 Socastee

Table 49 Impacts to HTRW from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Minor	- Floodwall construction and weir removal might involve excavation and soil disturbance. - Site assessments and handling procedures are important to manage potential HTRW issues.
S2	Minor to Moderate	- Clearing 50 acres for a detention pond and diversion canal involves substantial excavation which could disturb HTRW. - Comprehensive assessments and management plans are essential to address potential contamination.
S3	Minor	- Weir removal is highly unlikely to involve any HTRW
S4	Minor to Moderate	- The combined impact of floodwalls, detention pond, diversion canal, and property acquisition increases the potential for encountering and managing HTRW. - Thorough assessments and robust waste management plans are needed.
SNS3	Minor	- Elevation of homes generally involves minimal excavation and disturbance of soils, reducing the likelihood of encountering HTRW. - Effective handling and disposal practices are still required if contamination is found.
SNS4	Minor to Moderate	- Similar to SNS3, with a slightly increased risk due to the scale of property acquisition and demolition. - Effective waste management practices are necessary to address any HTRW found.

4.11.6 Bucksport

Table 50 Impacts to HTRW from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor	- Floodgate construction involves excavation which may disturb contaminated soils. - Site assessments and waste management protocols are necessary to handle any potential HTRW issues.
B2	Minor to Moderate	- Raising 7 miles of highway involves extensive excavation, increasing the risk of encountering and handling HTRW. - Detailed assessments and effective management practices are required.
BNS2	Minimal	- Elevation of homes generally involves minimal excavation and disturbance of soils, reducing the likelihood of encountering HTRW. - Effective handling and disposal practices are still required if contamination is found.

Alternative	Impact Relative to NAA	Details
BNS4	Minor to Moderate	- Property acquisition and demolition activities might reveal HTRW, particularly in older or industrial areas. - Site assessments and safe handling protocols are important to manage any discovered waste.

4.12 Aesthetics

4.12.1 No Action

Flooding will continue to inhibit the ability of individuals of the area to enjoy aesthetic qualities of the study area beyond the targeted areas for measures as well as those areas nearby. It is expected that outside of Federal action by USACE on this project, other entities will continue to pursue flood risk reduction efforts and have similar effects to aesthetics, including both those that may improve aesthetics and those that may be adverse. However, these efforts may be limited to resources available to those entities and over a longer timeline, potentially reducing the ability to ameliorate the effects flooding has on aesthetics. Similarly, it is not known whether those entities would pursue similar actions in the areas considered here.

4.12.2 Alternatives Evaluated

The similarity zones described in Section 2.14.1 were all found to meet the modification class management classification described in WES Instructional Report EL-88-1. According to EL-88-1, "*These areas are not noted for their distinct qualities and are often considered to be of average visual quality. Project activity may attract attention and dominate the existing visual resource. Structures, operations, and use activities may display characteristics of form, line, color, texture, scale, and composition that differ from those of the existing visual resources. However, the project should exhibit good design and visual compatibility with its surroundings.*"

Under most of the alternatives, effects to aesthetics would be of limited consequence. Given the flat topography, the remote and highly rural areas affected, and the lack of accessibility to the areas where measures are being considered, much of the visual resources directly affected would be unrealized. Where measures would create disturbances in the aesthetic qualities of visual environments (e.g., floodwall in Longs, floodgate in Bucksport), these changes are expected to be of low magnitude. Some benefits, however, may be realized from many of the alternatives considered as flood reduction would enable individuals to continue to physically navigate their surroundings and visual resources would not be inundated to the same degree. In addition, to the extent practicable, visual quality objectives or visual resource criteria will also be applied during detailed planning and design to avoid or minimize impacts to visual resources and aesthetics.

The following tables outline the anticipated impacts on aesthetics resources from the evaluated alternatives.

4.12.3 Longs/Red Bluff

Table 51 Impacts to Aesthetics from alternatives evaluated in Longs/Red Bluff

Alternative	Impact Relative to NAA	Details
LR1	Moderate to Major	- Construction of floodwalls over 3 miles can alter the landscape, introducing large, industrial structures that may detract from the natural visual appeal of the area.
LR3	Minor to Moderate	- Benching and relief bridge construction can impact aesthetics by altering landforms and introducing new structures. The effects are generally limited but still noticeable.
LR6	Moderate to Major	- The combined impacts can notably alter the visual landscape, potentially creating a more urban or industrial appearance in previously natural areas.
LRNS3	Minor	- Elevation of homes is typically a smaller scale project with less visual impact. However, some changes in visual character might occur depending on the height and extent of elevation.
LRNS4	Minor	- Property acquisition and subsequent conversion to green spaces or buffers may have minor aesthetic impacts initially but could result in long-term visual benefits through enhanced natural areas.

4.12.4 Conway

Table 52 Impacts to Aesthetics from alternatives evaluated in Conway

Alternative	Impact Relative to NAA	Details
C3	Minor	- Relief bridge construction may introduce visible structures that could alter local aesthetics, but the impact is generally minor compared to larger-scale projects.
C5	Minor	- This represents a combined and cumulative impact
CNS1	Minor	- Elevation of homes is typically a smaller scale project with less visual impact. However, some changes in visual character might occur depending on the height and extent of elevation.
CNS2	Minor	- Property acquisition and subsequent conversion to green spaces or buffers may have minor aesthetic impacts initially but could result in long-term visual benefits through enhanced natural areas.

4.12.5 Socastee

Table 53 Impacts to Aesthetics from alternatives evaluated in Socastee

Alternative	Impact Relative to NAA	Details
S1	Moderate to Major	- Floodwall construction and weir removal could impact the visual appeal of the creek area by introducing large structures and altering the natural landscape.
S2	Moderate to Major	- Clearing 50 acres for a detention pond and diversion canal will substantially alter the landscape, creating large, visible changes in landform and vegetation.

Alternative	Impact Relative to NAA	Details
S3	Minor	-Removal of weirs likely to return aesthetics to more natural form along creek
S4	Major	- The combined impacts of floodwalls, detention pond, diversion canal, and property acquisition will lead to substantial changes in the visual landscape, potentially creating an industrial or altered aesthetic.
SNS3	Minor	- Elevation of homes is typically a smaller scale project with less visual impact. However, some changes in visual character might occur depending on the height and extent of elevation.
SNS4	Minor	- Property acquisition and subsequent conversion to green spaces or buffers may have minor aesthetic impacts initially but could result in long-term visual benefits through enhanced natural areas.

4.12.6 Bucksport

Table 54 Impacts to Aesthetics from alternatives evaluated in Bucksport

Alternative	Impact Relative to NAA	Details
B1	Minor to Moderate	- Floodgate construction may introduce new structures into the landscape, with visual impacts dependent on the scale and design of the floodgate.
B2	Moderate	- Raising 7 miles of highway will result in substantial changes to the landscape, creating a more industrial appearance and altering the existing visual character.
BNS2	Minor	- Elevation of homes is typically a smaller scale project with less visual impact. However, some changes in visual character might occur depending on the height and extent of elevation.
BNS4	Minor	- Property acquisition and subsequent conversion to green spaces or buffers may have minor aesthetic impacts initially but could result in long-term visual benefits through enhanced natural areas.

4.13 Cumulative Impact Analysis

This section presents the cumulative impacts of the alternatives considered. NEPA regulations require that cumulative impacts of a proposed action be assessed and disclosed. The Council on Environmental Quality (CEQ) regulations define a cumulative impact as "*the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (federal or non-federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time.*" (40 CFR 1508.7).

The alternatives evaluated herein are expected to have at least some impacts with potential for cumulative impacts on resources which include land use, water resources, and biological resources. With respect to the remaining topics (i.e., air quality, climate, cultural resources, recreation, transportation, socioeconomics environmental justice, HTRW, and aesthetics), the considered alternatives are not expected to result in meaningful contribution to any cumulative effects or would involve resources with no other known actions which have or will contribute to cumulative impacts.

An assessment of cumulative impacts was performed within the context of relevant past, present and reasonably foreseeable actions (Table 55) in, or reasonably near, each measure included in the alternatives being analyzed. For example, this included the physical boundaries of structural measures as well as the resources which are estimated to be affected by the measures, such as downstream reaches of waterways, nearby communities, and land uses which may be influenced by such measures. For each flood impact area, the cumulative impacts were considered by examining the potential additive and interactive impacts of these alternatives with the other past, present, and reasonably foreseeable future actions. The NAA is not examined for cumulative effects since there is no incremental impact.

Table 55: Cumulative impacts analysis for alternatives evaluated.

<table>
<tr><th>Resource Area</th><th>Flood Impact Area</th><th>Projected Impacts</th><th>Past Actions/Conditions (from 1993)</th><th>Present Actions/Conditions (2024)**</th><th>Reasonably Foreseeable Actions (2040+)</th><th>Cumulative Impacts</th></tr>
<tr><td rowspan="3">Land Use**</td><td rowspan="2">Longs/Red Bluff</td><td rowspan="2">Direct:
LR1: 27-acre footprint (mostly OS-Dev., and forested wetlands)
LR3: 6-acre footprint (mostly forested wetlands and shrub wetlands)
LRNS3, LRNS4: None
LR6: 33-acre footprint
Indirect:
LR1, LR3:
• Minor change in wetland hydrology
• Preservation of other existing land uses from changes associated with recurrent flooding
LRNS3, LRNS4: None
LR6: Additive</td><td>49% forested wetland
17% evergreen forest
10% cultivated
6% OS-Dev.
≤5% other</td><td>43% forested wetland
16% evergreen forest
10% shrub wetland
8% cultivated
7% OS-Dev.
6% shrub
6% LI-Dev.
≤5% other</td><td>(Based on Horry County IMAGINE 2040)

Additional change of about 10% from mix of land uses to mostly suburban development.

Buck Creek Benching Project – impacts are beyond area of analysis.</td><td rowspan="2">LR1, LR3:
Insignificant - Represent minor contribution to land use changes relative to those past, present and reasonably foreseeable
LRNS3, LRNS4:
Insignificant – Represent no land use changes
LR6:
Insignificant – Additive impacts remain minor</td></tr>
<tr><td>49% forested wetland
12% evergreen forest
12% cultivated
9% shrub wetland
9% shrub
≤5% other</td><td>46% forested wetland
20% evergreen forest
11% cultivated
10% shrub wetland
≤5% other</td><td>(Based on Horry County IMAGINE 2040)

Little to no change</td></tr>
<tr><td>Conway</td><td>Direct:
C3: <1 acre footprint
CNS1, CNS2: None
C5: <1 acre footprint
Indirect:
C3:
• Minor in wetland hydrology
• Preservation of other existing land uses from changes associated with recurrent flooding
CNS1, CNS2: None
C5: Additive</td><td>50% forested wetland
12% LI-Dev.
10% water
8% OS-Dev.
≤5% other</td><td>49% forested wetland
13% LI-Dev.
10% water
8% OS-Dev.
≤5% other</td><td>(Based on Horry County IMAGINE 2040)

Little to no change

Hawthorne Dr. and Long Ave. Wetland Park Project, Sherwood Forest-Crabtree Swamp Flood Solutions Projects – impacts are beyond area of analysis.</td><td>C3:
Insignificant – Represents minor contribution to land use changes relative to those past, present and reasonably foreseeable
CNS1, CNS2:
Insignificant – represent no land use changes
C5:
Insignificant – Additive impacts remain minor</td></tr>
</table>

<table>
<tr><th>Resource Area</th><th>Flood Impact Area</th><th>Projected Impacts</th><th>Past Actions/Conditions (from 1993)</th><th>Present Actions/Conditions (2024)**</th><th>Reasonably Foreseeable Actions (2040+)</th><th>Cumulative Impacts</th></tr>
<tr><td rowspan="2"></td><td>Socaste e</td><td>Direct:
S1: 39-acre footprint
S2: 63-acre footprint
S3, SNS3, SNS4: None
S4: 102-acre footprint
Indirect:
S1, S2, S3:
• Minor change in wetland hydrology
• Preservation of other existing land uses from changes associated with recurrent flooding
SNS3, SNS4: None
S4: Additive</td><td>22% evergreen forest
19% forested wetland
17% LI-Dev.
14% OS-Dev.
7% shrub
≤5% other</td><td>31% LI-Dev.
20% OS-Dev.
13% forested wetland
9% MI-Dev.
8% evergreen forest
≤5% other</td><td>(Based on Horry County IMAGINE 2040)

Small percentage of increased development of suburban households is likely.

McCormick Bridge Supplemental Culvert Project - Represents minor contribution to land use changes.</td><td>S1, S2, S3:
Insignificant - Represent minor contribution to land use changes relative to those past, present and reasonably foreseeable
SNS3, SNS4:
Insignificant – Represent no land use changes
S4:
Significant – Additive impacts would cause moderate to major loss of existing forested wetland in area of analysis</td></tr>
<tr><td>Buckspo rt</td><td>Direct:
B1: 2-acre footprint
B2: 200-acre footprint
BNS2, BNS4: None
Indirect:
B1:
• Minor change in wetland hydrology
• Preservation of other existing land uses from changes associated with recurrent flooding
B2: None
BNS2, BNS4: None</td><td>46% forested wetland
28% evergreen forest
9% shrub
6% cultivated
≤5% other</td><td>39% forested wetland
27% evergreen forest
9% shrub wetland
8% shrub
6% cultivated
≤5% other</td><td>(Based on Horry County IMAGINE 2040)

Little to no change is expected

Big Bull Landing Project – little to no adverse impact on land use</td><td>B1, B2:
Insignificant - Represent minor contribution to land use changes relative to those past, present and reasonably foreseeable
BNS3, BNS4:
Insignificant – Represent no land use changes</td></tr>
<tr><td>Air Quality</td><td colspan="6">Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.</td></tr>
<tr><td>Climate</td><td colspan="6">Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.</td></tr>
<tr><td>Geologic Resources</td><td colspan="6">Direct and indirect impacts to geological resources are largely absent under any of the alternatives with exception to potential impacts to farmland. Analysis of these impacts would be very similar to that for land use described above. Impacts to farmland under any alternative would be in significant when considered with past, present, and reasonably foreseeable impacts.</td></tr>
</table>

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
Water Resources **	**Longs/Red Bluff**	***Direct:*** **LR1:** 10-acre footprint in wetlands (mostly forested) **LR3:** 5-acre footprint in wetlands (mix forested and emergent) **LRNS3, LRNS4:** None **LR6:** 15-acre footprint in wetlands ***Indirect:*** **LR1, LR3:** • Minor shifts in hydrology • Neutral effects to water quality • Minor reduction in floodplain extent • Minor changes in hydromorphology of creeks • Neutral effects to groundwater **LRNS3:** Potentially improved water quality **LRNS4:** Potentially improved water quality and water storage **LR6:** Additive	3,049 acres forested wetland 310 acres shrub wetland 35 acres emergent wetland Total 3,394 acres of wetlands Channelization of Buck Creek Impaired water (mercury) where Buck Creek meets Waccamaw River	-360 acres forested wetland (-12%) +318 acres shrub wetland (+103%) -11 acres emergent wetland (-29%) Net loss of 53 acres of wetland (-2%) Impaired water (mercury) where Buck Creek meets Waccamaw River No groundwater wells known near affected area	Some wetland filling and drainage expected to continue with future development based on land use forecast in Horry County (2019). Reliance on surface waters of water supply is expected to increase. Buck Creek Benching Project – impacts are beyond area of analysis.	**LR1, LR3, LR6:** Insignificant - Wetland loss would be offset by mitigation and potential changes to water quality, floodplain, hydrology, and groundwater represents minor contribution to changes relative to those past, present and reasonably foreseeable **LRNS3, LRNS4:** Insignificant – No adverse impacts
			1,173 acres forested wetland 225 acres shrub wetland 92 acres emergent wetland Total 1,490 acres of wetlands Channelization of Simpson Creek upstream Hwy 905 Impaired water (*E. coli*) where Simpson Creek meets Hwy 905	-52 acres forested wetland (-4%) +16 acres shrub wetland (+7%) -65 acres emergent wetland (-71%) Net loss of 100 acres wetlands (-7%) Impaired water (*E. coli*) where Simpson Creek meets Hwy 905	Similar or less wetland filling and drainage expected based on land use forecast in Horry County (2019). Reliance on surface waters of water supply is expected to increase.	

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
	Conway	***Direct*:** **C3:** <1 acre footprint in wetlands **CNS1, CNS2:** None **C5**: <1 acre footprint in wetlands ***Indirect*:** **C3:** • Minor shifts in hydrology • Potentially improved water quality • Minor reduction in floodplain extent • Neutral effects to groundwater **CNS1:** Potentially improved water quality **CNS2**: Potentially improved water quality and water storage **C5:** Additive	2,770 acres forested wetland 225 acres emergent wetland 120 acres shrub wetland Total 3,115 acres of wetlands	-81 acres forested wetland (-3%) +8 acres emergent wetland (+3%) +46 acres shrub wetland (+38%) Net loss of 27 acres wetlands (-1%) These estimates do not include the approximate 265 acres of emergent wetland increase from draining of Lake Busbee in 2018.	Similar or less wetland filling and drainage expected based on land use forecast in Horry County (2019). More tree planting and evaporation is expected at Lake Busbee and resulting in some increased emergent wetlands. Reliance on surface waters of water supply is expected to increase. Hawthorne Dr. and Long Ave. Wetland Park Project, Sherwood Forest-Crabtree Swamp Flood Solutions Projects – impacts are beyond area of analysis.	**C3, C5:** Insignificant - Wetland loss and potential changes to water quality, floodplain, hydrology, and groundwater represents minor contribution to changes relative to those past, present and reasonably foreseeable. **CNS1, CNS2:** Insignificant – No adverse impacts
	Socastee	***Direct:*** **S1:** 34-acre footprint in wetlands (mostly forested) **S2:** 22-acre footprint in wetlands (mostly forested) **S3:** None **S4:** 56-acre footprint in wetlands ***Indirect*:** **S1:** • Minor shifts in hydrology • Neutral effects to water quality • Moderate to major reduction in floodplain extent • Minor changes in hydromorphology of creek • Minor effects to groundwater **S2:** • Potential for creation of new wetlands • Moderate shifts in hydrology • Potential for minor build-up and release of contaminants/water quality impacts • Minor reduction in floodplain extent **S3:** • Improved hydrology • Improved water quality • Minor reduction in floodplain extent **SNS3:** Potentially improved water quality **SNS4:** Potentially improved water quality and water storage **S4:** Additive	826 acres forested wetland 191 acres shrub wetland 40 acres emergent wetland Total 1,056 acres of wetlands In 1993, USACE channelized about 2 miles of Socastee Swamp and performed clearing and snagging. Two weirs were also added as part of this project to maintain the groundwater table.	-289 acres forested wetland (-35%) -45 acres shrub wetland (-23%) +43 acres emergent wetland (+8%) Net loss of 300 acres wetlands (-31%)	Some wetland filling and drainage expected to continue with future development based on land use forecast in Horry County (2019). Reliance on surface waters of water supply is expected to increase. McCormick Bridge Supplemental Culvert Project – Potential wetland loss would be offset by mitigation and potential changes to water quality, floodplain, hydrology, and groundwater represents minor contribution to changes.	**S1,S2,S4:** Significant - Wetland loss would be offset by mitigation, however, potential changes to water quality, floodplain, hydrology, and groundwater represents moderate to major contribution to changes relative to those past, present and reasonably foreseeable **S3:** Insignificant – No wetland loss and potential changes to water quality, floodplain, hydrology, and groundwater represents minor contribution to changes relative to those past, present and reasonably foreseeable **SNS3, SNS4:** Insignificant – No adverse impacts

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
	Bucksport	***Direct:*** **B1:** 1-acre footprint in wetlands **B2:** 20-acre footprint in wetlands **BNS2, BNS4:** None ***Indirect:*** **B1:** • Minor change from woody wetlands to (other) forest • Minor to moderate impacts to hydrology • Minor reduction in floodplain extent **B2:** None **BNS2:** Potentially improved water quality **BNS4:** Potentially improved water quality and water storage	8,166 acres forested wetland 635 acres shrub wetland 131 acres emergent wetland Total 8,932 acres of wetlands	-1,265 acres forested wetland (-15%) +980 acres shrub wetland (+154%) +35 acres emergent wetland (+27%) Net loss of 250 acres wetlands (-3%)	Similar or less wetland filling and drainage expected based on land use forecast in Horry County (2019). Reliance on surface waters for water supply is expected to increase. Big Bull Landing Project – wetland loss would be offset by mitigation and potential changes to water quality, floodplain, hydrology, and groundwater represents minor contribution	**B1, B2:** Insignificant - Wetland loss would be offset by mitigation and potential changes to water quality, floodplain, hydrology, and groundwater represents minor to moderate contribution to changes relative to those past, present and reasonably foreseeable. **SNS3, SNS4:** Insignificant – No adverse impacts
Biological Resources	Longs/Red Bluff	***Direct:*** **LR1:** • Minor loss of forested/shrub wetland habitat and some lost plants and wildlife • Potential minor to moderate barrier to wildlife movement **LR3:** • Minor loss of forested/shrub wetland habitat and some lost plants and wildlife • Minor gain of aquatic habitat complexity **LRNS3, LRNS4:** Minor potential for habitat loss for sensitive species where potentially present in structures are modified or destroyed **LR6:** Additive ***Indirect:*** **LR1:** Minor to moderate floodplain reduction and alteration leading to loss of system complexity and associated ecological niches **LR3:** • Minor floodplain reduction and alteration • Neutral change to system complexity and associated ecological niches • Minor modulation of flooding frequency and intensity and potentially improved productivity and species richness **LRNS3:** None **LRNS4:** Minor potential for habitat restoration **LR6:** Additive	Previous land use changes and changes in water resources (i.e., development of area and channelization of creeks) have reduced habitat quantity and quality and left a system of habitat patches. This generally creates new habitat types for some species at the expense of others while also reducing necessary resources for species which are habitat specialists or need extensive unsegmented habitat. Simplification of habitat features, through practices like channelization of waterways, has also led to a general loss of biodiversity.	Many habitat types in the Longs/Red Bluff region have not experienced significant declines. However, emergent wetlands, shrublands and grasslands in the area around Simpson Creek are relatively rare and have become rarer with time. Several protected species which may occur in the area include wood stork, red-cockaded woodpecker and tricolored bat. Populations of wood stork appear to be stable or increasing while other species like red-cockaded woodpecker and tricolored bat remain susceptible or declining.	Continued development in the Longs area is likely to contribute to further fragmentation of the landscape and direct reduction in the quantity and quality of habitat along with incidental losses of plants and wildlife. Protected species are projected to both recover and continue decline depending on the species. Buck Creek Benching Project – impacts are beyond area of analysis.	**LR1, LR3, LR6:** Insignificant – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants and wildlife, habitat impacts would not be of any more than minor to moderate change for areas of analysis **LRNS3, LRNS4:** Insignificant – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to wildlife and their habitat

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
	Conway	***Direct*:** **C3:** Minor loss of forested/emergent wetland habitat and some lost plants and wildlife **CNS1, CNS2:** Minor potential for habitat loss for sensitive species where potentially present in structures are modified or destroyed **C5:** Additive ***Indirect:*** **C3:** • Minor floodplain reduction and alteration • Minor improvement in habitat connectivity and movement of wildlife **CNS1:** None **CNS2:** Minor potential for habitat restoration **C5:** Additive	Listing of several species of plant and wildlife by state and Federal resource agencies which may have previously or continue to occupy the area, including species and critical habitat listed in Section 4.6.10.	Many habitat types in the Conway region have not experienced significant declines. However, evergreen forest and grasslands have moderately declined. Several protected species which may occur in the area include wood stork, red-cockaded woodpecker and tricolored bat. Populations of wood stork appear to be stable or increasing while other species like red-cockaded woodpecker and tricolored bat remain susceptible or declining.	Some development in the Conway area is likely to lead to minor contribution to more fragmentation of the landscape and reduction in the quantity and quality of habitat along with incidental losses of plants and wildlife. Protected species are projected to both recover and continue decline depending on the species. Hawthorne Dr. and Long Ave. Wetland Park Project, Sherwood Forest-Crabtree Swamp Flood Solutions Projects – impacts are beyond area of analysis.	**C3, C5:** Insignificant – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants and wildlife, habitat impacts would not be of any more than minor change for areas of analysis **CNS1, CNS2:** Insignificant – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to wildlife and their habitat

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
	Socaste e	***Direct:*** **S1:** • Minor loss of forested/shrub wetland habitat and some lost plants and wildlife • Moderate to major barrier to wildlife movement **S2:** Major and moderate changes in habitat type from forested wetland and evergreen forest, respectively, to open water, emergent wetland, and OS-Dev., and some lost plants and wildlife **S3:** • Neutral change in habitat type from impounded creek habitat to free-flow creek from removal of structural barriers • Moderate removal of barrier to wildlife movement **SNS3, SNS4:** Minor potential for habitat loss for sensitive species where potentially present in structures are modified or destroyed **S4:** Additive ***Indirect***: **S1:** Moderate to major floodplain reduction and alteration leading to loss of system complexity and associated ecological niches **S2:** Minor to moderate floodplain reduction and alteration leading to loss of system complexity and associated ecological niches **S3:** Restoration of creek hydromorphology and associated habitat complexity and ecological niches **SNS3:** None **SNS4:** Minor potential for habitat restoration **S4:** Additive		Significant development in this area of Socastee has led to moderate to major losses of evergreen forest, forested wetland, scrub/shrub, shrub wetland, and grasslands. Several protected species which may occur in the area include wood stork, red-cockaded woodpecker, tricolored bat and West Indian manatee. Populations of wood stork and West Indian manatee appear to be stable or increasing while other species like red-cockaded woodpecker and tricolored bat remain susceptible or declining. Several types of EFH also exist in the stretch of the AIWW intersecting this area.	Some development in the Socastee area is likely to lead to minor contribution to more fragmentation of the landscape and reduction in the quantity and quality of habitat along with incidental losses of plants and wildlife. Protected species are projected to both recover and continue decline depending on the species. No notable changes in EFH in the AIWW are expected. McCormick Bridge Supplemental Culvert Project – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants, wildlife, and habitat.	**S1, S2, S4:** Significant –Habitat impacts would be of moderate to major change for areas of analysis **S3, SNS3, SNS4:** Insignificant – Avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants, wildlife, and habitat (including EFH).

Resource Area	Flood Impact Area	Projected Impacts	Past Actions/Conditions (from 1993)	Present Actions/Conditions (2024)**	Reasonably Foreseeable Actions (2040+)	Cumulative Impacts
	Bucksport	***Direct:*** **B1:** • Minor loss of forested/shrub wetland habitat and open water habitat and some lost plants and wildlife • Moderate barrier to wildlife movement **B2:** • Minor loss of a variety of habitat and some lost plants and wildlife • Neutral barrier to wildlife movement **BNS2, BNS4:** Minor potential for habitat loss for sensitive species where potentially present in structures are modified or destroyed ***Indirect:*** **B1:** • Moderate floodplain reduction and alteration leading to loss of system complexity and associated ecological niches • Potential for incidental take of wildlife from entrainment and formation of ecological trap **B2:** None **BNS2:** None **BNS4:** Minor potential for habitat restoration		Forested wetlands and deciduous forests in the area have experienced moderate declines with time. Several protected species which may occur in the area include Atlantic and shortnose sturgeon, wood stork, red-cockaded woodpecker, tricolored bat and West Indian manatee. Populations of wood stork and West Indian manatee appear to be stable or increasing while other species like sturgeon, red-cockaded woodpecker and tricolored bat remain susceptible or declining.	Some development in the Bucksport area is likely to lead to minor contribution to more fragmentation of the landscape and reduction in the quantity and quality of habitat along with incidental losses of plants and wildlife. Protected species are projected to both recover and continue decline depending on the species. Big Bull Landing Project – avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants and wildlife, habitat impacts would not be of any more than minor change for areas of analysis	**B1:** Significant –Habitat and wildlife impacts would be of moderate impact **B2, BNS2, BNS4:** Insignificant – avoidance and minimization measures could be incorporated into design and construction to result in no more than minor impacts to plants and wildlife, habitat impacts would not be of any more than minor change for areas of analysis
Cultural Resources	Contributions to positive or negative trends in this resource are expected to be minimal under any of the alternatives and are considered to be less than significant.					
Recreation	Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.					
Transportation	Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.					
Socioeconomics and EJ	Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.					
HTRW	Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.					
Aesthetics	Contributions to positive or negative trends in this resource are expected to be none or minor under any of the alternatives and are considered to be insignificant.					
*Abbreviations used above include the following: OS-Dev. = open space developed, LI-Dev. = low-intensity developed, MI-Dev. = medium-intensity developed **All comparisons of land cover and wetland data is computed from the 1996 and 2016 land use datasets maintained by NOAA Coastal Services Center C-CAP Landcover Atlas 2024						

4.14 Irreversible and Irretrievable Commitment of Resources

The alternatives evaluated involve the use of both natural and socioeconomic (industrial) resources. Irreversible and irretrievable general industrial resource commitments that would be associated with the implementation of either alternative include capital resources, labor resources, fuels, and other construction-related materials. The use of such resources would not adversely impact the availability of such resources for other projects both now and in the future.

Natural resources utilized or changed under any of the action alternatives would include biotic resources, water resources, existing land uses and visual resources. In general terms, the use and/or associated changes of natural and industrial resources would be considered irretrievable under any of the alternatives. Most of the adverse impacts associated with each alternative can be mitigated.

5.0 PLAN COMPARISON AND SELECTION

The following sections provide a summary of the comparison of alternatives in the final array with respect to the four accounts, comprehensive benefits, evaluation criteria, contribution to the planning objectives, and risk and uncertainty.

5.1 Plan Comparison

The final array of alternatives was comprised of those plans that best met the planning criteria, reduced flood risk to the neighboring communities, and provided positive benefits to the communities. Any alternative lacking a positive net increase in benefits to the four accounts was removed from consideration (Section 5.1). Tradeoffs between plan impacts are shown below in Tables 24-27. Afterwards, the plans were screened and scored against the following criteria: EJ/Socioeconomics, Life Safety Risk, Emergency Services Impacts, Community Cohesion, Emergency Response Cost, and Temporary Evacuation and Relocation. The final array of alternatives did not provide substantial benefits or disproportionately high and adverse impacts to disadvantaged communities (Table 33-36). While only two plans received a positive increase in benefits and would be dropped from consideration, each of the final array of alternatives continued analysis until the Recommended Plan was identified.

5.1.1 National Economic Development

The NED account displays changes in the economic value of the national output of goods and services, expressed in monetary units. The objective of the NED analysis and identification is to maximize the value to the nation. This is done by comparing the difference in the benefits produced by the project to the costs required to implement the project. These are the direct net economic benefits that accrue in the study area and the rest of the Nation. For this study, the flood damages associated monetary costs of the future without action and the alternatives were developed using LifeSim 2.0. These include damages to private and public buildings and their contents, as well as vehicle damages. The incremental economic consequences were annualized based on the system response curve and combined with annual benefits foregone, resulting in the average annual incremental economic consequences associated with each alternative plan. The difference between the average annual cost of the FWOPAC and the RMPs represents the annual benefits. These were then compared against the average annual project costs to determine the net benefits and benefit-to-cost ratio (BCR). BCR is a procedure to evaluate what is accomplished (benefits) in comparison to what would be invested (costs) in dollars. This procedure is used to compare costs and benefits over potential expected futures wherein an investment is made (With Project Condition) and where no investment is made (Without Project Condition).

The Corps uses the BCR to prioritize projects. Projects with a BCR below 1.0 face challenges in securing funding and approval as they do not meet the threshold for demonstrating a positive return on investment. As such, projects below that threshold are not considered economically justified under current criteria.

Tables 56-59 detail alternatives based on NED analysis for each of the locations of the project area.

5.1.1.1 Longs/Red Bluff

Table 56: Longs/Red Bluff National Economic Development

Plans	Plan Type	Average Annual Benefits	Net Benefits	BCR
LR 1	Flood Wall	$113,000	($2,817,847.64)	0.04
LR 3	Floodplain benching and relief bridge	$42,500	($2,573,279.79)	0.02
LR 6	Comprehensive Structural + Nonstructural Plan	$729,000	($6,086,584.51)	0.11
Nonstructural	Elevation + Acquisition	$503,000	($765,957.08)	0.40

5.1.1.2 Conway

Table 57: Conway National Economic Development

Plans	Plan Type	Average Annual Benefits	Net Benefits	BCR
C3	Floodplain Relief (bridge relief)	$1,500,000	$1,226,416	5.48
Nonstructural	Elevation + Acquisition	$276,000	($90,211)	0.75

5.1.1.3 Bucksport

Table 58: Bucksport National Economic Developments

Plans	Plan Type	Average Annual Benefits	Net Benefits	BCR
B1	Floodgate	$518,000	($311,843)	0.62

B2	Road elevation	$609,000	($2,371,628)	0.20
B3	Floodgate + Road Elevation	$499,000	($3,311,471)	0.13
Nonstructural	Elevation + Acquisition	$155,000	$20,802	1.16

5.1.1.4 Socastee

Table 59: Socastee National Economic Development

Plans	Plan Type	Average Annual Benefits	Net Benefits	BCR
S1	Floodwall & barrier removal	($278,000)	($5,341,208)	-0.05
S2	Detention with channel to Socastee Swamp	$974,000	($2,612,394)	0.27
S3	Barrier Removal	$648,000	$587,290	10.67
S4	Comprehensive Structural + Nonstructural Plan		($10,366,944)	0.00
Nonstructural	Elevation + Acquisition	$719,500	($937,132)	0.43

As shown above, through development and calculation of average annual benefits, net benefits, and the benefit to cost ratio for each alternative, only a few alternatives would have a positive net economic benefit with a positive benefit to cost ratio and would contribute to the national economy. Specifically, the net annual economic benefits and BCR for the Conway Relief Bridge (cross drains) is $1,226,416 and 5.48, respectively, and the Socastee Barrier Removal alternative has net annual benefit of $587,290 and BCR of 10.67. There are no plans identified in Longs/Red Bluff or Bucksport that reach a positive net benefit BCR calculation.

5.1.2 Regional Economic Development

The RED account is used to analyze the potential impacts to the local or regional economic area and registers changes in the distribution of regional economic activity that result from an alternative plan. A quantitative RED analysis was undertaken as part of the study. Implementation of an alternative would result in positive direct, indirect, and induced effects to the region. It is expected that regional employment and income would be directly related to construction expenditures; however, these effects would be temporary during construction. Differences in the effects between alternatives were anticipated to be minimal and were not likely to play a role in decision making.

5.1.3 Environmental Quality

The EQ account displays non-monetary effects on natural and cultural resources. EQ resources and attributes of the human environment may include ecological, aesthetic, and other attributes of natural and cultural resources.

For comparison and evaluation of the final array of alternatives, several environmental quality factors were identified. These include terrestrial impacts, aquatic impacts, wetland impacts, cultural resource impacts, and threatened and endangered species impacts. Each EQ resource identified was evaluated, given consideration and provided a score (Table 28) below which defines the same values for scoring used here) for each alternative based on its potential to affect that environmental factor negatively or beneficially, in comparison to the potential effect for a future without action.

Tables 60-63 detail alternatives based on EQ analysis for each of the locations of the project area.

5.1.3.1 Longs/Red Bluff

Table 60: Longs/Red Bluff Qualitative Environmental Quality Analysis

Plans	Plan Type	Terrestrial Impacts	Aquatic Impacts	Wetland Impacts	Cultural Resource Impacts	T&E Impacts
LR 1	Flood Wall	-1	0	-1	0	0
LR 3	Floodplain benching and relief bridge	-1	1	-1	0	0
LR 6	Comprehensive Structural + Nonstructural Plan	-1	1	-1	0	0
Nonstructural	Elevation + Acquisition	1	1	1	1	0
LRNS3	Elevation	0	0	0	1	0
LRNS4	Acquisition	1	1	1	1	0

5.1.3.2 Conway

Table 61: Conway Qualitative Environmental Quality Analysis

Plans	Plan Type	Terrestrial Impacts	Aquatic Impacts	Wetland Impacts	Cultural Resource Impacts	T&E Impacts

C3	Floodplain Relief (bridge relief)	1	1	-1	-1	0
C5	Comprehensive Structural (relief bridges) + Nonstructural Plan	1	2	0	1	0
CNS1	Acquisition	1	1	1	-1	0
Nonstructural	Elevation + Acquisition	1	1	1	-1	0
CNS2	Elevation	0	0	0	1	0

5.1.3.3 Bucksport

Table 62: Bucksport Qualitative Environmental Quality Analysis

Plans	Plan Type	Terrestrial Impacts	Aquatic Impacts	Wetland Impacts	Cultural Resource Impacts	T&E Impacts
B1	Floodgate	0	-1	-1	0	-1
B2	Road elevation	-1	0	-1	-1	0
BNS2	Elevation	0	0	0	1	0
Nonstructural	Elevation + Acquisition	-1	1	1	0	0
BNS3	Acquisition	1	1	1	-1	0

5.1.3.4 Socastee

Table 63: Socastee Qualitative Environmental Quality Analysis

Plans	Plan Type	Terrestrial Impacts	Aquatic Impacts	Wetland Impacts	Cultural Resource Impacts	T&E Impacts
S1	Floodwall & barrier removal	-1	-2	-2	0	0
S2	Detention with channel to Socastee Swamp	-2	-2	-2	1	0
S3	Barrier Removal	0	1	-1	0	0
S4	Comprehensive Structural + Nonstructural Plan	-2	-2	-2	1	0
Nonstructural	Elevation + Acquisition	1	1	1	1	0

5.1.4 Other Social Effects

The OSE account is a means of displaying and integrating into water resource planning information that is not reflected in the other three accounts. Some of the metrics which may be considered include social vulnerability, urban plans, community impacts and resilience; life, health, and safety factors; displacement, long-term productivity, energy requirements and emergency management. In evaluation of the final array of alternatives the OSE is utilized in the comparison of alternatives and ultimately identification of the TSP.

To evaluate other social effects, alternatives were scored based on potential to affect communities within each flood impact area relative to FWOP conditions (Table 64). This outlines the scoring system as described in the *Applying Other Social Effects in Alternative Analysis* (USACE, 2013). Collectively, the team evaluated the final array of alternatives by their regional influence on Socioeconomics and Environmental Justice challenges, Life Safety Risks, Emergency Services, Community Cohesion, Emergency Response Costs, and Temporary Evacuation and Relocation. The other social effects criteria are described further below.

Table 64: Other Social Effects

Score	Effects
-3	Substantial negative effects
-2	Moderate Negative Effects
-1	Minor Negative Effects
0	Negligible Effects/No Impact

1	Minor Beneficial Effects
2	Moderate Beneficial Effects
3	Substantial Beneficial Effects

- **EJ/Socioeconomics:** Affecting the environment, health, and wellbeing of already overburdened communities. Environmental justice characterizes overburdened communities within each impact area. Substantial negative effects equate to loss of life, irreversible health issues (from changes in water, air, soil quality), and other damaging alterations impacting overburdened communities.
- **Life Safety Risk:** Affecting communities with acute social characteristics, customs, or vulnerabilities that contribute to life safety risk such as vulnerable age groups (youth and persons 55 years and older), limited English speaking populations, and limited transportation capabilities. Substantial negative effects equate to loss of life, induced flood risk that adversely impact socially vulnerable groups disproportionately, and reduced transportation reliability.
- **Emergency Services:** Affecting emergency management, services, and critical facilities. This includes supporting infrastructure required to fulfill emergency services and critical community functions. Substantial negative effects equate to, operational or structural loss of Horry County and the City of Conway's critical and essential facilities. This includes the following facilities, as well as the egress/ingress routes to: The Horry County Government Center, E911, Emergency Operating Center, City of Conway Police Department, City of Conway Fire Department, and the Grand Strand Sewer and Water Authority Sewage and Water treatment facilities.
- **Community Cohesion:** Affecting communities negatively influenced by displacement or separation (involuntary displacement, local relocation limitations) in a manner that perpetuates community dispersion. This includes supporting infrastructure such as community centers, schools, access to essential facilities, and religious/cultural spaces. Substantial negative effects equate to excessive involuntary acquisition, mass exodus, community segmentation, or risk transfer to supporting infrastructure.
- **Emergency Response Costs:** Affecting the municipal, operational, and financial responsibility associated with emergency response and recovery (including cost to evacuate). This should include response delayed, increased staffing, nontraditional response and recovery equipment, and other operational setbacks. Substantial negative effects equate to extensive or unmanageable response and recovery obligations to local and state government.
- **Temporary Evacuation and Relocation:** Affecting evacuation rate/frequency, relocation duration, temporary displacement. Substantial negative effects equate to inducing new barriers to effective evacuation and return, extensive relocation/displacement (duration), or increase the likelihood of sheltering in place.

Tables 65-68 identify the OSE for each location within the project area.

5.1.4.1 Longs/Red Bluff

Table 65: Longs/Red Bluff Qualitative Other Social Effects Analysis

Plans	Plan Type	EJ Socioeconomics	Life Safety Risk	Emergency Services Impacts	Community Cohesion	Emergency Response Cost (Comprehensive)	Temporary Evacuation & Relocation
LR 1	Flood Wall	1	1	0	0	-1	1
LR 3	Floodplain benching and relief bridge	0	1	2	0	1	1
LR 6	Comprehen sive Structural + Nonstructur al Plan	2	2	2	-1	1	1
Nonstruct ural	Elevation + Acquisition	1	1	0	-1	1	2
LRNS3	Elevation	1	1	0	1	1	2
LRNS4	Acquisition	1	1	0	-2	0	1

5.1.4.2 Conway

Table 66: Conway Qualitative Other Social Effects Analysis

Plans	Plan Type	EJ Socioeconomics	Life Safety Risk	Emergency Services Impacts	Community Cohesion	Emergency Response Cost (Comprehensive)	Temporary Evacuation & Relocation
C3	Floodplain Relief (bridge relief)	1	1	1	0	1	1
C5	Comprehensive Structural (relief bridges) + Nonstructural Plan	1	1	1	-1	1	2
CNS1	Acquisition	-2	1	0	-2	1	1
Nonstructural	Elevation + Acquisition	0	2	0	-1	1	1
CNS2	Elevation	1	1	0	1	0	1

5.1.4.3 Bucksport

Table 67: Bucksport Qualitative Other Social Effects Analysis

Plans	Plan Type	EJ Socioeconomics	Life Safety Risk	Emergency Services Impacts	Community Cohesion	Emergency Response Cost (Comprehensive)	Temporary Evacuation & Relocation

B1	Floodgate	1	1	0	0	0	1
B2	Road elevation	1	1	1	0	1	1
BNS2	Elevation	1	1	0	1	0	1
Nonstructural	Elevation + Acquisition	1	1	0	1	0	1
BNS3	Acquisition						

5.1.4.4 Socastee

Table 68: Socastee Qualitative Other Social Effects Analysis

Plans	Plan Type	EJ Socioeconomics	Life Safety Risk	Emergency Services Impacts	Community Cohesion	Emergency Response Cost (Comprehensive)	Temporary Evacuation & Relocation
S1	Floodwall & barrier removal	0	1	0	0	1	1

S2	Detention with channel to Socastee Swamp	0	1	0	0	0	1
S3	Barrier Removal	0	1	0	0	0	0
S4	Comprehensive Structural + Nonstructural Plan	0	1	0	0	1	1
Nonstructural	Elevation + Acquisition	0	1	0	0	1	1

These other social effects categories were qualitatively determined through discussion of the study team. The proposed alternative was evaluated with respect to location, neighborhood, activity, along with impacts it could have during a flooding event.

The final array of alternatives will not provide substantial benefits or disproportionately high and adverse impacts to disadvantaged communities. Implementation of an alternative will provide benefits to communities. Adverse impacts to the area would result from traffic and trucking that would be required for construction. However, these impacts are minor and temporary.

5.1.5 Identification of the NED or NER Plan

As identified through the evaluation and analysis, two plans within the project areas were identified as the NED plan. The Conway relief bridges and the Socastee barrier removal alternatives. No plans were found to have positive net benefits within the flood impact areas of Longs/Red Bluff or Bucksport.

5.1.6 Identification of Comprehensive Benefits

The comprehensive benefits discussed above were totaled for each alternative to provide an overall total comprehensive benefits rating. Those results are presented below in Tables 69-72.

5.1.6.1 Longs/Red Bluff

Table 69: Longs/Red Bluff Qualitative Comprehensive Benefit Analysis Totals

Plans	Plan Type	Total
LR 1	Flood Wall	0
LR 3	Floodplain benching and relief bridge	4
LR 6	Comprehensive Structural + Nonstructural Plan	6
Nonstructural	Elevation + Acquisition	8
LRNS3	Elevation	7
LRNS4	Acquisition	5

5.1.6.2 Conway

Table 70: Conway Qualitative Comprehensive Benefit Analysis Totals

Plans	Plan Type	Total
C3	Floodplain Relief (bridge relief)	5
C5	Comprehensive Structural (relief bridges) + Nonstructural Plan	9
CNS1	Acquisition	1
Nonstructural	Elevation + Acquisition	5
CNS2	Elevation	5

5.1.6.3 Bucksport

Table 71: Bucksport Qualitative Comprehensive Benefit Analysis Totals

Plans	Plan Type	Comp Totals
B1	Floodgate	0
B2	Road elevation	2
B3	Floodgate + Road Elevation	1
BNS2	Elevation	5
Nonstructural	Elevation + Acquisition	5
BNS3	Acquisition	2

5.1.6.4 Socastee

Table 72: Socastee Qualitative Comprehensive Benefit Analysis Totals

Plans	Plan Type	Comp Totals
S1	Floodwall & barrier removal	-2
S2	Detention with channel to Socastee Swamp	-3
S3	Barrier Removal	1
S4	Comprehensive Structural + Nonstructural Plan	-2
Nonstructural	Elevation + Acquisition	7

6.0 THE RECOMMENDED PLAN

Based on the evaluation of alternatives, the Tentatively Selected Plan (TSP) is the Conway Relief Bridges (cross drains) and the Socastee Barrier Removal. These alternatives best meet the planning criteria, reduces flood risk to the neighboring communities, and provides positive benefits to the communities.

6.1 Plan Accomplishments

6.1.1 Conway Relief Bridges (Cross Drains) (C3)

The structural measure retained in Conway consists of adding relief bridges/culverts at Hwy 501 Business, Hwy 501 Bypass, and Hwy 905 to increase conveyance through these areas where potential bottlenecking is occurring (Figure 16). Exact location and length of the bridges along these roadways is still being determined and will depend on the amount of additional flow needed. The proposed protection is that the relief bridges/culverts at 501 and 905 increase conveyance through these areas where potential bottlenecking of flood waters is occurring.

The 1% AEP water depths in Conway were modeled to show effects of implementation. The relief bridges were combined into a single model because the single relief bridge would not show a significant decrease in water surface elevation (WSE). Since the three bridges were near one another, the three relief bridges were included in the FWP model.

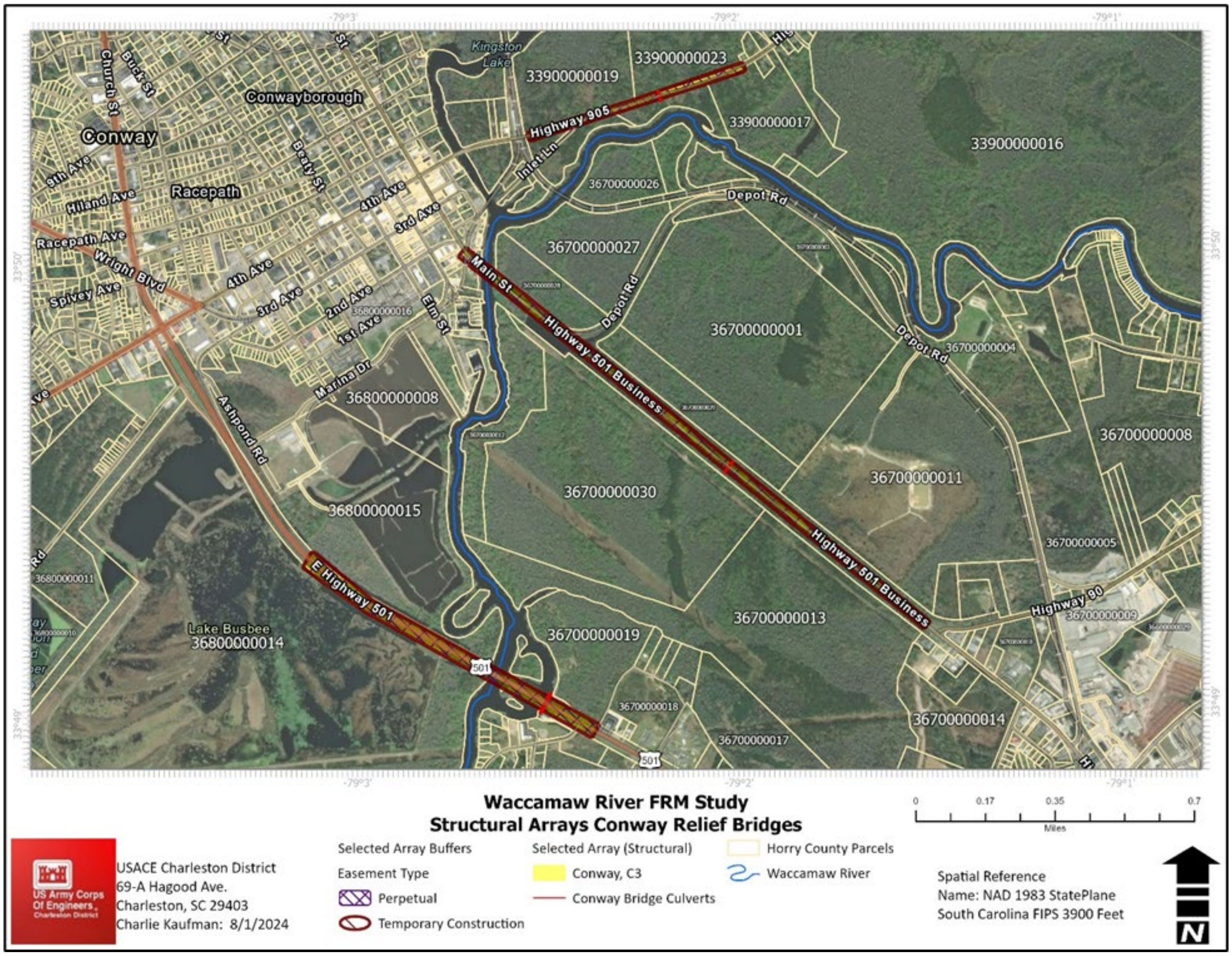

Figure 16: Conway Relief Bridge Modification

The proposed protections include decreasing the flood depths and size of the floodplain upstream of the Edward E. Burroughs highway along the Waccamaw River. This relief bridge would convey more water away from the inundated zone.

Relief bridges in the City of Conway, also known as grade separation structures, are designed to elevate one transportation route over another to avoid intersections or conflicts between traffic flows. While they offer several benefits such as improved traffic flow, safety, and reduced congestion, they can also have hydrologic and hydraulic effects, both positive and negative. Relief bridges can minimize the risk of flooding by allowing water to flow more freely underneath, especially during heavy rainfall or flood events. By providing a larger opening for water to pass through, they can reduce the chances of water backing up and causing localized flooding. By maintaining a clear path for water flow, relief bridges can help stabilize the natural channels underneath. This can prevent erosion and sediment buildup, maintaining the integrity of the watercourse and reducing the risk of channel shifting or bank erosion. Relief bridges can increase the hydraulic capacity of waterways by providing a wider and deeper opening for water to pass through. This can improve overall drainage and reduce the likelihood of overtopping during high-flow events.

Figures 17 and 18 show the location of the relief bridge and WSE along Highway 501.

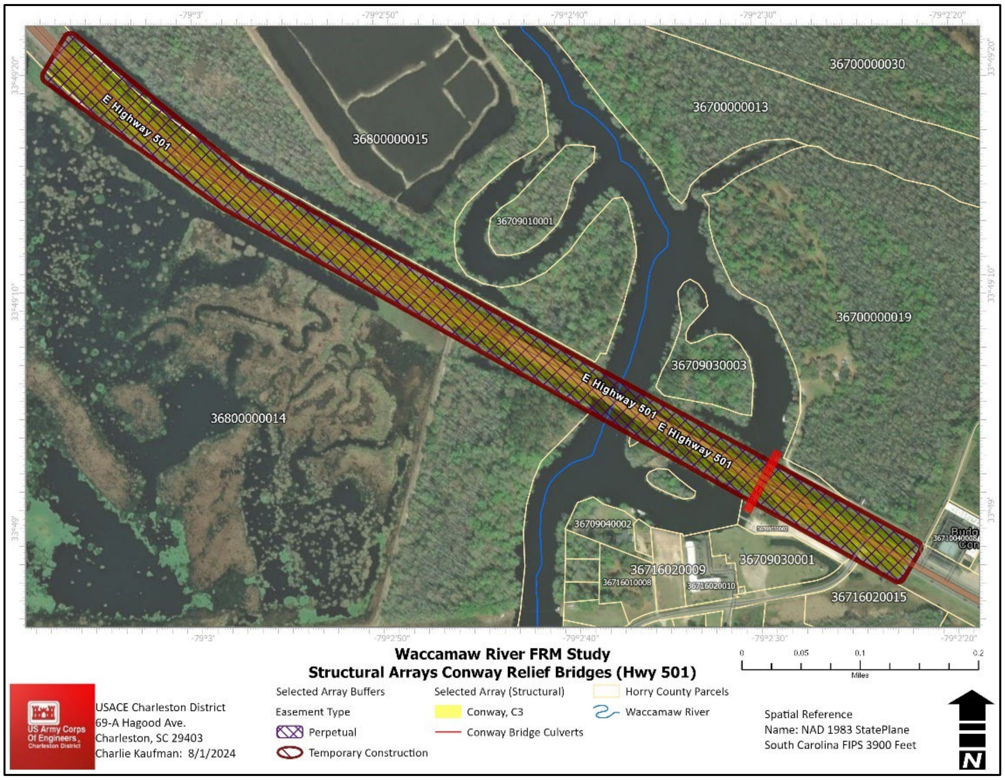

Figure 17: Conway Relief Bridge along Highway 501.

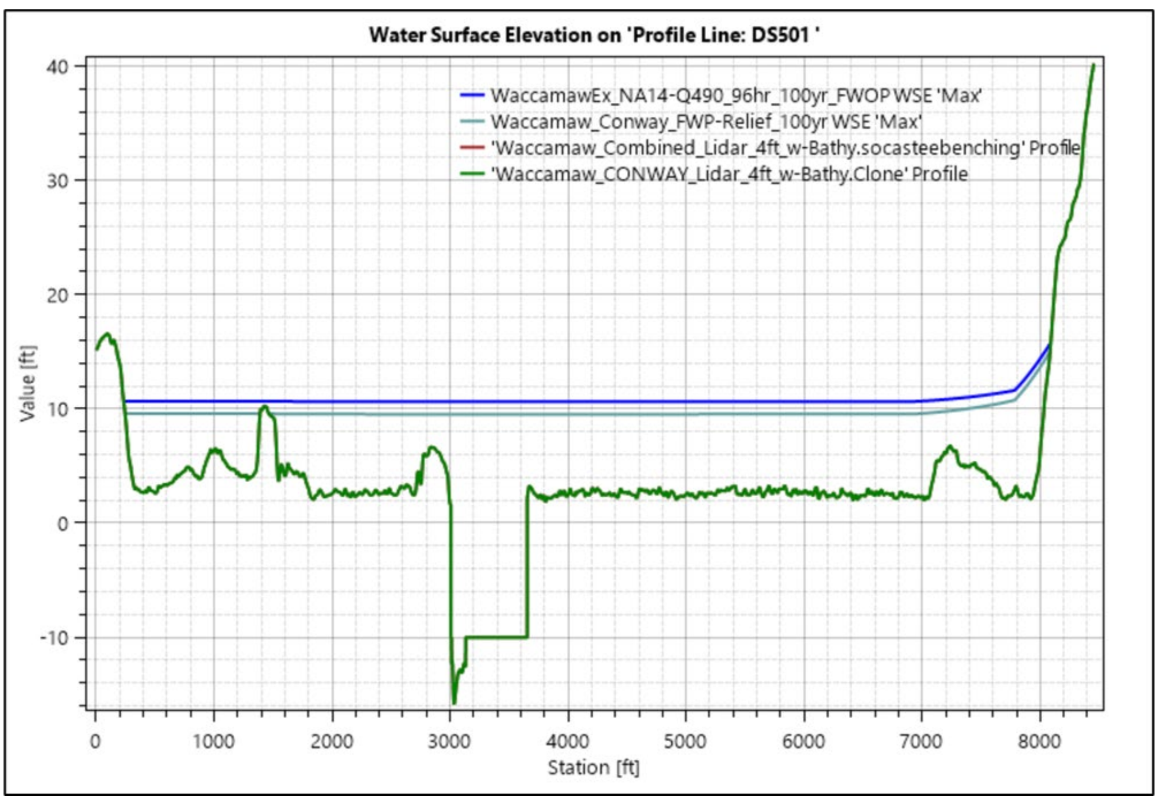

Figure 18: Water Surface Profile cross section comparison for downstream of 501.

Figures 19 and 20 show the location of the relief bridge and WSE along Highway 501B.

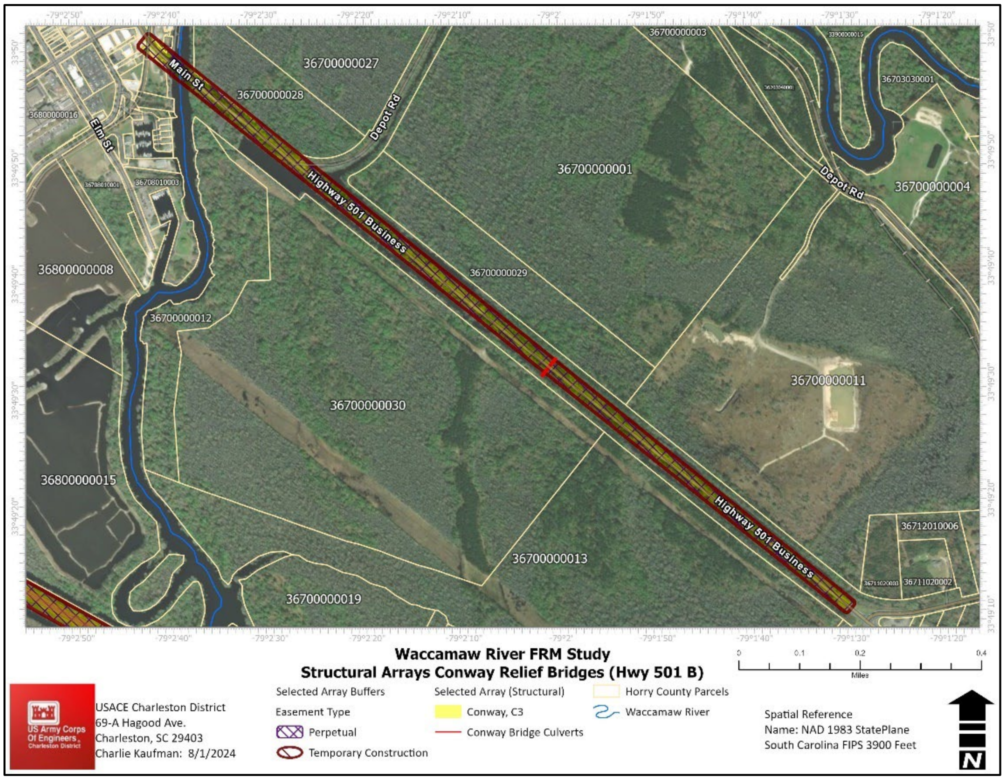

Figure 19: Conway Relief Bridge along Highway 501 Business.

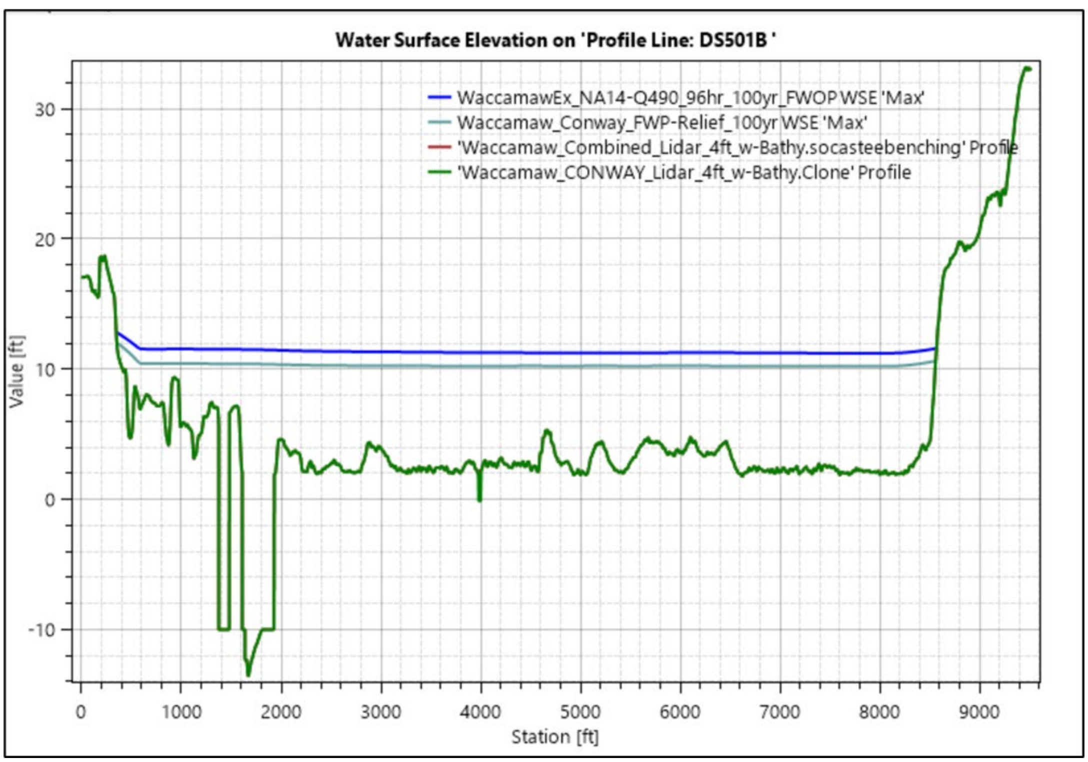

Figure 20: Water Surface Profile cross section comparison for upstream of 501.

Figures 21 and 22 show the location of the relief bridge and WSE along Highway 905.

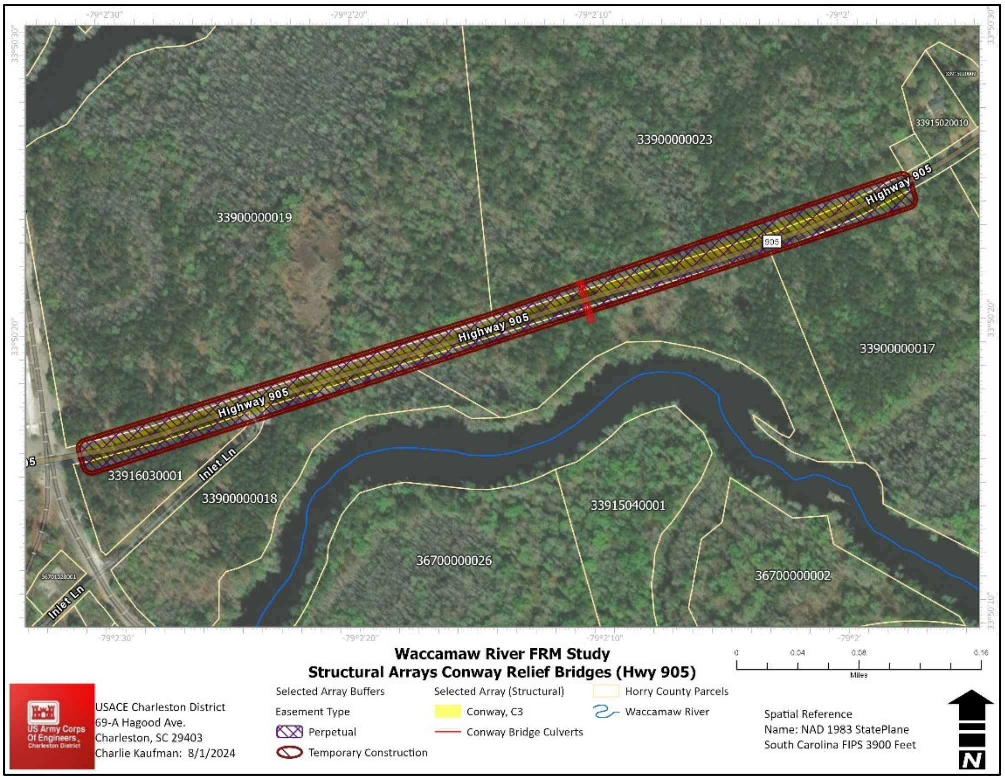

Figure 21: Conway Relief Bridge along Highway 905.

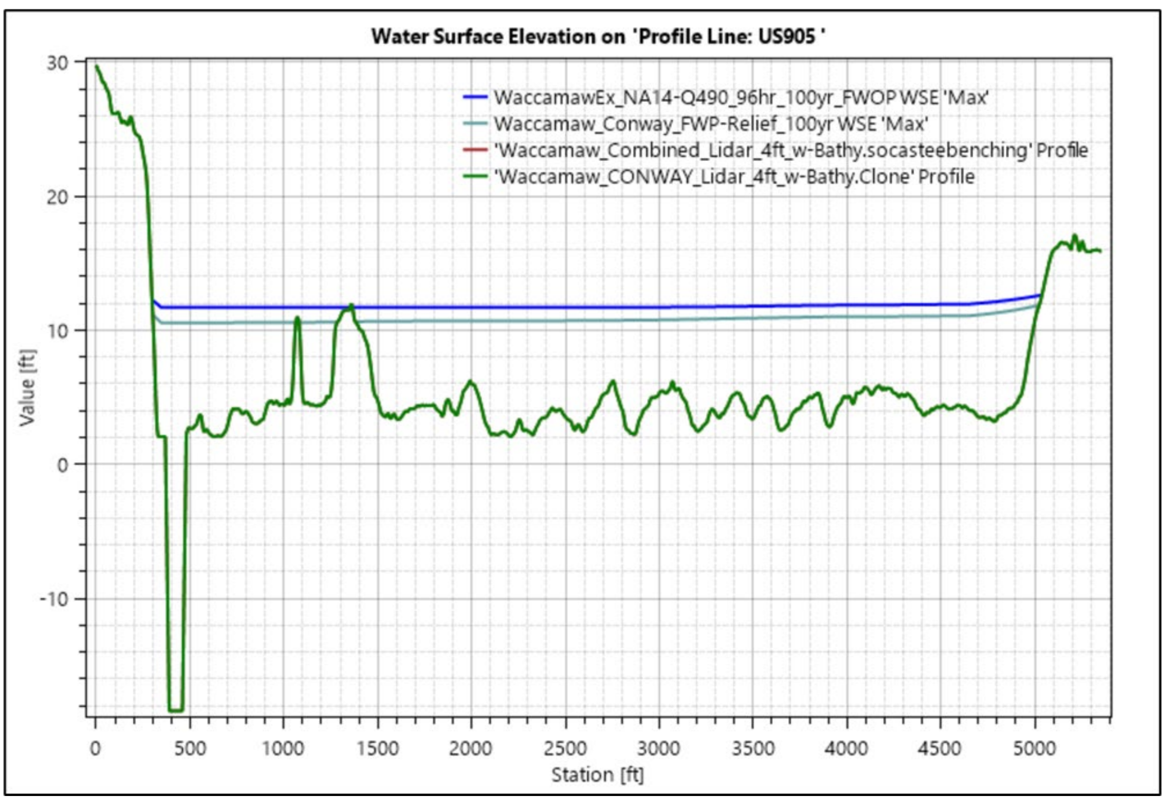

Figure 22: Water Surface Profile cross section comparison for upstream of 905.

Table 73 shows the differential in water surface elevation for cross sections both up and downstream of each relief bridge. Each cross section had a reduction in water surface elevation. Proper design, mitigation measures, and ongoing maintenance are essential to minimize negative impacts and maximize the positive contributions of relief bridges to both transportation networks and hydrological systems.

Table 73: WSE differential FWOP vs. FWP for Relief Bridges in Conway

Location	Reduction in WSE (ft)
Upstream Highway 905	**1.01**
Downstream Highway 905	**1.16**
Upstream Highway 501B	**1.18**
Downstream Highway 501B	**1.09**
Upstream Highway 501	**0.89**
Downstream Highway 501	**1.10**

The addition of three relief bridges in Conway indicated a reduction of WSE for 684 properties out of 1684 properties for up to -1 foot. However, the model showed an increase in WSE for 200 properties.

Overall, the relief bridges offer flood relief benefits for hundreds of homes and several business owners. While the TSP will potentially increase flooding marginally at some properties, there will be a net positive effect on flood impacts as a whole. Model outputs of the TSP will be assessed to better understand the potential of these effects, including additional real estate impacts (See Appendix E).

6.1.2 Socastee Barrier Removal (S3)

This alternative consists of the removal of two barriers/weirs along Socastee Creek (Figure 23). Both the upstream and downstream weirs are 40 foot wide and 10 foot tall-concrete sheet pile and with a rip rap 2 ft layer for both upstream and downstream.

Water currently flows around the weirs, eroding the area and causing damage to the weir structures. This measure would increase conveyance in the adjacent flood impact area. The weirs were originally constructed to maintain a certain ground water level to mitigate loss of surrounding wetland areas. With increased development in this area, weirs are not likely preserving the natural habit as constructed.

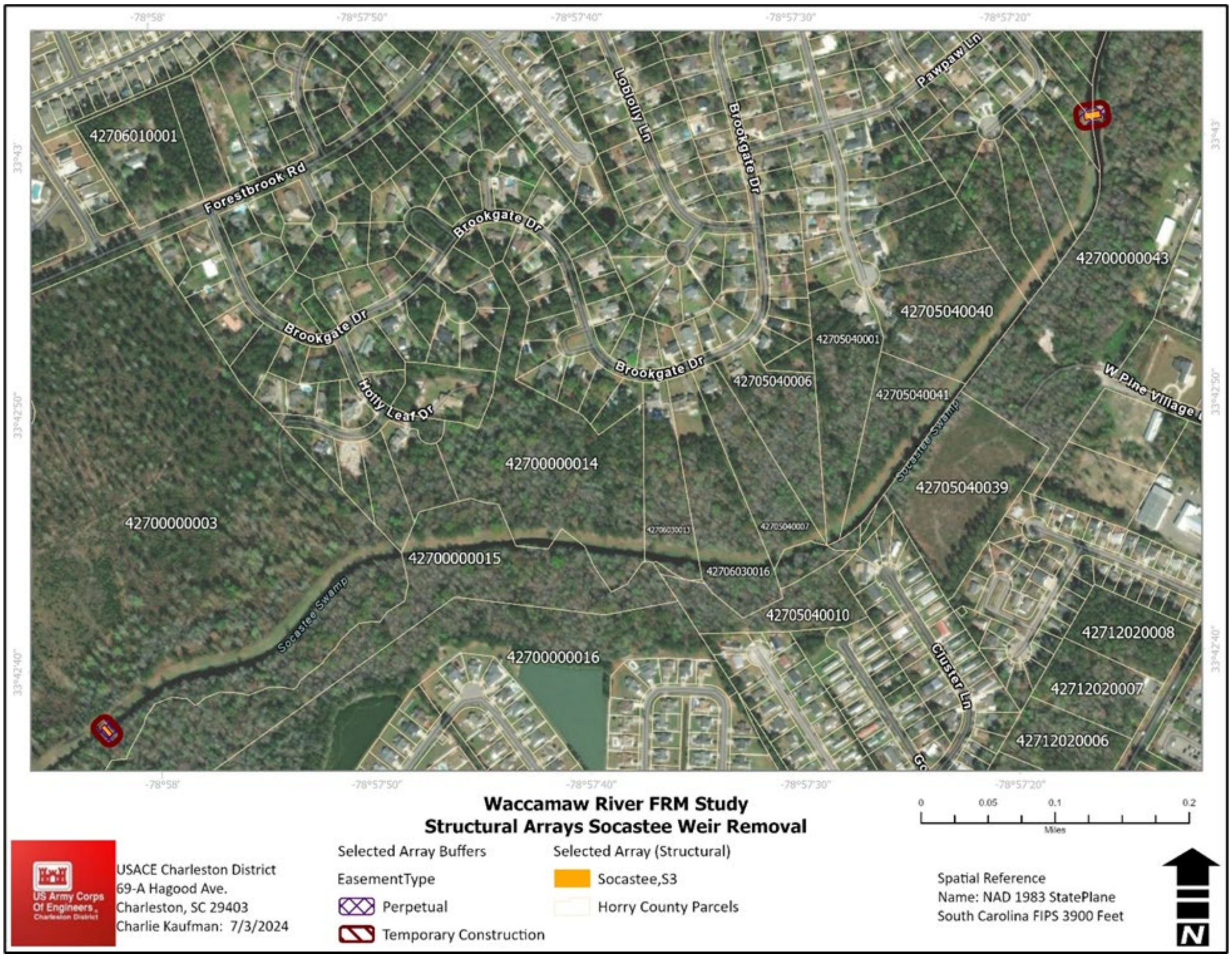

Figure 23: Socastee Barrier Removal

Figures 24-27 show the WSE changes with the recommended plan. Both upstream (U/S) and downstream (D/S) WSE are compared.

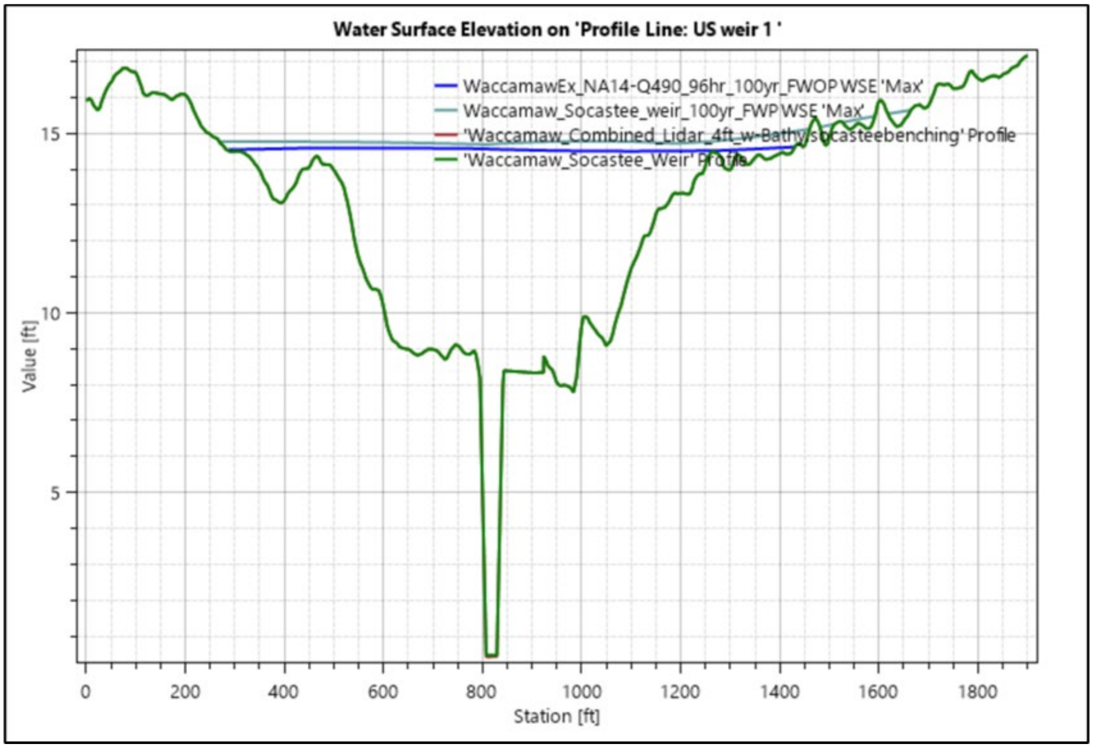

Figure 24: Cross section WSE comparison of the FWOP and FWP weir removal U/S weir 1.

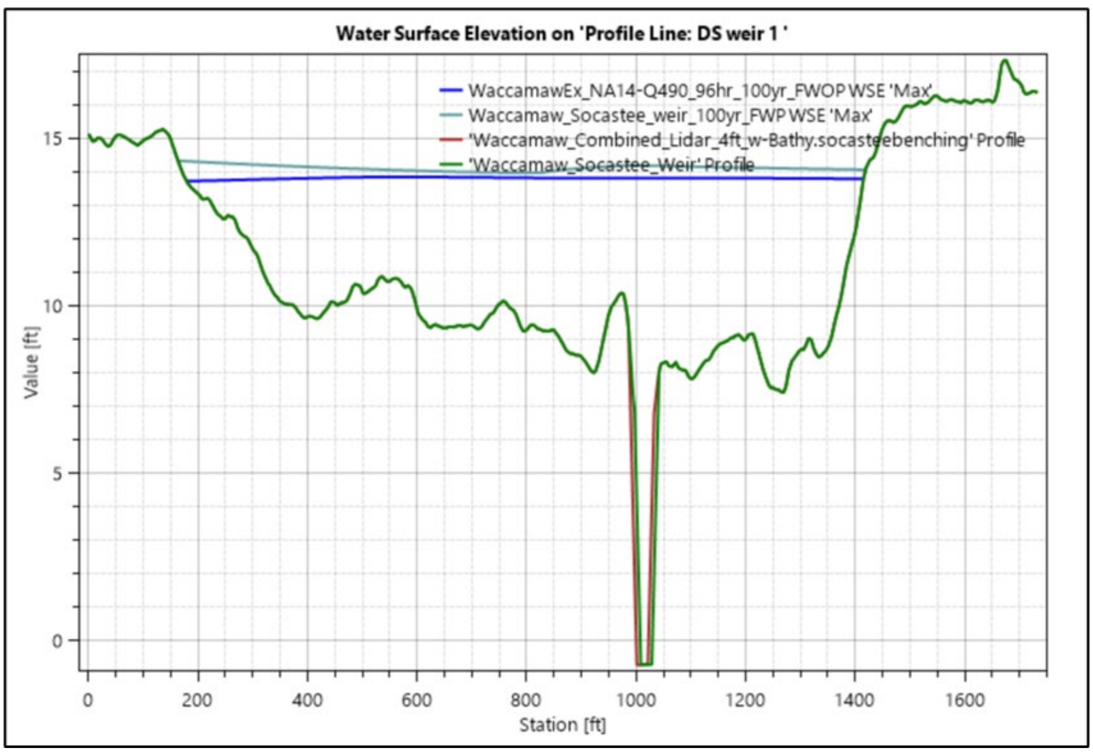

Figure 25: Cross section WSE comparison of the FWOP and FWP weir removal D/S weir 1.

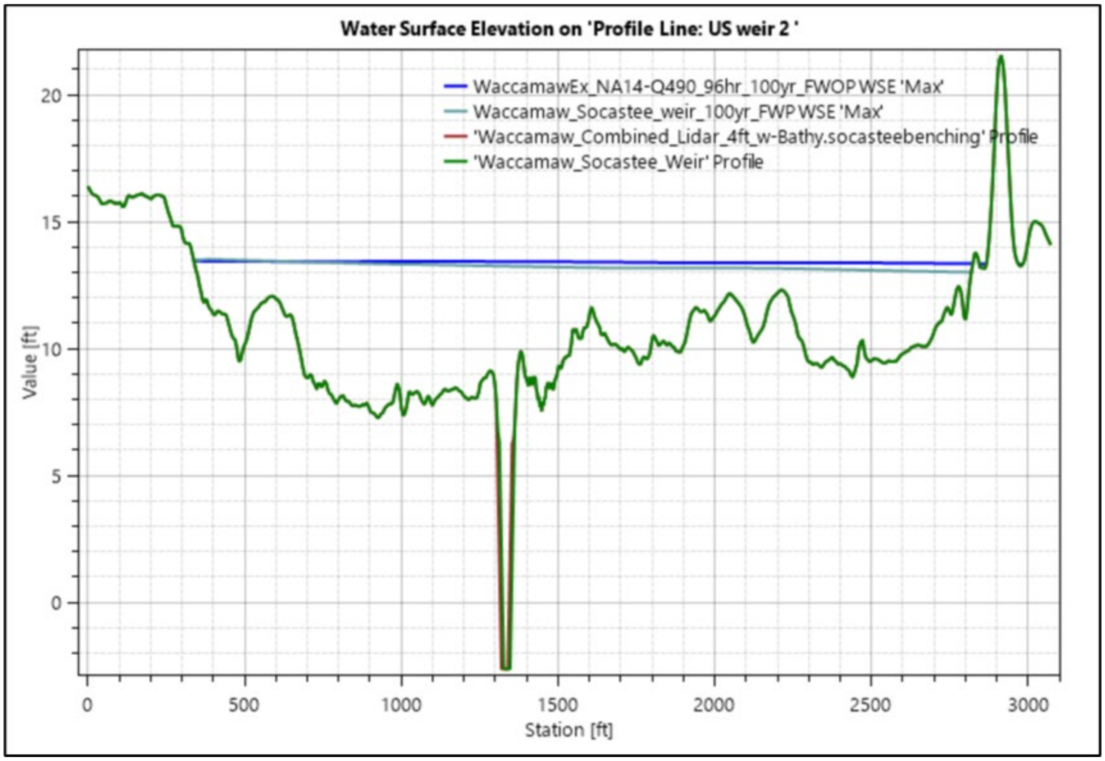

Figure 26: Cross section WSE comparison of the FWOP and FWP weir removal U/S weir 2.

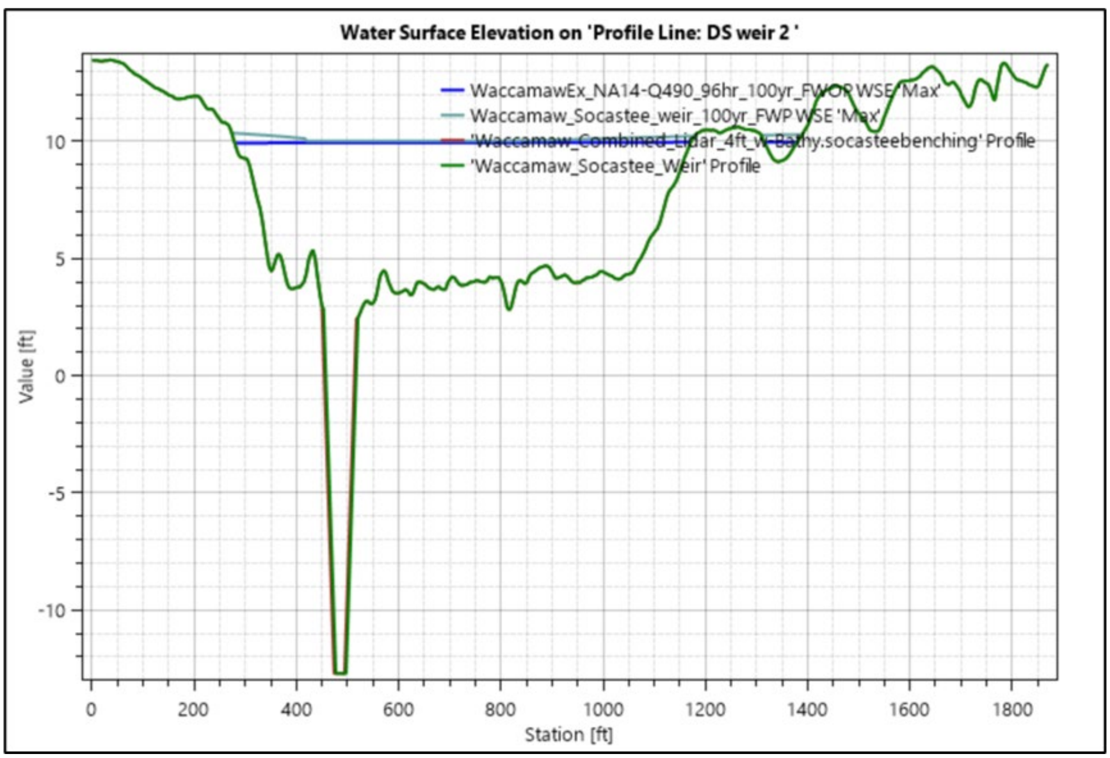

Figure 27: Cross section WSE comparison of the FWOP and FWP weir removal D/S weir 2.

Table 74 shows the differential of the water surface elevation at various cross sections both up and downstream of the weirs to be removed for the 1%AEP event. The negative values indicate an increase in WSE, and the positive values indicate a decrease in WSE.

Table 74: Differential in WSE with FWOP and FWP weir removal

Cross section location	Differential in WSE (ft)
Upstream Weir 1	**-0.22**
Downstream Weir 1	**-0.27**
Upstream Weir 2	**0.3**
Downstream Weir 2	**0.12**

In addition to flood reduction impacts, the removal of weirs, which are low-head dams built across streams or rivers, should provide several positive impacts on the local hydrology. Weir removal allows the stream or river to return to its natural flow regime, including variations in flow intensity and frequency. This restoration of natural hydrological patterns can benefit aquatic ecosystems by providing suitable habitat conditions for native flora and fauna, promoting nutrient cycling, and supporting biodiversity. Weirs act as barriers to fish migration, particularly for species that need to move upstream to spawn or access important habitat areas. Removing the weirs restores connectivity along the river or stream, allowing fish to freely move between different sections of the watercourse and access essential spawning grounds, nursery areas, and feeding habitats. Weirs also disrupt the natural transport of sediment downstream, leading to sediment accumulation and channel degradation upstream of the structure. This improved connectivity can enhance ecosystem resilience, support ecological processes, and facilitate the movement of aquatic organisms. This alternative can potentially enhance recreational opportunities for activities such as kayaking, canoeing, and fishing. Removal of the weirs also affords the opportunity to restore the natural sediment transport processes, promoting the movement of sediment through the river or stream system and helping to maintain channel morphology, substrate diversity, and aquatic habitat quality.

Some considerations and assumptions are that the floodplain encroachment and pre-construction site clearing pose possible environmental impacts. For removal of the weir a perpetual 25-foot-wide easement is required for maintenance on both sides, plus a 10-foot-wide temporary easement during construction, totaling 70 feet.

Construction activities include loading/staging, site clearing, placement of fill in the floodplain, etc. Floodplain encroachment and pre-construction site clearing pose temporary environmental impacts. Disturbed areas not needed to maintain the floodwall post construction will be restored to previous conditions.

Overall, weir removal offers flood relief benefits for the community overall, the TSP will potentially increase flooding marginally at some properties. Model outputs of the TSP will be assessed to better understand the potential of these effects, including additional real estate impacts (See Appendix E).

6.2 Plan Components

- **Conway**
  Add three relief bridges/cross drain culverts at 501 Business, 501 Bypass, and 905 to increase conveyance through these areas where potential bottlenecking is occurring. Exact location and length of the bridges along these roadways is still being determined and will depend on the amount of additional flow needed.
- Each of the three relief bridges was designed at 48 inches. Culverts with a headwall, with the length spanning across the width of the state roads. In accordance with SCDOT regulations, the design would require the pipes to be a minimum distance (>500ft) away from any existing bridges. SCDOT requires bore and jack for the pipe install, assuming Geotech shows that is feasible. O&M includes culvert cleanout annually and post major storm events.

- **Socastee Creek**
- Remove two existing weirs and associated riprap along Socastee Creek by improving flow consistency and overall channel performance. Each weir is 40ft wide and 10ft high – constructed from concrete and sheet pile. They are protected by a layer of rip-rap 2 ft thick and 50 ft wide on both the upstream and downstream sides. Removal would include excavation of rip rap and employing geo-textile materials to provide additional stabilization and support for channel banks and beds.

6.3 Cost Estimate

The project first cost ROM estimate for the tentatively selected plan is $7,386,000 for the Relief Bridges Modification in Conway (Table 75) and $1,640,000 for the Barrier Removal in Socastee (Table 76). Preconstruction Engineering & Design (PED) and Construction Management (E&D, S&A) cost estimates for the TSP will be developed during refinement.

Table 75: Project Cost Summary Relief Bridges

Relief Bridges Modification Conway	
Construction Items	**Cost**
Lands and Damages	497,397.00
Fish and Wildlife Facilities	$ 207,800
Channels and Canals	$ 5,172,000
Cultural Resource Preservation	$ 250,000

Subtotal	$ 7,386,000
Preconstruction Engineering & Design (PED)	TBD
Construction Management (E&D, S&A)	TBD
Total First Cost	**$ 7,386,000**

*Preconstruction Engineering & Design (PED) and Construction Management (E&D, S&A) cost estimates for the TSP will be developed during refinement. October 2023 Price Level

Table 76: Project Cost Summary Barrier Removal

Barrier Removal Socastee	
Construction Items	**Cost**
Lands and Damages	106,086.00
Dams	$ 1,114,500
Fish & Wildlife Facilities	$ 241,700
Cultural Resource Preservation	$ 62,500
Subtotal	$ 1,640,000
Preconstruction Engineering & Design (PED)	TBD
Construction Management (E&D, S&A)	TBD
Total First Cost	**$ 1,640,000**

*Preconstruction Engineering & Design (PED) and Construction Management (E&D, S&A) cost estimates for the TSP will be developed during refinement. October 2023 Price Level

6.4 Lands, Easements, Right-of-Way, Relocations, and Disposal

In accordance with the future Project Partnership Agreement (PPA), the non-Federal Sponsor will be responsible for acquiring, or ensuring the performance of acquiring, all the LER required for the construction, operation, and maintenance of the Tentatively Selected Plan, excluding Federal properties.

For civil works projects that are cost-shared between the Federal Government and a nonfederal interest, the Water Resources Development Act of 1986 (“WRDA 86”) assigns the non-Federal partner the responsibility of acquiring the LER and of performing the facility/utility Relocations and borrow/excavated material Disposal (i.e., “LERRD”) requirements for the project. All LERRD must be acquired in accordance with the project’s PPA, WRDA 86, and the Uniform Relocation Assistance and Real Property Acquisition Policies Act of 1970 (“Public Law 91-646”), as amended.

LERRD costs represent a non-Federal partner’s estimated upfront direct and indirect financial costs in fulfilling its real estate responsibilities. The non-Federal partner will receive credit for their actual associated costs if found to be reasonable, allowable, and allocable. Supporting documents (i.e., receipts, invoices, official certified timesheets, etc.) of all LERRD costs incurred by the non-Federal partner will be submitted to USACE for review and evaluation as part of their claim for credit. LERRD costs are determined by adding the non-Federal costs in the Plan’s 01 Lands & Damages cost account with the cost in the Plan’s 02-Relocations cost account (See Appendix E for LERRD requirements and costs).

6.5 Operations, Maintenance, Repair, Replacement and Rehabilitation

Conway Relief Bridge Modification OMRR&R would include annual inspection and clearing out of the culverts along with additional clearing necessary after any major flow event. This would be conducted by use of a long reach excavator and potentially a vac truck for maintenance and cleaning. This is anticipated to take 30-40 hours costing approximately $10K including labor and equipment.

Socastee Barrier Removal is not anticipated to have any annual maintenance.

6.6 Project Risks

At the feasibility level of planning, there is always risks and uncertainty about the extent to which the TSP will meet the planning objectives. The TSPs will continue to be analyzed and refined throughout the feasibility study. The current cost estimate is a rough order of magnitude which is used to identify a TSP. During refinement the cost will also be refined and developed further. A cost and schedule risk assessment will be conducted to identify and account for project risk and uncertainty with implementation.

6.6.1 Residual Risk

The TSP would have residual risk associated with climate change over the next 100 years. Increases in the frequency and intensity of extreme rainfall events throughout the watershed could result in reduced performance of each TSP. Stronger hurricanes coupled with extreme precipitation will destroy or damage public and private buildings and property. Increased inland flooding caused by extreme precipitation events will further increase economic and agricultural losses after an event. Vulnerable populations are most at risk of flooding and may have difficulty evacuating when necessary.

The relief bridge alternative in Conway reduces equivalent annual damages from $11.7M to $10.2M, a reduction of $1.5M or about 12.8%. Likewise, the barrier removal alternative reduces equivalent annual flood damages from $8.1M to $7.4M, a reduction of $0.7M or about 8.6%. These monetary reductions correlates to the modest reduction of flood waters (as described in detail in the hydraulics sections of this report) due mainly to the low country topography and numerous streams flowing into the Waccamaw that the recommended alternatives do not significantly affect flooding throughout the study area.

The current rough order of magnitude estimates are October 23 price level and may change due to inflation prior to study finalization and construction. These current estimates will be refined during optimization of the TSPs throughout completion of the feasibility study. Residual Risk Residual risk in the context of flood risk management refers to the risk that remains even after all feasible flood risk mitigation measures have been implemented. This concept acknowledges that no flood management strategy can eliminate the possibility of flooding, and thus some level of risk will always persist. Management of the residual risks is implemented in this study by developing and implementing emergency response and evacuation plans to address residual risk and educating and preparing communities to respond effectively in the event of a flood despite existing protections. Residual risk is an important concept in flood risk management because it emphasizes the need for comprehensive planning and preparedness beyond the implementation of flood defenses. It ensures that flood risk management strategies are realistic and that communities are aware and prepared for potential flood events that cannot be completely prevented.

Identifying and managing risk is critical to making informed planning decisions in the face of uncertainty. However, some level of uncertainty will remain following any decision. Understanding and characterizing this remaining uncertainty is also critical as it can affect the outcome of any decision.

Average annual benefits from project implementation have been calculated for the Conway Bridge Relief Modification and Socastee Barrier Removal. Calculation of the average annual benefits show a positive benefit to cost ratio for both TSPs. While both TSPs will provide benefits to the surrounding communities further investigation will be conducted to gain additional knowledge on any potential impacts to the downstream areas.

There is a degree of uncertainty surrounding project performance of either TSP given the highly complex hydrology and hydraulics of the watershed. The timing of storm and flood events can greatly impact project performance. Further modeling and refinement will be conducted through the study and in PED.

6.7 Cost Sharing

Tables 77 (bridge relief) and 78 (barrier removal) identify the cost-share totals for both the government and non-federal sponsor.

Table 77: Bridge Relief Preliminary Cost-Share Apportionment for Recommended Plan

Conway: Bridge Relief Modification Cost Sharing (October 2023 Price Level)			
	Federal (65%)	***Non-Federal (35%)***	**Total**
Initial Project Cost	$4,800,900	$2,585,100	$7,386,000
LERRD Credit	-	$1,756,200	-
Cash Contribution	-	$828,900	-

[1]Costs are in 2023 price levels.
[2]Land and Damages and Relocation costs are the responsibility of the non-Federal sponsor and deducted from the cash contribution to meet the required 35% non-Federal cost share apportionment.

Table 78: Barrier Removal Preliminary Cost-Share Apportionment for Recommended Plan

Socastee: Barrier Removal Cost Sharing (October 2023 Price Level)			
	Federal (65%)	***Non-Federal (35%)***	**Total**
Initial Project Cost	$1,066,000	$574,000	$1,640,000

LERRD Credit	-	$220,400	-
Cash Contribution	-	$353,600	-

[1]Costs are in 2023 price levels.
[2]Land and Damages and Relocation costs are the responsibility of the non-Federal sponsor and deducted from the cash contribution to meet the required 35% non-Federal cost share apportionment.

6.8 Design and Construction

Additional detail will be developed during TSP refinement and provided in the final report.

6.9 Environmental Commitments

Environmental commitments are mainly relatively standardized and compulsory best practices. They represent sound and proven methods to reduce the potential effects of an action. To avoid and minimize construction-related effects, the environmental commitments identified below would be implemented to reduce or offset short-term, construction-related effects.

The following environmental commitments are intended to avoid and minimize environmental impacts:

- Relief bridge (cross drain) design considerations will be informed by U.S. Forest Service guidelines and stream simulation method ("Stream Simulation: An Ecological Approach to Providing Passage for Aquatic Organisms at Road-Stream Crossings" [USFS 2008]) to avoid impacts to the entire ecosystem and associated species.
- Where necessary, avoid removing trees from December 15th to February 15th (winter torpor) and April 1st to July 15th (summer occupancy) to avoid impacts to bats.
- Erosion and sediment control Best Management Practices (BMPs) outlined in SCDES' Stormwater BMP Handbook will be incorporated into all construction actions to prevent introduction of sediment and pollutants into waterways.
- Relevant Nationwide Standard Conservation Measures (USFWS 2015) should be included in specifications where they would provide necessary protections for migratory birds.
- NHPA 106: A programmatic agreement (PA) is currently in development for additional cultural resources surveys in the Preconstruction, Engineering, and Design phase (after signing the FONSI) to determine effects to historic properties. A phase I survey will be needed for each project APE.
- Coordination letters will be sent to agencies and tribes informing them of the TSP and inviting them to be a signatory on the PA.

6.10 (Environmental Operating Principles

This study and the associated TSP maintain the USACE commitment to environmental stewardship by conforming to the following USACE Environmental Operating Principles:

- **Foster sustainability as a way of life throughout the organization.** The TSPs foster environmental sustainability by representing the plans with no significant or permanent environmental impacts.
- **Proactively consider environmental consequences of all USACE activities and act accordingly.** The study team coordinated with appropriate environmental agencies to identify all possible environmental impacts and sought avenues to minimize those impacts throughout the development and evaluation/comparison of alternative plans.
- **Create mutually supporting economic and environmentally sustainable solutions.** The TSPs reduce flood risk to communities throughout the study area through the implementation of measures that have no significant environmental impacts.
- **Continue to meet our corporate responsibility and accountability under the law for activities undertaken by USACE, which may impact human and natural environments.** The study team is engaged in the activities necessary to assess and minimize cumulative impacts to the environment through NEPA via necessary surveys and agency coordination. It is expected that the TSPs will be compliant with all applicable laws and policies.
- **Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs.** Environmental risks were identified early in the study process and used to inform plan formulation decisions.
- **Leverage scientific, economic, and social knowledge to understand the environmental context and effects of USACE actions in a collaborative manner.** The study team worked with local and regional stakeholders and held multiple scoping meetings with the public to obtain all existing scientific, economic, and social knowledge regarding environmental context and used this information during the plan formulation process.
- **Employ an open, transparent process that respects views of individuals and groups interested in USACE activities.** The study team was open and transparent regarding the study process and possible outcomes during site visits and the public scoping meetings. All feedback obtained during these outreach activities was incorporated into the planning process. The TSPs will be reviewed and potentially modified during the PED phase. USACE and its contractors commit to avoiding, minimizing, and mitigating for adverse effects during construction activities.

6.11 Views of the Non-Federal Sponsor

The NFS, represented by Horry County, has expressed support of the TSP. A letter of intent acknowledging the NFS's intent to support project implementation will be included in the final report.

7.0 ENVIRONMENTAL COMPLIANCE

7.1 Environmental Compliance Summary

Table 79 below provides a list of relevant environmental laws, regulations, and executive orders (EOs) with a brief statement summarizing how the project will comply with the requirements.

Table 79: Environmental Compliance Summary

Title of Public Law	US Code	Compliance Status	Compliance Status
Abandoned Shipwreck Act of 1987	43 USC 2101	Not Applicable	The project area does not include any abandoned shipwrecks. No action necessary.
The Bald and Golden Eagle Protection Act of 1940, As Amended	16 USC 668	Full Compliance	Generally, has no applicability other than instances where incidental take of migratory birds or their nests/eggs may occur (e.g. tree removal). Contractor will be responsible for compliance with Bald Eagle Act and will implement BMPs (e.g. nationwide standard conservation measures) to comply with these acts.
Clean Air Act of 1972, As Amended	42 USC 7401 et seq.	Full Compliance	Horry County is designated as in attainment under the CAA. Implementation of the TSP would not include use of any major stationary sources and would not require any permitting under the CAA.
Clean Water Act of 1971, As Amended	33 USC 1251 et seq.	Partial Compliance	Based on an initial estimate of wetland dredge and fill needed in construction of the relief bridges (cross drains), which would be considered independent and full-functioning constructions, <0.1 acres of impacts would occur at each structure. USACE has determined that this action is eligible for authorization under NWP 14. USACE has also determined the barrier removal in Socastee is eligible for authorization under NWP 53. Therefore, these actions would be performed in compliance with CWA Section 404(e) and the 404(b)(1) guidelines. Prior to signing of a FONSI, a 401 WQC pre-filing meeting request will be filed with the BOW, followed by 401 WQC application for each individual action proposed under the TSP. All conditions issued with 401 WQC will be applied to action design and specifications to the extent practicable. A copy of the 401 Certification for authorization will be included in Appendix C prior to signing of a FONSI.
Coastal Barrier Resources Act of 1982	16 USC 3501-3510	Not Applicable	The project area does not fall within any established CBRS. No action necessary.
Coastal Zone Management Act of 1972, As Amended	16 USC 1451 et seq.	Partial Compliance	Conditions under the tentatively selected plan have been considered by USACE and determined to be eligible for authorization under Nationwide Permits 14 and 53 for the relief bridge (cross-drains) in Conway and the barrier removal in Socastee, respectively. A General Coastal Zone Consistency Certification Notification Request Form is included in Appendix C. Concurrence from DES that the General Certification is authorized for these actions will be verified prior to signing a FONSI and included in Appendix C.
Comprehensive Environmental Response, Compensation and Liability Act of 1980	42 USC 9601	Full Compliance	An assessment of databases of existing HTRW (i.e., RCRA, TRI, NPL, etc.) in the project area show no known overlap with proposed measures. Any HTRW discovered during the acquisition of land easements, or preconstruction or construction phases would be the responsibility of the NFS to remove prior to initiation or completion of works.
Endangered Species Act of 1973	16 USC 1531	Full Compliance	Federally listed species under the jurisdiction of USFWS were identified using the USFWS' Information for Planning and Consultation (IPaC) tool (list updated July 1, 2024), and listed species under the jurisdiction of NMFS known to occur in the Southeast US were reviewed as of July 1, 2024. Suitable

			habitat for the Northern-long eared bat may be affected by implementation of the TSPs. USACE has made a "*may affect, not likely to adversely affect*" determination for this species. Input of project-specific information using determination keys on IPaC tool led to issuance of a letter of concurrence for this determination from USFWS on July 31, 2024. A "*no effect*" determination has been made for all other listed species which may occur in or near the action area. Reinitiation of consultation would occur if any of the conditions outlined in 50 CFR 402.16(a) are met prior to completion of construction.
Estuary Program Act of 1968	16 USC 1221 et seq.	Not Applicable	There are no estuarine waters in the action area
Farmland Protection Policy Act	7 USC 4201 et seq.	Full Compliance	Parts I and III of the Farmland Conversion Impact Rating Form (Form AD 1006) and a transmittal letter, will be submitted to the NRCS upon further design should it be deemed necessary and prior to signing of a FONSI.
Federal Environmental Pesticide Act of 1972	7 USC 136 et seq.	Full Compliance	Where applicable, all use of pesticides will be in compliance with the act as specified in contract(s). Contractor personnel applying pesticides will use registered pesticides, use properly licensed applicators, provide proper training, and store materials in approved containers and buildings.
Federal Water Project Recreation Act of 1965, As Amended	16 USC 4601	Full Compliance	Discussion of recreation opportunities occurs within this report.
Fish and Wildlife Coordination Act of 1958, As Amended	16 USC 661	Full Compliance	Coordination with USFWS, NMFS and state agencies was initiated in October 2022 in the formation of the ICT. In June 2023, in recognition of staffing shortages experienced by the Service, USFWS and USACE agreed to collaboratively draft a Coordination Act Report (CAR) to inform decision-making and be included in the feasibility report. A draft CAR was developed in August 2024 and information and recommendations are incorporated herein and a copy included in Appendix C
Flood Control Act of 1944, As Amended, Section 4	16 USC 460b	Full Compliance	Discussion of recreation opportunities occurs within this report.
Food Security Act of 1985 (Swampbuster)	16 USC 3811 et seq.	Not Applicable	Proposed actions not designed for protection of agricultural lands.
Historic and Archeological Data Preservation	16 USC 469	Partial Compliance	Working on draft PA and consultation letters for involved agencies and awaiting comment following 30-day review to reach full compliance prior to signing a FONSI.
Land and Water Conservation Fund Act of 1965	46 USC 4601	Not Applicable	No property acquired or developed with assistance from this Act will be converted to other than outdoor recreation uses
Magnuson-Stevens Fishery Conservation and Management Act	16 USC 1801	Partial Compliance	No adverse effects to EFH are anticipated as a result of implementing the TSP(s). This conclusion is based on analysis provided in Section 4.6.11 above and as detailed in the FWCA report included in Appendix C. Consultation requirements of sections 305(b)(2) through (4) of the MSA are ongoing in following with procedures outlined in 50 CFR § 600.920(f). A record of consultation proceedings will be included in Appendix C of the final feasibility report.
Marine Mammal Protection Act of 1972, As Amended	16 USC 1361	Not Applicable	No effects to marine mammals would occur from implementation of the TSP(s).
Migratory Bird Treaty Act of 1918, As Amended	16 USC 703	Full Compliance	Generally, has no applicability other than instances where incidental take of migratory birds or their nests/eggs may occur (e.g. tree removal). Contractor will be responsible for compliance with Migratory Bird Treaty Act and will implement BMPs (e.g. nationwide standard conservation measures) to comply with these acts.

National Environmental Policy Act of 1969, As Amended	42 USC 4321 et seq.	Full Compliance	Development of Environmental Assessment is concurrent with this report.
National Historic Preservation Act of 1966, As Amended	16 USC 470	Partial Compliance	Working on draft PA and consultation letters for involved agencies and awaiting comment following 30-day review to reach full compliance prior to signing a FONSI.
National Historic Preservation Act Amendments of 1980	16 USC 469a	Partial Compliance	Working on draft PA and consultation letters for involved agencies and awaiting comment following 30-day review to reach full compliance prior to signing a FONSI.
Native American Religious Freedom Act of 1978	42 USC 1996	Partial Compliance	Working on draft PA and consultation letters for involved agencies and awaiting comment following 30-day review to reach full compliance prior to signing a FONSI.
National Trails System Act	16 USC 1241	Not Applicable	No impacts to the National Trail System
National Wildlife Refuge Systems Administration Act	16 USC 668	Full Compliance	No impacts to NWR system.
Noise Control Act of 1972, As Amended	42 USC 4901 et seq.	Full Compliance	Action will comply with Federal, State, interstate, and local requirements respecting control and abatement of environmental noise.
Resource Conservation and Recovery Act of 1976	42 USC 6901-6987	Full Compliance	All solid wastes generated will be managed in accordance with state and local solid waste regulations.
River and Harbor Act of 1888, Sect 11	33 USC 608	Not Applicable	No piers, wharves, bulkheads, or other works proposed in-water.
Rivers and Harbors Act of 1889, Sections 9, 10, 13	33 USC 401-413	Not Applicable	No impacts to navigable waters.
River and Harbor and Flood Control Act of 1970, Sections 122, 209, and 216	33 USC 426 et seq.	Full Compliance	Full consideration given to air, noise, and water pollution; destruction or disruption of man-made and natural resources, esthetic values, community cohesion and the availability of public facilities and services; adverse employment effects and tax and property value losses; injurious displacement of people, businesses, and farms; and disruption of desirable community and regional growth.
Safe Drinking Water Act of 1974, As Amended	42 USC 300f	Full Compliance	Activities that may impact underground drinking water supplies are being reviewed by the SCDES BOW.
Toxic Substances Control Act of 1976	15 USC 2601	Not Applicable	No activities involving PCBs
Wild and Scenic Rivers Act	16 USC 1271 et seq.	Not Applicable	The Waccamaw River and Pee Dee Rivers are listed on the NRI but the actions identified in the TSP would not directly or indirectly adversely affect the river segments listed nor would it foreclose options to classify any portion of the NRI segments as wild, scenic, or recreational river areas.
Title of Executive Order	**EO**	**Compliance**	**Status**
Floodplain Management	11988	Full Compliance	Actions are formulated to reduce the risk of flood loss, to minimize the impact of floods on human safety, health and welfare, and to restore and preserve the natural and beneficial values served by floodplains.
Protection of Wetlands	11990	Full Compliance	Action will include measures to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values.
Federal Actions to Address Environmental Justice and Minority and Low-Income Populations	12898	Full Compliance	Actions do not have the effect of excluding persons (including populations) from participation in, denying persons (including populations) the benefits of, or subjecting persons (including populations) to discrimination because of their race, color, or national origin.
Protection of Children from Environmental Health Risks and Safety Risks	13045	Full Compliance	No disproportionate risks to children such as environmental health risks or safety risks were identified relevant to the purpose and action of this study.

Invasive Species	13112	Full Compliance	Design specifications incorporate preventative actions regarding the introduction of invasive species
Marine Protected Areas	13158	Not Applicable	No actions in marine environment
Responsibilities of Federal Agencies to Protect Migratory Birds	13186	Full Compliance	EA evaluates effects of actions and agency plans on migratory birds, with emphasis on species of concern.

7.2 Mitigation, Monitoring and Adaptive Management

In developing the array of construction activities necessary to implement the TSP, proactive actions (including those resulting from coordination under the FWCA), including BMPs, to avoid or minimize anticipated impacts to the extent practicable will be incorporated (see Section 6.8 above). Neither of the actions outlined in the TSP (relief bridges/cross drains in Conway and barrier removals in Socastee) are expected to incur direct environmental impacts that would require compensatory mitigation. For instance, the relief bridges (cross drains) in Conway are each expected to require <0.01 acre of wetland impacts during their construction, which is below the typical threshold which would require mitigation for authorization under a NWP. Likewise, removal of low-head dams or weirs, like the ones in Socastee, are expected to result in a net increase in ecological functions and services provided by the stream and generally requires no mitigation for these activities.

The need for mitigation or monitoring and adaptive management plans, however, would likely need to be further defined and analyzed in detail through subsequent planning and agency coordination. Currently, based on previous analyses of similar actions at a programmatic level in the development of NWPs and through ongoing interagency coordination and findings of the FWCA report (see Appendix C), it is the determination of USACE that no mitigation is necessary. If, based on further intra- or inter-agency coordination and consultation or through substantive public input, it is determined to be necessary at a later time, compensatory mitigation will be developed consistent with USACE mitigation policy and requirements specified in ER 1105-2-103.

7.3 Public Involvement

Public outreach events were held from June 14-16, 2023, at locations in Little River, SC (Longs/Red Bluff), Bucksport, SC, and Conway, SC. Outreach events consisted of a two-hour open house-style presentation of the study. Resources were provided to participants including maps with preliminary measures, information sheets on project description and issues being addressed, a story map, and stations where the public could provide input and ask questions. Public comment forms were distributed and about 51 questions and comments were received and compiled to be addressed by the project delivery team.

7.4 Scoping and Agency Coordination

On October 28, 2022, a scoping letter went out to Federal and state resource agencies. In the letter, agencies were requested to provide input on the scope of issues to be addressed, any resources or habitats of concern in the study area, information on ongoing projects in the area, and any feedback on the management measures being considered. Also included was a request, in accordance with Section 1005 of the Water Resources Reform and Development Act of 2014 and other applicable laws and regulations (including the Fish and Wildlife Coordination Act), to hold an Interagency Coordination Team (ICT) webinar meeting on 15 November 2022. This letter was provided to members of the following agencies:

- National Marine Fisheries Service (NMFS) (including Habitat Conservation Division, Office of Protected Resources)
- National Park Service
- South Carolina Department of Archives and History (SCDAH)
- South Carolina Department of Environmental Services (SCDES) (including Office of Ocean and Coastal Resource Management, Bureau of Water)
- South Carolina Department of Natural Resources (SCDNR) (including Office of Environmental Programs, Hydrology Section, State Climatology Office)
- South Carolina State Historic Preservation Office
- US Department of Agriculture Natural Resources Conservation Service
- US Environmental Protection Agency (EPA)
- US Geological Survey
- US Fish and Wildlife Service (USFWS) (including South Carolina Ecological Services Field Office, Waccamaw River National Wildlife Refuge)

Scoping input was received from representatives of SCDNR, EPA, and NMFS (HCD) via letter or email on November 22 and 28, and December 5, 2022, respectively. A copy of each letter is included in Appendix C.

On November 22, 2022, the first ICT meeting was held and included members of the agencies above as well as members of the City of Conway, Horry County, and USACE. The meeting provided further information to members of the ICT on scoping progress and allowed an opportunity to provide feedback. Another meeting was held on March 14, 2023, following development of an initial array of alternatives, followed by meetings on September 27, 2023, and February 16, 2024, leading up to the development of a final array of alternatives. In general, feedback received was with respect to other agency activities in the area (e.g., land procurements) and concerns regarding potential impacts to natural resources from alternatives involving construction of hardened structures (i.e., floodgates and floodwalls).

7.5 Tribal Consultation

Consultation with Tribes was initiated with a letter dated 1 November 2022. There are 11 Tribes that consider Horry County within their Area of Interest (AOI). The Tribes include the Absentee-Shawnee Tribe of Oklahoma, Alabama-Quassarte Tribal Town, Catawba Indian Nation, Chickasaw Nation, Delaware Tribe of Indians, Eastern Band of Cherokee Indians, Eastern Shawnee Tribe of Oklahoma, Kialegee Tribal Town, Poarch Band of Creek Indians, Shawnee Tribe, and Thlopthlocco Tribal Town.

7.6 Public Comments Received and Responses

TBD

8.0 DISTRICT ENGINEER RECOMMENDATION

Based on the conclusions of this study, I recommend the implementation of the TSP, which consists of Bridge Relief Modification in the City of Conway and Barrier Removal in Socastee. The project was developed consistent with national environmental statutes, applicable executive orders, and Federal planning requirements. The TSP avoids, minimizes, or mitigates adverse environmental effects to the extent practicable and identifies feasible measures to adequately compensate for unavoidable effects to resources. The benefits of the TSP is in the public interest and does not constitute a major federal action that would significantly affect the quality of the environment; therefore, preparation of an EIS is not required. The TSP also aligns with the legislative requirements authorizing the Waccamaw River, Horry County, South Carolina Flood Risk Management Feasibility Study. The District recommends that the TSP located in Horry County, South Carolina move forward to detailed design and implementation as described in this report.

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Signature Block

9.0 List of Preparers

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Name	Office	Position
Nancy Parrish	SAC	Planning Chief
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Lance Mahar	SAC	Mechanical Engineer
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Amy Schwartz	SAC	Office of Counsel
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*Additional references provided with Appendix.