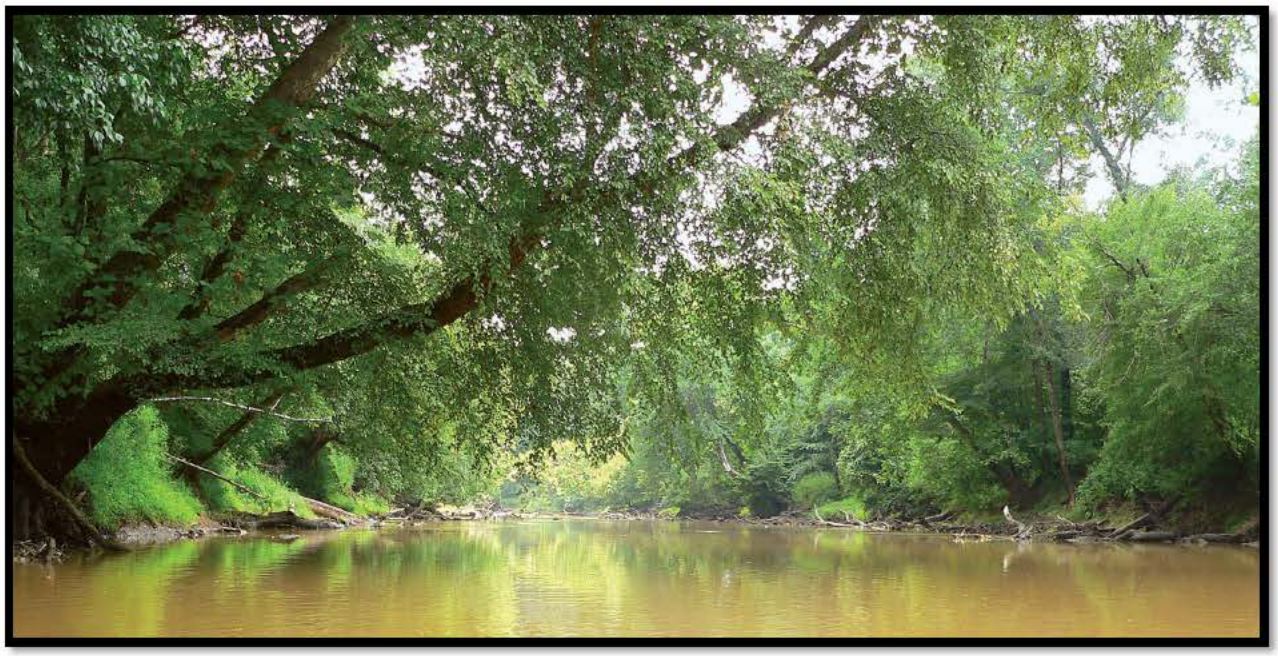
Neuse River Basin Flood Risk Management North Carolina

Technical Report



28 February 2023

US Army Corps of Engineers ®
Wilmington District

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NEUSE RIVER BASIN
FLOOD RISK MANAGEMENT, NORTH CAROLINA
TECHNICAL REPORT

EXECUTIVE SUMMARY

IMPORTANT REPORT INFORMATION: This Technical Report is a final transitional document from the draft Integrated Feasibility Report and Environmental Assessment (IFR/EA) that was provided for technical, policy, legal and public review between March and July 2022. For the purposes of this Technical Report, references to 'draft IFR/EA' and 'draft Recommended Plan' refer to information presented in the original draft document that was circulated for public and agency review. This study was terminated prior to completing the entire U.S. Army Corps of Engineers (USACE) review process, and the IFR/EA was not completed. This Technical Report was prepared to document the key findings achieved before study termination.

1. Introduction

This Technical Report was prepared by the USACE and describes a series of analyzed alternatives designed to reduce on-going flood risks throughout the Neuse River basin. These alternatives included a No Action plan, as well as various combinations of structural and nonstructural measures.

The total study area comprised the entire Neuse River basin in North Carolina. The basin begins in the Piedmont of North Carolina and extends 248 miles southeast through the Coastal Plain and flows into the Pamlico Sound, covering approximately 6,200 square miles. Also, the feasibility study encompassed all or part of 18 counties and population centers including the cities of Durham, Raleigh, Wilson, Smithfield, Goldsboro, Kinston, and New Bern, NC (Figure 1-2, Chapter 1).

As the feasibility study progressed following the preliminary screening phase, the project delivery team (PDT) determined that more detailed coastal modeling tools are required for the tidally influenced southeastern portion of the study area including the New Bern area. USACE concluded that additional studies are needed to evaluate coastal storm risk for this tidally influenced area. Therefore, this Technical Report only presents detailed analyses for flood risk caused by riverine flooding in non-tidally influenced areas.

The non-Federal study sponsor is the North Carolina Department of Environmental Quality (NCDEQ).

2. Purpose and Need

The purpose of the Neuse River Basin Flood Risk Management Feasibility Study was to document the assessment of and recommend federal actions to reduce risk and damages caused by flooding along the Neuse River and its tributaries. Flood damages have ranged from more frequent riverine flooding to severe and widespread impacts like those sustained during Hurricane Matthew in 2016 and Hurricane Florence in 2018.

Recurring flooding within the basin results in considerable economic damages to homes, businesses, industry, and public infrastructure. For example, Hurricane Matthew is estimated to have caused over $180 million in damage to residential, non-residential, and public structures located within the floodplain of the Neuse River and its tributaries (NCEM and NCDOT, 2018). Inundation of structures and roadways also resulted in increased life-safety risks both during and following this flood event.

In response to recent flooding that occurred because of Hurricanes Matthew (2016) and Florence (2018), the USACE received funding through the Federal 2019 Additional Supplemental Appropriations for Disaster Relief Act (H.R. 2157) to conduct a feasibility study. This study assessed and recommend actions to reduce flood risk damage and increase resiliency, allowing property owners to rebound and adapt from flood risk given changes in climate and other conditions, within the Neuse River basin. This Technical Report describes both the without- and with-project conditions including potential alternatives designed to reduce flood risks throughout the basin.

3. Plan Formulation

Due to the large size of the study area, having a logical plan to develop and evaluate possible solutions was recognized as especially critical. The general strategy for this study identified separate focus areas within the basin that are typically population centers with expected notable flood risk. Each of these focus areas was formulated individually to identify measures that would address at least one of the study objectives. Then, through the formulation process, viable measures are combined into alternative plans for that specific area. Rural areas within the floodplain are also considered, although structural measures are less likely to be economically viable due to less concentrations of development. It was also recognized that some large-scale measures could have a regional impact, for example, a large water detention structure. These large-scale measures are considered “basinwide” measures.

Finally, viable plans are selected from individual focus areas and combined across the basin, which resulted in a set of system-wide alternatives. Figure 3-1, Chapter 3 illustrates this strategy.

A preliminary assessment was conducted in the tidally influenced coastal area of the Neuse River basin, including consideration of both structural and nonstructural measures. Due to the complex combination of riverine and coastal influences in this portion of the basin, the PDT determined that different coastal modeling tools would be required in a separate study. A future study would adequately formulate for alternatives in this area with sufficient technical details and still comply with 3x3x3 study guidelines. Therefore, only general information is provided on the flood risk of tidally influenced areas within this Technical Report.

The USACE project delivery team developed an extensive list of structural and nonstructural flood risk management measures throughout the basin to address one or more of the planning objectives. These measures are carried through a series of screenings using an increasing level of detail. This resulted in a preliminary array of alternatives for each viable focus area which included combinations of both structural and nonstructural alternatives. These preliminary alternatives by focus area are screened, combined as appropriate and presented as the preliminary array of alternatives in the draft IFR/EA.

The draft Recommended Plan presented in the draft IFR/EA included elevation or floodproofing of 768 structures located adjacent to four specific areas of this basin: Crabtree Creek, Raleigh; Hominy Swamp Creek, Wilson; Big Ditch, Goldsboro; and the Neuse River in Wayne and Johnston Counties, generally located between Goldsboro and Smithfield, all in NC. This plan was also preliminarily identified as the National Economic Development (NED) Plan that provided the greatest positive difference annual benefits and annual costs.

Based on public, agency, technical and policy reviews of the draft IFR/EA, the scale and footprint of the draft Recommended Plan was significantly reduced. Details describing the reasons for the scale and footprint reduction are noted in Section 3.7.2 of this report. The resultant draft Recommended Plan only proposed dry floodproofing of 12 structures located adjacent to Crabtree Creek in Raleigh, NC. This is also the only plan where the benefit-to-cost ratio exceeded unity.

Upon further detailed analyses, the proposed dry floodproofing of these 12 structures, of which 10 are residential apartment buildings, did not meet the planning screening acceptability criteria described in Section 3.7.6 and Table 3-21. This alternative would also potentially conflict with federal and local floodplain regulations. Therefore, this plan could not be proposed as the final Recommended Plan.

With no other identified alternatives which are either implementable, acceptable and/or economically viable under federal regulations, policy and/or guidelines, No Action

ultimately became the Recommended Plan for the Neuse River basin study as noted below in the final array of basinwide alternatives:

Alternative 1: No Action **(Recommended Plan)**
Alternative 2: Structure Floodproofing (Crabtree Creek, Raleigh, NC)
Alternative 3: Property Buyouts (included selected structures and associated land) – (NOTE: Alternative 3 is not economically viable but is provided for comparison purposes only)

4. Recommended Plan

As noted above, the Recommended Plan described in the Technical Report is Alternative 1, No Action. Alternative 2 is the only action alternative determined to be economically feasible and is the National Economic Development (NED) plan. This alternative is a nonstructural plan of dry floodproofing of 12 structures, 10 of which are multi-family residential apartment buildings, and located adjacent to Crabtree Creek in Raleigh, NC. Ultimately, this alternative did not meet the planning screening acceptability criteria shown in Table 3-21, based on the following issues.

Alternative 2 potentially conflicted with the following federal and local regulations:

- FEMA National Flood insurance Program (NFIP) Technical Bulletin 3 dated January 2021 – Requirements for the Design and Certification of Dry Floodproofing Non-Residential and Mixed-Use Buildings), Section 1.3. and
- City of Raleigh, NC, Stormwater Design Manual, dated 22 July 2022, (Chapter 7, section 7.7)

Implementation of a flood risk management plan that potentially conflicted with these regulations could negatively impact a community's, or certain property owners' ability to participate in the NFIP and other federally funded flood emergency disaster recovery programs.

Additionally, since dry floodproofing measures associated with Alternative 2 would only be intended to reduce flood damage, a detailed Emergency Evacuation Plan (EEP) for affected residents would be required as a critically needed component to successfully implement Alternative 2. Even with the EEP, implementation of Alternative 2 could potentially increase the risk of loss of life given that an EEP would not generally provide the authority to implement nor enforce mandatory evacuation of residents.

Therefore, if residents refused to evacuate their residences under any circumstances, even if recommended by law enforcement, residents' ingress and egress would be severely restricted during a flood event. As a result, residents would be placed at a

heightened risk if floodwaters overtopped the design flood level creating the need for immediate rescue and emergency assistance.

There are no other identified alternatives which are either implementable nor economically viable under federal regulations, policy and/or guidelines. Therefore, No Action ultimately became the Recommended Plan.

While there is no federal interest found for implementation of a flood risk management plan, there are three other federal authorities that may benefit the non-Federal sponsor and stakeholders within the Neuse River basin. These include the Planning Assistance to States (PAS), Floodplain Management Services (FPMS), and Continuing Authorities Program (CAP) authorities. The PAS and FPMS authorities offer an opportunity to tap into USACE's engineering expertise to help identify potential solutions that could be implemented without federal involvement. The CAP authority, however, does allow the implementation of a Federal/non-Federal cost-shared project of a smaller scale.

5. Significant Resources/Environmental Considerations

Since no federal action is recommended, there are no environmental impacts to any significant resource nor adverse impacts to culturally significant historic properties caused by federal action.

As noted above, prior to study termination, the draft IFR/EA was reviewed by the public and resource agencies in accordance with the National Environmental Policy Act of 1969, as amended (NEPA). Comments received on the draft IFR/EA and USACE responses are included in Appendix I (Public and Agency Comments and Responses).

6. Plan Implementation

No implementation plan was developed since no federal action is recommended.

7. Views of the Non-Federal Sponsor

The non-Federal sponsor, the North Carolina Department of Environmental Quality (NCDEQ), did not object to the final Recommended Plan of no federal action. Leading up to the determination of the final Recommended Plan, multiple information exchange meetings were held since the start of this study in April 2020 with NCDEQ and representatives of other state agencies including, but not limited to, the North Carolina Department of Transportation (NCDOT), North Carolina Division of Emergency Management (NCEM) and North Carolina Office of Resiliency and Recovery (NCORR).

8. Views of the Public, Agencies, Stakeholders, and Tribes

During the first year of the study, ten separate onsite and/or virtual information gathering events within the Neuse River basin study area were held with town, city, county, and state officials between September and November 2020. These events helped inform this study by providing existing information about past flood risk studies, mapping, and other technical data. Concurrent verbal discussions with officials from at least six other counties located along the perimeter of the basin validated the minor level of flood risk from tributaries of the Neuse River because most urban and rural development are located above the 1% AEP flood level.

Three virtual public involvement meetings were held between March and April 2021. These meetings individually focused on the eastern, central and western portions of the Neuse River basin, confirmed strong public interest in this study and provided opportunities to discuss potential measures that could be evaluated to reduce flood risk.

The U.S. Fish and Wildlife Service, the U.S. Environmental Protection Agency, National Marine Fisheries Service's Habitat Conservation Division (HCD), and the Federal Emergency Management Agency are cooperating agencies for this study. Other federal agencies, non-Federal agencies, and tribes are part of the ongoing overall coordination process.

Formal views of the public, agencies, stakeholders, and tribes were obtained on the draft IFR/EA released for public review and comment in April 2022. Also, a public information meeting was held on 10 May 2022 where multiple stakeholders and the public participated. Four additional focused virtual meetings were held with officials of communities where initial flood risk management measures were proposed as part of the draft Recommended Plan and draft IFR/EA. Participating counties and communities included Wayne and Johnston Counties, and the cities/towns of Goldsboro, Wilson, and Raleigh, all in North Carolina. The results of these reviews and meeting feedback have been incorporated as applicable into this Technical Report and Appendix F (Correspondence) and Appendix I (Public and Agency Comments and Responses).

9. Technical and Policy/Legal Reviews

Multiple reviews were completed between March and July 2022 on the draft IFR/EA including District Quality Control (DQC), Agency Technical Review (ATR), Policy and Legal Review (P&LR) and Public Review. Review comments were considered and incorporated into this Technical Report, as appropriate. A final DQC review was conducted and completed on the revised report. Since the study was terminated after completion of this DQC, no further technical and policy/legal reviews were conducted on the Technical Report.

10. Unresolved Issues/Areas of Controversy

There are no unresolved issues or areas of controversy identified.

11. Conclusions

While there is no federal interest found for implementation of a flood risk management plan, there are potential opportunities for a non-Federal entity to pursue additional analysis to further define flood risk within different parts of the basin. One example could be further assessment of the multi-building apartment complex located adjacent to Crabtree Creek (Alternative 2) by working with the USACE to conduct a Planning Assistance to States (PAS) study, Floodplain Management study (FPMS) or Continuing Authorities Program (CAP) study. This potentially socially vulnerable area is subject to flood damage that could benefit from an additional study. These programs could also be used to develop education materials for the public describing basinwide flood risk based on the analyses to date, including socially vulnerable communities.

Based on coordination to date with the non-Federal sponsor, this report is expected to be used to inform the Neuse River resilience study recently initiated by the NCDEQ Division of Mitigation Services.

Additionally, due to the complex dynamics of the tidally influenced portion of the Neuse River basin, which is greatly influenced by coastal storm surge and sea level rise, it is concluded that this portion of the basin should be evaluated under a separate study specific to this unique area using the appropriate technical evaluation tools.

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LIST OF ACRONYMS AND ABBREVIATIONS

ACHP	Advisory Council on Historic Preservation
ACS	American Community Survey
AEP	Annual Exceedance Probability
APE	Area of Potential Effects
ATR	Agency Technical Review
BCR	Benefit-to-Cost Ratio
BD	Big Ditch, Goldsboro, NC
CDC	Council for Disease Control and Prevention
CEQ	Council on Environmental Quality
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFR	Code of Federal Regulations
CONUS	Continental United States
CSRA	Cost Schedule Risk Assessment
CTC	Crabtree Creek, Raleigh, NC
CWCCIS	Civil Works Construction Cost Index System
DPS	Distinct Population Segment
DQC	District Quality Control
EA	Environmental Assessment
EAD	Expected Annual Damage
EC	Engineer Circular
ECB	Engineering and Construction Bulletin
EEP	Emergency Evacuation Plan
EFH	Essential Fish Habitat
EJ	Environmental Justice
EO	Executive Order
EQ	Environmental Quality
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 Planning Center of Expertise
FPPA	Farmland Protection Policy Act
FWOP	Future Without-Project
FWP	Future With-Project
FY	Fiscal Year
GHG	Greenhouse Gases

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)	
GIS	Geographic Information System
H&H	Hydrology and Hydraulics
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/EA	Integrated Feasibility Report and Environmental Assessment
IPAC	Information for Planning and Consultation
LERRDs	Lands, Easements, Right-of-Ways, Relocations, and Disposal Areas
LifeSim	Life Loss Simulation Model
LPP	Locally Preferred Plan
mg/l	Milligram Per Liter
MHW	Mean High Water
MHHW	Mean Higher High Water
MLLW	Mean Lower Low Water
MMT	Million Metric Tons
MS	Neuse River Mainstem
MSFCMA	Magnuson-Stevens Fishery Conservation and Management Act
MSL	Mean Sea Level
NAAQS	National Ambient Air Quality Standards
NACSE	Northwest Alliance for Computational Science and Engineering
NC	North Carolina
NCDCM	North Carolina Division of Coastal Management
NCDENR	North Carolina Department of Environment and Natural Resources
NCDMF	North Carolina Division of Marine Fisheries
NCDEQ	North Carolina Department of Environmental Quality
NCDOT	North Carolina Department of Transportation
NCDPS	North Carolina Department of Public Safety
NCDWR	North Carolina Division of Water Resources
NCEM	North Carolina Emergency Management

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)	
NCFMP	North Carolina Floodplain Mapping Program
NCFRIS	North Carolina Flood Risk Information System
NCORR	North Carolina Office of Resiliency and Recovery
NCOSA	North Carolina Office of State Archaeology
NCSHPO	North Carolina State Historic Preservation Office
NCSU	North Carolina State University
NCWRC	North Carolina Wildlife Resources Commission
NED	National Economic Development
NEPA	National Environmental Policy Act
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
NRC	National Resources Council
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NS	Nonstructural Measure
NST	Nonstationary Detection Tool
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
PL	Public Law or Price Level
PPA	Project Partnership Agreement
ppt	Parts Per Thousand
RECONS	Regional Economic System Model, U.S. Corps of Engineers
RED	Regional Economic Development
ROM	Rough Order of Magnitude
RP	Recommended Plan
S	Structural Measure
SACS	South Atlantic Coastal Study
SLC	Sea Level Change
SLR	Sea Level Rise
SVI	Social Vulnerability Index
TES	Threatened, Endangered and Sensitive Species

LIST OF ACRONYMS AND ABBREVIATIONS (Continued)	
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
WRRDA	Water Resources and Recovery Development Act
WSEL	Water Surface Elevation
WWTP	Wastewater Treatment Plant

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Chapter 1 Overview

1.1. Introduction

This Technical Report documents the key findings of the feasibility study was initiated in April 2020 by the U.S. Army Corps of Engineers – Wilmington District (USACE-SAW) in partnership with the North Carolina Department of Environmental Quality (NCDEQ). The study identified, evaluated, and compared alternatives for flood risk management, consistent with the U.S. Army Corps of Engineers (USACE) policy and regulations, within the Neuse River basin for the purpose of reducing risk and damages caused by flooding along the Neuse River and its tributaries.

1.2. USACE Planning Process

The USACE planning process, which was used in the feasibility study, followed the six-step process defined in the U.S. Water Resources Council Principles and Guidelines (P&G) (USACE 1983). This process was a structured approach to problem solving which provides a rational framework for sound decision-making. The six-step process was used for all planning studies conducted by the USACE. The six steps are:

- Step 1 – Identifying problems and opportunities
- Step 2 – Inventorying and forecasting conditions
- Step 3 – Formulating alternative plans
- Step 4 – Evaluating alternative plans
- Step 5 – Comparing alternative plans
- Step 6 – Selecting a plan

USACE decision-making is generally based on the accomplishment and documentation of all these steps. It is important to stress the iterative nature of this process. As more information was acquired and developed, it became necessary to reiterate some of the previous steps. The six steps, though presented and discussed in a sequential manner for ease of understanding, usually occur iteratively and sometimes concurrently. Iterations of steps are conducted as necessary to formulate efficient, effective, complete, and acceptable plans.

The structure of this report generally follows these 6 steps. This report also includes a discussion of the environmental analysis conducted in accordance with the 1969 National Environmental Policy Act (NEPA) and the 1969 version of the Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations (CFR) parts 1500-1508). It should be noted that the feasibility study began prior to the implementation of the updated (CEQ) NEPA 2020 regulations.

1.3. Study Authority

The feasibility study is authorized by House Resolution 2532 and adopted by the Committee on Transportation and Infrastructure of the United States House of Representatives on July 23, 1997. House Resolution 2532 authorized an analysis of measures and alternative plans for reducing flood and storm damage to the Neuse River basin.

Title IV of the Additional Supplemental Appropriations for Disaster Relief Act, 2019, authorized the federal government to conduct the feasibility study at full federal expense to the extent that appropriations provided under the Investigations heading of the FY 19 Supplemental are available and used for such purpose.

1.4. Study Area and Scope

The study area included the entire Neuse River basin in North Carolina. This area begins in the Piedmont section of North Carolina and extends 248 miles southeast through the Coastal Plain which flows into the Pamlico Sound, covering approximately 6,200 square miles. The Neuse River is the longest river in North Carolina, and at its mouth is the widest river in the United States at 6 miles. The Neuse River basin includes numerous small to moderately sized tributaries that join the Neuse River mainstem at a consistent interval throughout its delineation. Major confluences within the Neuse are located near Raleigh, Smithfield, Goldsboro, Grifton, and New Bern. Its headwater tributaries rise in the hilly Piedmont section of North Carolina, then flow through a belt, or zone, known as the “Fall Line”, where the streams flatten in slope as they reach the Coastal Plain. Streams in the lower reaches of the Coastal Plain tend to be sluggish in flow, and swamp and marshes were predominant (USACE, 1960). The feasibility study encompassed all or part of 18 counties. Population centers in the Neuse River basin included the cities of Durham, Raleigh, Wilson, Smithfield, Goldsboro, Kinston, and New Bern, NC.

Table 1-1 provides the population of key communities located near the Neuse River or major tributaries and Figure 1-1 provides some quick facts about the Neuse River basin. Figure 1-2 displays the Neuse River basin study area:

Table 1-1 Population of Key Communities within Study Area

Community	Population
Raleigh	460,000
Durham	265,000
Wilson	50,000
Goldsboro	36,000
New Bern	30,000
Kinston	21,000
Smithfield	12,000
Grifton	2,700
Pollocksville	289
Trenton	287
Seven Springs	111

- **Municipalities: 73**
- **Counties: 18**
- **Population: approximately 2.2 million**
- **Major tributaries: Crabtree, Swift, Contentnea Creeks; and Eno, Little and Trent Rivers.**
- **USACE Operated Falls Lake Dam and Reservoir on the Neuse River in upper basin northwest of Raleigh, NC**

Figure 1-1 Neuse River Basin Quick Facts

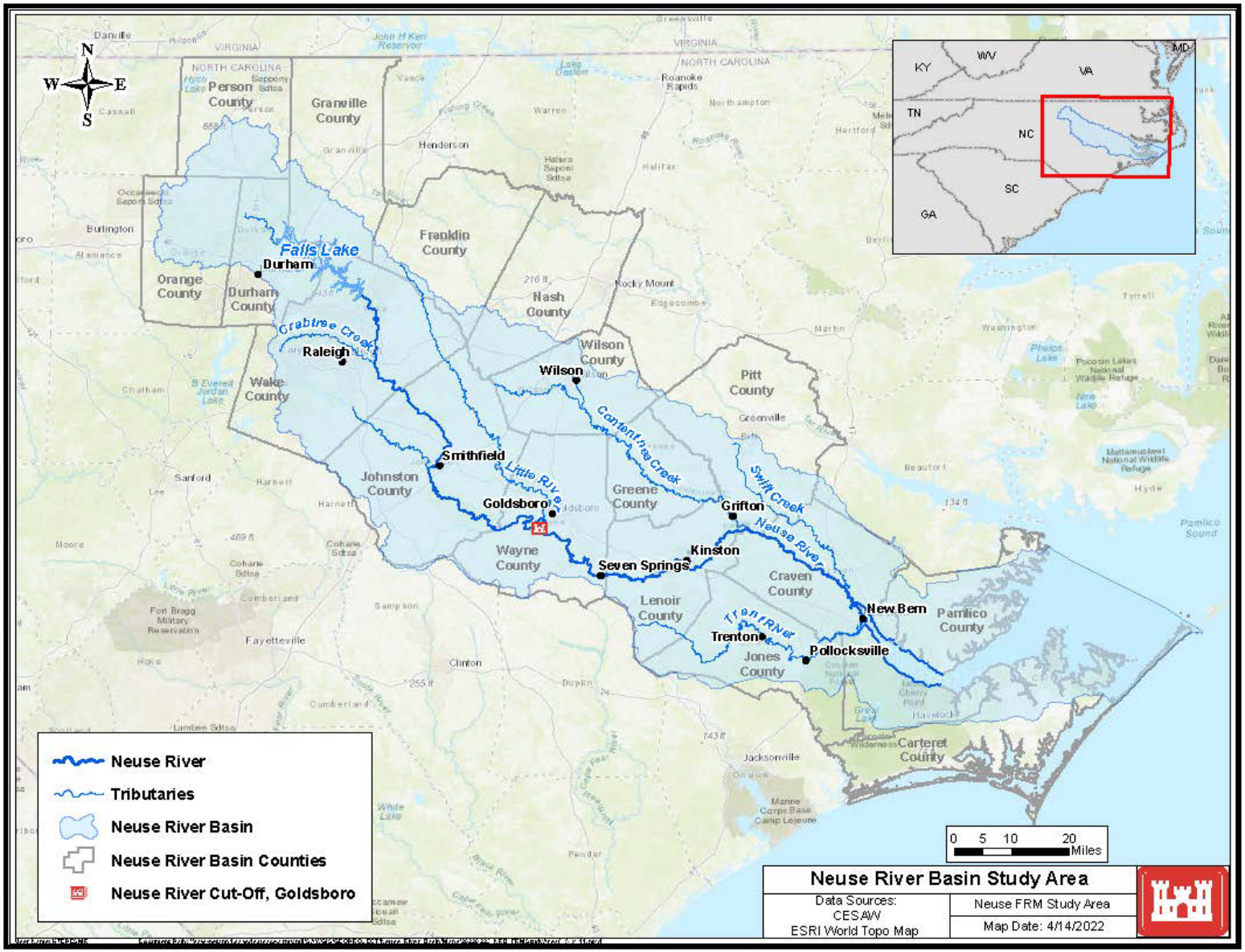

Figure 1-2 Neuse River Basin Study Area Map

As the study progressed after the preliminary screening phase, the project delivery team (PDT) determined that more detailed analyses would be required for the tidally influenced southeastern portion of the study area. Therefore, this Technical Report only presents detailed analyses for flood risk caused by riverine flooding. USACE determined that additional studies would be needed to fully evaluate coastal storm risk for this tidally influenced area.

1.5. Prior Studies and Reports

House Document 89-175, 1965. Neuse River Basin, North Carolina. This generalized plan for development for the Neuse River basin was authorized in the Flood Control Act of 1965 as a guide for immediate and future development of 13 multi-purpose reservoirs within the basin. The Falls Lake and Reservoir project, completed in 1981, was the only feature recommended in this report for immediate construction in the interest of flood control, water supply, water quality control and recreation. To date, none of the remaining 12 reservoir projects have been constructed by the federal government; however, one project, Buckhorn Reservoir on Contentnea Creek, was constructed by the City of Wilson in 1974 and subsequently expanded in 1999.

U.S. Army Corps of Engineers, Wilmington District, 1991, Neuse River, NC Final Survey Report. This report was authorized to review water resource needs of the Neuse River basin, with reference to the feasibility of constructing the Wilson Mills, Buckhorn, and Beulahtown Dams and Reservoirs. The findings in this report concluded there was no federal interest in reservoir development in the basin at that time.

U.S. Army Corps of Engineers, Wilmington District, 1995, Detailed Project Report and Environmental Assessment, Adkin Branch, City of Kinston, NC. This report was prepared under the authority of Section 205 of the 1948 Flood Control Act, as amended, and established an economically feasible plan of 8,700 feet of channel improvements on Adkin Branch to reduce riverine flood damages. If this project had been implemented within the funding limits of the Continuing Authorities Program, no additional federal construction authorization would have been needed. However, no non-Federal sponsor was identified to cost share the implementation of this project.

U.S. Army Corps of Engineers, Wilmington District, 2012. Neuse River Basin Integrated Feasibility Report and Environmental Assessment, NC. This report recommended implementation of water quality improvements in the overall Neuse River basin ecosystem in partnership with the North Carolina Division of Environment and Natural Resources. The project was authorized for implementation under the Water Resources Development Act of 2014. However, no non-Federal sponsor was identified to cost share the implementation of this project.

North Carolina Division of Emergency Management and Department of Transportation, 2018. Neuse River Basin Flood Analysis and Mitigation Strategies Study. The objectives of this study in the Neuse River basin were to identify the primary sources of flooding and identify and assess possible mitigation strategies to prevent future flood damage in the wake of Hurricane Matthew. This report provided assessments of flooding sources, structural flood impacts, and planning level mitigation strategies for this basin.

Doll, Barbara, PhD, PE, et. al., 2020. Evaluating the Capacity of Natural Infrastructure for Flood Abatement at the Watershed Scale: Goldsboro, NC Case Study. Prepared for the NC Department of Transportation, this report evaluated the impacts of expanding natural infrastructure in two case study watersheds in Goldsboro, NC, where local stakeholders have reported multiple streams prone to flooding that impact property and transportation infrastructure.

Doll, Barbara, PhD, PE, et. al., 2020. Flood Abatement Assessment for Neuse River Basin. Prepared for the NC Department of Transportation, the objectives of this assessment were to better understand the sources and nature of riverine flooding, test potential measures to mitigate flooding, improve early warning systems for transportation-related infrastructure, evaluate future storm severity, and identify potential improvements to local floodplain ordinances. This assessment also included identification and prioritization of state highway crossing improvements at multiple tributaries within the basin.

1.6. Purpose and Need for Action

Communities within the Neuse River basin, North Carolina have a long history of flooding, both from impactful localized rainfall events, and from less frequent major rainfall and hurricanes. Specific to hurricanes, many communities within the basin have experienced major recurring flood events over the past 38 years associated with Hurricanes Gloria (1985), Fran (1996), Bonnie (1998), Floyd (1999), Matthew (2016) and Florence (2018)—the last three of which rank among the most destructive storms in state history. Recurring flooding within the basin has resulted in considerable economic damages to homes, businesses, industry, and public infrastructure. For example, Hurricane Matthew is estimated to have caused over $180M in damage to residential, non-residential, and public structures within the Neuse River basin alone (NCEM and NCDOT, 2018). Inundation of structures and roadways also resulted in increased life-safety risks both during and following flood events.

In response to flooding that occurred as a result of Hurricanes Matthew (2016) and Florence (2018), USACE received funding through the 2019 Additional Supplemental Appropriations for Disaster Relief (H.R. 2157) to conduct this feasibility study. The

primary focus of the study is to assess and recommend actions that reduce flood and storm damage risk and increase resiliency, allowing property owners to rebound and adapt from flood risk given changes in climate and other conditions, within the Neuse River basin. This Technical Report documented the analyses of a series of alternatives designed to reduce the on-going flood risks throughout the basin, including a No Action plan, as well as various combinations of structural and nonstructural measures.

1.7. Problems and Opportunities

Identifying the problems and opportunities within the study area is an important initial step in the planning process. Once the problems and opportunities were described, then objectives were identified that guide efforts to select actions that contribute to addressing the problems and realizing the opportunities. The problems and opportunities identified for the Neuse River basin flood risk management study are described below.

Two problems were identified:

1. Economic damage resulting from flood inundation
    - Expected annual damages (EAD) over $43 million for the study area over the 50-year period of analysis including the Hominy Swamp Creek in Wilson, NC, Crabtree creek in Raleigh, NC, Big Ditch in Goldsboro, NC, and Neuse River
    - Structure and infrastructure damaged throughout study area
    - Impacts to homes, transportation, and damage to public/critical infrastructure
2. Risks to life-safety associated with flood inundation
    - Elevated risk to vulnerable populations within the floodplain
    - Limitations on travel due to inundation of transportation infrastructure
    - Risk of life loss due to inundation of occupied vehicles on roadways

The following opportunities were identified within the study area:

- Maintain or improve environmental habitat
- Improve resiliency and sustainability
- Address at risk socially vulnerable populations
- Improve recreational opportunities
- Increase awareness of and preparedness for flood risk

1.8. Objectives and Constraints

1.8.1. Objectives

The following study objectives were developed to address identified problems while maximizing the potential to realize identified opportunities:

- Reduce economic damage associated with inundation (residential, non-residential, socially vulnerable communities, critical facilities, and public infrastructure) throughout the basin over the period of analysis (2040-2090)
- Reduce life-safety risk associated with inundation of structures (residential, non-residential, socially vulnerable communities, transportation, critical facilities) and public infrastructure throughout the basin over the period of analysis (2040-2090)

1.8.2. Constraints and Considerations

Constraints are restrictions that limit the planning process. The following policy constraint was identified:

- Policy: USACE Engineering Regulation (ER) 1165-2-21 limited the scope of studies being conducted under a flood risk management authority to flooding along natural streams and/or modified natural waterways within urbanized basins characterized by a drainage area of greater than 1.5 square miles and river discharges greater than 800 cubic feet per second for the 10% annual exceedance probability (AEP) flood event

- Study-specific: No study-specific constraints were identified

There are several other considerations that informed the planning process, including:

- Plans should avoid or minimize transferring flood risk to other areas
- Plans should not reduce performance of existing flood risk management projects in the study area
- Plans should not induce development in the floodplain
- Plans should avoid negative impacts to endangered species and other protected environmental resources to the extent practicable and minimize and/or mitigate any negative impacts
- Plans should avoid negative impacts to cultural/archeological resources

Chapter 2 EXISTING AND FUTURE WITHOUT-PROJECT (FWOP) CONDITIONS

2.1. Planning Horizon

The planning horizon encompassed the planning study period, project implementation, period of economic analysis, and the effective life of the project. Before study termination, the feasibility study period started on April 8, 2020 and was estimated at three years (Figure 2-1). The total implementation period for a flood risk management project was initially estimated at over 10 years, subject to receipt of project construction authorization and appropriation of funds. The period of economic analysis represents the timeframe used when forecasting and quantifying benefits associated with the future without- and with-project conditions. The period of economic analysis and assumed project life for flood risk management projects is 50 years.

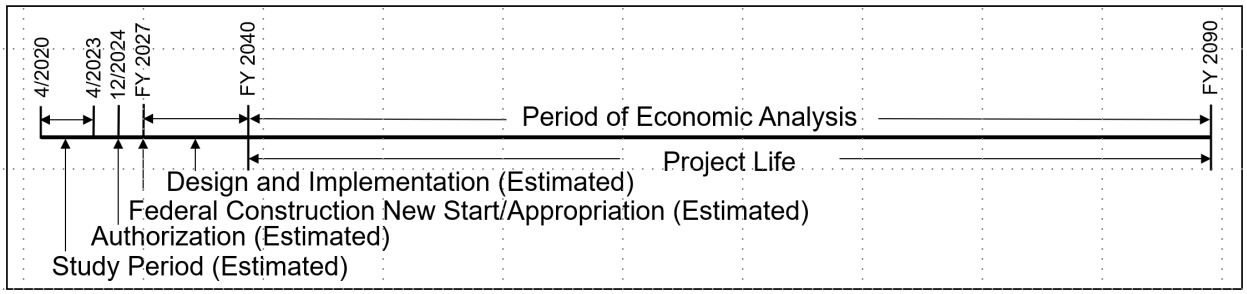

Figure 2-1 Planning Horizon for the Neuse River Basin Flood Risk Management Feasibility Study

2.2. Without-Project Analysis – Key General Assumptions

The key assumptions made for the feasibility study were:

- Current physical and social trends occurring from the recent past until the present would continue into the future for the 50-year period of analysis. The period of analysis for the majority of quantitative analyses for this study is 2040 – 2090.
- Damaging storms would continue to occur with comparable strength and frequency as have occurred in the past.
- No other Flood Risk Management project in the study area would be constructed over the period of analysis that would result in a quantitative reduction in flood risk. The FWOP analysis in the study assumed no local project implementation beyond targeted repair of small individual flood risk management infrastructure. This assumption is deemed valid due to the high level of uncertainty about any

actions regarding the timing, location, and type of project which made it impossible to accurately model the effects.

- The FWOP analysis did not attempt to model the potential reaction of individual properties to worsening flood damages, or the effect of the Federal Emergency Management Agency (FEMA) response to disaster declarations. The FWOP did attempt to capture large-scale intentions of communities related to land use zone designation that may be substantially different in the future. This assumption is dependent on approved policies and regulations already in place and being actively enforced by local government entities.
- The occurrence of compound flooding within the Neuse River basin and its influence in causing disproportionately extreme events was not fully understood. Limited research specific to the study area suggests potential for compound flooding to drive peak economic damages and life-safety risk (Ye et al., 2021). The FWOP presents qualitative analyses for portions of the study area in which compound flooding is assumed to be associated with Flood Risk Management plan formulation. Beyond these qualitative analyses, a separate study effort that included appropriate hydrodynamic and coastal modeling would be needed in the tidally influenced portion of the basin in order to adequately quantify FWOP conditions, identify flood risk associated with compound flooding, and investigate implementation of flood risk management measures.

2.3. Without-Project Analysis – Climate Change

The following section describes the effects of climate change for the Without-Project analysis.

2.3.1. Climate Change Impacts to Inland Hydrology

USACE Engineering and Construction Bulletin (ECB) 2018-14 (Revision 1) (Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects) provides guidance for incorporating climate change information in hydrologic analyses in accordance with pertinent USACE overarching climate preparedness and resilience policies. Air temperatures, precipitation, and sea level rise are anticipated to be affected by climate change in eastern North Carolina. Per ECB 2018-14 (Revision 1) guidance, a simple assessment was conducted for the Neuse River basin study. The assessment included literature review of observed and future trends, statistical analyses, nonstationary detection (a time series whose statistical properties are changing through time), a screening level vulnerability assessment, as well as an evaluation of residual risk due to climate change. Based on climate model limitations, a target year of 2100 represented the approximate 100-year planning horizon for this qualitative climate change assessment. Refer to Appendix A (Hydrology and Hydraulics) for additional details.

Based on the literature review, evidence in observed precipitation records showed mixed results of upward and downward patterns and suggest no consensus on precipitation average trends in the future. Conversely, precipitation extremes are predicted to have a small increase in the future based on a majority consensus. Trends in observed temperature and streamflow indicated a small upward and small downward trend, respectively. Similar to precipitation averages, there is no consensus on streamflow trends in the future. However, there is high consensus that future average and maximum temperatures areforecasted to have a large increase.

There is agreement that by the latter half of the 21st century, air temperatures would have increased by approximately 2 to 4 ºC (35.6 to 39.2 ºF). Sources of this temperature increase include variations in the sun's energy reaching Earth, changes in the reflectivity of Earth's atmosphere and surface, and changes in the greenhouse effect, which affects the amount of heat retained by Earth's atmosphere.

Greenhouse gases come from a variety of human activities including burning fossil fuels for transportation, heat and energy, clearing forests, fertilizing crops, storing waste in landfills, raising livestock, and producing some kinds of industrial products (https://www.epa.gov/ghgemissions/overview-greenhouse-gases). A review of the U.S. Environmental Protection Agency's analysis for climate change for North Carolina titled, "What Climate Change Means for North Carolina," (https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-nc.pdf) states:

- Most of North Carolina has warmed 0.5-1.0 degrees Fahrenheit in the last 100 years. The southeastern United States has warmed less than most of the nation.
- Tropical storms and hurricanes have become more intense during the past 20 years. Hurricane wind speeds and rainfall rates are likely to increase as the climate continues to warm.
- Increased rainfall may further exacerbate flooding in some coastal areas. Since 1958, the amount of precipitation during heavy rainstorms has increased by 27 percent in the southeast, and the trend toward increasingly heavy rainstorms are likely to continue.

Trends in observed annual peak streamflow for seventeen gages within the Neuse River basin were examined using the USACE Climate Hydrology Assessment Tool (CHAT). Linear upward and downward trends in peak streamflow and their statistical significance were identified by the CHAT. Two streamflow gages were identified to have statistically significant trends. The Neuse River near Falls gage showed a statistically significant downward trend in observed annual peak flows that would be

expected as the flow at this station is regulated by flood reduction of Falls Lake Dam operations. The Little River tributary at the Fairntosh gage also showed a statistically significant downward trend, however, results are highly driven by a specific peak flow in 1996. When that data point is removed, the site no longer showed a statistically significant trend.

The USACE Nonstationarity Detection Tool (NDT) was utilized to assess changes in annual peak flow over time for select gages within the Neuse River basin. Two out of seventeen streamflow gages produced nonstationarities, United States Geologic Survey (USGS) Neuse River near Falls, NC and USGS Neuse River near Clayton, NC. Nonstationarity of the Falls gage was attributed to changes in operations of Falls Lake Dam during the detected timeframe and, as stated before, was not unexpected. Nonstationarity of the Clayton gage was detected in the late 1960s, prior to Falls Lake Dam regulation. Isolation of post-dam records resulted in no detection of nonstationarity.

The USACE Vulnerability Assessment (VA) Tool was applied for the 0302 Neuse-Pamlico Basin Hydrologic Unit Code – 4 (HUC-4) to assess the study area's vulnerability to climate change impacts relative to the other 201 HUC-4 watersheds within the Continental United States (CONUS). For the flood risk management business line, the 0302 Neuse-Pamlico basin HUC-4 was not within the top 20% of vulnerable watersheds according to the VA tool. The primary indicators driving vulnerability are the flood magnification factor, predicted future change in monthly flow exceeding 10% of time, and acres of urban area within the 0.2% Annual Exceedance Probability (AEP) floodplain.

2.3.2. Relative Sea Level Change

To ensure compliance with Engineering Regulation (ER) 1100-2-8162 and Engineering Pamphlet (EP) 1100-2-1, which establishes current policy regarding incorporation of future sea level changes into USACE projects, an analysis was conducted of the project impacts relative to increased sea levels over the life of the Neuse River basin study. This guidance requires that "Potential relative sea-level change must be considered in every USACE coastal activity as far inland as the extent of estimated tidal influence." The analysis included development of relative sea level rise projection curves, identification of potential impact areas and associated risks and establishing adaptive measures to adjust to future sea level rise.

Using the methods published in ER 1100-2-8162, the relative sea level rise curves are developed for "low," "intermediate," and "high" rates of future sea-level change. The "low" sea level change curve is simply an extrapolation of the observed sea-level trend obtained by averaging the sea level rise rates from a local gage. The "intermediate"

curve represents sea level rise using the National Research Council (NRC) Curve I and the “high” curve represents NRC Curve III. Details of the SLC analysis can be reviewed in Appendix A (Hydrology and Hydraulics).

This analysis is based on the NOAA tide buoy station located in Beaufort, North Carolina, approximately 35 miles southeast of the City of New Bern, NC. Location of Beaufort station relative to the Neuse River basin study area is shown in Figure 2-2. The gage is active and compliant with data from 1967 to present. The linear relative sea level trend for this gage is 3.36 millimeters/year (0.011 feet/year) with a 95% confidence interval of +/- 0.34 millimeters/year (0.0011 feet/year) based on monthly mean sea level data, see Figure 2-3. For the 50-year period of analysis, this is equivalent to an increase of 0.55 feet in sea level.

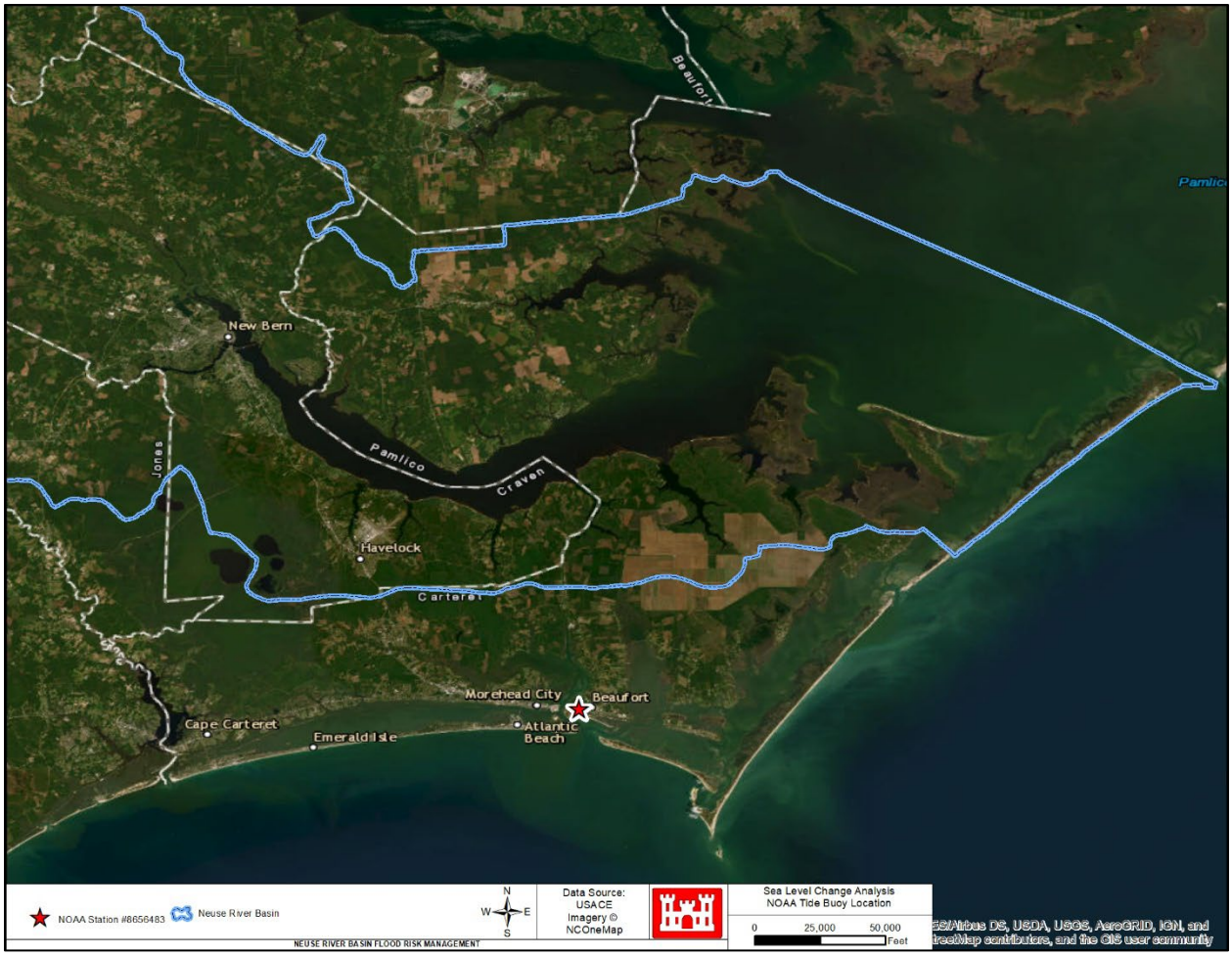

Figure 2-2 Location of Beaufort, NC NOAA Tide Buoy Station #8656483

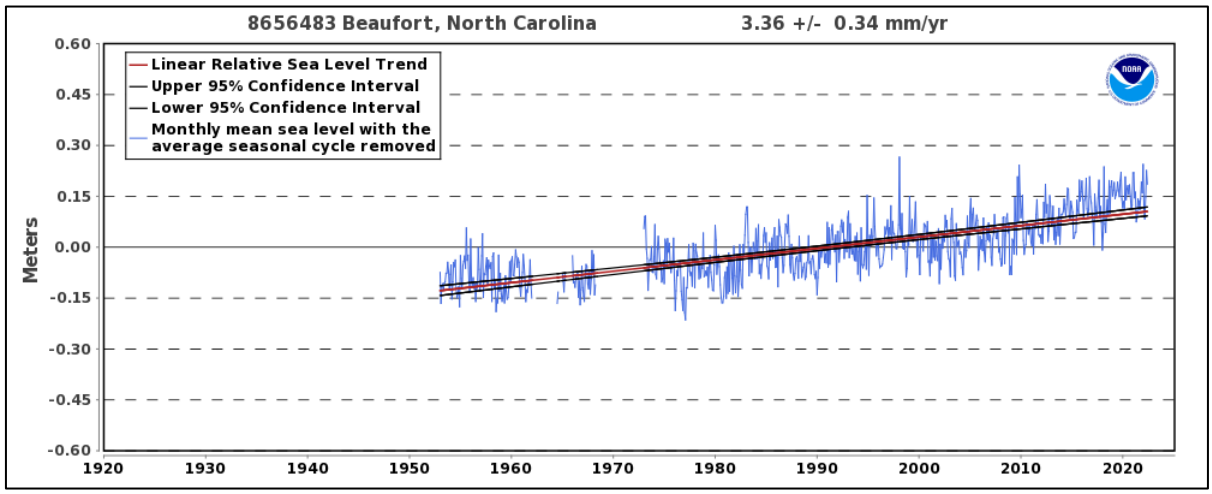

Figure 2-3 Beaufort, NC Gage #8656483 Relative Sea Level Trend

The USACE online tool Sea Level Tracker (https://climate.sec.usace.army.mil/slr_app/) was used to determine the current rate of SLC observed and the projected future trends in the rate of SLC. The Sea Level Tracker was used to compare actual mean sea level (MSL) values and trends for specific NOAA tide stations with the USACE SLC scenarios as described in ER 1100-2-8162 and EP 1100-2-1. The Sea Level Tracker tool calculated the USACE Low, Intermediate and High sea level change scenarios based on global and local change effects. Historical MSL can be represented by either 19-year or 5-year midpoint moving averages.

The Sea Level Tracker tool was used to evaluate the Beaufort, NC NOAA tide buoy data. The regionally corrected rate of 0.00249 millimeters/year (0.00817 feet/year) was used as the rate of SLC and was obtained from NOAA Technical Report NOS CO-OPS 065 and accounts for vertical land motion. Based on the regional rate only, the sea level increase is 0.41 feet during the 50-year period of analysis. Figure 2-4 presents the results of the Tracker tool focused on trends from 1967 to 2021. The light blue line represents the 5-year moving average and the heavy dark blue line represents the 19-year moving average. The 19-year average is useful in that this represents the moon's Metonic cycle and the tidal datum epoch. These estimates are referenced to the midpoint of the latest National Tidal Datum epoch, 1992. The National Tidal Datum epoch is a 19-year time period established by NOAA's National Ocean Service for collecting observations on water levels and calculating tidal datum values (e.g. mean sea level, mean lower low water). The red line is the High SLC prediction, the green is the Intermediate and the blue is the Low rate prediction. From Figure 2-4 it can be noted that the 19-year moving average has covered a majority of the vertical distance that separates the Intermediate and High curves. The 5-year rate is tracking nearly on top of the High curve though it displays more cyclical characteristics.

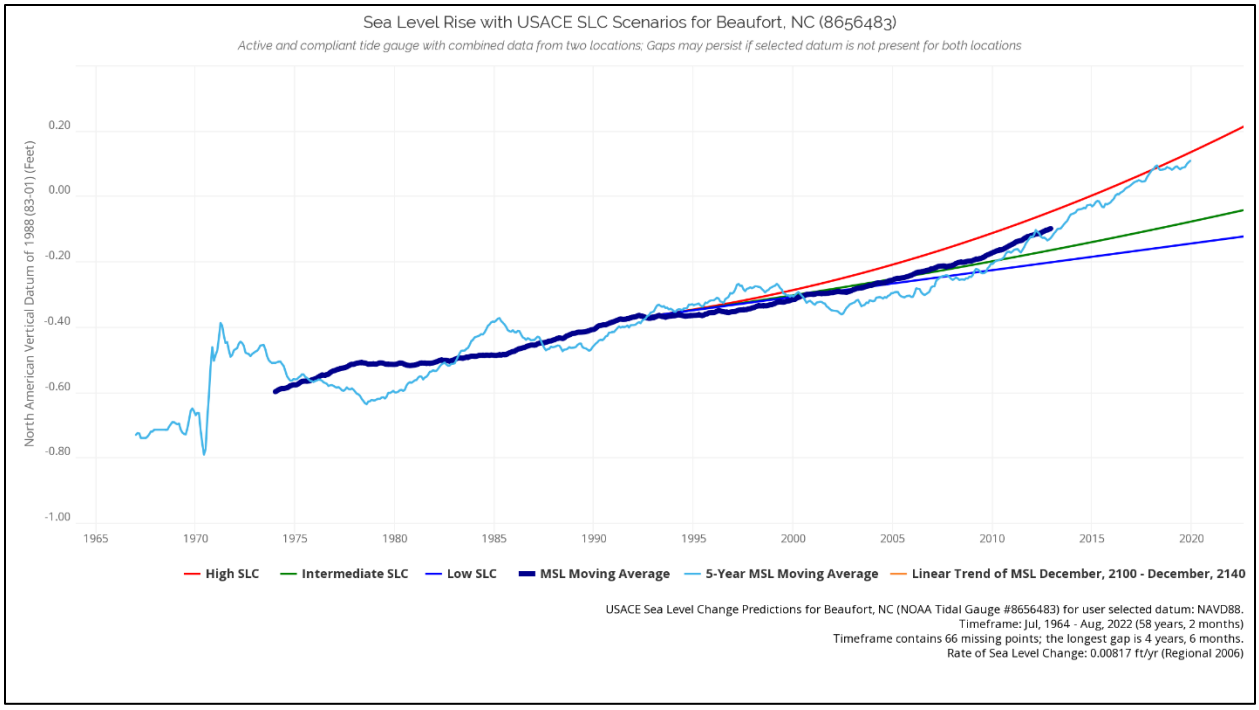

Figure 2-4 USACE Sea Level Tracker for Beaufort, NC (#8656483) through Year 2021

The future USACE sea level predictions for the Neuse River basin study based on the NOAA Beaufort station are provided in Figure 2-5. For predicted SLC through year 2080, the Low rate sea level rise is 0.133 meters (0.44 feet), the Intermediate SLC increase is 0.395 meters (1.30 feet), and the High SLC increase is 1.229 meters (4.03 feet). For predicted SLC through year 2140, the Low rate sea level rise is 0.257 meters (0.84 feet), the Intermediate SLC increase is 0.855 meters (2.81 feet), and the High SLC increase is 2.75 meters (9.02 feet).

The USACE High SLC scenario was selected for the Neuse River basin study because it tracked well with the 19-year and 5-year moving averages in Figure 2-5. This High SLC scenario with moving averages plotted consistently above the Intermediate SLC scenario is similarly noted at a regional tide gage (Wilmington, NC NOAA station (8658120). The High rate was also selected in coordination with the USACE Climate Preparedness and Resilience Community of Practice.

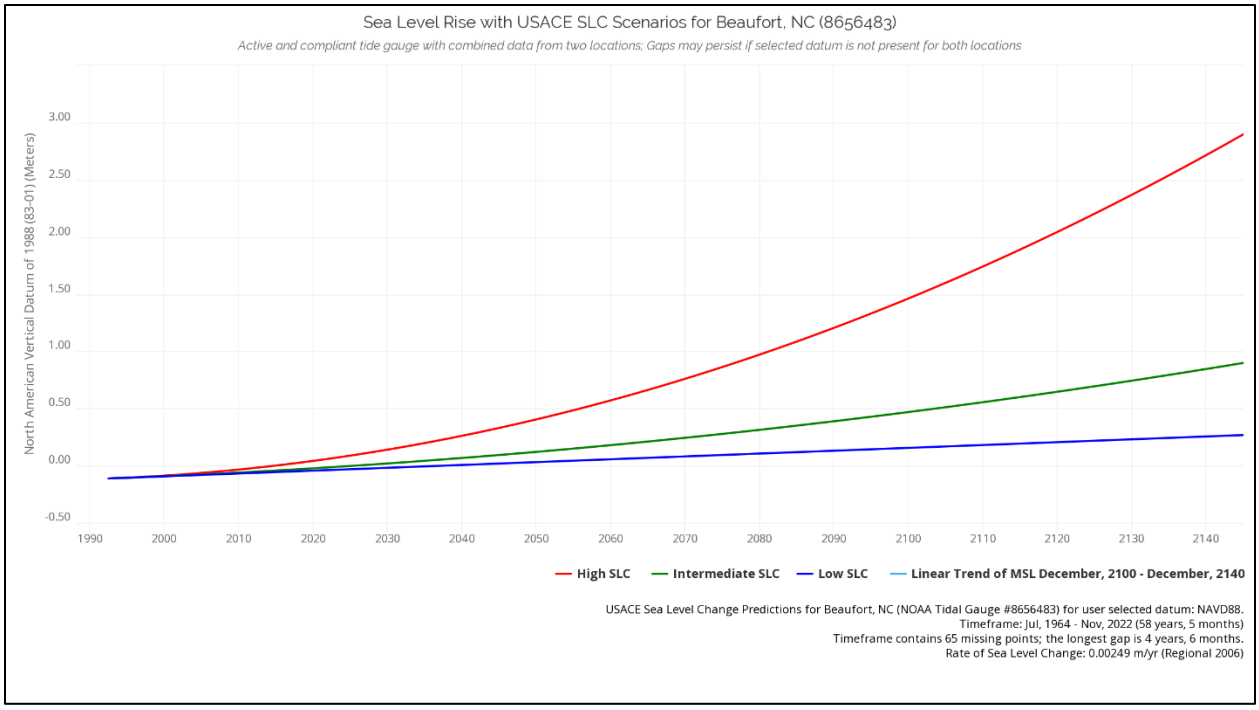

Figure 2-5 USACE Sea Level Change Predictions for Neuse River Basin Study

2.3.3. Residual Risk

Climate change, whether a function of changes to inland hydrology, sea level, or a combination of both are likely to impact the study area. Sea Level Change in the tidally influenced portion of the Neuse River basin would result in increased water levels for virtually any flood risk management infrastructure proposed. Increased water levels may lead to higher frequency of loading, probability of overtopping, and/or a reduced level of intended protection. Consequences from these impacts may generate economic damages, influence local stormwater drainage, and disrupt transportation infrastructure. Primary climate change impacts beyond the tidally influenced region may be attributed to increased water levels and runoff due to higher intensity and greater volume of rainfall in the future. For nonstructural flood risk management infrastructure, such as elevation and floodproofing, increased water levels have the potential to undermine their effectiveness and reduce the level of intended protection. In order to maintain the intended flood risk management of a recommended plan, project modifications may be necessary in response to future climate change impacts.

In order to maximize the potential to perceived residual risk under FWOP conditions, the hydraulic analysis was conducted within the tidally influenced region of the Neuse River basin assuming a scenario of high sea level rise for future without-project conditions. This boundary condition would approximate the increased water level of over four feet of sea level rise by year 2090. Additionally, National Oceanic and Atmospheric

Administration (NOAA) tools (https://coast.noaa.gov/slr/) are utilized to characterize geographic extents of sea level rise-induced water levels up to approximately ten feet above present-day Mean Higher High Water tides (MHHW) that extend up the mouth of the Neuse River. One-foot increments of sea level rise scenario on top of MHHW are shown in Figures 2-6, 2-7 and 2-8.

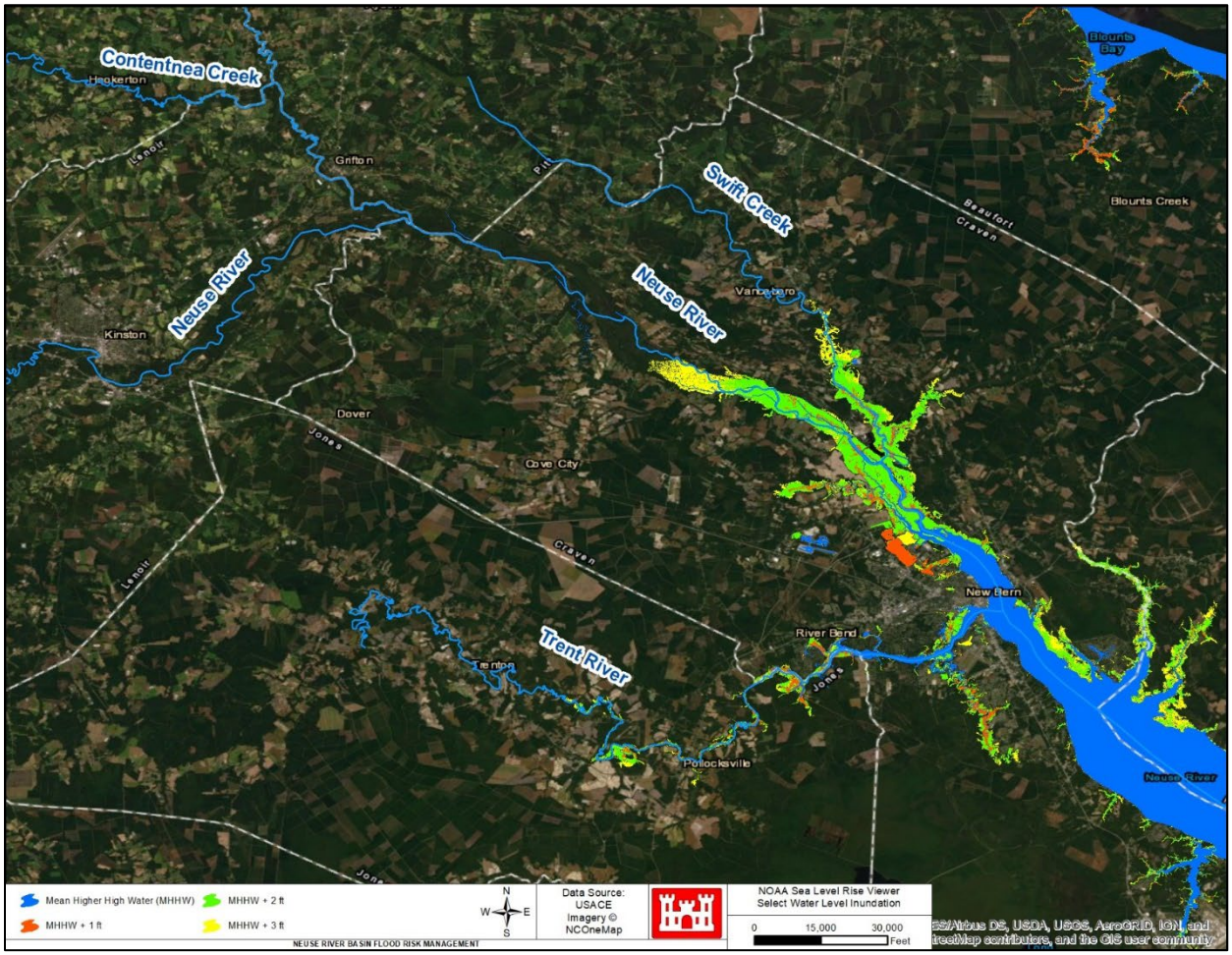

Figure 2-6 NOAA Sea Level Rise Viewer – MHHW & 1-, 2-, 3-foot Water Level Increases

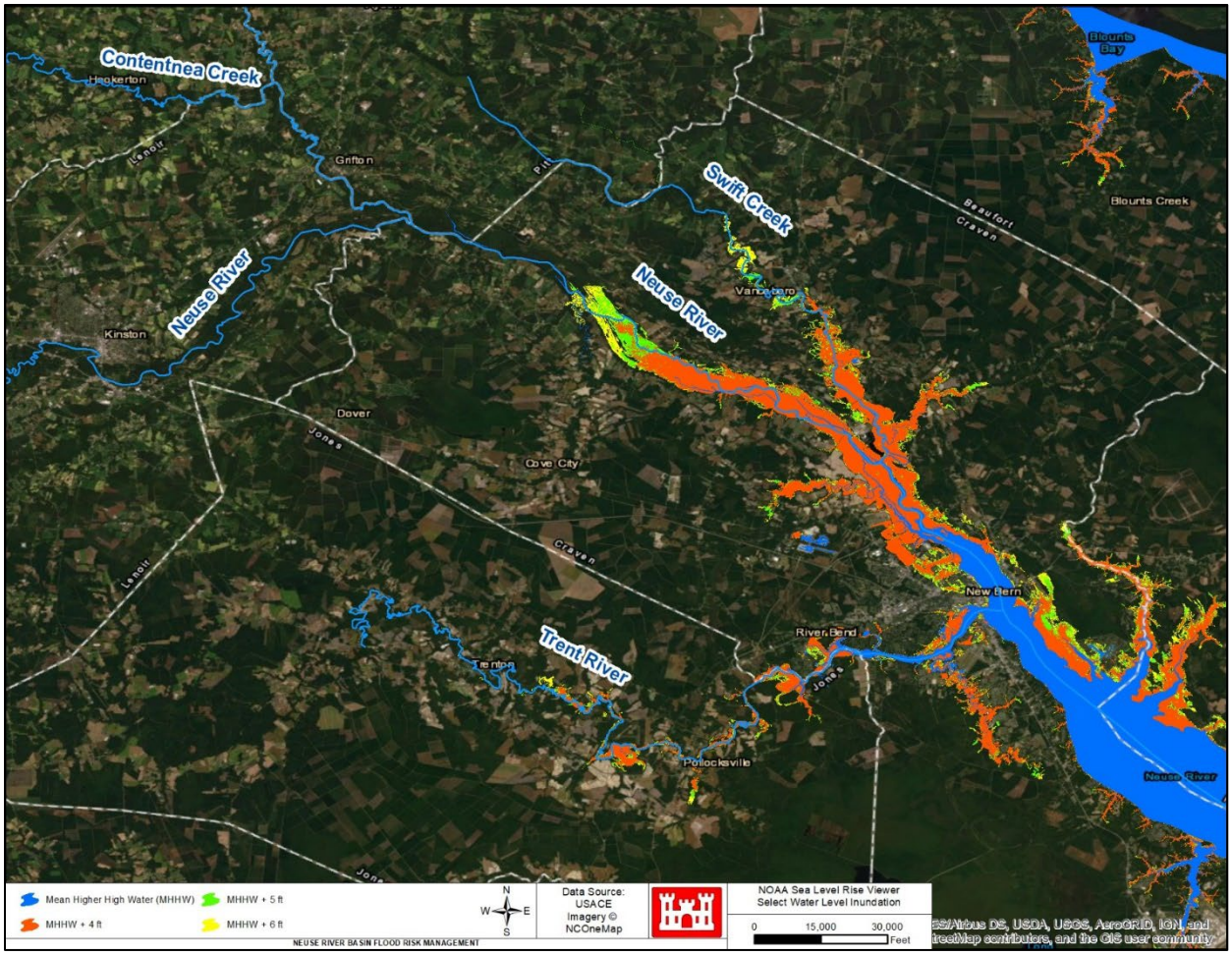

Figure 2-7 NOAA Sea Level Rise Viewer – MHHW & 4-, 5-, 6-foot Water Level Increases

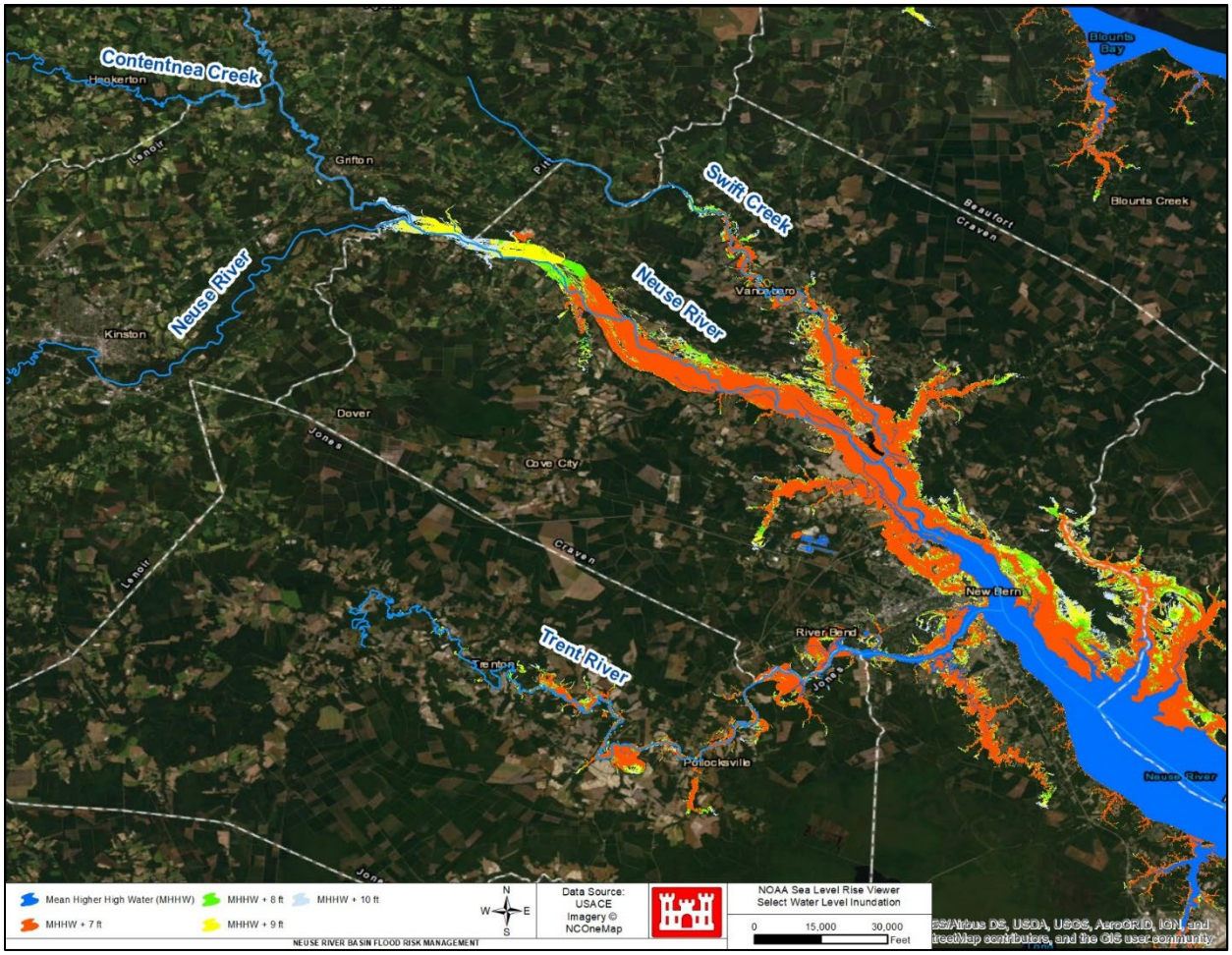

Figure 2-8 NOAA Sea Level Rise Viewer – MHHW & 7-, 8-, 9-, 10-foot Water Level Increases

2.4. Existing and Future Without-Project Flood Risk

Storm occurrences in the Neuse River basin are typically in the form of thunderstorms, northeasters, and hurricanes. The most severe floods of record over the basin have been associated with tropical storms and hurricanes. North Carolina lies in the path of tropical hurricanes as they move northerly from their origin north of the Equator in the Atlantic Ocean. These hurricanes usually occur in the late summer and autumn and have caused the heaviest rainfall and largest floods throughout the basin. These extreme hurricane events are characterized by heavy and prolonged precipitation. Basin response to these historical events is sensitive to storm size, path, and other parameters that are typically unique to individual storms. These storm characteristics can create the potential for compound flooding in the basin, in which two or more flooding sources occur simultaneously or within a short duration. For the lowest portions of the study area, compound flooding would be a result of the Atlantic Ocean, Pamlico Sound, and the Neuse River watershed.

The wide variety of land use, land cover, and geologic relief throughout the large study area exposes the population to multiple forms of flood risk. In urban, high density population centers such as Raleigh, NC, flood risk may be realized quickly in the form of flash flooding. In these areas, the time between rainfall occurrence and surface runoff are short and partially due to high percentages of impervious areas such as dense zones designated for commercial infrastructure. These areas don't allow for adequate ground infiltration that would naturally help to slow the runoff process. The natural terrain can also exacerbate flooding problems, as in upper portions of the basin where streams are typically characterized by steep gradients with high, narrow banks.

In the middle and lower portions of the basin, a significant percentage of floodplain land cover is utilized for agricultural purposes. There is a shift away from densely populated development, especially within segments of the Neuse River mainstem floodplain that can expand to a width of several miles. As the river traverses through these segments that transition between the Piedmont and Coastal Plain regions, more of the study area becomes exposed to significant weather events that originate from tropical systems. As noted earlier, tropical storms and hurricanes have historically impacted the middle and lower portions of the study area. The impact duration of these events is highly conditional on secondary frontal systems as well, that in some cases such as during Hurricane Florence in 2018, create slow moving systems that lead to intense precipitation.

In the lowest portions of the basin that share common characterization of flood risk as the Pamlico Sound, coastal hazards from hurricanes and extreme extratropical storms can include storm surge, waves, wind, rainfall, compound coastal-inland flooding, seiche, and extreme tides, among others. Climate change and sea level rise are expected to significantly exacerbate coastal flooding in the upcoming decades. These coastal hazards can threaten the lives of millions of people living in coastal regions, and devastate coastal communities and infrastructure, which resulted in profound adverse social, economic, and environmental impacts.

When flood events also include major tributaries to the Neuse River, it can result in prolonged flood stages that take multiple weeks to recede back to a normal condition. Significant structural and economic damages are associated with this flood risk scenario. Characteristic of most of the study area are flooding issues related to constrictions to flow, either by temporary debris dislodged upstream during a flood event that eventually becomes trapped at a road crossing or created by historically undersized bridge spans or culvert openings.

The future without-project conditions flood risk outside of tidally influenced areas appears to be driven by several important factors: land use changes, changes in stormwater management, enforcement and growth of floodplain management, and

public education of flood risks. It is possible for inland climate change to become more influential in driving FWOP flood risk. However, current analyses provide no clear indication based on trends of precipitation and streamflow. The Environmental Protection Agency's (EPA) Integrated Climate and Land-Use Scenarios tool (version 1.3) is used to assess the degree of potential land use changes in the future. The dataset of estimated percent impervious surface is used to estimate the future land use conditions of the basin. This dataset uses population projections through the end of the century, reflecting different assumptions about fertility, mortality, and immigration to determine the demand for new homes, and estimates the amount of impervious surface that can be expected. The results of the analysis show that predicted changes in land use for this basin are not associated with significant increases in impervious areas.

Nearly all communities within the Neuse River basin are active in FEMA's National Flood Insurance Program (NFIP). Multiple communities have placed progressive requirements for development within the floodplain such as the mandate for higher design standards and elevations and/or strict allowances for what types of structures may be built within the regulatory floodway and floodplain. This acknowledgment coupled with community stormwater management plans that share a core regulation that post-hydrology shall mimic pre-construction hydrology appear to shape a future of improved flood risk management for the Neuse River basin. Continued collaboration between state agencies, including NCDOT, NCEM, and NCFMP, is likely to lead to further technical enhancements such as the North Carolina Flood Risk Information System (NCFRIS) tool, and comprehensive hydrologic studies, such as the recent Tar-Pamlico River, Neuse River, and Lumber River basins' flood analysis and mitigation strategies efforts.

2.5. Existing and Future Without-Project Environmental Conditions

The existing environmental conditions of the project are briefly discussed below and are described in more detail in Chapter 4 – *Affected Environment and Environmental Consequences*. The following subsections detail the future without-project conditions of several environmental resources that likely would be impacted without a flood risk management project (e.g. no federal action).

2.5.1. Water Quality

More frequent flood events could negatively impact water quality within the Neuse River basin with sedimentation from these flood events causing increases in suspended sediments and pollution in the water column throughout the river basin.

2.5.2. Threatened and Endangered Species

The increase in the sedimentation from more frequent flood events may cause increases in suspended sediments and pollution in the waters of the basin are designated Critical Habitat for endangered species located in the area. These include species such as the Atlantic Sturgeon and the Neuse River Waterdog.

2.6. Existing and Future Without-Project Cultural Resources

The Neuse River basin contains prehistoric and historic period sites reflecting more than 12,000 years of human discovery and settlement. Prehistoric sites within the basin range from the typically limited physical remains of Paleo-Indian hunter-gatherers (~12,000 B.C.) to the extensive collections recovered from large agricultural villages that came to dominate the floodplain and terraces by the 1400s. Heavy precipitation events and associated erosion adversely affect buried resources and artifacts.

European explorers arriving at the eastern sounds first encountered Algonquian tribes. These Native Americans were the southernmost of the eastern Algonquian language family, which extended northward to the maritime provinces of Canada. The Carolina branch of the Algonquian occupied the central Tidewater region of North Carolina from the Neuse River north to the Chesapeake Bay. To the west of the Carolinas lived the Iroquoian-speaking Tuscarora, Meherrin, and Nottaway. At the western extremity of the basin, the influential Occoneechee controlled trade and served as intermediaries between early European explorers and other Native American tribes.

The Neuse River also reflects an area of distinction between earlier prehistoric groups of differing cultures. Archaeologists generally recognize stylistic differences in the early pottery styles of two sub-regions evident within the basin, and those differences were attributed to culturally distinct influences emanating from South Carolina and Georgia on the west and the Mid-Atlantic on the east. The distinctions seem to date back to the Late Archaic Period, around 3,000 years ago, when the region saw the emergence of the earliest pottery styles, the rise of regional agriculture, and the establishment of more or less permanent, defended, ethnic territories.

Although Raleigh, Durham, Hillsborough, Cary, Apex, and Wake Forest are currently the largest municipalities in the Neuse River basin, in the late 18th and early 19th centuries, New Bern, James City, and Kinston had among the highest resident populations of cities included in the study area. New Bern is the second-oldest city in North Carolina, served as the colonial and state capital during 1746-1792, and it boasts the well-known Tryon Palace and New Bern Historic District. Tryon Palace is the state's first capital building, built between 1767-1770 by royal governor William Tryon. Less well known are the historic archaeological ruins that have been unearthed in various parts of the city. Across the Trent River from New Bern is James City, one of North

Carolina's better-known Freedmen Towns. Freedmen Towns were established by freed African American slaves after the Civil War. Kinston is known for the Confederate States Navy (CSS) Neuse Museum, with its famous full-scale reconstruction of this Confederate gunboat. Also, the remains of the CSS Neuse are on display at this museum. New Bern, James City, and Kinston all contain recognized historic districts, historic properties eligible for listing on the National Register of Historic Places (NRHP), or both (NC Department of Natural and Cultural Resources, 2021).

Less well known are the earlier explorations of an Englishman named John Lawson. John Lawson visited Indian villages in the winter of 1700-1701 and provided valuable insights to historians and archaeologists attempting to reconstruct Native American history and the era of European contact. Lawson and his party were captured when they stumbled upon the Tuscarora and other tribes preparing to wage war on English settlers in North Carolina. Lawson was well known by his captors and was inexplicably executed, though his associate was spared. That tumultuous time was recounted at several sites in the basin and northward in the neighboring Roanoke River basin. Displaced tribes traveled great distances to escape European conflict and, in some cases, were not welcomed by those Indians already established in a local territory, who had to face their own struggles with Europeans.

Based on information presented in the USACE's May 26, 2020 scoping letter, the North Carolina State Historic Preservation Office's (NCSHPO) records indicated that there are 6,689 archaeological sites recorded within the area of interest (Appendix F - Correspondence). Of these, fifteen (15) are listed in the NRHP, while one hundred and thirty-one (131) had been determined eligible for listing in the NRHP. An additional two (2) sites had been placed on the state study list, an internal listing process that occurs before being nominated to the NRHP. Two thousand six hundred and sixty-seven (2,667) sites had been determined not eligible, while the remaining three thousand eight hundred and seventy-four (3,874) are either unassessed or did not have their eligibility status recorded in NCSHPO's GIS database. The NCSHPO GIS website (NC Department of Natural and Cultural Resources, 2021) is used in assessing potential project impacts.

The Neuse River basin continues to grow and develop the human environment at a rate similar to that of the greater United States. Although predicted land use changes are not associated with significant increases in impervious areas, future development would somewhat reduce the floodplain's natural ability to mitigate negative flooding and erosion effects associated with storm events. As future storm events may increase in frequency and severity, negative effects to prehistoric and historic cultural resources in terms of erosion and inundation risk may continue at least to the degree currently experienced.

2.7. Existing and Future Without-Project Socioeconomic Conditions

This section describes the demographic characteristics for the population at risk. The total population count in the Neuse River basin is approximately 2.2 million as of 2019. The following figures display the distribution of the population by census tract, and other socioeconomic and demographic factors that impact the population at risk in the study area. Demographic data for the following maps is taken from American Community Survey (ACS) 2019 5-year estimates available on census.gov, unless otherwise indicated.

Figure 2-9 displays population count by census tract. More densely populated census tracts include those near Raleigh, while the lower end of the basin contains less densely populated tracts.

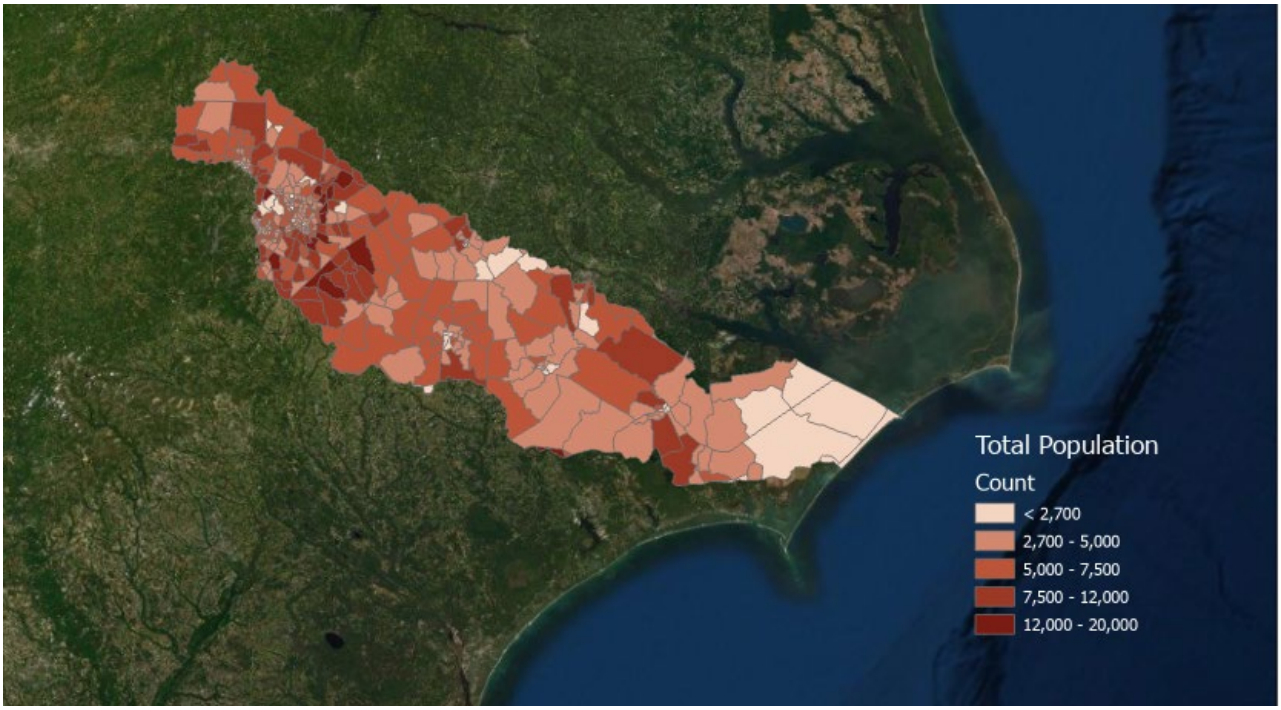

Figure 2-9 Population Count by Census Tract, ACS 2019 5-year Estimates

Figure 2-10 displays median household income in 2015 inflation-adjusted dollars overlaid by average household size, by census tract. The average median household income by tract is $58,000 annually, while the lowest is $10,300 and the highest is $165,300. Census tracts with the highest median income are concentrated near Raleigh and other census tracts in Wake County. Lower income households are located in Craven, Wilson, Johnston, Nash, Pitt, and Greene Counties.

The average household size is 3 individuals, and there doesn't appear to be a strong directional correlation between household income and household size. Smaller households tend to be near the confluence of the Neuse River with the Atlantic Ocean.

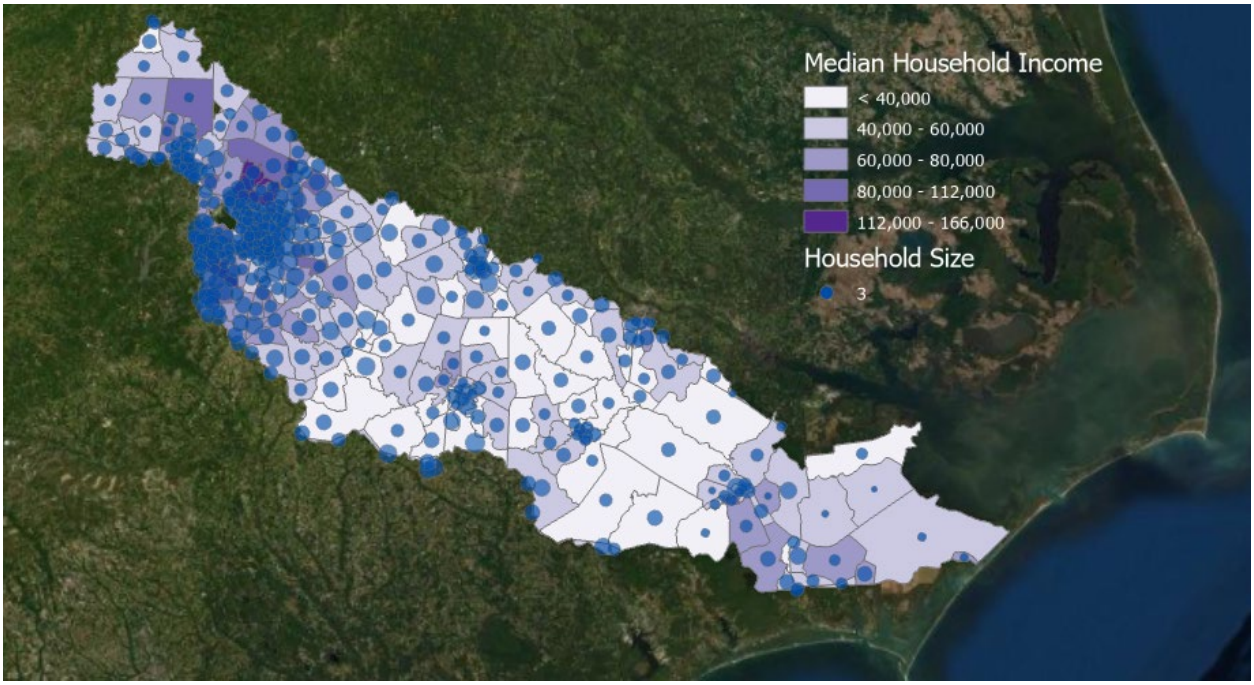

Figure 2-10 Median Household Income in 2015 Inflation Adjusted Dollars vs Household Size

Figure 2-11 shows the non-white population count by census tract. Census tracts located in Wake County near Raleigh have the highest non-white population count. These census tracts are also more densely populated than tracts in the lower part of the basin.

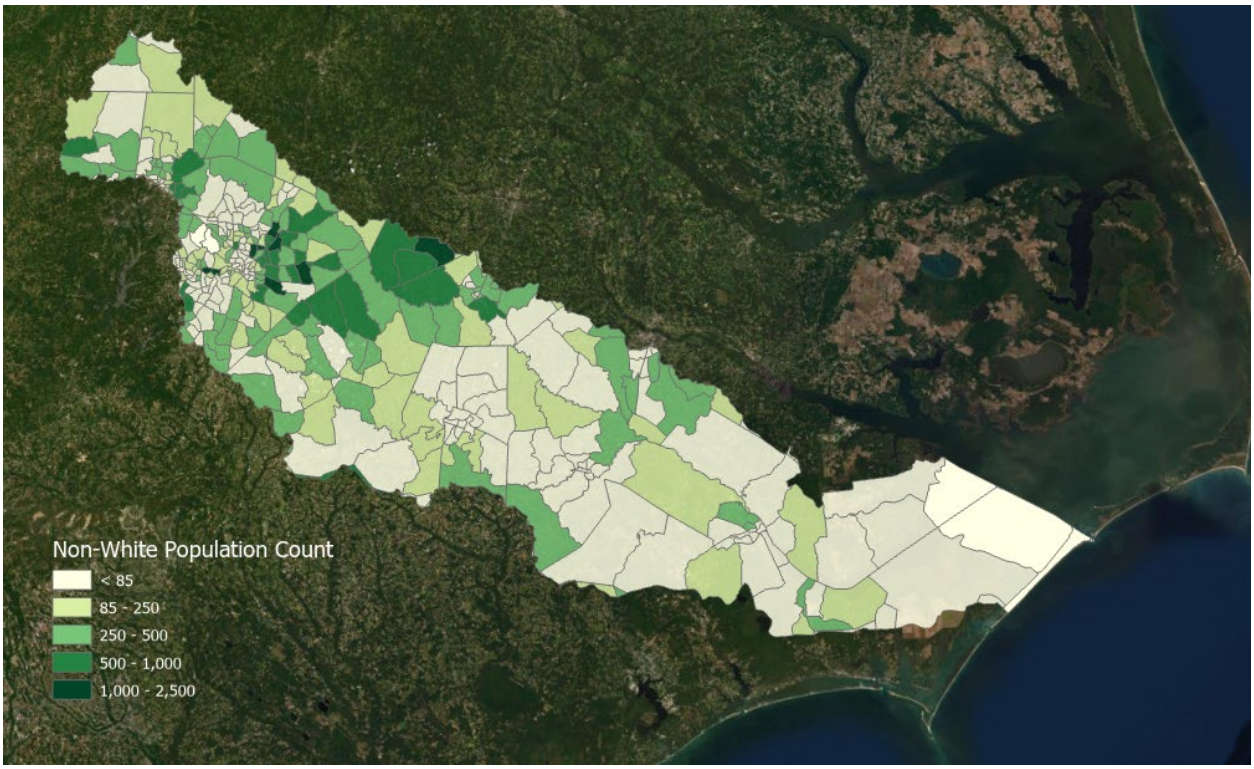

Figure 2-11 Non-White Population Count by Census Tract, ACS 2019 5-year Estimates

Figure 2-12 shows the percent of the population that is older than 65 years and may be more vulnerable in event of a flood than younger individuals who often can more easily evacuate. The darkest green color shows census tracts where 25-50 percent of the population is older than 65 years. These tracts are located mainly in the lower part of the basin, with a few tracts in the upper basin above Raleigh.

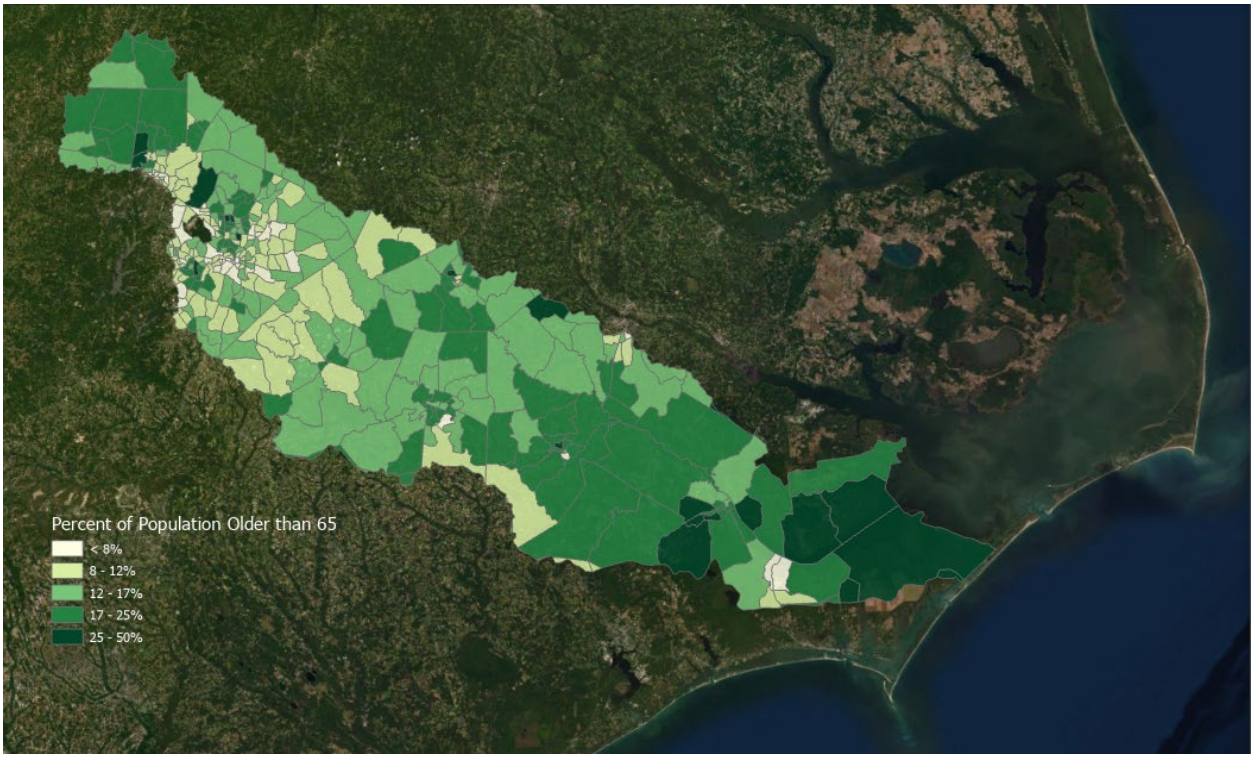

Figure 2-12 Percent of Population Age 65 Years or Older, ACS 2019 5-year Estimates

Figure 2-13 displays the percent of the population in each census tract under the poverty line, which is $24,250 for a household of four in 2015. The basin wide average poverty rate is 16.5 percent, which is higher than the 2015 national average of 13.5 percent. The highest tract level poverty rate occurs near Kinston, in Tract 103, where 71 percent of the population is under the poverty line in 2015. Seven tracts have poverty rates below one percent and all are located near north or northwest Raleigh.

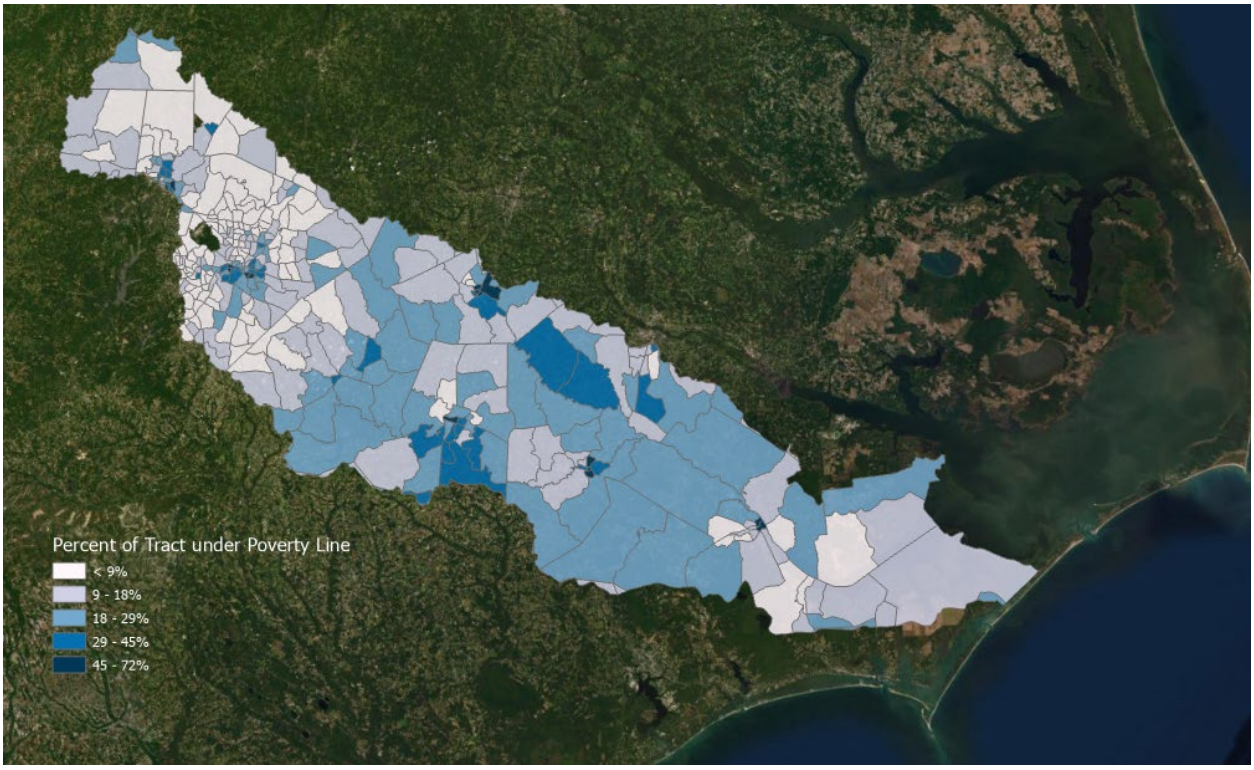

Figure 2-13 Percent of Population under Poverty Line by Census Tract, 2015 ACS 5-year Estimates

The Center for Disease Control computes a Social Vulnerability Index (SVI) based on composite census data.[1] The SVI is represented as a percentile ranking in Figure 2-14 by census tract. Census tracts with a score of 0.95 would be, on average, 95 percent more vulnerable than the rest of North Carolina, for example. Census tracts with a score of 0.30 would be 30 percent more vulnerable than the rest of the state. Census tracts that are lighter orange or yellow represent lower SVI scores, while census tracts that are darker orange or red represent higher SVI scores, indicating higher social vulnerability. Figure 2-14 shows that there are socially vulnerable areas throughout the basin, with lower social vulnerability scores near the confluence with the Atlantic Ocean and in certain parts of Raleigh.

[1] https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download html

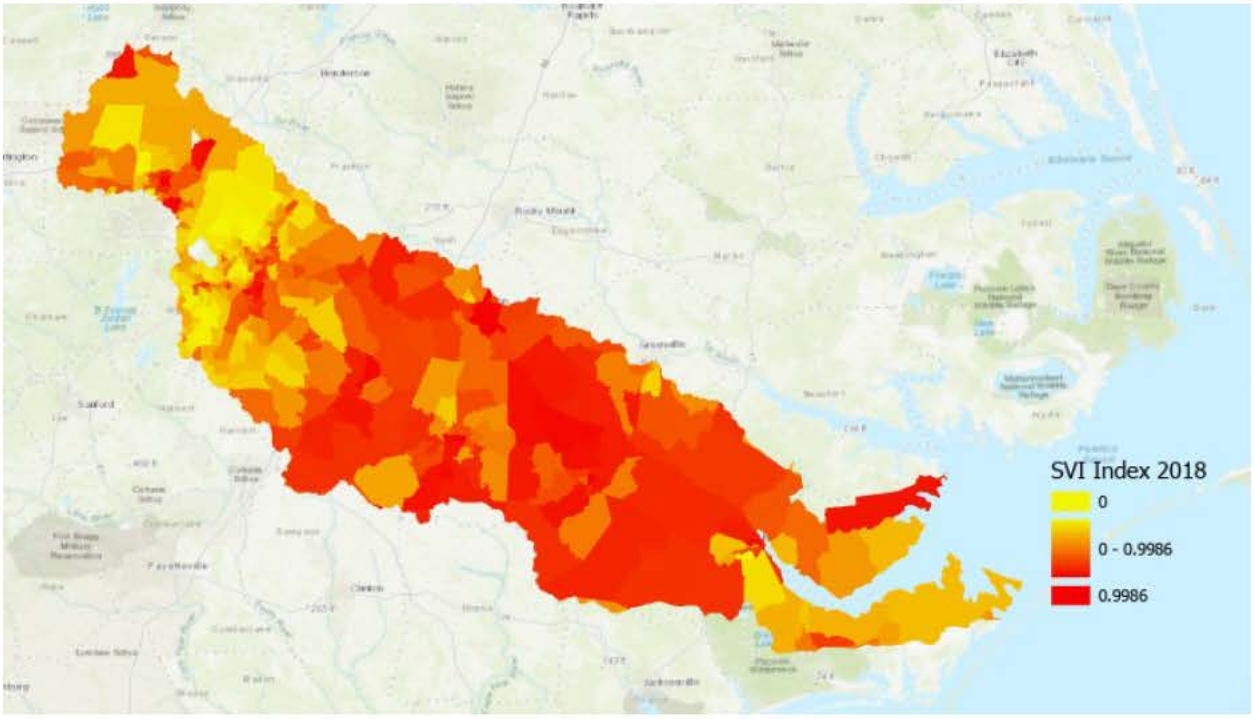

Figure 2-14 CDC Social Vulnerability Index
Source: https://www.atsdr.cdc.gov/placeandhealth/svi/data_documentation_download.html

The following tables display demographic data taken from the ACS 5-year estimates (2015-2019). Table 2-1 displays population data from 2010 and 2020 for North Carolina and the United States. The growth rate for the study area in the past decade is similar to that of the entire United States.

Table 2-1 Study Area and Comparison Area Population Trends

Geography	2010	2020	Percent Change 2010-2020
North Carolina	9,535,486	10,439,388	9%
United States	308,745,538	331,449,281	7%

Source: census.gov/quickfacts

Table 2-2 shows the selected population characteristics including distribution of race and income in North Carolina and the United States. North Carolina has a larger percent of African American people than the United States, on average, and a lower percent of Hispanic, Latino, or Asian people. The age distribution is roughly equal to that of the entire United States.

Table 2-2 Selected Population Characteristics 2020

Demographic	North Carolina	United States
Population	10,439,388	331,449,281
% 65 and above	16.7	16.5
% 18 and under	21.9	22.3
Two or more races, %	2.3	2.8
Hispanic or Latino (of any race) %	9.8	18.5
White alone %	70.6	76.3
Black or African American alone %	22.2	13.4
American Indian and Alaska Native alone%	1.6	1.3
Asian %	3.2	5.9

Source: census.gov/quickfacts

Table 2-3 displays household demographics for North Carolina and the United States. The median value of owner-occupied housing is lower than that of the national average, as is the percent households that speak a language other than English at home. Other demographic traits are similar to the national average.

Table 2-3 Household Demographics

Demographic	North Carolina	United States
Total Housing Units in 2019	4,747,943	139,684,244
% Owner Occupied	65	64
Median Value of Owner-occupied Housing	$172,500	$217,500
Median Gross Rent	$907	$1,062
Average Household Size	2.52	2.62
Language Other than English Spoken at Home %	11.8	21.6
Bachelor's Degree or Higher, Percent of Persons Age 25+ Years	31.3	32.1

Source: census.gov/quickfacts

Table 2-4 displays income demographics for North Carolina and the United States. North Carolina's unemployment rate is similar to that of the national average, while the per capita and median household incomes are lower than the national average. The poverty rate is approximately 1.5 percentage points above the average United States rate.

Table 2-4 Income Demographics 2019

Geography	Unemployment Rate 2019	Per Capita Income Last 12 months	Median Household Income 2019 dollars	Percent of Individuals Living Below Poverty
North Carolina	3.50%	$30,783	$54,602	12.9
United States	3.60%	$34,103	$62,843	11.4

Source: census.gov/quickfacts

2.8. Life-Safety Assessment

Life-safety risk is considered throughout the study process. At the outset of the study, life-safety risk reduction was identified as one of the two study objectives. However, as the study progressed, no significant life-safety risk was identified throughout the majority of the basin due to several factors:

1. Other than the USACE operated Falls Lake Dam and Reservoir, there are no existing federal levees and dams that have residual risk. Although these types of structural measures were considered in the feasibility study, they were screened out prior to development of alternatives (Section 3.5 and Appendix A (Hydrology and Hydraulics)).
2. The majority of the study area is a flat, wide floodplain. Accordingly, the duration of flooding is the dominant concern, as opposed to depth, velocity, and warning times, which have a greater impact on life-safety.
3. Overall, life-safety risk did not become a significant factor qualitatively, which is consistent with LifeSim modeling analysis conducted later in the study. For details on LifeSim modeling refer to the Section 6.1 of Appendix B (Economics).
4. Alternatives developed address the objective of reducing risk to life-safety, with the understanding that as a starting point, risk is generally not significant.

The only portion of the study area that has significant life-safety risk is the tidally influenced areas of the mainstem Neuse River lower basin (Reach MS1). This area is subject to complex forces including coastal storm surge and the potential for coincidental flooding from simultaneous riverine flooding and coastal storm surge

events. Additionally, projected increases in sea levels would bring greater risk to this area over future decades.

2.9. Existing and Future Without-Project Conditions – General Conclusions

The Neuse River basin has a population which continues to grow at a rate similar to that of the greater United States. This growth would include continued development; however, predicted land use changes are not associated with significant increases in impervious areas. At the same time, trends in improved enforcement and floodplain management, as well as interagency initiatives to manage flood risk within the basin, appear to shape a future of improved flood risk management. Inland hydrology associated with climate change may have experienced increased trends in the magnitude of annual and seasonal precipitation for parts of the study area, although with limited historical consensus. Projections of future precipitation are uncertain in either an upward or downward trend based on a number of conflicting studies. There is a majority consensus that air temperatures would increase in the study area over the next century.

Specific to the tidally influenced region of the Neuse River basin, compound flooding as a result of riverine and coastal forces, and significance of projected future sea level change would likely cause flood hazards to noticeably increase within the next 50 to 100 years.

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Chapter 3 PLAN FORMULATION AND EVALUATION OF ALTERNATIVES

3.1. Study Strategy

In the very early stages of the study, a strategy was developed in coordination with the USACE's Flood Risk Management Planning Center of Expertise (FRM-PCX) and shared with the vertical USACE team and state partners at an in-progress review meeting on September 15, 2020. Due to the large size of the study area, having a logical plan to develop and evaluate possible solutions is recognized as especially critical.

The general study strategy identified separate focus areas within the basin typically focusing on population centers in the vicinity of the Neuse River with notable flood risk. Each of these focus areas was formulated individually to identify measures to address at least one of the study objectives, and through the formulation process, to combine potentially viable measures into alternative plans for that specific focus area. Rural areas within the floodplain are also considered, although structural measures are less likely to be economically viable due to less concentrations of development.

It is also recognized that some larger-scale measures could have a regional impact, for example a new dam and reservoir. These are considered "basinwide" measures. Finally, viable plans are selected from individual focus areas and combined across the basin and resulted in a final array of system-wide alternatives. Figure 3-1 on the following page provides a conceptual illustration of the overall strategy.

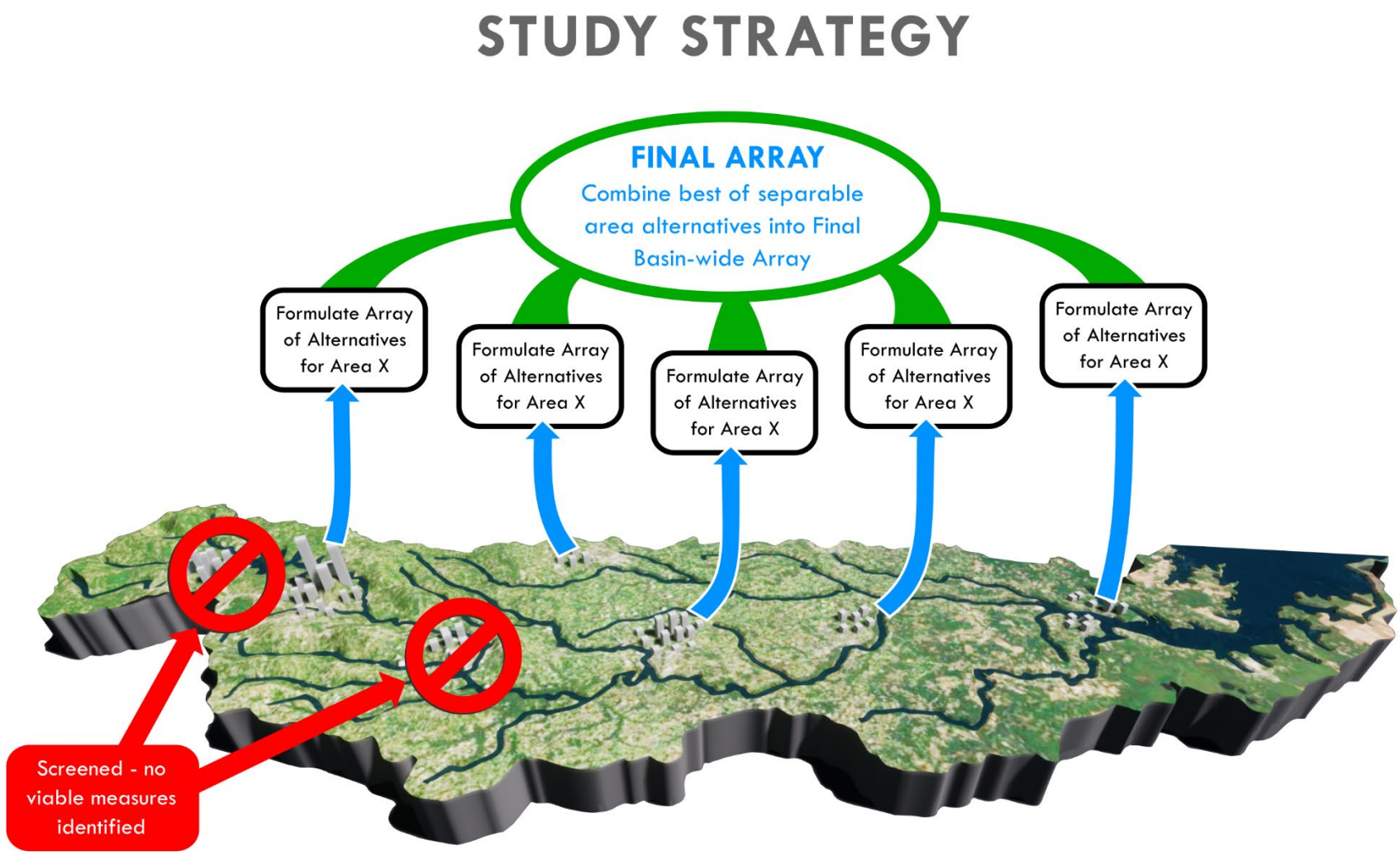

Figure 3-1 Conceptual Illustration of the Study Strategy of the Neuse River Basin Flood Risk Management Feasibility Study

Table 3-1 outlines the process for the study strategy focusing on five planning iteration levels:

Table 3-1 Study Strategy Process

Planning Iteration	Description/tasks	Notes
1st Iteration	Qualitative analysis; use of **readily available information** and **tools**; **professional judgement**; and completion of a **planning charrette**	• Existing State data/tools • Historical USACE documents • Qualitative life-safety assessment
2nd Iteration	Still largely qualitative analysis; Obtained **additional existing data**; **community outreach**	• Community Outreach (in-person and virtual) • Existing reports/tools • Qualitative life-safety assessment
3rd Iteration	**Rough quantitative** and **continued qualitative evaluations** to determine where to invest resources for detailed quantitative analysis	• Available data/tools (USACE/FEMA/State) • ROM benefits and costs • Qualitative life-safety risk assessment

4th Iteration	**Detailed quantitative analysis** to evaluate viability and develop final alternatives array in each separable area. Included **new H&H and economics modeling**, **cost engineering** and **coordination**.	• Models
		  • HEC-RAS
		  • HEC-HMS
		  • HEC-FDA
		  • LifeSim
		  • RECONS

5th Iteration	Combined plans from separable areas into final system-wide plans	

3.2. Study Methods and Assumptions

Key study methods included:

- Use of available data
  - Existing State data
  - Historical USACE documents
- Community Outreach
  - Sites visits, coordination, and virtual public information exchange meetings
- Qualitative Evaluations
  - Planning Charrette
  - Professional Judgement
- Quantitative Evaluations
  - Flood Damage Analysis (FDA) model

- Regional Economic Systems (RECONS) model
- LifeSim model
- Screening Level Climate Vulnerability Assessment Tool
- Hydrologic Engineering Center (HES)-River Analysis System (RAS)/Hydrologic Modeling System (HMS)/Statistical Software Package (SSP)

Key assumptions included:

- Due to the very large study area size, leveraging existing data and modeling are critical in determining which areas to concentrate resources for the development of additional detailed modeling and analysis
- The structure data database utilized from the North Carolina Flood Risk Information System (NCFRIS) during the early iterations of the study is accurate
- Underlying data for the FEMA National Flood Insurance Program (NFIP) models are valid
- Alternatives considered could induce downstream flooding/damages to additional properties requiring mitigative actions
- The USACE Engineer Research and Development Center (ERDC) Coastal Hazard System (CHS) is leveraged in development of assumptions for hydraulic conditions within the tidally influenced regions of the Neuse River basin study area
- Preliminary analyses within the tidally influenced regions of the study area that were conducted during early planning iterations do not fully incorporate the impacts from compound flooding. Therefore, it may be appropriate to reevaluate measures that were screened within the tidally influenced area within this study's scope under a separate study that specifically allows for appropriate engineering analysis and plan formulation with respect to compound flooding within the Neuse River basin.

3.3. Environmental Operating Principles

The USACE Environmental Operating Principles (Principles) were developed to ensure that Corps of Engineers' missions include totally integrated sustainable environmental practices. The Principles provide corporate direction to ensure the workforce recognized the Corps of Engineers role in, and responsibility for, sustainable use, stewardship, and restoration of natural resources across the nation and, through the international reach of its support missions. More information on the Principles can be

found here:
http://www.usace.army.mil/Missions/Environmental/EnvironmentalOperatingPrinciples.aspx

For the feasibility study, these Principles were adhered to over the entire planning process, including the screening of potential structural and nonstructural measures to reduce flood risk and avoid impacts to listed species to the maximum extent practicable.

3.4. Formulation and Evaluation Criteria

The following four screening criteria, listed in Table 3-2, are used during the initial planning iterations. Other social effects, such as the presence of substantial life-safety or vulnerable communities, are also considered before screening a measure in accordance with the below criteria.

Table 3-2 Screening Criteria during Iterations 1 through 3

Criteria Type	Description
Practical Engineering	Is the measure sound, acceptable and safe from an engineering standpoint?
Effectiveness	Does the measure address at least one of the study objectives?
Cost Efficiency*	Does the measure have the potential to be economically justified?
Engineering Regulation**	Does the hydrologic subbasin generate a river/creek discharge that exceeds 800 cubic feet per second (cfs) for the 10 percent AEP flood event and 1.5 square miles of drainage area within urbanized areas?

** During iterations one through three, if a measure was determined to have feasible engineering and met study objectives, it was preliminarily evaluated by Economics, prior to being modeled in HEC-FDA. At this stage, economic evaluation was completed using damages contained in the NCFRIS data, which were calculated by the State of North Carolina using FEMA's HAZUS model. Measures were screened in areas with very low damages, where the likelihood of federal interest in a project was deemed to be zero.*

*** Engineering Regulation (ER) 1165-2-21 was used as an initial criterion for screening and resulted in a substantial number of measures in urbanized areas located on tributaries of the Neuse River to be eliminated from consideration. These measures may still be viable efforts for other entities to investigate further but were not carried forward as part of this feasibility study.*

Measures that were still considered viable after the initial 3 iterations are carried forward into the 4th iteration for more detailed quantitative analysis, and screened against the following four planning criteria shown in Table 3-3:

Table 3-3 Screening Criteria during Iterations 4 and 5

Criteria Type	Description
Completeness	Does the measure/alternative function independently, and account for all necessary investments to realize the planning objectives?
Effectiveness	The extent to which an alternative plan contributes to achieve the planning objectives. The plan must make a significant contribution to at least one of the objectives.
Efficiency	The extent to which an alternative plan is the most cost-effective means of achieving the objectives. The plan outputs cannot be produced more cost-effectively by another plan.
Acceptability	Is the plan feasible from all angles (legally, financially, environmentally, politically, technically)? In essence, is there a red flag that would prevent its implementation?

There are also specific technical criteria related to engineering, economics, and the environment that were considered in evaluating alternatives. These were:

Engineering Criteria:

- The plan must represent a sound, acceptable, and safe engineering solution

Economic Criteria:

- The plan must contribute benefits to National Economic Development (NED)
- Economic benefits of a plan must exceed economic costs
- Each separable unit of improvement must provide benefits at least equal to costs.
- The Benefit-to-Cost Ratio (BCR) must be equal to or greater than 1.0 to 1

Environmental Criteria:

- The plan would fully comply with all relevant environmental laws, regulations, policies, and executive orders
- The plan would represent a balance between economic benefits and environmental sustainability
- The plan would be developed in a manner that is consistent with the USACE Environmental Operating Principles
- The plan would be formulated to avoid adverse impacts to the environment and in cases where substantial adverse effects cannot be avoided, mitigation must be provided to minimize impacts

3.5. Management Measure Identification and Screening

A management measure was defined in the feasibility study as an action that is intended to contribute to meeting the study objectives.

The process of developing measures consisted of several factors, as follows:

- Use of extensive existing data, models, and reports
- Professional judgement
- Planning Charrette meeting held to inform potential flood risk management measures
- Public outreach to affected counties and municipalities
- State and local government coordination
- Supplemental technical modeling

Measures were considered in three categories, as follows:

- Structural
- Nonstructural
- Natural and Nature-based Features

Structural Measures (S) – Measures that reduce or avoid flood damages by modifying the nature or extent of the flood hazard.

Nonstructural Measures (NS) – Measures that reduce or avoid flood damages, without significantly modifying the nature or extent of flooding. This is done by changing the use made of floodplains or accommodating existing uses to the flood hazard.

Natural and Nature-based Features (NNBF) – Use of natural features, or features created by human design, engineering, and construction that work in concert with natural processes or that mimic natural conditions in the area absent human changes to the landscape or hydrology. NNBFs can be structural or nonstructural in nature.

As described in Section 3.1, Study Strategy, five planning iterations were conducted. Many measures were identified in the first iteration through a combination of reviewing existing reports, studies, and data, as well as coordinating with the non-Federal sponsor and stakeholders in combination with professional judgement. As measures were identified, they were categorized as either basinwide measures, or site-specific measures within each focus area. The majority of measures identified were site-specific.

3.5.1. Measure Identification and Evaluation Summary

This section describes the measures which were identified throughout the study area and summarizes the evaluation methods. Due to the need to narrow down the large number of proposed measures throughout the large study area, early assessment iterations focused on leveraging available existing reporting, data, and modeling to determine measure viability. Subsequent iterations involved a more detailed assessment approach that included quantitative modeling to determine measure viability. Details on evaluation methods can be found in Appendix A (Hydrology and Hydraulics – Section 7), and Appendix B (Economics). Table 3-4, located at the end of this section, presents the screening of measures during iterations 1 through 4.

Structural Measures Considered

Detention Structures

Detention structures are designed to minimize flooding downstream by capturing upstream runoff and releasing it from storage at a controlled rate. The study area has one existing large-scale detention structure in place in the upper basin, namely Falls Dam and Reservoir, and several moderately sized reservoirs operated and maintained by a wide range of non-Federal entities. Construction of new large-scale detention structures was considered in multiple areas of the Neuse River basin. These areas were also previously considered by the State of North Carolina in their 2018 Neuse River Mitigation Strategies Report and the USACE as part of the initial Falls Lake Dam reconnaissance study in the 1960s. Site locations were considered along the tributary of Swift Creek near Smithfield, at two locations along the tributary of the Little River at Beulahtown and Baker's Mill, and at two locations along the main stem of the Neuse River, one at Wilson's Mill and another further downstream just above the Johnston and Wayne County line. Existing reports were primarily used to assess these measures in the early iterations to determine whether to invest more significant detailed analysis as part of the study. Downstream of the upper urbanized areas of the Neuse River basin, there continued to be significant engineering concerns with the flatter topography and no natural pinch points in any river and tributary which resulted in significant dam embankment lengths ranging from 1 to 4 miles. Although not used for screening, environmental mitigation and real estate impacts would likely be a critical consideration to the total project cost of any detention structure. For more details about the evaluation of potential detention structures, see Appendix A (Hydrology and Hydraulics – Section 7).

Modify Existing Reservoirs

Initial investigations within the study area identified multiple existing Natural Resources Conservation Service (NRCS) detention structures within the upper Crabtree Creek

watershed. Preliminary analysis is done to determine the potential for flood risk reduction in the Crabtree Creek watershed by modifying one or more existing NRCS reservoirs. The NRCS structures were originally proposed in the 1960s, and ultimately constructed, as part of a watershed masterplan (Crabtree Creek Watershed Work Plan, Neuse River Soil and Water Conservation District/SCS, 1964). The Crabtree Creek HEC-HMS study model is used for this evaluation. Modeling results indicated a negligible impact on reducing the existing downstream water surface elevations. Another potential cost impact of this alternative would be the requirement to modify these structures to meet current federal dam safety standards. For more details about the location and evaluation of these existing detention structures, see Appendix A (Hydrology and Hydraulics – Section 7.3.13).

New Levees

New levee alignments were considered to varying extents throughout different portions of the mainstem Neuse River, as well as in Crabtree Creek (Raleigh) and Hominy Swamp Creek (Wilson). HEC-RAS modeling was used in the evaluations. This measure was not extensively assessed for Crabtree Creek due to several engineering and design implementation constraints. Overall, the highly urbanized Crabtree Creek corridor made it challenging to identify an ideal site for implementation of any new levee alignment.

Along the mainstem of the Neuse River, levees considered required lengthy alignments due to the flat topography to tie into higher ground. New levees also imposed engineering and economic challenges related to potential induced damages and redirected flood risk outside of the leveed area. Based on the significant costs versus potential benefits, and the overall lack of effectiveness improving flood risk management in the study area, these measures were screened from further consideration. For more details about the evaluation of levee alignments, see Appendix A (Hydrology and Hydraulics – Section 7).

Channel Modification (Channel Bench)

Multiple locations throughout the basin were considered for channel modification by incorporation of a channel bench widening design by increasing the channel bank's capacity to allow a greater volume of water at a lower water elevation. Figure 3-2 provides an example of a channel bench. Locations considered were Crabtree Creek in Raleigh, Hominy Swamp Creek in Wilson, and along the mainstem Neuse River adjacent to the City of Kinston. HEC-RAS modeling was used in the evaluation. Based on the results, these measures were carried forward in all three areas for further consideration in the 4th iteration of analysis. For more details about the evaluation of channel modifications, see Appendix A (Hydrology and Hydraulics – Section 7).

Channel Modification (Excavation)

Channel modifications in the form of deepening and/or widening a waterway were considered in multiple areas throughout the Neuse River basin. This type of measure is considered for its potential to improve flow conveyance and increase channel capacity. Primary locations considered were along Crabtree Creek in Raleigh and Hominy Swamp Creek in Wilson. Secondary locations considered were in the Spring Branch and Buffalo Creek tributaries in Smithfield; Big Ditch and Stoney Creek tributaries in Goldsboro; Adkins Branch tributary in Kinston; and Jack Smith Creek in New Bern. Engineering model results for the primary locations revealed negligible flood risk management benefits in the form of lowered water levels and were ultimately screened from further consideration. Due to the smaller tributary sizes and limited drainage areas associated with the secondary Smithfield, Goldsboro, and New Bern locations, the viability of these measures is affected by Engineering Regulation 1165-2-21 (see Table 3-2) and were screened from further consideration.

Additionally, two locations along the mainstem Neuse River were also considered for channel improvements adjacent to Smithfield and Kinston, respectively. Engineering concerns associated with channel sedimentation issues and a general lack of effectiveness in reducing the water surface elevations led to the screening of this measure at these locations.

Channel excavation along the Trent River near Pollocksville and Trenton was also considered. Implementation of this measure at these locations was determined to be ineffective in reducing the water surface elevations and was initially screened as part of the feasibility study. However, the qualitative analysis to date indicates that more detailed coastal modeling tools are required to properly evaluate this and other tidally influenced areas. Therefore, initiation of a separate/new study would be focused on the coastal storm risk in tidally influenced areas which would include this area. This area is influenced by coastal storm surge and sea level change.

For more details about the evaluation of channel improvements, see Appendix A (Hydrology and Hydraulics – Section 7).

Culvert Improvements

Culvert improvements would typically modify the size of flow openings under road crossings to increase flow capacity and prevent water backup. These measures were initially considered in the Goose Creek, Ellerbe Creek, and South Ellerbe Creek tributaries in the City of Durham; Crabtree Creek in the City of Raleigh; Hominy Swamp Creek in the City of Wilson; and Contentnea Creek South tributary in the Town of Grifton. After preliminary evaluation, due to limited flow and drainage area per Engineering Regulation 1165-2-21, culvert improvement measures in the City of

Durham and the Town of Grifton were screened. Culvert improvement measures in Crabtree Creek and Hominy Swamp Creek were carried forward into more detailed evaluation. For more details about the evaluation of culvert improvements, see Appendix A (Hydrology and Hydraulics – Section 7).

Road Crossing Modifications

This measure involved modification of existing bridges to increase their span opening over the width of the Neuse River mainstem or its tributaries. There were multiple crossings identified in the study area where constricted flow may have influenced upstream flooding. These locations were at the I-95 and US-301 North overpasses near Smithfield; at the Arrington Road Bridge in Goldsboro; at Adkins Branch in Kinston; and at the NC-43 crossing upstream of New Bern.

At the time of initially investigating this measure, there were multiple similar efforts being undertaken by the State of North Carolina. The 2018 Neuse River Mitigation Strategies Report and the 2020 NCDOT Flood Abatement Assessment evaluated ways to increase conveyance through major bridge structures over the mainstem Neuse River.

During this preliminary screening process, hydraulic modeling was completed for these potential road crossing modifications by the state and results were shared with USACE. These findings were reviewed as part of the feasibility study using the Neuse River hydraulic model to validate the State's findings. Overall, these measures were screened due to a lack of effectiveness at reducing flood risk. For more details about the evaluation of road crossing modifications, see Appendix A (Hydrology and Hydraulics – Section 7).

Rose Lane Improvements (Walnut Creek, Raleigh, NC)

This measure was selected based on a cursory assessment of vulnerable residential areas within the Raleigh area using the North Carolina Flood Risk Information System (NCFRIS). The communities of Rosalynn Place and Maplewood Forest are located on Rose Lane in southeastern Raleigh, NC. Rose Lane, to the north, is the only means of egress for the residents of these neighborhoods. Rose Lane crosses over Walnut Creek approximately 1,000 feet north from the intersection of Rose Lane and Jimmy Carter Way. If this crossing is inundated by a flood event, there would be a potentially significant impact to evacuation and/or emergency services accessibility. As there appeared to be limited structural damages due to flooding, this measure was developed to improve life-safety risk, rather than reduction of flood risk. During coordination with the City of Raleigh, the city acknowledged this flood risk and as of January 2021, are pursuing bridge improvements with a conceptual design already completed. This measure was screened from further consideration due to this information and challenges associated with a lack of structural damage. For more details about the

evaluation of Rose Lane improvements, see Appendix A (Hydrology and Hydraulics – Section 7).

Floodwalls

A preliminary design for a floodwall was evaluated in the New Bern area. Floodwall alignments were assessed adjacent to downtown New Bern on the west bank of the Neuse River, and adjacent to the Town of Bridgeton on the east bank. Evaluated floodwall lengths were extended sufficiently long enough to tie into natural high ground, both upstream and downstream. Floodwall design height is assumed to provide comprehensive flood risk protection to the approximate 1% AEP event. This initial assessment is performed using the North Carolina Flood Risk Information System (NCFRIS).

A preliminary screening exercise was conducted to determine the likelihood of measure viability prior to a more significant time investment in a more detailed analysis. Existing data was utilized from the South Atlantic Coastal Study (SACS) to help facilitate this assessment, as well as data from the NCFRIS and FEMA HAZUS data. Ultimately, this measure was screened due to the anticipated disproportionate cost versus benefits. Although screened as part of this study, the analysis to date indicates that more detailed coastal modeling tools are required to properly evaluate this tidally influenced area. Therefore, initiation of a separate/new study including this area would be needed. This area is influenced by coastal storm surge and sea level change. For more details about the evaluation of floodwalls, see Appendix A (Hydrology and Hydraulics – Section 7).

Storm Surge Barrier

A storm surge barrier is a hardened engineered structure that creates a physical barrier reducing the flood risk from storm surges from traveling upstream. The coastal area of the Neuse River basin is susceptible to storm surge. A storm surge barrier measure was initially considered in the lower basin either at a nearby tidal inlet, or near the mouth of the Neuse River below the City of New Bern. Due to the significant width of the Neuse River in this vicinity, and the presence of multiple nearby tidal inlets, this measure was screened due to its anticipated disproportionate cost versus benefits.

Clearing and Snagging

This measure involved the removal of vegetation along the bank and selective removal of snags, drifts, and other obstructions from the Crabtree Creek channel, Raleigh. It was determined that clearing and snagging would be needed for approximately 15.7 miles of Crabtree Creek, beginning at its mouth and stopping at Ebenezer Church Rd.

This measure was assessed using the Crabtree Creek HEC-RAS model. Modeling results indicated that this measure offered potential as a component of a larger alternative plan. Due to this potential, it was carried forward for more detailed analysis in alternative plan formulation. For more details about the clearing and snagging, see Appendix A (Hydrology and Hydraulics – Section 7).

Wastewater Treatment Plant Flood Risk Reduction, Johnston, NC

This measure was selected to represent additional flood risk management improvements that would be made to the existing Johnston County Wastewater Treatment Plant (WWTP). The plant is located near Smithfield, NC near the southeastern bank of the Neuse River. The site is entirely within the FEMA 1% AEP flood zone and partially in the regulatory floodway. Prior to coordination with county representatives, review of the site within NCFRIS showed some degree of existing earthen levee embankment surrounding the WWTP. The current status of the site was confirmed during a coordination call with Johnston County Public Utilities (phone conversation, Feb-2021). The county had long term goals of relocating the primary plant operations to a site completely outside of the floodplain, and in the interim had secured FEMA grant funding to engineer and construct more robust flood risk management features for the current plant. Conceptual drawings supplied to the PDT proposed a parapet wall on top of the existing earthen levee to reduce overtopping frequency. Due to this existing grant and engineering efforts in place, this measure was screened from further consideration. For more details about the evaluation of improvements at this wastewater treatment plant, see Appendix A (Hydrology and Hydraulics – Section 7).

Nonstructural Measures Considered

Property Buyouts

Areas of potential flood risk throughout the Neuse River basin were evaluated for the presence of clusters of structures where property buyouts might be viable. Property buyouts remove a structure from the floodplain to fully mitigate its risk of future flood damage. Vacated property could be subsequently converted to other uses including recreation or reestablishment of natural areas. Property buyouts as a measure were carried forward for more detailed analysis for the entire study area.

Structure Elevation

Areas of potential flood risk throughout the Neuse River basin were evaluated for the presence of clusters of structures which might benefit from structure elevation. Structure elevation raises a house or building so that the lowest habitable floor is above

a targeted flood level. Structure elevation was carried forward for more detailed analysis for the entire study area.

Structure Floodproofing

Areas of potential flood risk throughout the Neuse River basin were evaluated for the presence of clusters of structures which might benefits from floodproofing. Two types of floodproofing were evaluated – dry and wet. Dry floodproofing makes a structure watertight below the level for which flood risk management is provided by preventing floodwaters from entering the structure. Wet floodproofing allows water to enter the structure but makes exterior and interior modifications to reduce damages. Structure floodproofing was carried forward for more detailed analysis for the entire study area.

Flood Warning System Improvements

Flood warning systems can help provide advance information of potential future flooding to allow individuals and decision-makers to make better informed decisions on whether to take emergency action, and when to do so. Streamflow gages are an important component of a flood warning system. Due to the large size of the Neuse River basin, no individual flood warning system acts for the entire area. Rather, municipalities in different areas use different sets of stream gages to help forecast and warn residents of potential flooding impacts. Through initial community outreach during this feasibility study, two locations within the basin were identified for flood warning system enhancements in the form of updated or additional stream gages. The first location would contribute to flood warning system enhancements with installation of a stream gage in the Eno River at the North Roxboro Street crossing in Durham County. This would consist of updating an existing stream gage to improve the accuracy of estimated flood depths. The second location is located on the Neuse River at the NC-43 (River Road) crossing, approximately 9 miles upstream of the City of New Bern. A new stream gage would be added in this location to improve warning times by providing estimated flood depths to the downstream communities in Craven County and the City of New Bern. These measures were carried forward for further analysis.

Educational Materials and Outreach of Residual Flood Risk

Based on feedback received during community outreach efforts, there appears to be a public need to improve the understanding of residual flood risk throughout the basin. Public educational materials could be developed with focus given toward clear messaging and strong visualize presentation to improve the understanding of residual flood risk and interactions within the Neuse River basin. This outreach opportunity was carried forward for further analysis.

Natural and Nature-based Features Considered

Dispersed Water Management

Dispersed Water Management (DWM), also referred to as Water Farming, is a practice that provides temporary shallow water storage, retention, and detention through the use of existing infrastructure and simple structures (weirs, berms, and culverts). Water would be retained on-site and removed by natural means of evaporation, transpiration, or seepage (SFWMD, 2014). An example of this practice is water management entities in Florida that work with farmers who are paid to keep stormwater and hold floodwaters from other areas on their properties. This measure was initially considered throughout the study area and the flat terrain in the lower basin near the Pamlico Sound was determined to offer the best opportunity for successful implementation. However, it was difficult to quantify how any improvements to flood risk management would be transferable to areas most vulnerable to flooding that exist upstream in the basin. For more details about the evaluation of dispersed water management, see Appendix A (Hydrology and Hydraulics – Section 7).

Green Infrastructure

Green infrastructure measures would mimic or use natural features to help achieve flood risk management objectives and could provide secondary environmental benefits as well. These measures could include restoration of the floodplain, protecting or restoring greenspace, or construction of wetland or other natural features. However, the economic benefits for these types of measures are not easily determined. Ultimately, it was determined that if viable structural measures were identified, green infrastructure features could potentially be added, but would be unlikely to solely achieve the flood risk management objectives of the study. Therefore, consideration and evaluation of the viability for these nature-based measures were assumed to take place during measure refinement, once there is a higher degree of confidence in their successful implementation. If a structural project's benefit-to-cost ratio is slightly below unity, nature-based measures could be pursued based on estimated environmental quality benefits. However, if the benefit-to-cost ratio is well below unity for more traditional measures, these nature-based measures would also be screened from further consideration.

Overbank Detention Structure

This measure was considered in both Crabtree Creek in Raleigh and Hominy Swamp Creek in Wilson using HEC-RAS modeling analyses. Results indicated negligible reductions in downstream water levels at both locations and the measures were screened out due to lack of effectiveness.

The screening process for the measures briefly discussed above are presented in Table 3-4 and organized by location. Additional details on all structural measures evaluated in the following table are further described in Appendix A (Hydrology and Hydraulics – Section 7):

Table 3-4 Management Measures Identification and Screening

LOCATION	MEASURE	Type	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration	SCREENING JUSTIFICATION
Regional/Basinwide	Detention Structure – Swift Creek	S	SCREENED				PRACTICAL ENGINEERING: Engineering factors for screening: Relative reservoir size versus average sedimentation rate. Location between Piedmont and Coastal Plain conducive to sedimentation. Significant embankment length and very shallow depth pool.
	Detention Structure – Wilson's Mill (Neuse Mainstem)	S	SCREENED				PRACTICAL ENGINEERING, EFFICIENCY: Engineering factors for screening: limited storage capacity and elongated detention shape negatively impacted by upstream flood release operations at Falls Dam and Reservoir. Existing State economic analysis indicates cost exceeds benefits.
	Detention Structure – Johnston/Wayne County boundary (Neuse Mainstem)	S	SCREENED				PRACTICAL ENGINEERING: Engineering factors for screening: with no natural "pinch point" due to topography, the dam embankment would need to exceed 4 miles in length. A shallow depth pool would be required, and sedimentation is a significant concern due to soil type.
	Detention Structure – Beulahtown/Baker's Mill (Little River)	S	Carried Forward	SCREENED			PRACTICAL ENGINEERING: Engineering factors for screening: Relative reservoir size versus average sedimentation rate. Location between Piedmont and Coastal Plain conducive to sedimentation. Significant embankment length and very shallow pool depth.
	Dispersed Water Management (Water Farming)	S/NNBF	Carried Forward	Carried Forward	SCREENED		EFFECTIVENESS: Suitable floodplain areas confined to lower basin near Pamlico Sound which would not provide flood risk management benefits upstream of this measure
	Green Infrastructure and Floodplain Restoration	NNBF	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS, EFFICIENCY: To address the study objectives of reducing flood damage and life-safety risk, it was determined that these measures would need to be predicated on and accompany the successful application of more traditional flood damage reduction measures. These were screened at the same time as the traditional structural measures were screened.
	Education/Outreach – Residual Flood Risk	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
Durham	Cole Mill Rd./Roxboro Culvert Improvements	S	Carried Forward	Carried Forward	SCREENED		REGULATION: Ellerbe Creek at Cole Mill Rd. did not meet drainage area or cfs requirements per ER 1165-2-21
	Flood Warning System Improvements at Roxboro	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure floodproofing	NS	Carried Forward	Carried Forward	SCREENED		REGULATION: Structure elevation located along (1) South Ellerbe Creek, (2) Ellerbe Creek South Tributary, (3) Goose Creek, (4) Goose Creek Tributary A do not meet ER 1165-2-21 drainage criteria
	Structure Elevation	NS	Carried Forward	Carried Forward	SCREENED		REGULATION: Floodproofing located along (1) South Ellerbe Creek, (2) Ellerbe Creek South Tributary, (3) Goose Creek, (4) Goose Creek Tributary A do not meet ER 1165-2-21 drainage criteria
	Property Buyouts	NS	Carried Forward	Carried Forward	SCREENED		REGULATION: Property buyouts located along (1) South Ellerbe Creek, (2) Ellerbe Creek South Tributary, (3) Goose Creek, (4) Goose Creek Tributary A do not meet ER 1165-2-21 drainage criteria

Table 3-4 Management Measures Identification and Screening (Continued)

LOCATION	MEASURE	Type	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration	SCREENING JUSTIFICATION
Raleigh	Modify existing NRCS Reservoirs (Crabtree Creek)	S	Not Yet Identified	Caried Forward	SCREENED		EFFECTIVENESS: modeling indicated negligible reduction in flood footprint in area of concern
	New Levee Along Crabtree Creek	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS, PRACTICAL ENGINEERING: causes significant induced negative impacts, limited options for mitigative measures due to dense development
	Channel Modifications (Channel Bench) in Crabtree Creek	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Concrete Railroad Flume	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Auxiliary Culverts (N. Raleigh Blvd)	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Clearing and Snagging	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Overbank Detention Structure	S/NNBF	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS: analysis showed negligible change in water levels
	Lassiter Mill Dam Removal	S/NNBF	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: Analysis indicates limited benefits in immediate area, plus increased flow downstream in reaches of greater flood risk. Limited life-safety benefits from removal due to small dam size.
	Channel Modifications (Channel Excavations) (Crabtree Creek)	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS, PRACTICAL ENGINEERING: negligible reduction in water levels; Excavation footprint constrained by existing bridge structures.
	Rose Lane Improvements (Walnut Creek)	S	Not Yet Identified	SCREENED			EFFECTIVENESS; EFFICIENCY: no structure damages; limited life-safety risk; substantial cost.
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
Wilson	New Levee Along Hominy Swamp Creek	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS; PRACTICAL ENGINEERING: causes significant induced damages for multiple miles, including new overtopping of bridges
	Culvert modification at CSX railroad (Hominy Swamp Creek)	S	Not Yet Identified	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Channel modification (Channel Bench) in Hominy Swamp Creek	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Overbank Detention Structure	S/NNBF	Not Yet Identified	Carried Forward	Carried Forward	SCREENED	EFFECTIVENESS: minimal reduction in water levels
	Structure floodproofing	NS	Not Yet Identified	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure elevation	NS	Not Yet Identified	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Property buyouts	NS	Not Yet Identified	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array

Table 3-4 Management Measures Identification and Screening (Continued)

LOCATION	MEASURE	Type	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration	SCREENING JUSTIFICATION
Smithfield/Johnston County	New Levee along Neuse River	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Clearspan Floodplain (I-95 bridge, US-301 bridge, railroad)	S	Carried Forward	SCREENED			EFFECTIVENESS, EFFICIENCY: very limited benefits in area of flood reduction
	Channel Modification (Spring Branch)	S	Carried Forward	Carried Forward	SCREENED		REGULATION, EFFICIENCY: portion of upper stream did not meet drainage area (DA) or cubic feet per second (cfs) requirements per ER 1165-2-21. Remaining portion did not have sufficient existing damages
	Channel Modification (Buffalo Creek)	S	Carried Forward	Carried Forward	SCREENED		REGULATION, EFFICIENCY: portion of upper stream did not meet drainage area (DA) or cubic feet per second (cfs) requirements per ER 1165-2-21. Remaining portion did not have sufficient existing damages
	Resiliency Routes – crossing upgrades	S	Carried Forward	Carried Forward	SCREENED		EFFECTIVENESS: did not meet study objective of flood damage reduction, and limited effectiveness at reducing life-safety risk based on relatively low existing FWOP risk
	Channel Modification (channel excavation) in Mainstem of Neuse	S	Not Yet Identified	Carried Forward	SCREENED		EFFECTIVENESS, PRACTICAL ENGINEERING: negligible reduction in water levels; Excavation footprint constrained by existing bridge structures.
	Johnston WWTP protection	S	Carried Forward	SCREENED			EFFICIENCY: Coordination revealed FEMA project (ring levee) recently put in place to protect facility
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
Goldsboro/Wayne County	Levee Improvements (Cherry Research Farm)	S	Carried Forward	SCREENED			EFFICIENCY: Coordination with U.S. Department of Agriculture in 2020 revealed that repairs to this levee are already underway by USDA.
	New Levee along Neuse River	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	PRACTICAL ENGINEERING, EFFICIENCY: significant threat of backwater due to topography and tributaries; significant inducement of flood damage in adjacent structures.
	Channel Modifications (Big Ditch)	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	REGULATION, EFFICIENCY: portion of upper stream did not meet drainage area (DA) or cubic feet per second (cfs) requirements per ER 1165-2-21. Remaining portion did not have sufficient existing damages
	Channel Modifications (Stoney Creek)	S	Carried Forward	Carried Forward	SCREENED		EFFICIENCY: limited available damages to prevent
	Road Crossing Improvements at Arrington Road Bridge	S	Carried Forward	SCREENED			EFFECTIVENESS: existing NCSU analysis indicates minimal water elevation change
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
Seven Springs	Levee	S	Carried Forward	Carried Forward	SCREENED		EFFICIENCY: very limited damage pool remaining after previous property buyouts.
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits

Table 3-4 Management Measures Identification and Screening (Continued)

LOCATION	MEASURE	Type	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration	SCREENING JUSTIFICATION
Kinston	Channel Modification (Channel Excavation) in Mainstem of Neuse	S	Carried Forward	SCREENED			PRACTICAL ENGINEERING: Potentially high sedimentation rate given its location in Coastal Plain conducive to erosion. Significant dredge length along Neuse mainstem.
	Channel Modifications (Channel Excavation) (Adkin's Branch)	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	REGULATION, EFFICIENCY: portion of upper stream did not meet drainage area (DA) or cubic feet per second (cfs) requirements per ER 1165-2-21. Remaining portion did not have sufficient existing damages
	Road Crossing Improvements (Adkin's Branch)	S	Carried Forward	Carried Forward	Carried Forward	SCREENED	REGULATION, EFFICIENCY: portion of upper stream did not meet drainage area (DA) or cubic feet per second (cfs) requirements per ER 1165-2-21. Remaining portion did not have sufficient existing damages
	Channel Modifications (Channel Bench) in Mainstem of Neuse	S	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	Carried Forward	Included in preliminary alternatives array
Greenville Area (within Neuse basin)	Unnamed Tributary #1 improvements (Upper Swift Creek and Fork Swamp)	S	Not Yet Identified	Carried Forward	SCREENED		REGULATION: Swift Creek did not meet ER 1165-2-21 discharge criteria; EFFECTIVENESS: Limited damage pool
	Detention (Upper Swift Creek and Fork Swamp)	S	Not Yet Identified	Carried Forward	SCREENED		REGULATION: Swift Creek did not meet ER 1165-2-21 discharge criteria; EFFECTIVENESS: Limited damage pool
Grifton	Culvert Improvements (Contentnea Creek South tributary)	S	Carried Forward	Carried Forward	SCREENED		REGULATION: Contentnea Creek South Tributary did not meet ER 1165-2-21 discharge criteria
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	EFFICIENCY: disproportionate costs versus benefits
New Bern**	Floodwall (downtown New Bern, Duffy Field, and Bridgeton)	S	Carried Forward	Carried Forward	SCREENED		**
	Storm Surge Barrier	S	SCREENED				**
	Channel Modification (Duffy Field – Jack Smith Creek)	S	Carried Forward	Carried Forward	SCREENED		**
	NC-43 Bridge Crossing Modification	S	Carried Forward	SCREENED			**
	Flood Warning Improvements (additional stream gage placed above New Bern to improve flood warning times)	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**

Table 3-4 Management Measures Identification and Screening (Continued)

LOCATION	MEASURE	Type	1st Iteration	2nd Iteration	3rd Iteration	4th Iteration	SCREENING JUSTIFICATION
Trenton/ Pollocksville**	Ditch Cleanouts (Jones County)	S	Not Yet Identified	SCREENED			**
	Dredging (Trent River)	S	Carried Forward	Carried Forward	SCREENED		**
	Structure floodproofing	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**
	Structure elevation	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**
	Property buyouts	NS	Carried Forward	Carried Forward	Carried Forward	SCREENED	**

** - Although this measure was initially screened as part of this study, the qualitative analysis to date indicates that more detailed coastal modeling tools are required to properly estimate coastal storm risk and potential measures to reduce this risk., Therefore, initiation of a separate/new study would be needed. This area is influenced by coastal storm surge and sea level change.

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3.6. Alternative Formulation

Table 3-5 shows the measures carried forward for consideration in alternative development, by location:

Table 3-5 Measures Considered for Alternatives by Separable Area

LEGEND		
HS = Hominy Swamp Creek (Wilson)		**MS = Neuse River Mainstem**
CTC = Crabtree Creek (Raleigh)		**S** = Structural measure
BD = Big Ditch (Goldsboro)		**NS** = Nonstructural measure
Measure	**Type**	**Location Applicable**
Channel Modification (channel bench)	S	HS, CTC, MS (near Kinston)
Culvert Modification	S	HS
Auxiliary Culverts	S	CTC
Concrete Railroad Flume	S	CTC
Clearing and Snagging	S	CTC
Structure Floodproofing	NS	HS, CTC, BD, MS (various locations)
Structure Elevation	NS	HS, CTC, BD, MS (various locations)
Property Buyouts	NS	HS, CTC, BD, MS (various locations)
Flood Warning System Improvements	NS	Eno River in Durham; MS above New Bern
Flood Risk Education/Outreach	NS	Basinwide

As discussed in Section 3.1, *Study Strategy*, alternatives were initially developed for separable areas based on measures that passed the initial screening processes and required further detailed analysis. The approach for combining measures into alternatives is as follows:

1. A series of structural alternatives are were developed by incrementally combining potentially viable structural measures

2. Nonstructural alternatives are developed. This included both structure elevation and floodproofing alternatives, and buyout/acquisition alternatives. The combination of a nonstructural alternative which included both structure elevation and floodproofing, plus property buyouts was assessed. However, it was determined that these separate measures addressed the same structure groups, and in each case property buyouts were less efficient. Therefore, these measures are not combined into the same alternative.

3. In separable areas where there are both viable structural and nonstructural measures, combined plans (structural plus nonstructural) are developed. However, detailed economic analysis of the preliminary array indicated there are no economically viable structural measures/alternatives (Section 3.7).

Table 3-6 includes a legend for descriptions of alternatives which is followed by descriptions of each alternative by separable area.

Table 3-6 Legend for Descriptions of Alternatives

HS (Hominy Swamp Creek)	**S** (Structural alternative)
CTC (Crabtree Creek)	**NS** (Nonstructural alternative)
BD (Big Ditch)	**C** (Combined structural/nonstructural)
MS (Mainstem of the Neuse River)	**Example:** CTC-S3 = Crabtree Creek - Structural alternative #3
F1 (Public Outreach and Education of Basinwide Residual Flood Risk)	**Example:** BD-NS1 – Big Ditch - Nonstructural alternative #1
F2 (Flood Warning System Enhancements)	

Separable Area: Hominy Swamp Creek (City of Wilson, NC)

Alternatives:

HS-S1 (Structural): Channel Modification (Channel Bench)

This alternative included nine segments of channel bench modifications located adjacent to Hominy Swamp Creek, as described in Section 7.3.2 of Appendix A (Hydrology and Hydraulics). The channel bench modifications totaled approximately 3.2 miles of stream length and would have increased the volume of water the channel would hold during flood events, reducing the risk of overbank flooding and damage to structures. A conceptual illustration of a typical channel bench modification is shown in Figure 3-2. Figure 3-3 shows the location of alternative HS-S1.

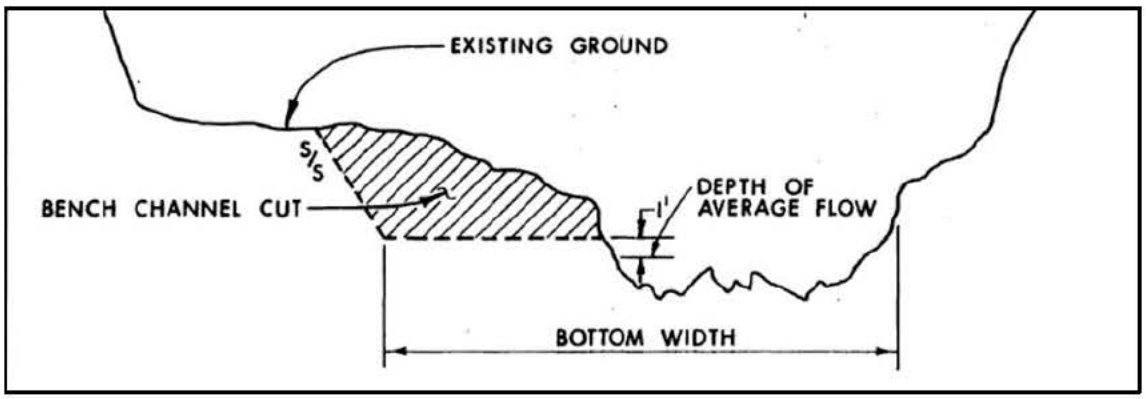

Figure 3-2 Conceptual Cross-section of a Channel Bench

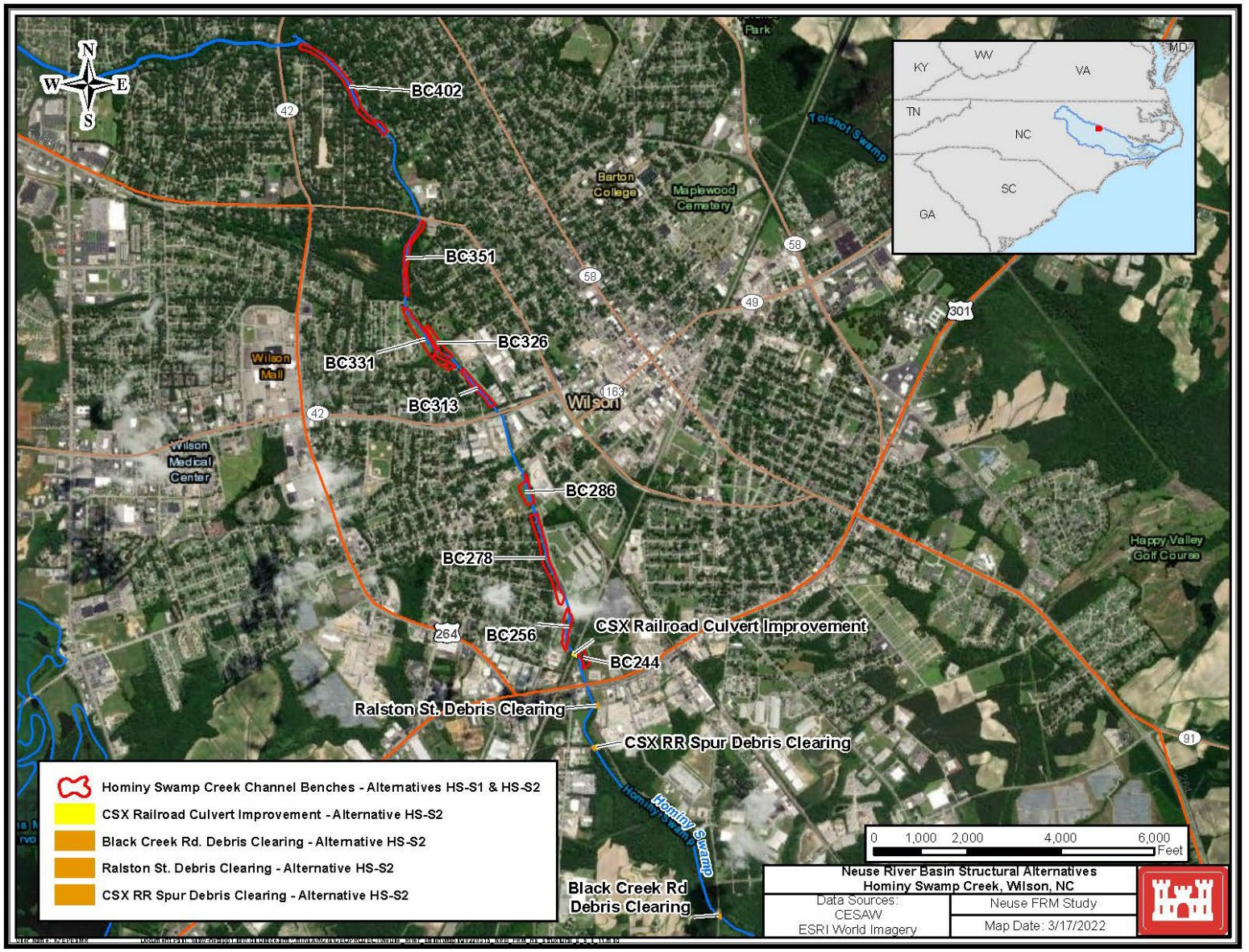

Figure 3-3 Hominy Swamp Creek, Wilson, NC Structural Alternatives HS-S1 and HS-S2

HS-S2 (Structural): Channel Modification (Channel Bench) / Railroad Culvert and other Improvements

This alternative included channel bench modifications described in HS-S1 plus the Hominy Swamp Creek CSX railroad culvert improvement. The added culvert improvement would improve the channel flow passing through the railroad embankment and complement the proposed upstream channel bench modification and associated stream clearing under three additional downstream bridge crossings. Figure 3-3 shows the location of alternative HS-S2.

HS-NS3 (Nonstructural): Structure Elevation and Floodproofing

This alternative initially included elevating 14 structures and dry floodproofing 6 structures along Hominy Swamp Creek. Figure 3-4 and 3-5 show examples of structure elevation and dry floodproofing nonstructural measures. Subsequent updates to the hydrology and hydraulics model led to a reduction in flood risk, which resulted in this alternative ultimately consisting of the dry floodproofing of 5 structures. See Section 3.7.3 for a definition of structure dry floodproofing. Figure 3-6 shows the location of alternative HS-NS3 (gold outlined areas).

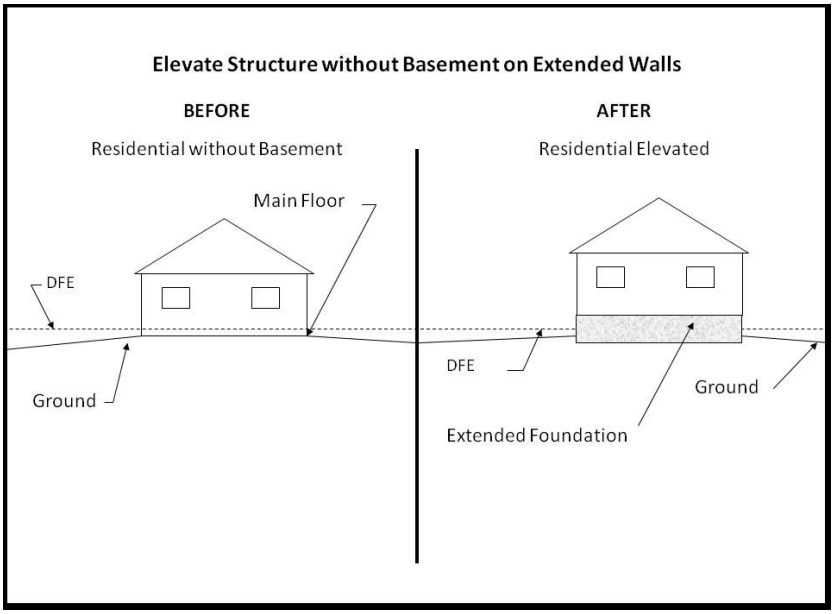

Figure 3-4 Structure Elevation Conceptual Illustration

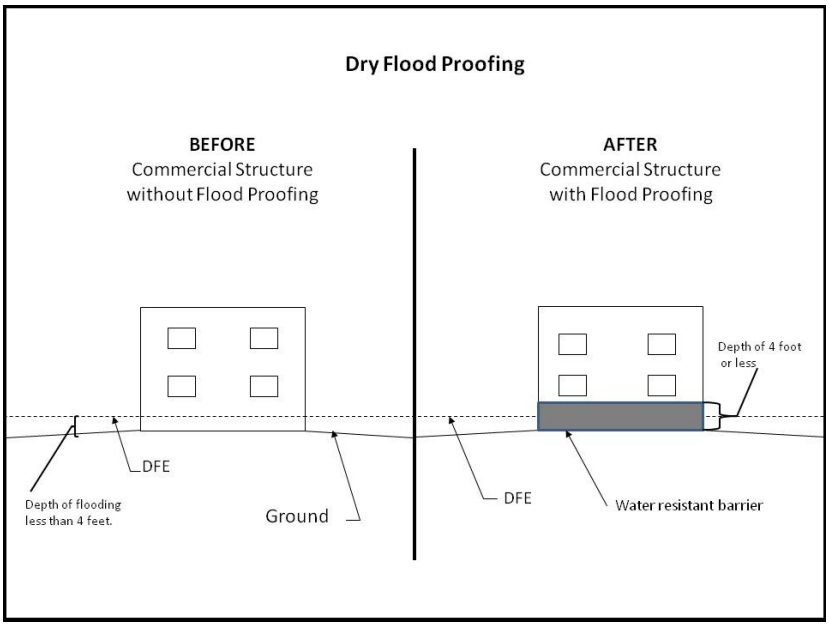

Figure 3-5 Structure Dry Floodproofing Conceptual Illustration

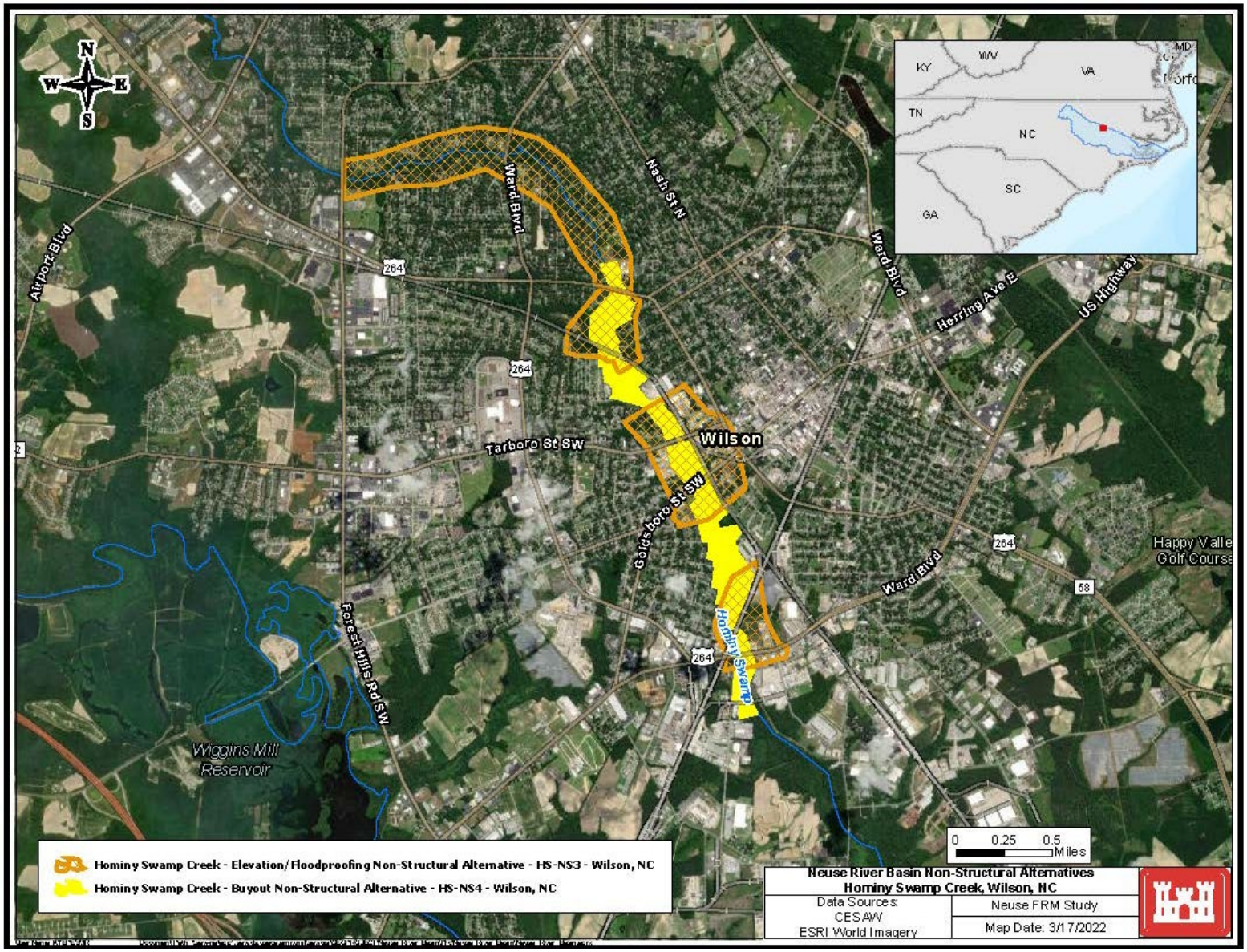

Figure 3-6 Hominy Swamp Creek, Wilson, NC Nonstructural Alternatives HS-NS3 and HS-NS4

HS-NS4 (Nonstructural): Property Buyouts

This alternative included the acquisition of approximately 36 properties and the associated lands along Hominy Swamp Creek. Figure 3-6 shows the location of alternative HS-NS4 (yellow highlighted area).

HS-C5 (Combined Structural and Nonstructural): Channel Modification (Channel Bench)/ structure elevation, floodproofing

This alternative included channel bench modifications associated with alternative HS-S1 combined with elevating 14 structures and dry floodproofing 6 structures, adjacent to Hominy Swamp Creek. Figure 3-7 shows the location of alternative HS-C5.

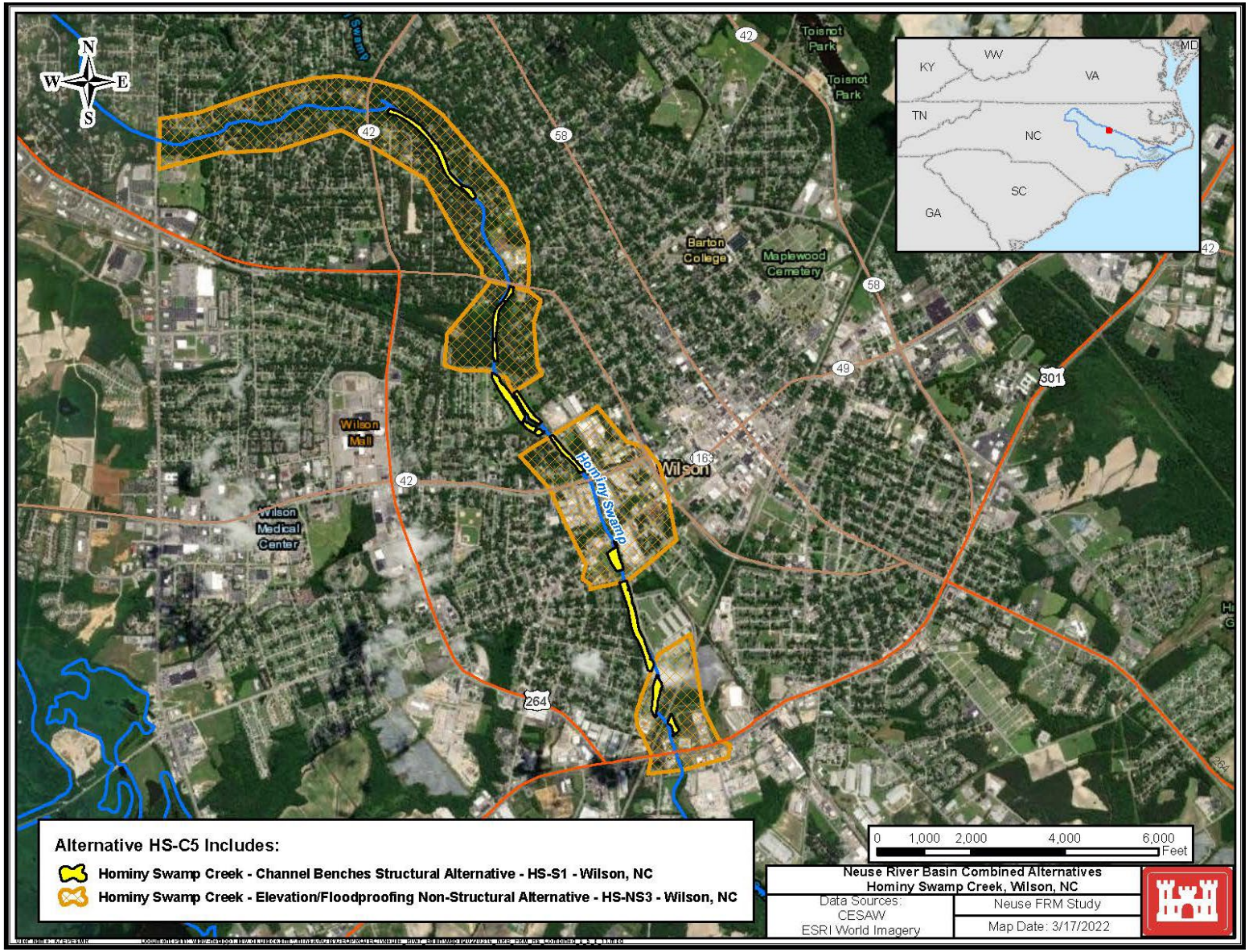

Figure 3-7 Hominy Swamp Creek, Wilson, NC Alternative HS-C5

Separable Area: Crabtree Creek (City of Raleigh, NC)

Alternatives:

CTC-S3 (Structural): Channel Modification (Channel Bench) / Clearing & Snagging
This alternative included seven segments of channel bench modifications located adjacent to Crabtree Creek in Raleigh, NC, as detailed in Section 7.3.3 of Appendix A (Hydrology and Hydraulics). The alternative also included the clearing and snagging measure, as described in Section 7.3.14 of Appendix A (Hydrology and Hydraulics). This alternative combined these two measures that represented simplified engineering methods to improve flood risk management. These two measures are not structurally complex in their design, which primarily involved excavation and debris removal. A conceptual illustration of a typical channel bench modification was previously shown in Figure 3-2. Figure 3-8 includes the location of alternative CTC-S3.

CTC-S4 (Structural): Channel Modification (Channel Bench)/ Clearing & Snagging/ Railroad Flume
This alternative included channel bench modifications and clearing and snagging measures in Alternative CTC-S3, plus the bridge modification measure at the Norfolk Southern railroad crossing. The bridge modification evaluated the proposed construction of a rectangular concrete flume within the Crabtree Creek channel as it passed under the railroad bridge, as described in Section 7.3.9 of Appendix A (Hydrology and Hydraulics). The water surface elevation (WSEL) reductions associated with the channel modification and clearing and snagging measures from CTC-S3 offset the increases directly related to the concrete flume. Figure 3-8 includes the location of alternative CTC-S4.

CTC-S5 (Structural): Channel Modification (Channel Bench)/ Clearing & Snagging/ Railroad Flume/ Auxiliary Culverts at N. Raleigh Blvd.
This alternative included channel bench modifications, clearing and snagging, and bridge modification at the Norfolk Southern railroad crossing in Alternative CTC-S4, plus the bridge modification measure at the N. Raleigh Blvd crossing. The N. Raleigh Blvd bridge modification included proposed construction of a triple box culvert within the left overbank, through the existing N. Raleigh Blvd embankment, as described in Section 7.3.9 of Appendix A (Hydrology and Hydraulics). The intent in this alternative is similar to Alternative CTC-S4. The inclusion of the N. Raleigh Blvd bridge modification would provide the greatest WSEL reduction, relative to the other standalone measures evaluated for the Crabtree Creek study area. Figure 3-8 shows the location of alternative CTC-S5.

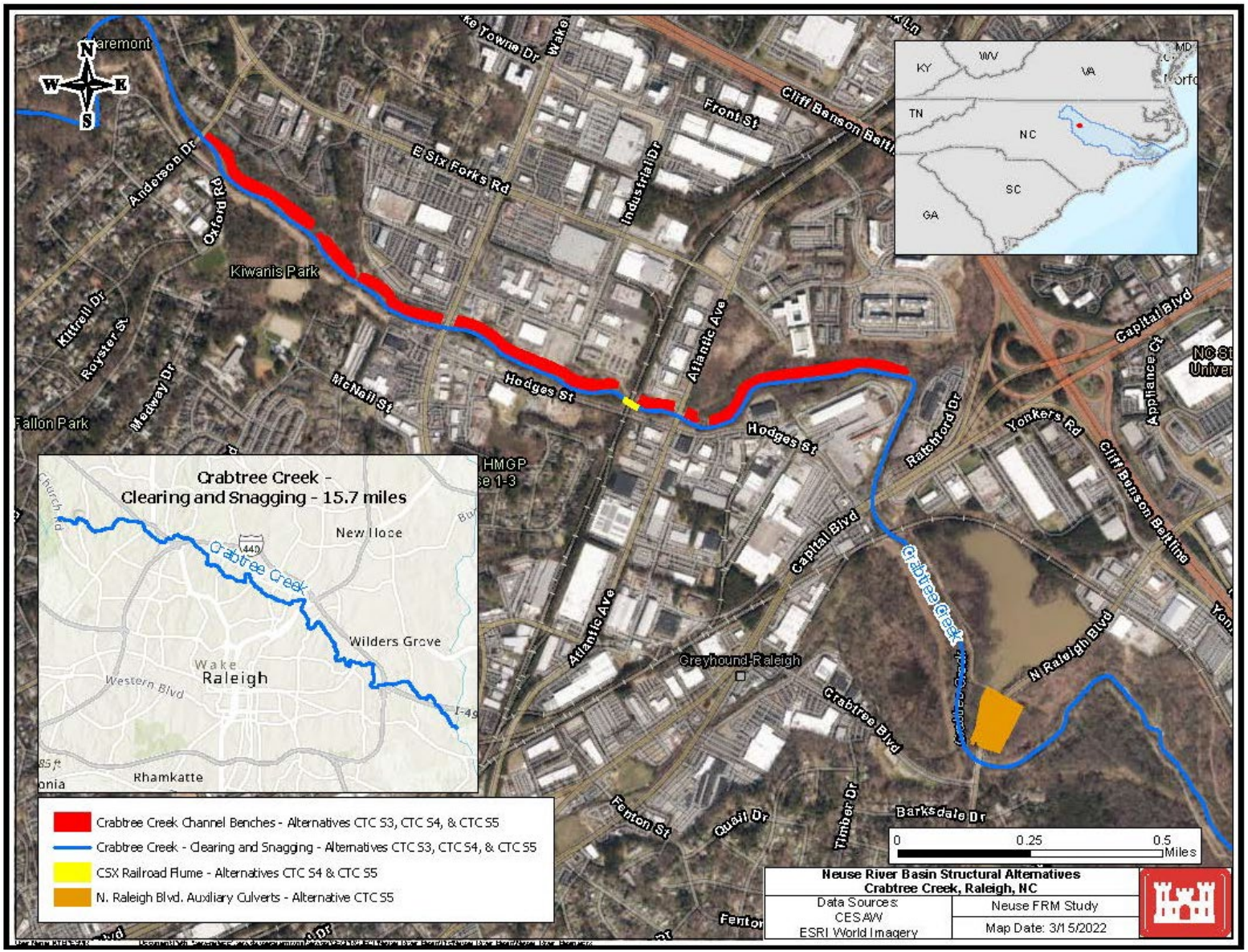

Figure 3-8 Crabtree Creek, Raleigh, NC Structural Alternatives CTC-S3, CTC-S4, and CTC-S5

CTC-NS6 (Nonstructural): Structure Elevation and Floodproofing

This alternative initially included elevating 38 structures, the wet floodproofing of 10 structures, and the dry floodproofing of 11 structures along Crabtree Creek in Raleigh. Figures 3-4 and 3-5 show examples of structure elevation and dry floodproofing nonstructural measures. Subsequent updates to the hydrology and hydraulics model led to a reduction in flood risk, which resulted in this alternative ultimately consisting of the dry floodproofing of 12 structures. See Section 3.7.2 for definitions of structure elevation, dry floodproofing and wet floodproofing. Figure 3-9 shows the location of alternative CTC-NS6.

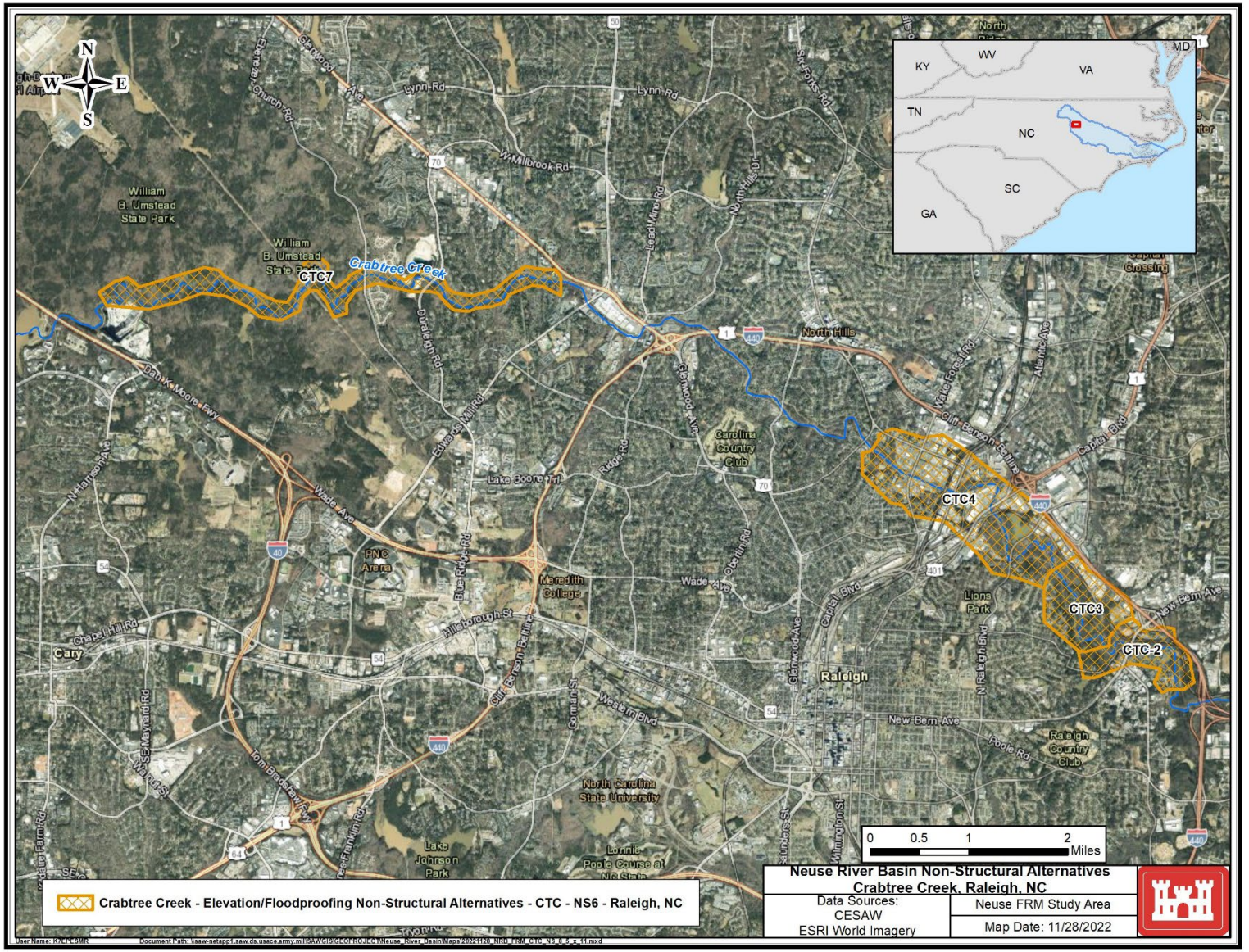

Figure 3-9 Crabtree Creek, Raleigh, NC Nonstructural Alternative CTC-NS6

Separable Area: Big Ditch (City of Goldsboro)

Alternatives:

BD-NS1 (Nonstructural): Structure Elevation and Floodproofing
This alternative included elevating 2 structures, wet floodproofing 4 structures and dry floodproofing 3 structures along the Big Ditch tributary in Goldsboro. Figure 3-10 shows the location alternative BD-NS1 (small gold highlighted area).

BD-NS2 (Nonstructural): Property Buyouts
This alternative included acquisition of approximately 67 properties and the associated lands along the Big Ditch tributary in Goldsboro. Figure 3-10 shows the location of alternative BD-NS2 (yellow highlighted area).

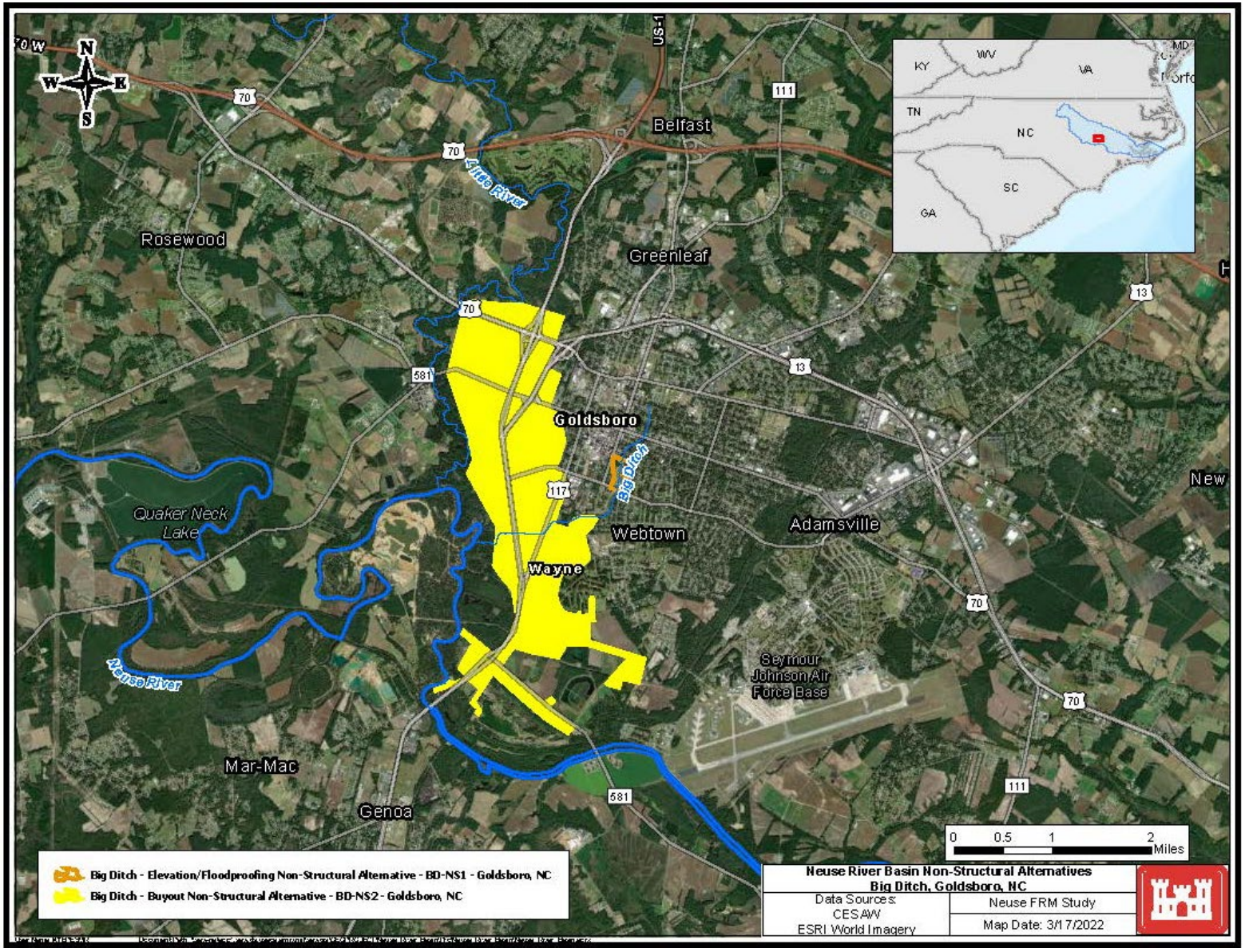

Figure 3-10 Big Ditch, Goldsboro, NC Nonstructural Alternatives BD-NS1 and BD-NS2

Separable Area: Neuse River Mainstem

Alternatives:

MS-S1 (Structural): Channel Modification (Channel Bench) near Kinston

This alternative included channel bench modifications located adjacent to the Neuse River mainstem in Kinston, NC. The measure consisted of two channel bench segments, one on each side of the bank, within the overbank floodplain of the Neuse River. The first bench segment (RB01) was placed within the right overbank floodplain between the US-11 and HWY-258 (S Queen St) bridges and had an approximate length of 1.3 miles. Bench segment RB01 had an average benched width of 500 feet, based on a footprint width that ranged from 100 feet near the tie-in points at the bridge embankments up to 900 feet near the midpoint of its length. The second bench segment (LB01) was placed within the left overbank floodplain between HWY-258 and multiple railroad bridges. Bench segment LB01's footprint length adjacent to the river's edge is about 1.5 miles. Bench segment LB01 had an average benched width of 1,000 feet. The purpose of this alternative was to increase the storage volume of water within the Neuse River near Kinston to reduce the risk of overbank flooding and structure damage during and after heavy rainfall events. Figure 3-11 shows the location of alternative MS-S1.

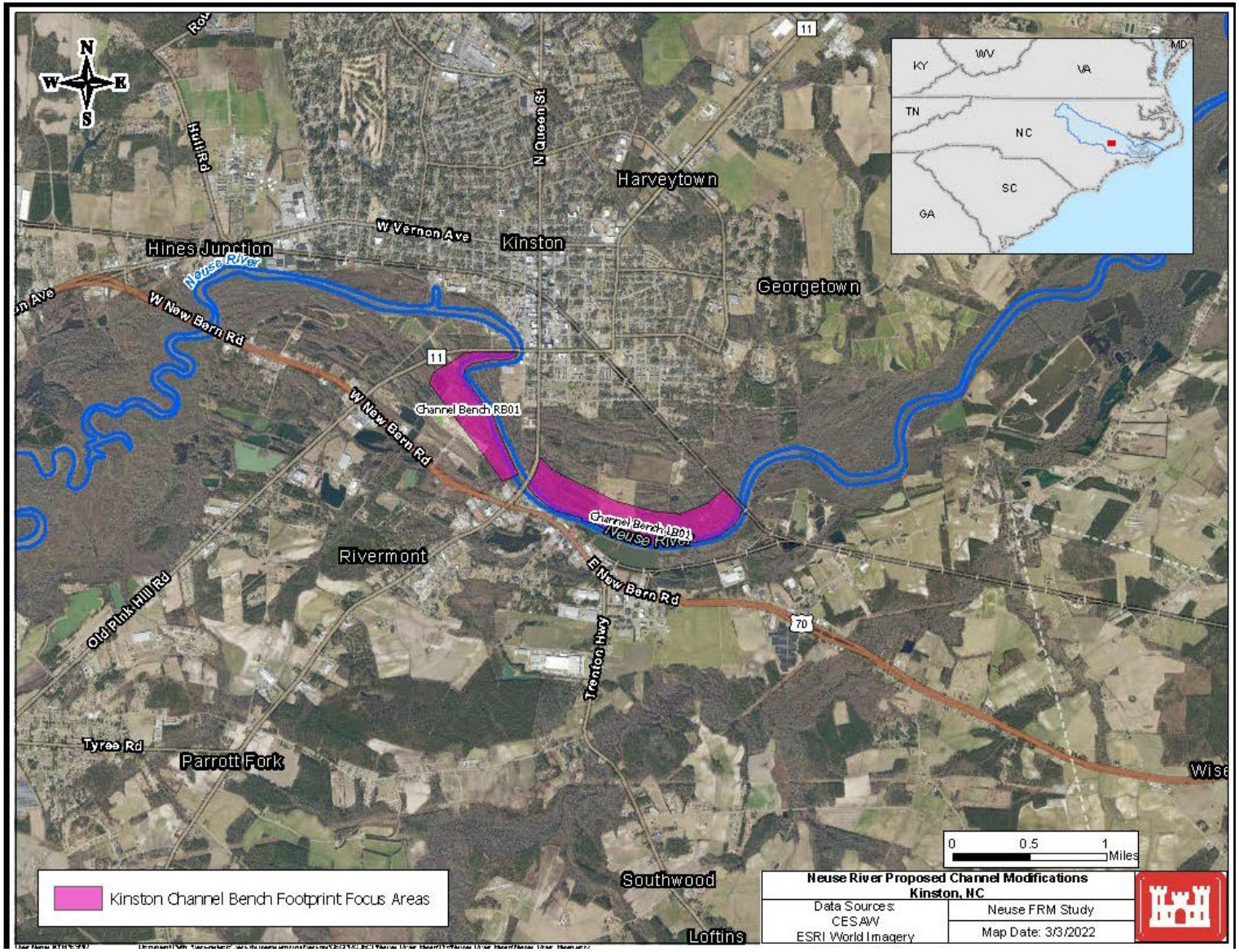

Figure 3-11 Neuse River Mainstem, Kinston, NC Structural Alternative MS-S1

MS-NS2 (Nonstructural): Structure Elevation and Floodproofing

This alternative included elevating approximately 365 structures, and floodproofing approximately 315 structures along the Neuse River mainstem for an estimated total of 680 structures. Figure 3-12 shows the location of alternative MS-NS2 in Wayne and Johnston Counties.

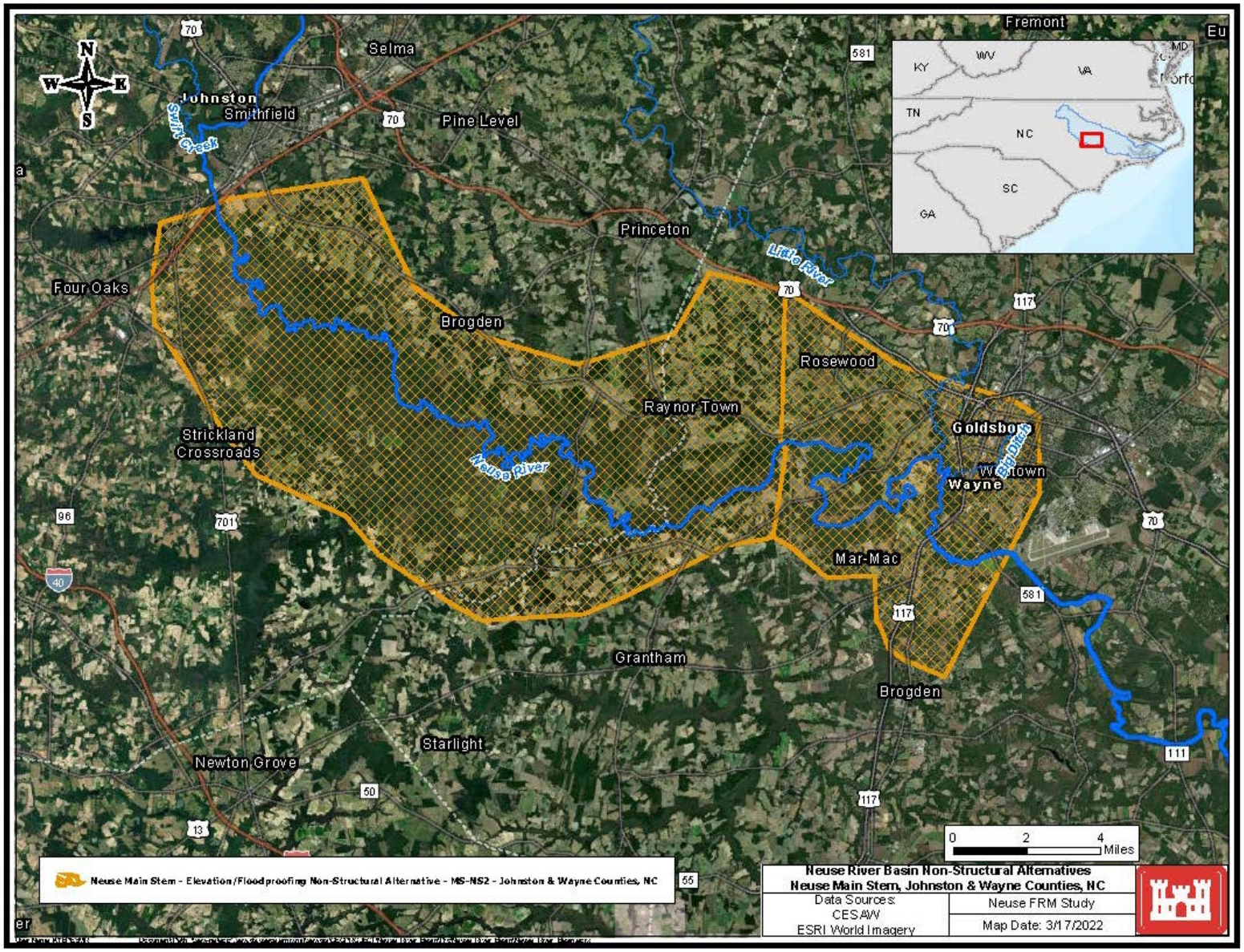

Figure 3-12 Neuse River Mainstem, Wayne/Johnston Counties, NC Nonstructural Alternative MS-NS2

MS-NS3 (Nonstructural): Property Buyouts

This alternative included acquisition of approximately 61 properties in Kinston and 67 properties in Goldsboro, for an estimated total of 128 properties, all located along the Neuse River mainstem. Figure 3-10 previously showed the location in which this alternative would be implemented west of Goldsboro, BD-NS2 (yellow highlighted area). Figure 3-13 shows the location of alternative MS-NS3 south of Kinston.

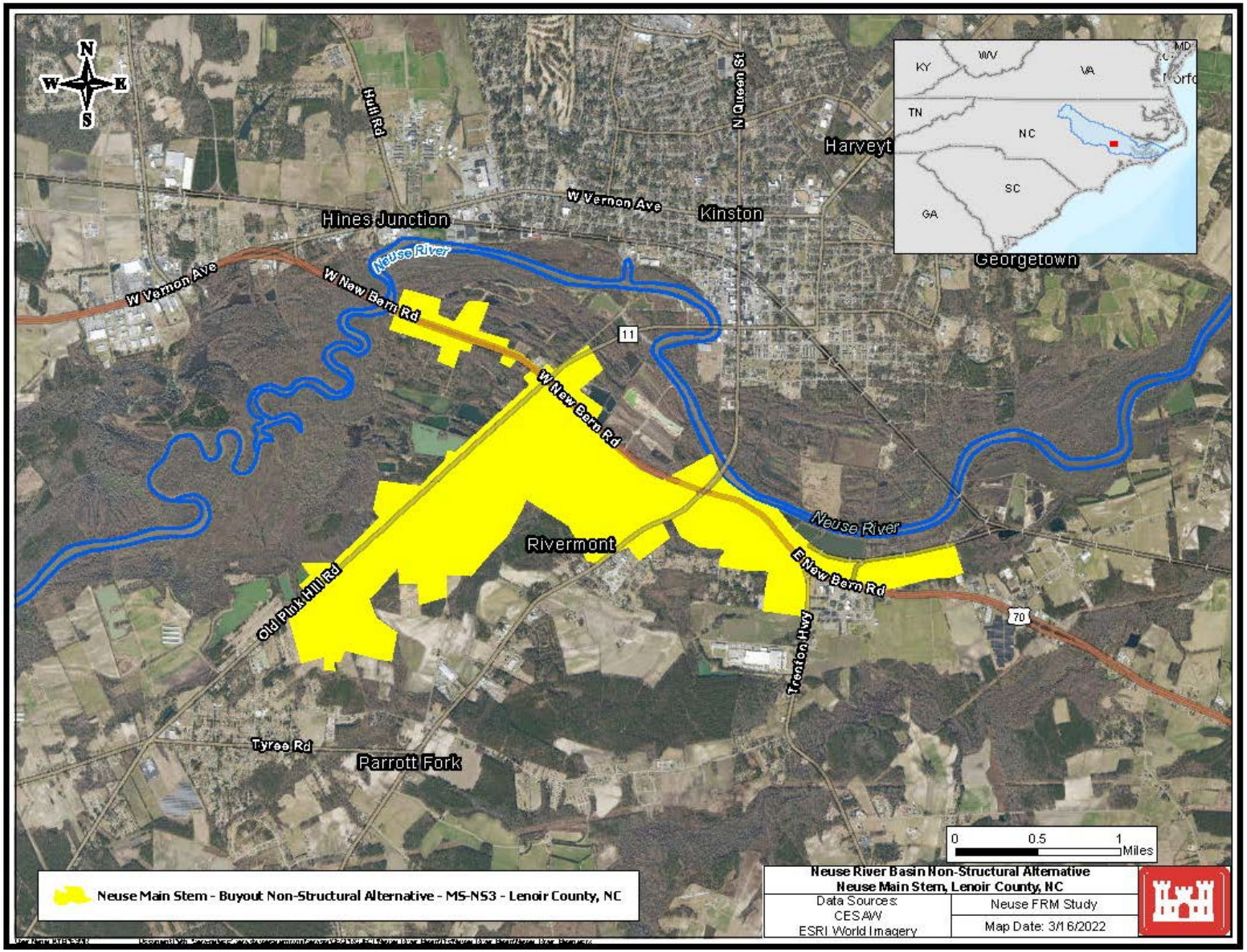

Figure 3-13 Neuse River Mainstem, Lenoir County, NC Nonstructural Alternative MS-NS3

Separable Area: Regional or Basinwide

The following measures were considered for inclusion with plans developed in the final basinwide array:

Measures:

F1 (NS): Public Outreach/Education Materials of Residual Risk in FWP conditions

This measure included the development of educational materials to describe residual flood risk in the Neuse River basin after implementation of this project.

F2 (NS): Flood Warning System Enhancements

Flood warning systems would provide more accurate information to allow individuals and decision-makers to make better informed decisions on whether to take emergency action, and when to do so. Streamflow gages are an important component of a flood warning system. Due to the large size of the Neuse River Basin, no individual flood warning system acts for the entire area. Rather, municipalities in different areas use different sets of stream gages. Through community outreach during this feasibility study, two opportunities were identified for flood warning system enhancements in the form of updated or additional stream gages. The first location is in the Eno River at the North Roxboro Street crossing in Durham County (USGS 02085070 Eno River Near Durham, NC) (Figure 3-14). This would consist of updating an existing stream gage to improve the accuracy of water volume estimations. The second location is in the Neuse River mainstem at the NC-43 (River Road) crossing, approximately 9 miles upstream of the City of New Bern (Figure 3-15). This consists of the addition of a new stream gage to improve warning times by providing stage data to the downstream communities in Craven County and the City of New Bern. There are currently approximately 50 stream gages in the Neuse River Basin which are operated by the U.S. Geological Survey (USGS), some of which arree maintained in partnership with USACE.

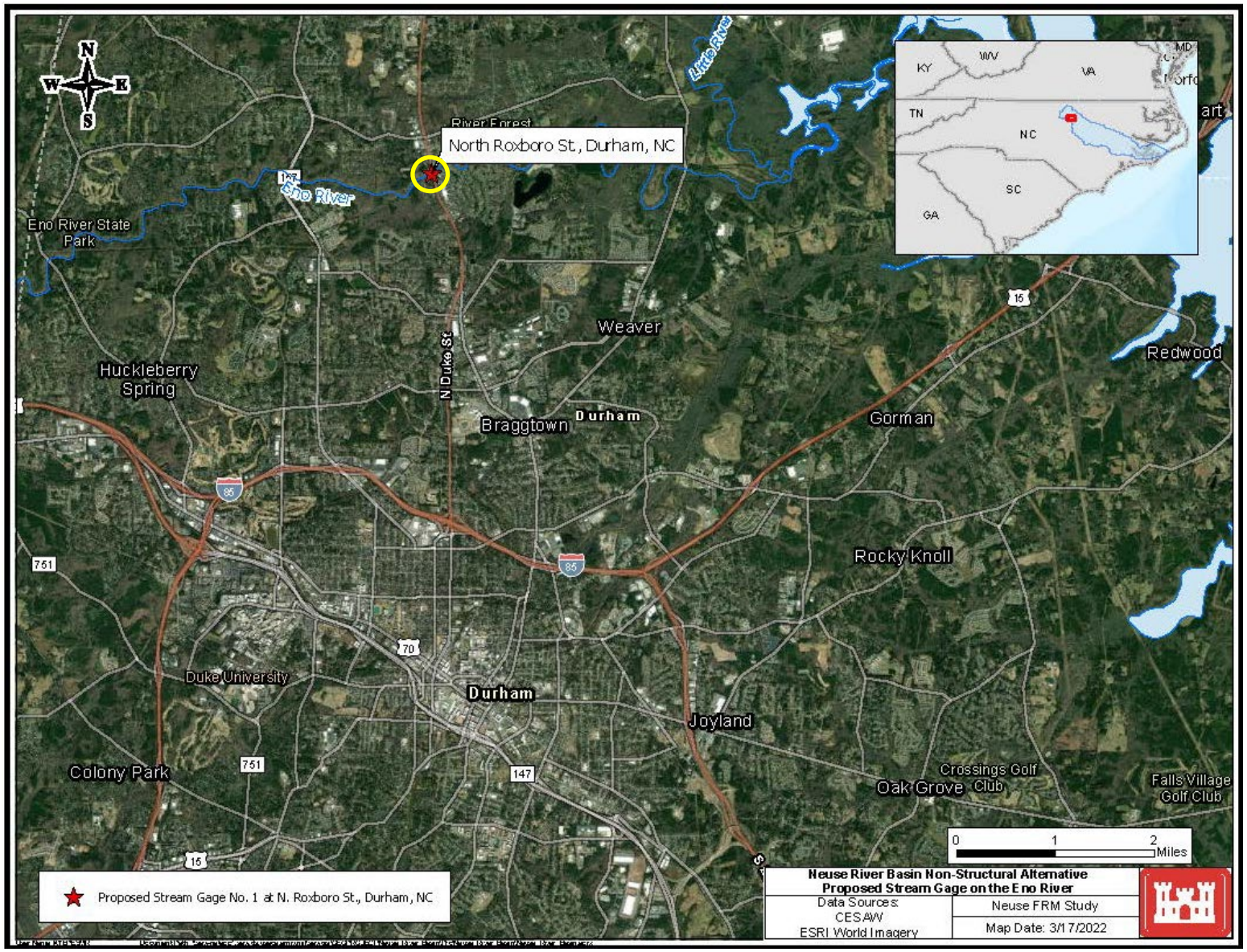

Figure 3-14 Eno River, Durham, NC Nonstructural Alternative F2, Stream Gage #1

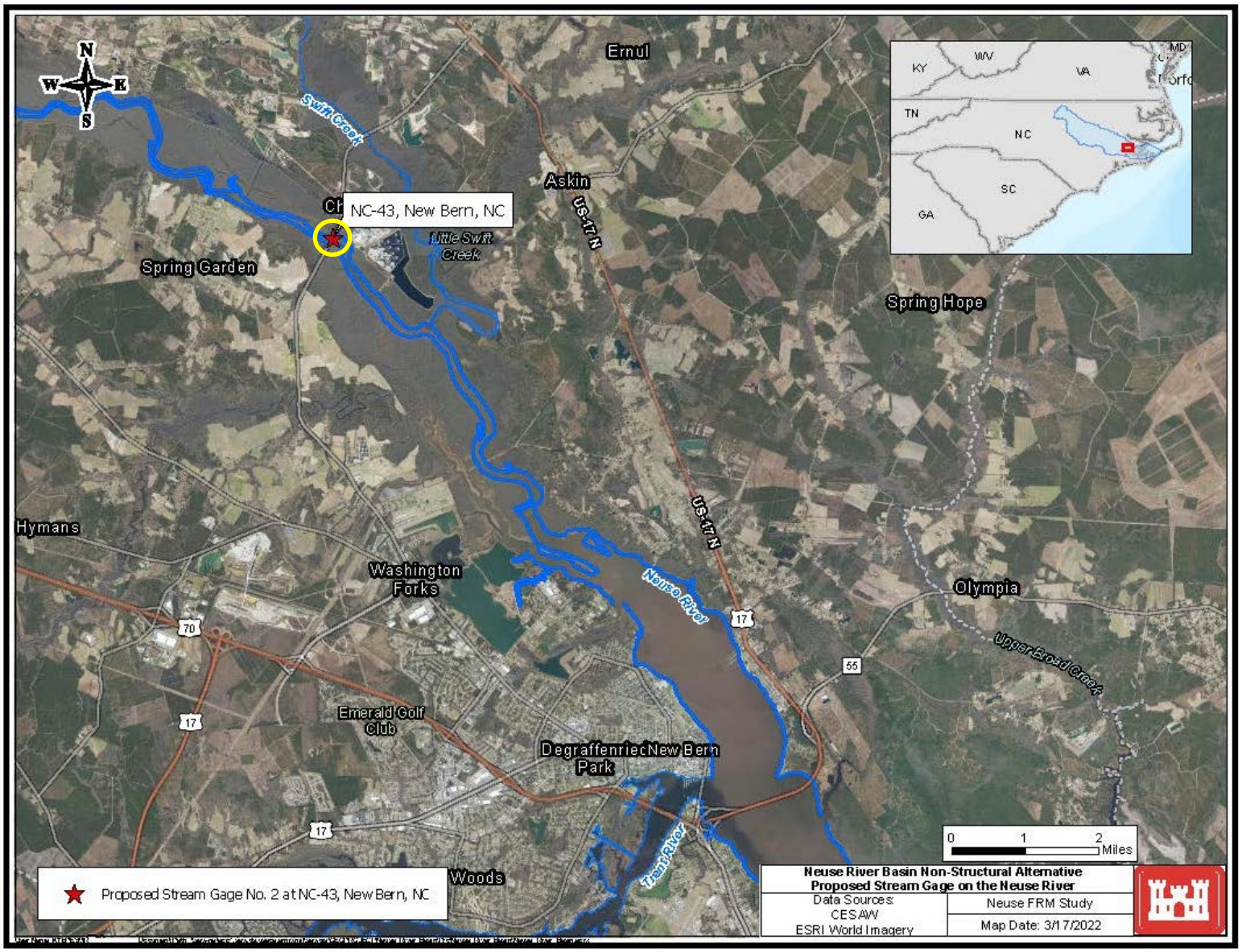

Figure 3-15 Mainstem Neuse River, New Bern, NC Nonstructural Alternative F2, Stream Gage #2

3.7. Alternative Evaluation and Comparison

3.7.1. Preliminary Alternatives by Separable Area

The alternatives developed for each separable area were evaluated against the four planning criteria of Completeness, Effectiveness, Efficiency, and Acceptability, as described in Section 3.4. For the Efficiency criteria, an economic assessment of costs and benefits was conducted and is summarized in Tables 3-7, 3-8, 3-9 and 3-10.

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Table 3-7 Economic Assessment of Alternatives for Hominy Swamp Creek (Wilson)

Alternative I.D.	Alternative	Net Benefits (Benefits minus Costs)	Total Project Cost (Millions)	BCR @2.25%	Screening	Reason
	No Action					
HS-S1	Channel Bench	<$0*	$59.2	<0.3*	Drop	Costs exceed benefits
HS-S2	Channel Bench and railroad culvert Improvement	<$0	$63.2	<0.3	Drop	Costs exceed benefits
HS-NS3	Structure Elevation and Floodproofing	$285,000	$4.8	2.8	Ultimately dropped	See Section 3.7.2
HS-NS4	Property Buyouts	$243,000	$7.8	1.9	Retain	Ultimately, costs exceeded benefits/retained for comparison
HS-C5	Channel Bench and Property Buyouts	<$0	$67.0	<0.3	Drop	Costs exceed benefits

**** Hominy Swamp Creek (HS-S1) initially appeared to provide preliminary benefits that exceeded the costs, which resulted in its inclusion in the basinwide final array. However, a more detailed analysis in the 5th iteration resulted in a BCR less than 0.3.***

Table 3-8 Economic Assessment of Alternatives for Crabtree Creek (Raleigh)

Alternative I.D.	Alternative	Net Benefits (Benefits minus Costs)	Total Project Cost (Millions)	BCR @2.25%	Screening	Reason
	No Action					
CTC-S3	Channel Bench and clearing & snagging	<$0	$86.7	<0.3	Drop	Costs exceed benefits
CTC-S4	Channel Bench, clearing & snagging and railroad flume	<$0	$88.3	<0.3	Drop	Costs exceed benefits
CTC-S5	Channel Bench, clearing & snagging, railroad flume and auxiliary culvert at N. Raleigh Blvd	<$0	$91.8	<0.3	Drop	Costs exceed benefits
CTC-NS6	Structure Elevation and Floodproofing	$59,000	$11.3	1.1	Retain	Scope Reduced – See Section 3.7.2

Table 3-9 Economic Assessment of Alternatives for Big Ditch (Goldsboro)

Alternative I.D.	Alternative	Net Benefits (Benefits minus Costs)	Total Project Cost (Millions)	BCR @2.25%	Screening	Reason
	No Action					
BD-NS1	Structure Elevation and Floodproofing	$950,000	$1.0	29.4	Ultimately dropped	See Section 3.7.2
BD-NS2	Property Buyouts	<$0	$7.5	<0.3	Drop	Costs exceed benefits/Retained for Comparison

Table 3-10 Economic Assessment of Alternatives for Neuse River Mainstem

Alternative I.D.	Alternative	Net Benefits (Benefits minus Costs)	Total Project Cost (Millions)	BCR @2.25%	Screening	Reason
	No Action					
MS-S1	Channel Modification (Channel Bench) near Kinston	<$0	$190.8	<0.3	Drop	Costs exceed benefits
MS-NS2	Structure Elevation and Floodproofing	$1,399,000	$73.9	1.6	Ultimately dropped	See Section 3.7.2
MS-NS3	Property Buyouts	$932,000	$30.6	1.4	Retain	Ultimately, costs exceeded benefits but retained for comparison

3.7.2. Additional Analysis of the Separable Areas

Notable changes were made to several alternatives after public, agency, and policy review of the draft IFR/EA. These changes are a result of several factors:

1) Optimization of the HEC-RAS models were completed which affected the water hydrographs and in effect reduced the identified flood risk in areas of the main stem Neuse River, and

2) Cost estimates of the alternatives were further refined.

These updated analyses resulted in an overall reduction of flood damages and benefits and an increase in alternative costs such that alternatives HS-NS3, BD-NS1, and MS-NS2 were no longer economically feasible. This also resulted a reduced number of structures in Crabtree Creek for elevation or floodproofing from 59 to 12 for alternative CTC-NS6 (Figure 3-16). Additionally, for alternative MS-NS2, structures within the upstream areas of the mainstem Neuse River between Smithfield and Goldsboro were eliminated as flood risk is significantly reduced with the updated hydraulics modeling.

Feedback during the public and agency review also resulted in the elimination of the previously identified flood warning system measures in Roxboro along the Eno River, and upstream of New Bern on the main stem of the Neuse River. This is due to redundancy with recent local community actions that were identified during the public and agency review process.

Based on available information through this stage of the study, any alternative that did not meet the four planning criteria was removed from consideration in the final array of basinwide alternatives, as summarized in Table 3-11.

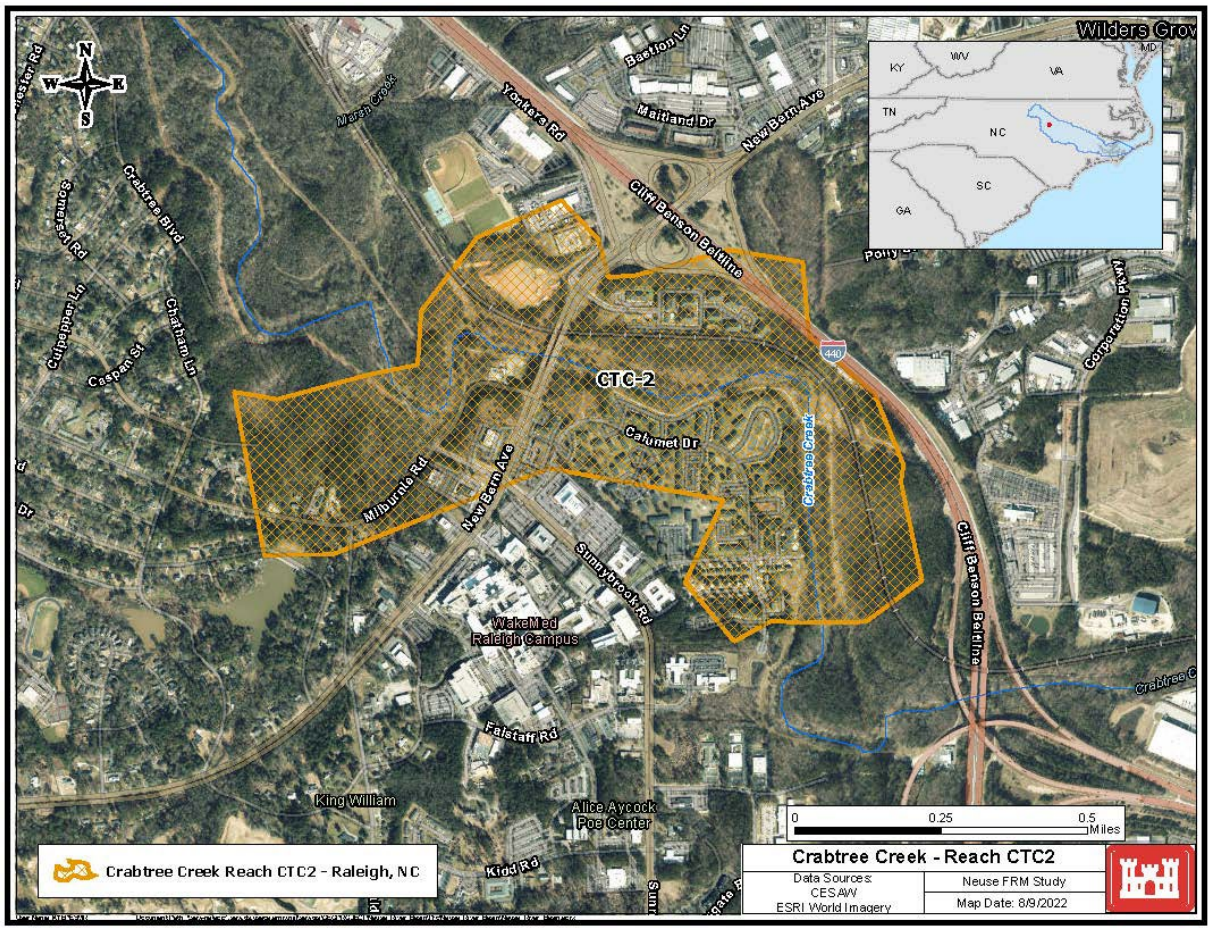

Figure 3-16 Crabtree Creek, Raleigh, Reach CTC2, Alternative CTC-NS6

Table 3-11 Evaluation of Separable Area Alternatives with Principles and Guidelines Screening Criteria

Alternative	Completeness	Effectiveness	Efficiency	Acceptability
HS-S1	Complete	Effective	No net benefits	Acceptable
HS-S2	Complete	Effective	No net benefits	Acceptable
HS-NS3	Complete	Effective	No net benefits	Acceptable
HS-NS4	Complete	Effective	No net benefits	Acceptable
HS-C5	Complete	Effective	No net benefits	Acceptable
CTC-S3	Complete	Effective	No net benefits	Acceptable
CTC-S4	Complete	Effective	No net benefits	Acceptable
CTC-S5	Complete	Effective	No net benefits	Acceptable
CTC-NS6	Complete	Effective	Positive net benefits	Acceptable
BD-NS1	Complete	Effective	No net benefits	Acceptable
BD-NS2	Complete	Effective	No net benefits	Acceptable
MS-S1	Complete	Effective	No net benefits	Acceptable
MS-NS2	Complete	Effective	No net benefits	Acceptable
MS-NS3	Complete	Effective	No net benefits	Acceptable

After evaluation and comparison of alternatives for each separable area, all structural or combined alternatives were screened based on the *Efficiency* criteria, as estimated costs were disproportionately greater than estimated benefits. Similarly, all nonstructural alternatives were also screened based on the Efficiency criteria with the exception of alternative CTC-NS6, which only consisted of structure dry floodproofing.

The plan formulation strategy for combining alternatives from separable areas into a final array of basinwide alternatives was straightforward, in part due to the limited variety of viable options. The strategy is as follows:

1. Separable area National Economic Development (NED) plans were combined for a basinwide NED plan. NED reflects the net difference between the annualized benefits and costs for an alternative. A NED greater than $0 indicates that the BCR is also greater than 1.0, and economically feasible.

2. Alternatives were combined into a property buyout-only plan as another option

3. A public outreach/education (F1) is added to each plan in the final array.

During the fourth iteration analysis of separable area alternatives, combining structure elevation with property buyouts was evaluated; however, these two options addressed some of the same structures, and the structure elevation and floodproofing option resulted in greater net benefits for each separable area.

Separable area alternatives were combined as follows into a final array of basinwide alternatives. The flood risk reduction measures for each of the alternative codes listed

below are described in Tables 3-7, 3-8, 3-9 and 3-10 and the separable area codes and type of alternative are repeated below:

Alternative 1: No Action

Alternative 2: CTC-NS6 + F1

Alternative 3: HS-NS4 + BD-NS2 + MS-NS3 + F1

Table 3-6 Legend for Descriptions of Alternatives (Repeated)

HS (Hominy Swamp Creek)	**S** (Structural alternative)
CTC (Crabtree Creek)	**NS** (Nonstructural alternative)
BD (Big Ditch)	**C** (Combined structural/nonstructural)
MS (Mainstem of the Neuse River)	**Example:** CTC-NS6 = Crabtree Creek - Nonstructural alternative #6
F1 (Public Outreach and Education of Basinwide Residual Flood Risk)	**Example:** BD-NS2 – Big Ditch - Nonstructural alternative #2

3.7.3. Final Basinwide Alternatives Array

This section describes the alternatives in the final basinwide array. Definitions associated with the plans are provided prior to the alternative descriptions:

Definitions:

Nonstructural Measures – Permanent or contingent measures applied to a structure and/or its contents that reduce the risk of damages that could result from flooding. Nonstructural measures differ from structural measures (i.e., levees, floodwalls, etc.) in that they focus on reducing the consequences of damages from riverine flood risks rather than reducing the probability of damages from riverine flooding. Nonstructural measures include:

Floodproofing – Any combination of structural and nonstructural additions, changes, or adjustments to structures which reduce the risk of flood damage to improved real property, water and sanitary facilities, structures and their contents (Figure 3-5) including:

> **Dry floodproofing** makes the structure watertight below the level for which flood risk management is provided by preventing floodwaters from entering the structure. Dry floodproofing may include one or more of the following methods: using waterproof membranes or sealants to reduce seepage of floodwater through walls; use of watertight shields for doors and windows; and/or installing measures to prevent sewer backup.

Acquisition (Property buyouts) – Acquisition, also referred to as property buyouts, refers to buying the structure and the associated land to manage risk in the floodplain. The buildings are either demolished or sold to others and relocated outside of the floodplain. Land acquisition can be in the form of fee title or permanent easement with fee title. After acquisition, the land must be maintained as open space through deed restrictions that prohibit any type of development that can sustain flood damages or restrict flood flows. Lands acquired as part of a nonstructural project may be converted to a new use such as ecosystem restoration and/or recreation that is consistent with open space restrictions. Examples could include trails, shoreline access, and interpretive markers.

Final Basinwide Array:

Alternative 1 – No Action

The future without-project condition, or the no-action plan, is Alternative 1. This alternative is the scenario that would most likely occur in the absence of a federal plan. The No Action plan would likely result in repeated flooding in an area where hurricanes, extreme tropical storms and other potential events bring heavy rainfall each year. Under this alternative, structures would continue to be inundated as outlined in Section 2 of this report.

Alternative 2 – Structure Dry Floodproofing

Alternative 2 is a nonstructural plan that included dry floodproofing of 12 structures adjacent to Crabtree Creek in Raleigh, NC in Reach CTC-2 (Figure 3-16).

Dry floodproofing makes a structure watertight below the level for which flood risk management is provided by preventing floodwaters from entering the structure. The specific nonstructural measures would be reviewed and refined in any potential subsequent detailed design phase. Specifically, dry floodproofing actions for each structure could include some or all of the following: sealing ground level doors and installing hardware to allow the use of drop-in flood shields; elevating external mechanical equipment such as HVAC units; floodproofing or raising electrical service connections; sealing utility pipes and/or plumbing penetrations; replacing gutters and downspouts; installing a sewer backflow check valve; and resealing and replacing grout masonry joints. Buildings constructed of poured concrete, concrete masonry, or brick are suitable for dry floodproofing. The total implementation period for this alternative is approximately 2.5 years with 100 percent homeowner participation. Illustrations are shown in Figure 3-17.

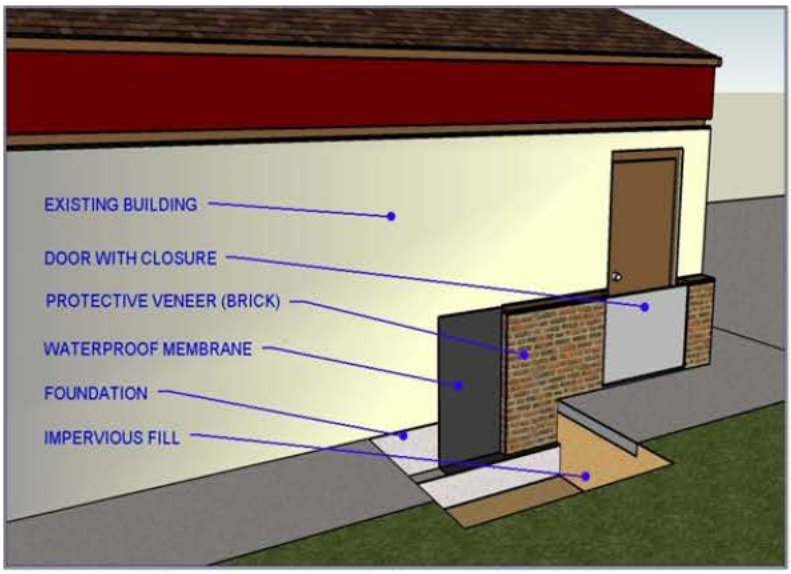

Figure 3-17 Illustrations of Structure Floodproofing

Example of Raising Utilities above Design Flood

Example of Applying Water Resistant Materials to Building

A detailed Emergency Evacuation Plan would be developed to complement Alternative 2. This plan would be expanded and enhanced during potential subsequent detailed design phase by the non-Federal entity and other emergency planning officials and officers. The primary purpose of the emergency evacuation plan is to help ensure that life-safely risk to the public is minimized upon implementation of this nonstructural plan focusing on the following factors: flood warning recognition and warning timeframes; notification; evacuation; coordination of temporary housing; installation and removal of floodproofing measures; flood recovery/cleanup; and safe return of residents back to their residences. Also, this action plan would ultimately establish the appropriate responsibility by specific name/person/facility owners and/or local officials for accomplishing each activity (Who, What, When and How).

This alternative also included development of public education materials highlighting residual, or remaining, flood risks throughout the Neuse River basin.

Alternative 3 – Property Buyouts

Alternative 3 is a property buyout/acquisition plan that included buying out 126 structures and their associated land in certain areas along the main stem of the Neuse River near Goldsboro and Kinston, Big Ditch in Goldsboro, and along Hominy Swamp Creek in Wilson. The total implementation period for this alternative is approximately 2 years with 100 percent homeowner participation. These areas cover a mix of residential neighborhoods, business areas, and rural areas. Structures included in these polygon areas are limited to those damaged by the 10% AEP flood event (Table 3-12).

Table 3-12 Alternative 3 Measures Summary

Separable Area	Reach	Structure Count 10% AEP Flood Event
Neuse River Mainstem	MS3, MS5	83
Big Ditch	BD1, BD2	20
Hominy Swamp	HS1-HS7	23
Total		**126**

To formulate this alternative, areas were drawn throughout the Neuse River basin that were in the 0.2% AEP floodplain and contained significant clusters of structures that appeared to be incurring damages. Then, HAZUS damages were used to calculate preliminary Expected Annual Damages (EAD) and eliminate areas that did not incur sufficient damages to cover partial costs (only demolition cost estimates were used at this time). The remaining areas included three polygons located in Kinston (Neuse River mainstem and Big Ditch), Goldsboro (Neuse River mainstem), and Wilson (Hominy Swamp Creek). Additionally, HAZUS damages were used to calculate preliminary aggregate EAD for each census tract in the basin. Damage estimates for census tracts were compared to partial costs (demolition costs were used) across 188 census tracts. Only one census tract, in Seven Springs, indicated that the estimated benefits were higher than demolition costs. This tract was added to the buyout polygon areas but was later removed due to the State of North Carolina projected property buyouts in this area.

Once damages were modeled in the HEC-FDA economics model, damages for the identified areas for the 1% and 10% AEP flood events are evaluated with full costs for buyout and acquisition. Structures damaged by the 10% AEP flood event in these areas were kept in the final alternative, since this maximized net NED benefits.

Property buyouts consisted of buying the structure and the associated land as defined above.

3.7.4. Economic Assessment of Final Array of Alternatives

3.7.4.1 Alternative 2 Benefits

Benefits are displayed for the reaches included in the final array.

In Crabtree Creek, Raleigh, NC, the 1% AEP flood event maximized net benefits and is included in the final array. The total average annual benefits in Crabtree Creek are approximately $583,000. (Table 3-13).

Table 3-13 Crabtree Creek Equivalent Annual Benefits, FY 2023 Price Levels, 2.50% Discount Rate

Reach	Structure and Contents	Other Related Damages	Total
CTC2	$542,000	$41,000	$583,000
Total	**$542,000**	**$41,000**	**$583,000**

NOTE: Reaches CTC1, CTC3, CTC4, CTC5, CTC6 and CTC7 resulted in zero equivalent annual benefits.

Total equivalent annual benefits for Alternative 2 are approximately $583,000 (Table 3-14).

Table 3-14 Alternative 2, Total Equivalent Annual Benefits, FY 2023 Price Levels, 2.50% Discount Rate

Area	Equivalent Annual Benefits
Crabtree Creek, Raleigh, NC	$583,000
Total	**$583,000**

3.7.4.2 Alternative 3 Benefits

The table below displays total average annual benefits for the property buyout alternative. Potential buyout areas were delineated prior to HEC-RAS/FDA models being completed, and therefore covered multiple modeling reaches. Associated reaches for the buyout areas are displayed below. Alternative 3 had a BCR of 0.6, and approximately $2 million in annual benefits would need to be generated from alternate use of the floodplain to increase the BCR to 1.0 or above. Looking at recreation unit day values only, this would equate to an aggregate of roughly 1,218 visitors per day to whatever recreation sites would be created in place of the structures. Anticipating this large number of daily visitors to this area for any new recreational opportunity is considered highly unlikely. Also, this assumption did not consider any additional costs from converting the current space into recreation areas. Therefore, alternative uses of the floodplain in the form of recreation are not included in the benefit-to-cost analysis for Alternative 3. The PDT did not anticipate any tangible ecosystem restoration benefits.

Total average annual benefits for Alternative 3 are approximately $2.4 million. These benefits include the damages reduced by removing the structures in the buyout areas indicated (Table 3-15). Reaches not listed resulted in zero equivalent annual benefits.

Table 3-15 Alternative 3, Total Equivalent Annual Benefits, FY 2023 Price Levels, 2.50% Discount Rate

Area	Equivalent Annual Benefits	Reaches
Neuse River Mainstem (MS-NS3)	$1,573,000	MS3, MS5
Big Ditch, Goldsboro, NC (BD-NS2)	$328,000	BD1, BD2
Hominy Swamp Creek, Wilson, NC (HS-NS4)	$525,000	HS1-HS7
Total	**$2,426,000**	

3.7.4.3 Costs

Costs were prepared by Cost Engineering for each of the screened structural alternatives. As previously stated, costs for structural alternatives far outweighed the benefits in all the separable areas and no structural alternatives are included in the final array of alternatives.

Costs for structure elevation and floodproofing were taken from the Civil Works Construction Cost Index System (CWCCIS) and reviewed by Cost Engineering. A Total Project Cost Summary (TPCS) was prepared by Cost Engineering after completion of a preliminary screening of nonstructural measures. Costs included real estate administration costs, contingency, and interest during construction (IDC). IDC for structure floodproofing is computed for a three-month period at the current discount rate of 2.50 percent.

Costs for property buyouts and acquisitions were prepared by Real Estate and Cost Engineering and include demolition costs, and the market value cost of the structure and land. Contingency and IDC are also included.

All costs are at FY 2023 price levels and reflect a project life cycle of 50 years at a discount rate of 2.50 percent.

Total project costs for Alternative 2 are approximately $6.6 million, and including interest during construction, average annual costs are approximately $230,000. Total project costs for Alternative 3 are approximately $116.6 million, and including interest during construction, average annual costs are approximately $4.1 million (Table 3-16).

Table 3-16 Alternatives 2 and 3, Project Costs, FY 2023 Price Levels, 2.50% Discount Rate

	Alternative 2 Structure Floodproofing	Alternative 3 Property Buyouts/ Acquisitions
Construction Cost		
Hominy Swamp Creek		$6,300,000
Crabtree Creek	$4,200,000	
Big Ditch		$10,800,000
Neuse River Mainstem		$32,900,000
Subtotal Project Costs	$4,200,000	$50,000,000
Lands and Damages	$1,200,000	$51,600,000
Planning, Engineering, and Design	$700,000	$7,500,000
Construction Management	$500,000	$7,500,000
Total Project Costs	$6,600,000	$116,600,000
Interest During Construction	$10,000	$1,000,000
Total Gross Investment	$6,610,000	$117,600,000
Average Annual Cost	**$230,000**	**$4,100,000**

3.7.4.4 Benefit-to Cost Analysis

NED benefits, the benefit-to-cost ratio, and the net NED benefits are calculated during the evaluation process. Net benefits represent the amount by which annual NED benefits exceed annual costs, thereby defining the plan's contribution to the economic output of the nation. The benefit-to-cost ratio informs the likely economic feasibility of a project. A project is considered feasible if it has positive net benefits and a BCR of 1.0 or greater. Average annual costs and benefits, annual net benefits, and the BCR are presented in this section for the final array of alternatives.

Table 3-17 shows that Alternative 2 results in net NED benefits of about $350,000, while Alternative 3 results in negative net annual benefits of -$1.7 million. Alternative 2 is therefore the plan that maximizes net annual NED benefits, also is the NED plan.

Table 3-17 Alternatives 2 and 3, Net Benefit Comparison, FY 2023 Price Levels, 2.50% Discount Rate, 50-year Period of Analysis

Category	Alternative 2 Structure Floodproofing	Alternative 3 Property Buyouts/ Acquisitions
Equivalent Annual Benefits	**$580,000***	**$2,400,000***
Hominy Swamp Creek		$500,000
Crabtree Creek	$580,000	
Big Ditch		$300,000
Neuse River Mainstem		$1,600,000
Average Annual Costs	**$230,000**	**$4,100,000**
Net Annual Benefits	**$350,000**	**-$1,700,000**

*Rounded to nearest $1,000

Table 3-18 displays average annual costs and benefits and the benefit-to-cost ratio (BCR). The BCR is 2.5 for Alternative 2 at the current discount rate of 2.50 percent and is 0.6 for Alternative 3 at the same discount rate.

Table 3-18 Alternatives 2 and 3, Benefit-to-Cost Analysis, FY 2023 Price Levels, 2.50% Discount Rate, 50-year Period of Analysis

	Alternative 2 Structure Floodproofing	Alternative 3 Property Buyouts/ Acquisitions
Average Annual Cost	$230,000	$4,100,000
Equivalent Annual Benefits	$580,000	$2,400,000
Net Annual Benefits	$350,000	-$1,700,000
Benefit-to-Cost Ratio	**2.5**	**0.6**

3.7.5. Principles and Guidelines Benefit Accounts

The System of Accounts defined by the Principles and Guidelines (para. 1.6.2(c)) is used to compare plans which are in the final array of basinwide alternatives. The four accounts used to compare proposed water resource development plans are the National Economic Development (NED), Regional Economic Development (RED), Environmental Quality (EQ) and Other Social Effects (OSE) accounts.

3.7.5.1 National Economic Development (NED) account

The NED Account represents increases in the net value of the national output of goods and services, expressed in monetary units, and are the direct net benefits that accrue in the planning area, and the rest of the Nation. The benefits, average annual cost and total cost are based on the monetary costs or damages prevented and are ranked accordingly. Additional information can be found in Appendix B (Economics).

3.7.5.2 Regional Economic Development (RED) account

The Regional Economic Development (RED) account registers changes in the distribution of regional economic activity that result from each alternative plan. The RED account displays information not analyzed in other accounts in this Technical Report that could have a material bearing on the decision-making process. Regional economic impacts and contributions are measured as economic output, jobs, income, and value added, based on multipliers that require construction dollars to be spent in order for a regional economic impact to occur. For the complete RED analysis, refer to Appendix B (Economics).

3.7.5.3 Environmental Quality (EQ) account

The Environmental Quality (EQ) account is an assessment of favorable or unfavorable ecological, aesthetic and cultural or natural resource changes. This review is conducted with the participation of agencies, local governments, and stakeholders through an on-going and engaging series of scoping meetings, public input meetings, agency and stakeholder meetings, and on-site meetings, and would have continued throughout the feasibility study process.

3.7.5.4 Other Social Effects (OSE) account

The Other Social Effects (OSE) account considers the effects of alternative plans in areas not already contained in the NED and RED accounts. The categories of effects contained within the OSE account include: urban and community impacts; displacement; long-term productivity; and public health and safety. Additional information can be found in Appendix B (Economics).

3.7.5.5 Comprehensive Documentation of Four Benefit Accounts

The 5 January 2021 memorandum “SUBJECT: POLICY DIRECTIVE – Comprehensive Documentation of Benefits in Decision Document,“ provides policy direction on the assessment and documentation of benefits for USACE water resources planning.

Per Section 7(e) of the Directive, studies fall under one of three categories (dependent on when the study initiated) which guide the level of implementation expected by the Directive. The following are the three categories as described in the Policy Directive. The Neuse River Basin Flood Risk Management Feasibility Study falls into category 7(e)(2), which is delineated in the red outline below.

1) Studies that have completed the Tentatively Selected Plan (TSP) milestone will document total benefits inclusive of all benefit types for the TSP. At a minimum, benefits will be described qualitatively for those benefits categories for which analysis is not included in the approved study plan.

(2) Studies that were underway but have not yet completed the TSP milestone will document total plan benefits inclusive of all benefit types for each alternative plan, either quantitatively or qualitatively, and fully consider such information in the decision-making process.

(3) Future detailed studies will include comprehensive analysis of the total benefits of each plan including equal consideration of all benefit types in the study scope of work. When determining the scope of work, the PDT must collaborate with the non-Federal sponsor and consider the views of the public and stakeholders.

To meet the 5 January 2021 Policy Directive, meaningful factors were identified for each of the 4 accounts to be evaluated with respect to how they would be impacted by each alternative in the final array (Table 3-19). Methods of evaluation were chosen, both qualitative and quantitative.

Table 3-19 Factors Evaluated for the Four Benefit Accounts

National Economic Development (NED)	Regional Economic Development (RED)
Structure and Content Damage	Jobs
Vehicle Damage	Labor Income
Emergency Costs	Value Added
Other Social Effects (OSE)	**Environmental Quality (EQ)**
Health and Safety	Habitat Change
Business Climate	Threatened & Endangered Species Risk
Community Cohesion	Cultural Resources Sites
Cultural/Community Identity	Historic Structures
Social Vulnerability and Resiliency	
Public Participation	
Recreational Opportunities	

Incorporating Other Social Effects (OSE) Into Formulation of Alternatives

Due to the large study area of approximately 6,200 square miles spanning 18 counties, the Project Delivery Team (PDT) used existing data to assist in determining areas of concentrated flood risk, and to identify which areas would be assessed with additional detailed modeling and analysis, including OSE. The PDT took the following steps during formulation:

- Identified concentrated areas of flood risk by using existing data to identify the extent of flood risk within the basin. This allowed screening that focused on areas within the Neuse River basin where additional detailed modeling and analysis could be applied within a 3x3x3 study
- Conducted more detailed analysis which included HEC-RAS and HEC-FDA models for areas where there is a potential for federal interest as defined by the Corps
- Evaluated Other Social Effects which included Life-safety and Social Vulnerability in areas where there is potential for federal interest (which included areas which ultimately did not have federal interest)

Factors assessed for OSE included Health and Safety, Economic Vitality, Social Connectedness, Social Vulnerability and Resiliency, and Participation. These factors are assessed both qualitatively and quantitatively, where possible. The PDT relied most heavily on Life-Safety Risk and Social Vulnerability in combination with Flood Risk in considering Other Social Effects during plan formulation and screening of measures. The LifeSim 2.0 model was used to assess life-safety risk for FWOP conditions. The Center for Disease Control (CDC) Social Vulnerability Index 2018 data was used to identify census tracts with socially vulnerable populations. This analysis is summarized in Table 3-20.

Table 3-20 Flood Risk and OSE

		Flood Risk and OSE			
REACH	**# Of Structures damaged at 10% event out of number of structures damaged for all events***	**Total Without Project EAD** for all events***	**Total EAD** divided by number of damaged structures**	**Life-Safety Risk (all events)**	**Social Vulnerability (CDC SVI)** 0.75 – 1.0 (highest vulnerability) 0.50 – 0.75 (above average vulnerability) 0.25 – 0.5 (below average vulnerability) 0.00 – 0.25 (lowest vulnerability)
Crabtree Creek					
CTC1	(1/3)	$300	$100	No	Above average
CTC2	(12/16)	$767,000	$47,900	No	Highest
CTC3	(1/33)	$48,000	$1,454	No	Highest
CTC4	(51/192)	$411,000	$2,140	No	Lowest/above average mix
CTC5	(7/94)	$69,000	$734	No	Lowest
CTC6	(5/22)	$67,000	$3,045	No	Lowest/below average mix
CTC7	(1/6)	$8,000	$1,333	No	Lowest/above average mix
Hominy Swamp Creek					
HS1	(6/11)	$130,000	$11,818	No	Highest
HS2	(15/60)	$107,000	$1,783	No	Highest
HS3	(16/58)	$286,000	$4,931	No	Highest
HS4	(18/34)	$137,000	$4,029	No	Highest
HS5	(9/28)	$161,000	$5,750	No	Highest
HS6	(12/45)	$75,000	$1,666	No	Lowest
HS7	(6/22)	$22,000	$1,000	No	Highest
Neuse River Mainstem					
MS2	(254/1032)	$1,151	$1,151	No	Above average/Highest mix
MS3	(181/2330)	$1,333	$1,333	No	Above average/Highest mix
MS4	(0/1644)	$2,003	$2,003	No	Low/High/Highest mix
MS5	(0/1959)	$2,796	$2,796	No	Above average/Highest mix
MS6	(100/391)	$3,056	$3,056	No	Above average/Highest mix
MS7	(35/476)	$1,245	$1,245	No	Above average/Highest mix
MS8	(3/97)	$773	$773	No	Below average/Above average mix

NOTE: This table reflects preliminary damage estimates used for screening, which differ from the final estimates that are shown in Appendix B (Economics)

* The upper limit event for this analysis is the 0.2% (500-year) event

** Estimated Annual Damages (EAD)

Synopsis of Table 3-20:

a. Excluding Reach MS1 on the Neuse River in the New Bern area, no significant Life-Safety risk is estimated for any reach evaluated during this study.

b. Reach CTC2 on Crabtree Creek in the Raleigh area has some of the highest social vulnerability values, included the greatest percentage of structures damaged by the 10% annual exceedance probably (AEP) flood event and the highest per structure damage over a range of flood events.

c. Ultimately, no areas are recommended for justification solely based on OSE due to the relatively limited flood risk. Areas with the greatest flood risk in the coastal area (New Bern vicinity) would require a separate future coastal study.

The following paragraphs summarize the evaluation of the final array of alternatives against the four Accounts. For a more detailed description of the NED, RED, and OSE Accounts analysis, see Appendix B (Economics).

Summary of NED, RED, EQ and OSE benefits:

NED Benefits

- Alternative 2 maximizes net NED benefits. Alternative 2 is therefore, the NED and the Recommended Plan. Annual net benefits are approximately $350,000 at FY 2023 price levels at a discount rate of 2.50 percent. The benefit-to-cost ratio for Alternative 2 is 2.5. **Alternative 2 (Structure floodproofing)** decreases equivalent annual damages from $2.7 million under the without-project condition to $2.1 million under the with-project condition within reach CTC2 in Crabtree Creek, Raleigh, NC.

- **Alternative 2 *(Structure floodproofing)*** maximizes NED benefits.

RED Benefits

- Considered factors are Jobs, Labor Income and Value Added

- RECONS model utilized

- Regional Economic Development is quantified by the RECONS model. For Alternative 2, nationally, the total number of full-time equivalent jobs created in the state is estimated at 117. Total value added at the state level exceeds $10 million. In the absence of a federal project, regional economic development would likely decline due to repeated flooding in the area. For Alternative 3, the RECONS model could not accurately assess RED for property buyouts because

they are not typical civil works construction activities. Therefore, the RED for this alternative cannot be determined using this model.

- **Therefore, neither Alternative 2 *(Structure floodproofing)* nor Alternative 3 *(Property buyouts)*** can either be conclusively identified as maximizing RED benefits.

EQ Benefits

- See Chapter 4, *Affected Environment and Environmental Consequences* for a more thorough discussion of potential impacts to environmental and cultural resources associated with each alternative.
- Considered factors are Habitat Change, Threatened, Endangered and Sensitive Species Risk, Cultural Resources Sites and Historic Structures
- Qualitative evaluation
- ***Alternative 1 (No Action)*** would be expected to have some negative impacts on environmental and cultural resources associated with continued erosion and flood events.
- ***Alternative 2 (Structure Floodproofing)*** could have a positive effect on cultural resources by reducing their risk to flood damage through structure floodproofing.
- ***Alternative 3*** **(Property Buyouts)** would have some positive impacts, albeit minimal, to the floodplain, water quality, and biological resources through the removal of structures from the floodplain, and the return of vegetative buffers. There is potential for negative impacts on cultural resources if historic structures are acquired.
- **Alternative 3** would be the preferable EQ alternative.

OSE Benefits

- Considered factors are Health and Safety, Business Climate, Community Cohesion, Cultural/Community Identity, Social Vulnerability and Resiliency, Public Participation, and Recreational Opportunities
- Per Center for Disease Control (CDC) data, the project area has many highly vulnerable populations.
- Other Social Effects included life-safety risk and social vulnerability for the future without-project condition and future with-project condition. Social vulnerability is reduced by Alternative 2 by floodproofing structures that would otherwise be

damaged in event of a flood in Crabtree Creek in Raleigh, NC. Furthermore, social cohesion is preserved by Alternative 2, which allows residents to remain in their current houses and communities, rather than relocating them outside the floodplain. In the absence of a federal project, socially vulnerable individuals would continue to suffer from the effects of repeated flooding.

- ***Alternative 2 (Structure Floodproofing) -*** while benefiting *Health and Safety*, this alternative could produce positive impacts to OSE associated with *Community Cohesion* and *Cultural/Community Identity*.
- ***Alternative 3 (Property Buyouts) -*** while benefiting *Health and Safety*, this alternative could produce negative impacts to OSE associated with *Community Cohesion* and *Cultural/Community Identity*.
- **Alternative 2** is identified as the preferred OSE alternative. Relevant to the EJ40 Initiative, 100% of overall benefits from this plan flow to disadvantaged communities.

The 5 January 2021 Policy Directive further states that each study must include, at a minimum, the following plans in the final array of alternatives for evaluation:

1. The "No Action" alternative ***(Alternative 1)***
2. A plan that maximizes net total benefits across all benefit categories ***(Alternative 2)***
3. A plan that maximizes net benefits consistent with the study purpose (NED for this study) ***(Alternative 2)***
4. For flood-risk management studies, a nonstructural plan ***(Alternative 2)***
5. There is no locally preferred plan

3.7.6. Principles and Guidelines Criteria

This section summarizes and compares the final array of basinwide alternatives with respect to the four Principles and Guidelines criteria.

Completeness: Alternatives 2 (Structure Floodproofing) and 3 (Property Buyouts) are complete in that they account for all necessary investments or other actions to ensure the realization of the planned effects (Table 3-21). Alternative 1 (No Action) is incomplete because it did not meet any of the planning objectives (Table 3-21).

Effectiveness: Alternatives 2 (Structure Floodproofing) and 3 (Property Buyouts) are both effective in that they would—to some extent—address one or more of the problems

while achieving one or more of the objectives (Table 3-21). Alternative 1 (No Action) ineffective because it would not address any of the specified problems or objectives (Table 3-21).

Efficiency: Alternative 2 (Structure Floodproofing) has positive net benefits and is economically justified. Alternative 3 (Property Buyouts) has negative net benefits and, thus, is not economically justifiable (Table 3-21).

Acceptability: The No Action and Alternative 3 are compliant with existing laws, regulations, and public policies. Upon further detailed analyses, Alternative 2, the floodproofing of 12 structures proposed for dry floodproofing, of which 10 are residential apartment buildings, did not ultimately meet the planning screening acceptability criteria shown in Table 3-21. Alternative 2 potentially conflicted with the following federal and local regulations:

- FEMA National Flood Insurance Program Technical Bulletin 3 dated January 2021 – Requirements for the Design and Certification of Dry Floodproofing Non-Residential and Mixed-Use Buildings), Section 1.3., and
- City of Raleigh Stormwater Design Manual, dated 22 July 2022, (Chapter 7, Section 7.7)

Implementation of a flood risk management plan that potentially conflicted with these regulations could negatively impact a community's, or certain property owners' ability to participate in the NFIP and other federally funded flood emergency disaster recovery programs.

Additionally, since dry floodproofing measures associated with Alternative 2 would only be intended to reduce flood damage, a detailed Emergency Evacuation Plan (EEP) for affected residents would be required as a critically needed component to successfully implement Alternative 2. Even with the EEP, implementation of Alternative 2 could potentially increase the risk of loss of life given that an EEP would not generally provide the authority to implement nor enforce mandatory evacuation of residents.

Therefore, if residents refused to evacuate their residences under any circumstances, even if recommended by law enforcement, residents' ingress and egress would be severely restricted during a flood event. As a result, residents would be placed at a heightened risk if floodwaters overtopped the design flood level creating the need for immediate rescue and emergency assistance.

With no other identified alternatives which are either implementable nor economically viable under federal regulations, policy and/or guidelines, No Action is ultimately determined to be the Recommended Plan for the Neuse River Basin study.

Table 3-21 Comparison of Alternatives with Respect to the Four Criteria Established in the Principles and Guidelines (USACE 1983)

Criteria	Alt 1: No Action	Alt 2: Structure Floodproofing	Alt 3: Property Buyouts
Completeness	Incomplete	Complete	Complete
Effectiveness	Ineffective	Effective	Effective
Efficiency	No net benefits	Positive net benefits	Negative net benefits
Acceptability	Acceptable	Unacceptable	Acceptable

NOTE: Green = meeting the criteria; yellow = no effect or mixed effects; red = not meeting criteria

3.7.7. Ability to Meet Planning Objectives

This section describes how, and the extent to which, each alternative meets the two planning objectives

Objective 1: Reduce economic damage associated with inundation (residential, non-residential, vulnerable communities, critical facilities, and public infrastructure) throughout the basin over the period of analysis (2040-2090)

Alternative 1. No Action

Economic damage associated with inundation would not be reduced under the No Action alternative.

Alternative 2. Structure Floodproofing

This alternative would reduce economic damages associated with floodwater inundation within the project footprint of approximately 12 structures. Expected annual damages would be decreased from $2.7 million under the without-project condition to $2.1 million under the with-project condition for Crabtree Creek, Raleigh, NC. There would be no change in inundation risk for at risk structures outside of the project footprint.

Alternative 3. Property Buyouts

Property buyouts would eliminate economic damages associated with floodwater inundation of approximately 126 structures in the 10% AEP floodplain across three areas: Hominy Swamp Creek, Wilson, NC; Big Ditch, Goldsboro, NC; and the Neuse River mainstem in the vicinity of Goldsboro and Kinston, NC.

Objective 2: Reduce life-safety risk associated with inundation of structures and public infrastructure throughout the basin over the period of analysis (2040-2090)

Alternative 1. No Action

Risk to life-safety associated with inundation of structures and public infrastructure would not be reduced under the No Action alternative.

Alternative 2. Structure Floodproofing

Structure floodproofing would reduce floodwater inundation and associated life and safety risk associated with the 12 structures located adjacent to Crabtree Creek, Raleigh, NC. However, as noted in Section 3.7.6, implementation of Alternative 2 would potentially increase the risk of loss of life given that an Emergency Evacuation Plan would generally not provide the authority to implement nor enforce mandatory evacuation of residents in advance of a projected flood event.

Therefore, if residents refused to evacuate their residences under any circumstances, even if recommended by law enforcement, residents' ingress and egress would be severely restricted during a flood event. As a result, residents would be placed at a heightened risk if floodwaters overtopped the design flood level creating the need for immediate rescue and emergency assistance. For these reasons, implementation of this alternative would increase the life-safety risk for residents of the 12 properties. There would be no change to life and safety risk outside of the project footprint.

Alternative 3: Property Buyouts

Property buyouts would eliminate life-safety risk associated with floodwater inundation of approximately 126 structures in the 10% AEP floodplain across three areas: Hominy Swamp Creek, Wilson, NC; Big Ditch, Goldsboro, NC; and the Neuse River mainstem, in the vicinity of Goldsboro and Kinston, NC. However, as noted in Section 2.9 and in Section 6 of Appendix B (Economics), there is limited life-safety risk in the study area.

3.7.7.1 Ability to Meeting Planning Objectives Summary & Comparison

Objective 1: Both action alternatives would result in reduced flood risk associated with inundation of structures and/or roadways and, thus, would meet objective 1.

Objective 2: Only action Alternative 3, property buyouts, would result in reduced life-safety risk associated with inundation of structures and/or infrastructure and, thus, would meet objective 2.

3.8. Plan Selection

3.8.1. Selection of Recommended Plan

Based on the economic analysis provided in Section 3.7.4.4, Alternative 2 (Structure Floodproofing) provides the greatest net benefits and is the NED Plan (Table 3-22).

Also, based on the analysis in Section 3.7.5.5, this alternative would have been the preferred plan considering the OSE account while Alternative 3 (Property Buyouts) provides the highest qualitative EQ account. However, Alternative 2 is unacceptable as described in Section 3.7.6. With no other identified alternative either implementable nor economically viable under federal regulations, policy and/or guidelines, No Action is determined to be the Recommended Plan for the Neuse River Basin study.

Table 3-22 Summary of Final Array of Alternatives

	Neuse River Basin (Basinwide)					
	Final Array of Alternatives	Net Benefits (Benefits less Costs)	Total Project Cost (Millions)	BCR @ 2.50%	Screening	Reason
1	No Action (Recommended Plan)				Retain	No Other Alternative was Implementable nor Economically Feasible
2	Structure Floodproofing Plan (NED Plan)	$350,000	$6.6	2.5	Drop	Unacceptable per Planning Screening Criteria
3	Property Buyout Plan	-$1,700,000	$119.4	0.6	Drop	Cost exceeds benefits
*	Structural Plan: HS-S1 + CTC-S5 + MS-S1	-$10,500,000	$59.2	<0.2	Drop	Cost exceeds benefits

**** This structural alternative was provided for comparative purposes only in the final array of alternatives***

3.8.2. Rationale for No Structural Plans in the Final Array

As described in Tables 3-7, 3-8, 3-9, and 3-10 and in Section 3.7.1, the analysis of structural alternative measures indicated that the expected benefits would not exceed the costs during the first 4 planning iterations. Many separate basinwide structural measures are evaluated using a mix of qualitative or quantitative means. However, one structural measure along Hominy Swamp Creek (HS-S1) initially appeared to provide preliminary benefits that exceeded the costs, but a more detailed analysis in the 5th iteration resulted in a BCR less than 0.3. This economically infeasible alternative and the associated environmental impacts are described here to demonstrate the exhaustive nature of the plan formulation process required to identify the most feasible measures as part of the Recommended Plan.

From an environmental impact perspective, this proposed measure to construct 9 channel bench segments along the banks of Hominy Swamp Creek would have required mitigation, likely in the form of payment into the State of North Carolina's in lieu fee program for impacts to the stream and associated wetlands. The estimated length

of stream to be impacted with the construction would be ~10,562 linear feet along with an estimated ~ 13 acres of wetlands. Although large areas of adjacent riparian wetlands were not identified during the site visit in November 2021, it is conservatively assumed that small riparian wetlands likely are present in some areas. The estimate of wetlands present is based on aerial maps, soil surveys, and National Wetland Inventory maps data, which is available in GIS. The construction of the channel bench segments would not have resulted in negative impacts to threatened or endangered species.

Proposed Hominy Swamp Creek channel bench locations would require systematic archaeological surveys to ensure compliance with Section 106 of the National Historic Preservation Act (NHPA). Again, citing field observations made during the November 2021 site visit, riparian vegetative composition at several proposed channel bench locations included large trees. The size of these trees (i.e., height, canopy cover, and diameter at breast height) suggested that construction-related ground disturbance in their immediate vicinity had not occurred in many decades and, perhaps, had never occurred. It is reasonable to presume that archaeological evidence of prehistoric Native American use could exist in proposed channel bench areas. According to the NC Office of State Archaeology (NCOSA) records, the majority of proposed channel bench areas have not been previously surveyed for cultural resources. Proposed channel bench footprints would require systematic archaeological surveys prior to any construction or ground disturbance and would be coordinated with the NCOSA / NC State Historic Preservation Office in accordance with the NHPA, Section 106.

3.8.3. Identification of a Locally Preferred Plan

The non-Federal sponsor, the North Carolina Department of Environmental Quality, did not object to the Recommended Plan of no federal action. No Locally Preferred Plan is recommended.

3.8.4. Value Engineering

Value Engineering is not addressed in the Technical Report. Since no federal action is recommended, no further value engineering analysis is needed.

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Chapter 4 AFFECTED ENVIRONMENT AND ENVIRONMENTAL CONSEQUENCES

This section begins with descriptions of the three alternatives in the final array, which included the *No Action* alternative. These descriptions are followed by discussions of the affected environment and environmental consequences evaluated against the three alternatives.

Final Basinwide Array of Alternatives:

Alternative 1 Recommended Plan - No Action

The without-project condition, or the no-action plan, is Alternative 1, which is the Recommended Plan. Alternative 1 is the scenario that would most likely occur in the absence of a federal plan. The No Action plan would likely result in repeated flooding in an area where hurricanes, extreme tropical storms and other events bring heavy rainfall each year. Under this alternative, structures would continue to be inundated as outlined in Chapter 2.

Alternative 2 –Structure Floodproofing

Though not the Recommended Plan, Alternative 2 is a nonstructural plan that evaluated dry floodproofing of structures located adjacent to Crabtree Creek, in southeastern Raleigh, NC. Alternative 2 included dry floodproofing 12 structures. The total implementation period for this alternative is approximately 2.5 years, assuming 100 percent homeowner participation.

There are several potential design considerations that would be more fully analyzed during any subsequent detailed design phase by a non-Federal entity to ensure that the proposed measures and the applicable population is appropriately identified. Structure modification would be based on structure type and condition. Land clearing and/or grading and tree cutting are not anticipated though it may be necessary in situations where required in order to access the structure. A non-Federal entity would be the responsible party for identifying and locating underground storage tanks (USTs) and above ground storage tanks (ASTs) within the project area. USTs (including septic systems would be capped and covered and left in place) and ASTs would be strapped down and secured. Retrofitting of the USTs and ASTs would be designed in accordance with the FEMA guidance: *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012). Each structure floodproofing action would require approximately 90 days to complete.

Alternative 2 also includes development of public education materials highlighting residual, or remaining, flood risks throughout the Neuse River basin would also be included in the plan. A visual example of structure floodproofing is shown in Figure 3-5.

Alternative 3 - Property Buyouts

Though not the Recommended Plan, Alternative 3 is a property buyout plan that included acquisition of 126 structures and their associated lands located adjacent to Hominy Swamp Creek in Wilson, Big Ditch in Goldsboro and the main stem of the Neuse River. The total implementation period for this alternative is approximately 2 years with 100 percent homeowner participation.

There are several potential design considerations that would be more fully analyzed during any subsequent detailed design phase by a non-Federal entity to ensure that the proposed measures and the applicable population are appropriately identified. Structures would be either demolished or sold to others and relocated to a location external to the floodplain. Demolition would take approximately one to two months for each structure. All debris would be required to be disposed in accordance with applicable regulations. A non-Federal entity would be the responsible party for identifying and locating underground storage tanks (USTs) and above ground storage tanks (ASTs) located within the project area. USTs (including septic systems would be capped and covered and left in place) and ASTs would be strapped down and secured. Retrofitting of the USTs and ASTs would be designed in accordance with the FEMA guidance: *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012). After acquisition, acquired lands must be maintained as open space through deed restrictions that prohibit any type of development that could sustain flood damages or restrict flood flows. Land acquired as part of a nonstructural project could be converted to a new use such as ecosystem restoration and/or recreation consistent with open space restrictions, such as trails, shoreline access, and interpretive markers.

Alternative 3 also included development of public education materials highlighting residual, or remaining, flood risks throughout the Neuse River basin.

4.1. Physical Resources

This section provides a description of the physical resources in the areas of the Neuse River basin potentially affected by the final array of alternatives.

4.1.1. Geology and Sediments

The Neuse River basin is in the Piedmont and Coastal Plain regions of North Carolina. Soils within the Piedmont region typically consist of residual soils above Metamorphic or Igneous bedrock. Soils within the Coastal Plain typically consist of alluvial sands and

clays with intermittent layers of sedimentary rock. Human placed materials, existing organic materials, and/or surficial deposits may overlay the residual and Coastal Plain soils.

Sedimentation and erosion within the study area is typically caused by bare soil being exposed to wind and water. In some cases, the velocity and volume of the wind and water can be high enough to cause soil erosion and transportation even if the soil is covered with vegetation or rock. In areas where excavation occurs and the soil is exposed, erosion and sediment transport are likely to occur. Erosion control measures should be put in place to help prevent the erosion and transportation of sediment.

Alternative 1 – Recommended Plan - No Action

The No Action plan assumes that no excavation activities would occur and there would be minimal changes to geology and sediment. Erosion and sedimentation could still be caused by flood events. Areas within the basin that do not have adequate surficial cover, either with vegetation or rock, would still be prone to erosion and sedimentation caused by wind and surface water.

Alternative 2 - Structure Floodproofing

Minimal ground disturbance is anticipated during structure floodproofing operations. Any soil that is disturbed during structure floodproofing operations would be covered with approved native vegetation to reduce the amount of erosion and sedimentation. After construction is complete, it's anticipated the erosion and sedimentation would be similar to the No Action plan.

Alternative 3 - Property Buyouts

Structures included in the buyout areas would be demolished or relocated from the property and the land would be returned to a natural state. Erosion and sedimentation could occur as a result of soil being exposed during the demolition activities. After demolition activities, the exposed soil could be covered with approved vegetation to limit the amount of erosion and sedimentation. Silt fences could also be used during the demolition activities to reduce the amount of soil transportation.

For a more detailed description of the regional geology, please refer to Appendix E (Geotechnical Engineering).

4.1.2. Water Quality

4.1.2.1 Wetlands and Floodplains

Wetlands are those areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions (33 C.F.R. § 328.3). Wetlands possess three essential characteristics: hydrophytic vegetation, hydric soils, and wetland hydrology. Within the floodplain, wetland hydrology is defined as inundation or saturation by surface or groundwater at a frequency and duration sufficient to support a prevalence of hydrophytic vegetation typically adapted for life in saturated soil conditions. Although a wetland can still occur without the presence of explicit hydrology, there is typically distinct evidence in the soils and vegetation that hydrology has and does exist for extended periods of time within an area (USDA, 2011). Various types of wetlands are present within the Neuse River basin. Some of the more common wetland types found in the basin include bottomland hardwood swamp, pocosin, freshwater marsh, riverine forested swamp, forested/shrub, brackish marsh, and tidal marsh (NCDWR, 2021).

The 1% AEP floodplain is established by the Federal Emergency Management Agency (FEMA) and is identified on Federal Insurance Rate Maps. Base flood elevations for flood zones and velocity zones are also identified by FEMA, as are designated floodways. Some portions of the Neuse River basin project area are located within the 1% AEP floodplain.

Executive Order 11988 requires federal agencies to avoid to the extent possible the long and short-term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "[e]ach agency shall provide leadership and shall take action 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 in carrying out its responsibilities…"

Alternative 1 - Recommended Plan - No Action

The No Action plan would result in no changes to wetlands or hydrology, and no impacts to the floodplain.

The eight steps discussed in E.O. 11988 are addressed as follows:

1. Floodplain and/or wetland determination.

The Recommended Plan would not adversely impact any floodplains or wetlands, upstream, within, or downstream of the project.

2. Public notification.

Public involvement began with scoping and continued throughout the NEPA process. The draft IFR/EA was provided to the public for comment. All comments received are considered prior to the study termination. The information received from the comments was considered during development of the Technical Report.

3. Identify and evaluate practicable alternatives to locating in the base floodplain.

The draft IFR/EA discusses all practicable alternatives and since the Recommended Plan is No Action, there are no new impacts made within the floodplain.

4. Identify the impacts of the Recommended Plan.

Impacts of the Proposed Action are fully discussed in the report and are compared in the Qualitative Environmental Quality (EQ) Account Evaluation of Final Basinwide Alternatives Array, Table 4-3.

5. Evaluate measures to reduce potential adverse impacts of the proposed action.

The draft IFR/EA has evaluated potential measures to reduce adverse impacts. The Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array, Table 4-3, contains a thorough analysis of all positive and negative impacts.

6. Re-evaluate the alternatives.

All alternatives are thoroughly evaluated during the USACE Planning process and are presented in Chapter 3 of this report.

7. Make the final determination and present the decision.

The final determination and presentation of the Recommended Plan would have been contained in the final report if the study had not been terminated. Public review was completed.

8. Implement the action.

Implementation of the Recommended Plan would result in no significant impacts to floodplains or wetlands. The existing hydrology of the floodplain would not be changed. The Recommended Plan complies with Executive Order 11988.

Alternative 2 - Structure Floodproofing

Alternative 2 would result in insignificant changes throughout the basin and therefore would not alter the existing hydrology in the floodplain. Additionally, this alternative would not result in significant impacts to wetlands within the project areas. The impacts that would occur relating to minor ground disturbance and any minor tree/vegetation removal needed to access property with respect to Alternative 2 would not be fully developed until any potential subsequent detailed design phase where each structure can be evaluated in further detail. For the feasibility study, is assumed that since most of the impacts would be occurring on previously disturbed ground new impacts likely would not occur outside of the previously disturbed footprint of the structure site, but this would need to be evaluated during in any potential subsequent detailed design phase. Wetland impacts and additional floodplain impacts would be avoided.

Alternative 3 - Property Buyouts

This alternative would provide nonstructural flood risk management in the form of acquisition of structures and associated lands for up to approximately 126 structures in multiple locations throughout the Neuse River basin located adjacent to Hominy Swamp Creek in Wilson, Big Ditch in Goldsboro, and Neuse River mainstem. Structures included in the buyout areas would be demolished or relocated from the property and the land would be returned to a natural state. This alternative would have a positive impact on the floodplain by removing structures currently located within the floodplain and allowing more natural vegetative areas to regenerate in place of the existing homes/structures. The buyout alternative would result in an insignificant, negligible change to existing wetlands found within the project area.

4.1.2.2 Water Quality

The Neuse River basin covers about 6,200 square miles and contains 14 separate sub-basins located throughout parts of 18 counties. The basin is centrally located within North Carolina with the headwaters starting northwest of Raleigh, NC and flowing approximately 275 miles to the river mouth located southeast of New Bern, NC.

The Clean Water Act regulations at 40 CFR 131 require that the surface waters of each state be classified according to designated uses. Those uses are defined by the classifications assigned to the water body. Surface Water Classifications are

designations applied to surface water bodies, such as streams, rivers, and lakes. These classifications define the best uses to be protected within these waters (for example swimming, fishing, drinking water supply) and carry with them an associated set of water quality standards to protect those uses.

The NC Division of Water Resources (NCDWR) primary freshwater and saltwater surface water classifications are:

- Class C and SC: For uses with aquatic life propagation/protection and secondary recreation.
- Class B and SB: Uses are primary recreation and Class C uses.
- Class SA*: Waters which are classified for commercial shellfish harvesting.
- WS: Water Supply Watershed. There are five additional classifications within this WS classification which provide a range of protection with WS-I being the highest protection and WS-IV being the least protected. Additionally, there is a Critical Area (CA) designated within half a mile and draining to the water supply intake or reservoir where the intake is located.

  **Primary classifications beginning with a "S" are assigned to saltwaters.*

The Neuse River has some areas that are classified as "WS" for Water Supply Watershed water bodies above and around the City of Raleigh area in sub-basin 03-04-01 and 03-04-02, also WS waters are identified to the northwest of Goldsboro in watershed 03-04-06 and 03-04-12. Additionally, some "SA" areas for commercial shellfish harvesting are located to the east of Havelock and Oriental in watersheds 03-04-10, 03-04-14, and 03-04-13. A figure from the NCDWR Neuse Basinwide Water Quality Plan (Figure 4-1) shows a water quality classification map for the Neuse River basin from the 2002 NCDWR Neuse Basinwide Water Quality Plan.

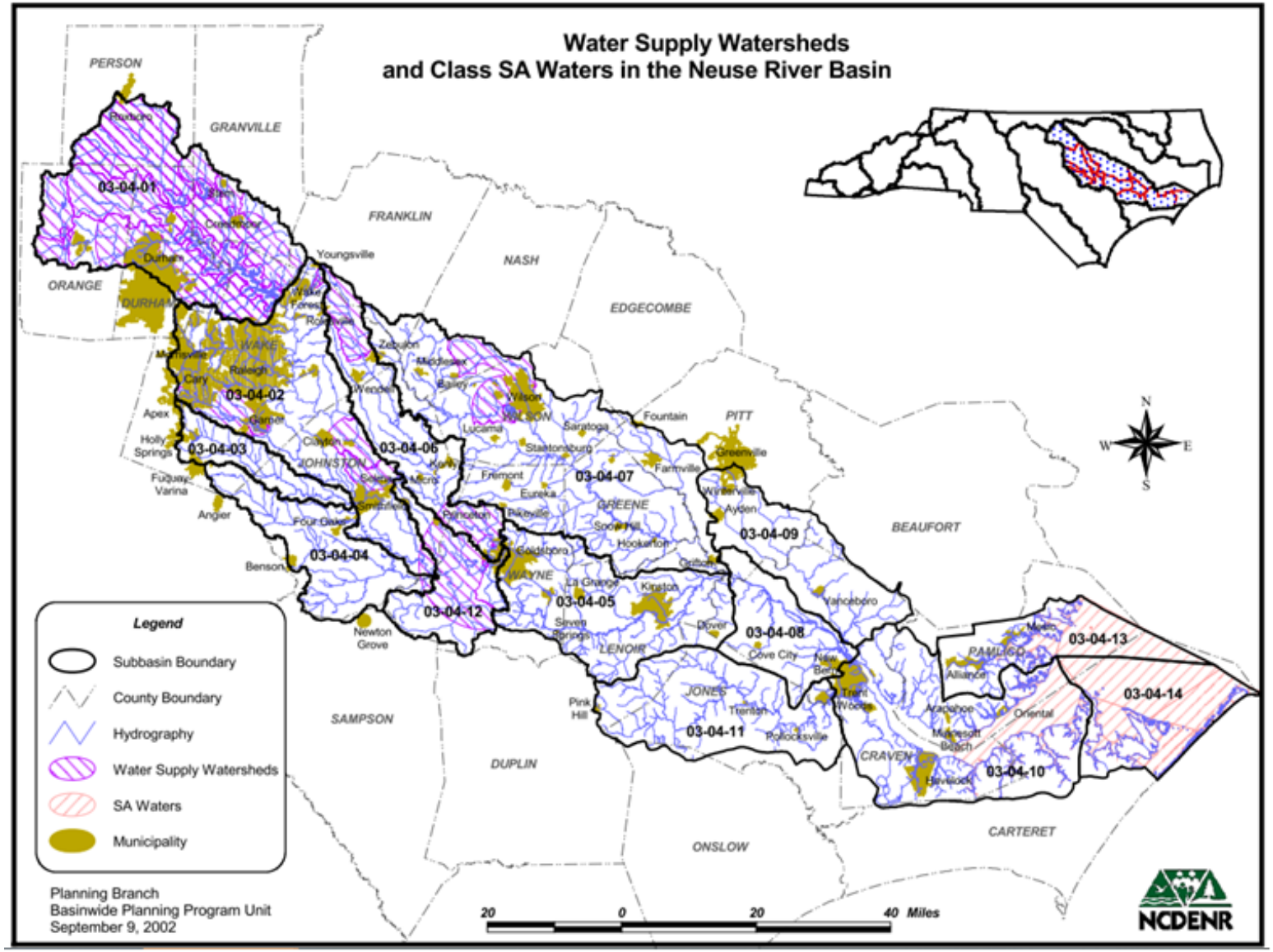

Figure 4-1 Neuse Basin Water Classifications Overview Map

In the 2009 Neuse River Basinwide Water Quality Plan, NCDWR identified major sources of water quality impacts to the Neuse River as having impaired biological integrity, low dissolved oxygen levels, and elevated turbidity for the freshwater portions. Also identified are elevated chlorophyll *a* and high pH (due to elevated nutrients), turbidity and bacteria (fecal coliform and enterococci) levels. Additionally, the NCDWR's report details that urban development is a concern causing alteration to the watershed hydrology, creating downstream flooding, streambank erosion, channel incision, increased turbidity and degrading of the aquatic and biological habitat.

Alternative 1 - Recommended Plan – No Action

The No Action plan would result in water quality within the Neuse River basin that continues to be negatively affected by erosion issues and increased suspended sediments and runoff related to frequent high flooding events within the basin.

Alternative 2 - Structure Floodproofing

Alternative 2 would have effects similar to Alternative 1 - the No Action plan. Alternative 2 would not reduce erosion, sedimentation or stormwater runoff within the basin and therefore is not expected to impact water quality.

Alternative 3 - Property Buyouts

The buyout alternative may result in minimal improvements to water quality within the Neuse River basin by removing structures currently located within the floodplain and allowing the natural vegetation to grow creating additional vegetated buffer in some areas. Natural river buffers are a known way to improve water quality by absorbing and filtering out nutrients and suspended sediments. Riparian buffers also slow down river discharges from a heavy rainfall, reducing the impacts of flooding.

4.1.3. Land Use & Associated Impacts

4.1.3.1 Hazardous, Toxic, and Radioactive Wastes (HTRW)

The Neuse River Basin Study is comprised of mostly moderately sized cities and small towns scattered amongst a mostly rural landscape with larger areas of land being used for agriculture or remaining undeveloped. According to the USEPA website, there are three superfund sites pursuant to the Comprehensive Environmental Response Compensation and Liability Act (CERCLA) reported in Wake County, none of these sites is listed on the National Priorities List (NPL). The Wake County CERCLA sites included: Koppers Co., Inc. (Morrisville Plant) (ID: NCD003200383); NC State University (Lot 86, Farm Unit 1) (ID: NCD980557656); and Ward Transformer (ID: NCD003202603). Additionally, within the Neuse River basin, but outside of the

identified flood risk management project area is an NPL site located at Cherry Point Marine Corps Air Station (NC1170027261). Per comment received from the North Carolina Division of Waste Management to review additional Superfund site files from website: http://deq.nc.gov/waste-management-laserfiche, additional review of the project area is completed. No other HTRW sites are identified in the project vicinity or in the Neuse River basin.

Alternative 1 - Recommended Plan - No Action

The No Action alternative would not adversely impact hazardous and toxic materials located in the proximity of the proposed project area, nor would it produce new hazardous and toxic materials within the Neuse River basin.

Alternative 2 - Structure Floodproofing

Alternative 2 would require a non-Federal entity to be the responsible party for identifying underground storage tanks (USTs) and above ground storage tanks (ASTs) located within the project area. Location of USTs and ASTs would be completed during in any potential subsequent detailed design phase. USTs (including septic systems would be capped and covered and left in place) and ASTs would be strapped down and secured in the floodway. Retrofitting of the USTs and ASTs would be designed in accordance with the FEMA guidance: *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012). Additionally, during any potential subsequent detailed design phase, a non-Federal entity would conduct asbestos and lead based paint investigations as part of the Phase 1 review of each property to be dry floodproofed. Any property containing asbestos or lead based paint would be abated and disposed of properly. Alternative 2 would not adversely impact hazardous and toxic materials located in the proximity of proposed project area, nor would it produce new hazardous and toxic materials within the Neuse River basin.

Alternative 3 - Property Buyouts

Alternative 3 would require a non-Federal entity to be the responsible party for identifying underground storage tanks (USTs) and above ground storage tanks (ASTs) located within the project area. Location of USTs and ASTs would be completed during in any potential subsequent detailed design phase. USTs (including septic systems would be capped and covered and left in place) and ASTs would be strapped down and secured in the floodway. Retrofitting of the USTs and ASTs would be designed in accordance with the FEMA guidance: *Engineering Principles and Practices for Retrofitting Flood-Prone Residential Structures* (2012). Additionally, during in any potential subsequent detailed design phase, a non-Federal entity would conduct asbestos and lead based paint investigations as part of the Phase 1 review of each property to demolished or relocated as part of a buyout. Any property containing

asbestos or lead based paint would be abated and disposed of properly. Alternative 3 would not adversely impact hazardous and toxic materials located in the proximity of proposed project area, nor would it produce new hazardous and toxic materials within the Neuse River basin.

4.1.3.2 Air Quality

The Clean Air Act requires the U.S. Environmental Protection Agency (EPA) to establish health and science-based standards for air pollutants that have the highest levels of potential harm to human health or the environment. These National Ambient Air Quality Standards (NAAQS) are in place for six air pollutants, also referred to as criteria pollutants. The six criteria pollutants are Ozone, Sulfur Dioxide, Particulate Matter, Lead, Nitrogen Dioxide, and Carbon Monoxide. Of the six current criteria pollutants, particle matter and ozone have the most widespread health threats, but they all have the potential to cause damage to human health and the environment. Areas of the country which persistently exceed the NAAQS are designated as “nonattainment” areas and those which meet or exceed the standards are designated “attainment” areas. There are 18 counties within the Neuse River basin. The ambient air quality for the 7 counties surrounding the project area have all been determined to be in compliance with the National Ambient Air Quality Standards and are designated as attainment areas.

Greenhouse gases absorb infrared radiation, thereby trapping heat and making the planet warmer. The most important greenhouse gases directly emitted by humans include carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), and several other fluorine-containing halogenated substances. Although CO2, CH4, and N2O occur naturally in the atmosphere, human activities have changed their atmospheric concentrations. From the pre-industrial era (i.e., ending about 1750) to 2017, concentrations of these greenhouse gases have increased globally by 45, 164, and 22 percent, respectively.

Gases in the atmosphere can contribute to climate change both directly and indirectly. Direct effects occur when the gas itself absorbs radiation. Indirect radiative forcing occurs when chemical transformations of the substance produce other greenhouse gases, when a gas influences the atmospheric lifetimes of other gases, and/or when a gas affects atmospheric processes that alter the radiative balance of the earth.

In 2019, total gross United States greenhouse gas emissions are 6,558 MMT, or million metric tons, of carbon dioxide. Total United States emissions decreased by 1.7 percent from 1990 to 2019, and greenhouse gas emissions in 2019 are 13 percent below 2005 (levels after accounting for sequestration from the land sector - Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019).

Alternative 1 - Recommended Plan - No Action

There would be no effect to air quality with the No Action Alternative. The No Action alternative would not involve construction or any other actions that could potentially increase emissions or contribute to increased greenhouse gases.

Alternative 2 - Structure Floodproofing

Alternative 2 may result in a very small, localized increase in CO2 air emissions from vehicular traffic and heavy machinery utilized to implement the dry floodproofing of 12 structures. The timeframe for structure floodproofing would take approximately three-months per structure. The total implementation period for this alternative would be approximately 2.5 years, assuming 100 percent homeowner participation. Increases in air pollutants or greenhouse gases from the use of construction equipment would be minor, temporary and localized to the immediate area of construction. There would be no large-scale permanent air quality or greenhouse gas impacts associated with Alternative 2 and no air quality permits would be required.

Alternative 3 - Property Buyouts

This alternative would result in very minimal impacts to air quality or greenhouse gases. There is the potential for a minor, localized increase in CO2 air emissions from vehicular traffic and heavy machinery utilized to execute the removal of the selected structures from the floodplain. There would be no expansive air quality impacts with the Alternative 3 and no air quality permits would be required. The impacts to any associated air quality or greenhouse gases during the actual demolition or relocating of the structure would be temporary and limited to approximately one to two months for the removal of each structure. The time frame for removal of all 126 structures considered in Alternative 3 is estimated to be two years.

4.1.3.3 Prime and Unique Farmland

The Farmland Protection Policy Act (FPPA) requires federal agencies to minimize the conversion of prime and unique farmland to non-agricultural uses. Prime and unique farmlands are designations assigned by the United States Department of Agriculture (USDA). Prime farmland is land that has the best combination of physical and chemical characteristics for producing food, feed, forage, fiber, and oilseed crops. The land is also used as cropland, pastureland, rangeland, forest land, or other land, but cannot be used as urban built-up land or a water feature. Unique farmland is land other than prime farmland that is used to produce specific high value food and fiber crops. Such land has a special combination of soil quality, location, growing season, and moisture supply that is required to economically produce sustained high quality of a specific crop when treated and managed according to acceptable farming methods. A review of the

U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) Web Soil Survey (https://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx) shows that there are soils which can be classified as prime farmland soils within the project area. Although there are soils classified as prime and unique farmland soils within the project area, they are occurring in areas that include homes and other existing structures on previously disturbed ground.

Alternative 1 - Recommended Plan - No Action, Alternative 2 - Structure Floodproofing and Alternative 3 - Property Buyouts

All three alternatives would not adversely impact prime and unique farmland soils located in the proposed project area. There would be no new land disturbing activities with any of the alternatives and any project would occur on previously disturbed residential or commercial property. No prime or unique farmland soils would be altered as part of Alternatives 1, 2 or 3.

4.1.3.4 Noise

North Carolina counties have the authority to regulate noise, pursuant to North Carolina General Statute 153A-133, which grants counties the general power to enact ordinances, stating that "[a] county may by ordinance define, regulate, prohibit, or abate acts, omissions, or conditions detrimental to the health, safety, or welfare of its citizens and the peace and dignity of the county; and may define and abate nuisances."

Noise levels in the vicinity of the Neuse River Basin project area are variable and often include vehicle traffic from adjacent roads, heavy machinery from ongoing construction projects in the area, and seasonal agricultural activities. The areas around the project are primary rural or suburban consisting mostly agricultural or open lands with small residential communities and associated small town businesses.

Alternative 1 - Recommended Plan - No Action

The No Action plan would have no effect on ambient noise levels within the project area since it would not involve construction.

Alternative 2 - Structure Floodproofing

The proposed action could cause noise levels to be temporarily elevated during construction activities. The proposed project construction would comply with the various county ordinances for noise. Alternative 2 includes dry floodproofing 12 structures. Elevated noise levels due to construction activity would be temporary, all work would be executed during standard daylight working hours, with no after hour or

night work would be expected and the construction on each structure should take approximately 3 months to complete. The total implementation period for this alternative is approximately 2.5 years, assuming 100 percent homeowner participation. No significant, long-term increases in noise levels would be expected.

Alternative 3 - Property Buyouts

There are no long-term negative effects to noise anticipated. Impacts to noise with Alternative 3 would be very similar to those described for Alternative 2 involving construction equipment needed to remove the home/structures from the floodplain. There would be no significant, long-term negative increases in noise anticipated. There could be a long-term positive effect with the decrease of residential noise once the buyouts are completed and the structures are removed, leaving the areas with less traffic and noise. The impacts to any associated construction noise during the actual demolition or relocating of the structure would be temporary and limited to approximately one to two months for the removal of each structure. Any construction completed for this alternative would be executed during standard daylight working hours, with no after hour or night work expected. The total time frame for removal of all 126 structures considered in Alternative 3 is estimated at two years.

4.1.4. Climate Change

The Neuse River basin study climate change assessment, pursuant to ECB 2018-14 (Revision 1) documents historical and projected future trends in the physical climatic parameters of air temperature, precipitation, and streamflow within the study area. Assessment results indicated a consensus of increased air temperatures over the past century as well as a strong consensus for increasing air temperatures over the next century. Results indicated limited consensus for a historical upward trend in precipitation over the past 50 to 100 years. There is an indication that precipitation extremes may have a small increase in the future. Results indicated a consensus for a historical downward trend in streamflow, particularly since the 1970s. However, the assessment shows contradicting predictions for precipitation and streamflow trends in the future.

As referenced in Section 2.3.1, greenhouse gases come from a variety of human activities including: burning fossil fuels for transportation, heat and energy, clearing forests, fertilizing crops, storing waste in landfills, raising livestock, and producing some kinds of industrial products. The most common gases referred to as greenhouse gases (GHG's) are: 79% Carbon dioxide (CO2); 11% Methane (CH4); 7% Nitrous Oxide (N2O); and 3% Fluorinated Gases (which are synthetic, such as: hydrofluorocarbons, perfluorocarbons, sulfur hexafluoride, and nitrogen trifluoride). CO2 is the most abundant of GHG's being emitted to the atmosphere, and the primary source of this

emission is from human activities such as: combustion of fossil fuels for transportation, electricity generation, and industrial processes. Carbon dioxide emissions can be reduced through energy conservation, more energy efficient products and transpiration, carbon capture and sequestration, and more conservative land use practices. Methane emissions are emitted from a mix of energy, industry/mining, agriculture, waste management/landfills, and land use. Reduction in waste and upgrades/modifications to equipment and practices are the best ways to reduce methane emissions currently. Nitrous Oxide emissions are primarily from agricultural soil management practices, but can also occur with wastewater treatment, production of some chemicals (nitric acid and adipic acid), and some fuel combustion. Nitrous Oxide emissions can be reduced by reducing the frequency and amount of fertilizers used in agriculture, reducing fuel used for vehicles, and upgrading technology in chemical production. Fluorinated Gases are mostly emitted through their use as refrigerants, aerosol propellants, solvents, fire retardants, and some industrial manufacturing processes. Fluorinated Gases can be reduced through better handling methods for refrigerants, gas recycling, leak reduction/prevention, and alternative refrigerants (EPA, 2022).

Summary conclusions for climate change may be drawn from the Hydrology and Hydraulics analysis located in Appendix A of this report. Appendix A, Section 11.7.1, includes a summary review of the Climate Hydrology Assessment Tool (CHAT) specific gage data available for the Neuse River basin project area. The review showed there are no statistically significant trends in the project area that would indicate significant changes in observed streamflow due to climate change, long-term natural climate trends, or land use/land cover changes. Furthermore, in Appendix A, Section 11.7.2, based on the literature review, there is strong consensus in the literature that air temperatures would increase in the study area, and throughout the country, over the next century. The studies reviewed generally agree on an increase in mean annual air temperature of approximately 35.6 to 39.2 ºF by the latter half of the 21st century for the South Atlantic-Gulf Region. Projections of precipitation in the study area are less certain than those associated with air temperature. Results of the studies reviewed are roughly evenly split with respect to projected increases vs. decreases in future annual precipitation.

Alternative 1 – No Action

Under the No Action alternative, climate change that is currently occurring within the Neuse River basin study area would continue to persist. The projected future trends identified by the climate change assessment methods within the ECB 2018-14 (Revision 1) have assumed future without-project conditions equivalent to the No Action alternative. It is likely that air temperature would increase and potential for extreme precipitation events to occur in the future though contradicting predictions for precipitation and streamflow result in no strong consensus. Therefore, the No Action

alternative would not affect climate change beyond what is already predicted to happen under the without-project condition.

The No Action alternative would not generate or create any additional GHG emissions since there would not be any construction with this alternative. This alternative would have no effect on GHG emissions.

Alternative 2 – Structure Floodproofing

Temporary and isolated increases of greenhouse gases (CO2) may be technically attributed to construction activities related to implementing the structure floodproofing alternative. However, the climate change-related effects from anticipated construction activities are almost certainly negligible and therefore, the structure floodproofing alternative would not affect climate change. Under this alternative, the potential for extreme precipitation amounts to increase in the future may decrease the effectiveness of floodproofing features. Floodproofing design criteria, such as targeted first floor or threshold elevations along structure exteriors, would be expected to be exceeded sooner than originally assumed.

Alternative 3 – Property Buyouts

Similar to the structure floodproofing alternative, temporary and isolated increases of greenhouse gases (CO2) may be technically attributed to construction activities related to implementing the property buyouts alternative. However, the climate change-related effects from anticipated construction activities are almost certainly negligible. Furthermore, permanent removal of the structure from the floodplain and returning its associated parcel to an undeveloped state may benefit in reducing the effects of climate change. Man-made influences such as excess temperatures related to infrastructure and greenhouse gases would no longer occur within this undeveloped parcel. Therefore, the property buyouts alternative would not affect climate change. Under this alternative, increases in extreme precipitation related to climate change would make it more advantageous for the properties identified for buyouts, as they would likely occur flood damages sooner. Future floodplain conditions for the properties once the buyouts have occurred may witness more frequent flooding and be restricted to any form of future development.

4.1.5. Sea Level Change

The sea level change (SLC) rate for the Neuse River basin study was evaluated following the guidelines presented in USACE EP 110-2-1. The USACE online tool Sea Level Tracker is used in determining the historic rate of SLC and the projected rate of SLC. The Sea Level Tracker tool calculated low, intermediate, and high sea level change scenarios based on global and local change effects.

The Neuse River basin study SLC analysis is based on the NOAA gage located in Beaufort, North Carolina (Station #8656483), approximately 35 miles southeast of the City of New Bern, NC. The gage is compliant with a historic data record of 1967 to present. This gage was selected to represent the project site since it is the closest long-term gage to the project location.

The mean sea level trend at the Beaufort, NC, NOAA station is based on regionally corrected (2006) mean sea level data of 0.00817 feet/year. The defined 50-year period of analysis is from 2040 to 2090. The projected low, intermediate, and high scenario SLC curves from the Sea Level Tracker tool are provided below in Figure 4-2. The USACE High SLC scenario was selected for the Neuse River basin study because it tracked well with the 19-year and 5-year moving averages. This High SLC scenario with moving averages plotted consistently above the Intermediate SLC scenario is similarly noted at a regional tide gage (Wilmington, NC NOAA station #8658120). The High rate was also selected in coordination with the USACE Climate Preparedness and Resilience Community of Practice. The USACE High SLC Scenario values through year 2090 and 2140 are 4.03 feet and 9.02 feet, respectively. The high rate through year 2090 is used in engineering and economic analysis. The low and intermediate SLC scenarios are used to qualitatively describe the risk associated with adopting the high rate. Detailed analysis on SLC is provided in Appendix A (Hydrology and Hydraulics).

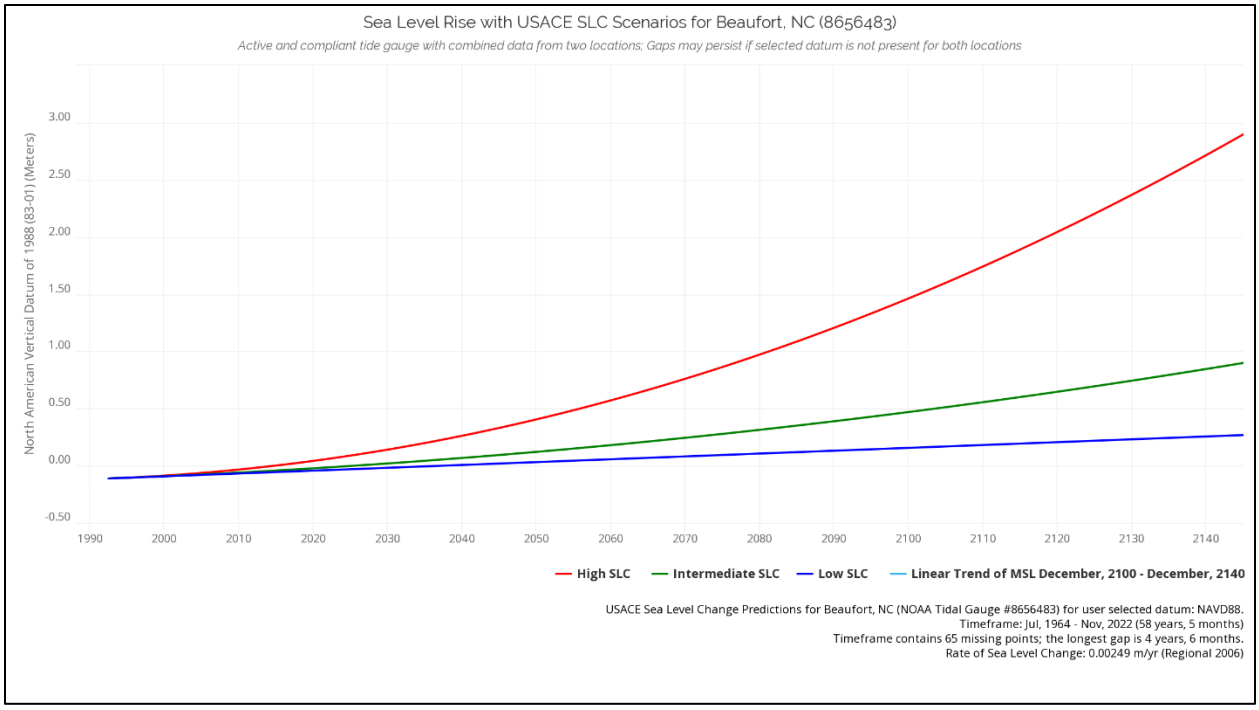

Figure 4-2 USACE Sea Level Change Predictions

Impacts from future sea level change would be most felt by those communities nearest the mouth of the Neuse River and the Pamlico Sound estuary. Predicted sea-level change may lead to permanent changes in land use and land cover due to alterations in hydrologic loading within the natural floodplain of the affected area. The amount of increased development within the floodplain would also exacerbate the effects of sea level change.

Persistent increased water levels within the estuary may cause changes in the flow regime for the lower Neuse River and its nearby tributaries. This regime may negatively impact the river's efficiency in adequately draining floodwaters following major storm events. Flood events may occur farther inland, within the middle and upper portions of the basin and still affect this change. The existing balance between fresh and saltwater concentration within the Pamlico Sound and lower Neuse would be shifted inland under permanently higher water levels. There is uncertainty in the range of future sea-level rise presented, and due to the lack of relief in terrain near the Pamlico Sound, the range of impacts between the low, intermediate, and high sea level change curves may be substantially different.

Currently, the location of Alternatives 2 and 3 are far enough inland from the coastal region such that the effects from permanent sea level and tidal influences are negligible.

Alternative 1 - Recommended Plan - No Action

The Recommend Plan focuses on locations along Crabtree Creek in Raleigh. This location is at least 50 river miles upstream from the influence of current sea level conditions and historical flooding is caused by riverine mechanisms only. The projected sea level change is not expected to change the current riverine flooding characteristics of this focus area. Therefore, under the No Action alternative, the existing identified vulnerable infrastructure would remain at risk for flooding but would not be impacted by sea level change. The No Action alternative would not affect sea level change.

Alternative 2 - Structure Floodproofing and Alternative 3 – Property Buyouts

Identified locations for implementing the Structure Floodproofing components of Alternative 2 or the Property Buyouts of Alternative 3 appear to fall beyond the footprint of sea-level change impact that would originate from the most downstream portion of the Neuse River basin. Therefore, no impacts from sea level change are expected under Alternative 2 or 3, and would be equivalent to conditions expected under Alternative 1. Neither the Structure Floodproofing alternative nor the Property Buyouts alternative would affect sea level change.

4.2. Biological Resources

4.2.1. Vegetation

Within the project area, the Neuse River basin passes through two distinctive regions, the Piedmont and Coastal Plain of North Carolina which can have some overlapping vegetation characteristics, but also offers some distinctions as the river gets closer to the coast. The North Carolina Natural Heritage Program has identified several natural community types within the Neuse River basin. These include Dry Oak – Hickory, Mesic mixed hardwood (coastal and piedmont), Mesic pine flatwoods, Coastal plain heath bluff, Pine/scrub oak sandhill, and Xeric sandhill scrub (North Carolina Natural Heritage Program 2012). Forests in the upland portion of the Piedmont are typically vegetated with an overstory of loblolly pine (*Pinus taeda*) and long-leaf pine (*Pinus palustris*), southern red oak (*Quercus falcate*) and white oak (*Quercus alba*), yellow poplar (*Liriodendron tulipifera*), and hickory (*Carya spp.*) and an understory of dogwood (*Cornus florida*), sourwood (*Oxydendrum arboreum*), American holly (*Ilex opaca*), and red cedar (*Juniperus virginiana*). Longleaf pines are native to the area. Coastal Plain forests are vegetated with an overstory of sweetgum (*Liquidambar styraciflua*) and red maple (*Acer rubrum*). The understory consists of dogwood (*Cornus florida*), sassafras (*Sassafras albidum*), and greenbrier (*Smilax spp.*) (NCDENR 2009). Herbaceous species may include pineland threeawn (*Aristida stricta*), western brackenfern (*Pteridium aquilinum*), pineland scalypink (*Stipulicida setacea*), Spotted Wintergreen

(*Chimaphila maculate*), Little brown jug (*Hexastylis arifolia*), and Christmas fern (*Polystichum acrostichoides*) (NCDENR 2009).

The Neuse River basin project area also includes multiple invasive plant species which can be found growing along the bank of the mainstem of the Neuse, as well as in many other locations throughout the river basin. They include Chinese privet (*Ligustrum sinense*), Chinaberry (*Melia azedarach*), Mimosa tree (*Albizia julibrissin*), Multifloria rose (*Rosa multiflora*), Japanese stiltgrass (*Microstegium vimineum*), Chinese wisteria (Wisteria sinensis), Chinese kudzu (*Pueraria montana*), and lespedeza (*Lespedeza bicolor*). Executive Order 13112 (Invasive Species), called upon executive departments and agencies to take steps to prevent the introduction and spread of invasive species, and to support efforts to eradicate and control invasive species that are established.

Large trees and other deep-rooted vegetation are vital to the health of the Neuse River basin by reducing soil erosion along stream banks and filtering out storm water runoff. With the establishment of the Neuse River Buffer Rules, the State of North Carolina established that a vegetive riparian buffer of 50 feet is required to be maintained around all streams, rivers, lakes, and estuaries within the Neuse River basin.

Alternative 1 - Recommended Plan – No Action

The No Action plan would result in continued frequent flood events within the Neuse River basin that have some level of negative effects on vegetation. The negative effects are compounding from years of streambank loss that result from continued erosion issues and stream incision in some parts of the basin. Invasive species would continue to grow and exist throughout the basin and the project areas.

Alternative 2 – Structure Floodproofing

The impacts that would occur relating to any minor tree/vegetation removal needed to access property with respect to Alternative 2 would not be fully developed until any potential subsequent detailed design phase where each structure can be evaluated in further detail to determine if structure floodproofing is best. Since most of the substantial impacts would be occurring on previously disturbed ground, it is not likely new impacts would occur outside of the previously disturbed footprint of the structure site, but this would need to be evaluated during any potential subsequent detailed design phase. If there is any minor tree/vegetation removal or trimming needed it would be for access to the property for equipment needed to complete structure dry floodproofing. Any vegetation trimmed or removed would be allowed to regenerate after construction is completed making the impact mostly temporary in nature. Neuse River buffer rule impacts are unlikely but would not be fully known until any potential subsequent detailed design phase. Any impacts to vegetation surrounding the

construction sites for the dry floodproofing of individual structures would be temporary and last approximately 90 days. The total estimated implementation time for Alternative 2 is 2.5 years for all structures in the project with 100 percent owner participation. No cutting or trimming of vegetation is planned as part of Alternative 2, resulting in no opportunity to reduce invasive species by replanting cut areas with native species, so the potential would exist for additional invasive species to grow within floodproofing areas. This could result in long-term negative impacts to surrounding native vegetation, though minor.

Alternative 3 – Property Buyouts

Property buyouts may result in minimal improvements to vegetation within the Neuse River basin by removing structures currently located within the floodplain and allowing the vegetation to regrow creating additional vegetated buffer. Natural river buffers are a known way to improve water quality by absorbing and filtering out nutrients and suspended sediments which could improve the river habitat that is considered critical habitat for the Carolina Madtom and the Atlantic Sturgeon. Riparian buffers also slow down the flow of water from a heavy rainfall, lessening the habitat reducing impacts caused by erosion from frequent flooding. Invasive species could potentially regrow in the buyout areas where homes or structures are removed from the floodplain property since Alternative 3 did not include replanting of any native species at the buyout site after structure removal. The potential for additional invasive species to regrow within the buyout areas would have a long-term minor impact to surrounding native vegetation.

4.2.2. Wildlife

Wildlife present within the Neuse River basin includes a mix of mammals, birds, reptiles and amphibians common to the North Carolina Piedmont and Coastal Plain Regions. Mammals common throughout the river basin include grey squirrels (*Sciurus carolinensis*), Eastern cottontail rabbit (*Sylvilagus floridanus*), white-tailed deer (*Odocoileus virginianus*), raccoon (*Procyon lotor*), grey fox (*Urocyon cinereoargenteus*), red fox (*Vulpes vulpes*), nutria (*Myocaster coypus*), river otter (*Lontra Canadensis*), muskrat (*Ondatra zibethicus*), beaver (Castor canadensis), black bear (*Ursus americanus*), coyote (*Canis latrans*) and opossum (*Didelphis virginiana*) (NCWRC, 2022).

Birds frequently found within the Neuse River basin include a mixture and variety of waterfowl, songbirds, and raptors, with many species being seasonal migratory birds. Waterfowl frequently seen in the basin include black duck (Anas rubripes), mallard (*Anas platyrhynchos*), wood duck (*Aix sponsa*), ruddy duck (*Oxyura jamaicensis*), Canada goose (*Branta canadensis*), double-crested cormorant (*Nannopterum auritum*), great blue heron (*Ardea herodias*), great egret (*Ardea alba*), and white ibis (*Eudocimus*

albus). A variety of common songbirds in the basin consist of northern cardinal (*Cardinalis cardinalis*), Carolina chickadee (*Poecile carolinensis*), tufted titmouse (*Baeolophus bicolor*), summer tanager (*Piranga rubra*), cedar waxwing (*Bombycilla cedrorum*), American robin (*Turdus migratorius*), downy woodpecker (*Dryobates pubescens*), song sparrow (*Melospiza melodia*), American crow (*Corvus brachyrhynchos*), blue jay (*Cyanocitta cristata*), and mourning dove (*Zenaida macroura*). Predominate raptors found in the basin are red-shouldered hawk (*Buteo lineatus), red-tailed hawk (Buteo jamaicensis), turkey vulture (Cathartes aura), bald eagle (Haliaeetus leucocephalus), Cooper's hawk (Accipiter cooperii), barred owl (Strix varia), great horned owl (Bubo virginianus), and Eastern screech-owl (Megascops asio)* (NCWRC, 2022 and LeGrand, H, et. al., 2022*).* The swamp, flood-plain, and river located within the basin study area are all very important habitats for many of various species of birds listed above.

The Neuse River included many unique and diverse amphibians and reptiles. Some notable ones are two species of giant aquatic salamanders the federally listed Neuse River waterdog (*Necturus lewisis)* and the dwarf waterdog (*Necturus punctatus).* Both giant aquatic salamanders can be found within the vicinity of the mainstem of the Neuse River and some of its tributaries. Some reptiles found within the Neuse basin include the American alligator (*Alligator mississippiensis*), slender glass lizard (*Ophisaurus attenuates*), green anole (*Anolis carolinensis)*, five-lined skink (Eumeces (Plestiodon) fasciatus), brown water snake (*Nerodia taxispilota*), eastern kingsnake (*Lampropeltis getula*), rough green snake (*Opheodrys aestivus*), cottonmouth (*Agkistrodon piscivorus*), and copperhead (*Agkistrodon contortrix*) (NCWRC, 2022).

Alternative 1 - Recommended Plan – No Action

The No Action plan would result in continued frequent flood events within the Neuse River basin that would have some level of negative effects on wildlife. The negative effects have compounded from years of habitat loss that resulted from continued erosion issues caused by stream bank loss and incision, decreased water quality due to increased sedimentation and pollution, loss of habitat, and lower food abundance.

Alternative 2 – Structure Floodproofing

The impacts that could occur relating to any minor habitat loss due to tree/vegetation removal or ground disturbance needed to access property with respect to Alternative 2 would not be fully developed until any potential subsequent detailed design phase where each structure can be evaluated in further detail to determine which measure of Alternative 2 is best. During the construction process wildlife within the immediate vicinity of the project area may leave the area but would be expected to return after the completion of the project. Additionally, each structure to be dry floodproofed is

expected to be completed in 90 days. The total estimated implementation time for Alternative 2 is 2.5 years for all structures in the project with 100 percent owner participation. The impacts of any noise or air quality effects from the construction of the structure dry floodproofing would be minor and temporary to local wildlife with possible effects to wildlife to briefly leave the area during the project construction within each of the identified areas. It is expected wildlife would return when conditions effecting noise and air quality improve or return to baseline conditions.

Alternative 3 – Property Buyouts

Property buyouts may result in minimal improvements to habitat for wildlife within the Neuse River basin by removing structures currently located within the floodplain and allowing the vegetation to regrow creating additional cover and foraging area for fauna. There could be temporary minor negative impacts to wildlife with associated construction noise and air quality effects during the actual removal of any structure on the property during which time wildlife may leave the localized area, but none of those impacts would be permanent and it is expected that wildlife would return once the project is completed.

4.2.3. Threatened and Endangered Species

Pursuant to Section 7 of the Endangered Species Act, the USACE coordinated with the United States Fish and Wildlife Service (USFWS) and the National Marine Fisheries Service (NMFS) to identify endangered and threatened species that might be present in the vicinity of the project area. Species that are currently federally listed as endangered or threatened (as well as Federal Species of Concern), which may or do occur in the Neuse River basin project area, and which may be subject to impacts from the proposed project are listed in Table 4-1.

Table 4-1 Threatened and Endangered Species and Critical Habitat found in the project area

Species Common Names	Scientific Names	Federal Status
Vertebrates		
Atlantic sturgeon	*Acipenser oxyrinchus oxyrinchus*	Endangered
Carolina Madtom	*Noturus furiosus*	Endangered
Neuse River Waterdog	*Necturus lewisis*	Threatened
Red-cockaded woodpecker	*Picoides borealis*	Endangered
Shortnose sturgeon	*Acipenser brevirostrum*	Endangered
Invertebrates		
Atlantic pigtoe	*Fusconaia masoni*	Threatened
Dwarf wedgemussel	*Alasmidonta heterodon*	Endangered
Tar River spinymussel	*Elliptio steinstansana*	Endangered
Yellow lance	*Elliptio lanceolata*	Threatened
Vascular Plants		
Michaux's sumac	*Rhus michauxii*	Endangered
Insects		
Monarch Butterfly	*Danaus plexippus*	Candidate
Critical Habitat (CH)		
Neuse River Waterdog	CH exists in some of the Mainstem of the Neuse River	
Atlantic Sturgeon	CH for the Carolina DPS exists within the Neuse River	

Sturgeon

Shortnose Sturgeon *(Acipenser brevirostrum)* - Populations of shortnose sturgeon range along the Atlantic seaboard from the Saint John River in New Brunswick, Canada to the Saint Johns River, Florida. It is apparent from historical accounts that this species may have once been fairly abundant throughout North Carolina's waters; however, many of these early records are unreliable due to confusion between this species and the Atlantic sturgeon (*Acipenser oxyrhynchus*). The shortnose sturgeon is principally a riverine species and is known to use three distinct portions of river systems: (1) non-tidal freshwater areas for spawning and occasional over wintering; (2) tidal areas in the vicinity of the fresh/saltwater mixing zone, year-round as juveniles and during the summer months as adults; and (3) high salinity estuarine areas (15 parts per thousand (ppt.) salinity or greater) as adults during the winter.

Atlantic Sturgeon (*Acipenser oxyrhynchus*) - Atlantic Sturgeon, an endangered anadromous fish, could possibly be found within the greater Neuse River basin project area during migration and spawning periods, which usually occur within the spring. Atlantic Sturgeon are a large species of fish that can grow to lengths up to 14 feet and weight as much as 800 pounds. Atlantic Sturgeon are bottom feeders with a diet that consisted mostly of worms, shrimps, crabs, snails, and small fish. The fish have an

average life span of around 60 years and although the exact age of maturity for the species found in North Carolina is not known, other nearby populations in South Carolina usually reach maturity between the ages of 5 to 13 years for males and 7 to 19 years for females. According to research completed by the NC Division of Marine Fisheries (NCDMF), the Roanoke River is the only river in North Carolina with a current spawning population of Atlantic Sturgeon; although, the historic spawning area for the species would have included the Tar/Pamlico, Neuse, and Cape Fear Rivers (NCDMF, 2022). The general life history pattern of Atlantic sturgeon is that of a long lived, late maturing, estuarine dependent, anadromous species. The species' historic range included major estuarine and riverine systems that spanned from Hamilton Inlet on the coast of Labrador to the Saint Johns River in Florida. Atlantic sturgeon spawn in freshwater but spend most of their adult life in the marine environment. Spawning adults generally migrate upriver in the spring/early summer; February-March in southern systems, April-May in mid-Atlantic systems, and May-July in Canadian systems.

Atlantic sturgeon spawning is believed to occur in flowing water between the salt front and fall line of large rivers, where optimal flows are 46-76 cm/s and deep depths of 11-27 meters. Sturgeon eggs are highly adhesive and are deposited on the bottom substrate, usually on hard surfaces. Juveniles spend several years in the freshwater or tidal portions of rivers prior to migrating to sea. Upon reaching a size of approximately 76-92 cm, the subadults may move to coastal waters, where populations may undertake long range migrations.

Effective September 18, 2017, the NMFS designated critical habitat for the distinct population segment of Atlantic sturgeon (Figure 4-3). Specific occupied areas designated as critical habitat for the Carolina distinct population segment of Atlantic sturgeon contain approximately 1,939 km (1,205 miles) of aquatic habitat in the following rivers of North Carolina and South Carolina: Roanoke, Tar-Pamlico, Neuse, Cape Fear, Northeast Cape Fear, Waccamaw, Pee Dee, Black, Santee, North Santee, South Santee, and Cooper, and the following additional water body: Bull Creek. Unit C3 (Neuse River, NC) is the closest critical habitat river to the proposed project. Carolina Unit 3 included the Neuse River main stem from the removed Milburnie Damsite (Raleigh, NC) downstream to river kilometer 0 (located at the mouth of the Neuse River entering the Pamlico Sound), approximately 218 miles of CH area.

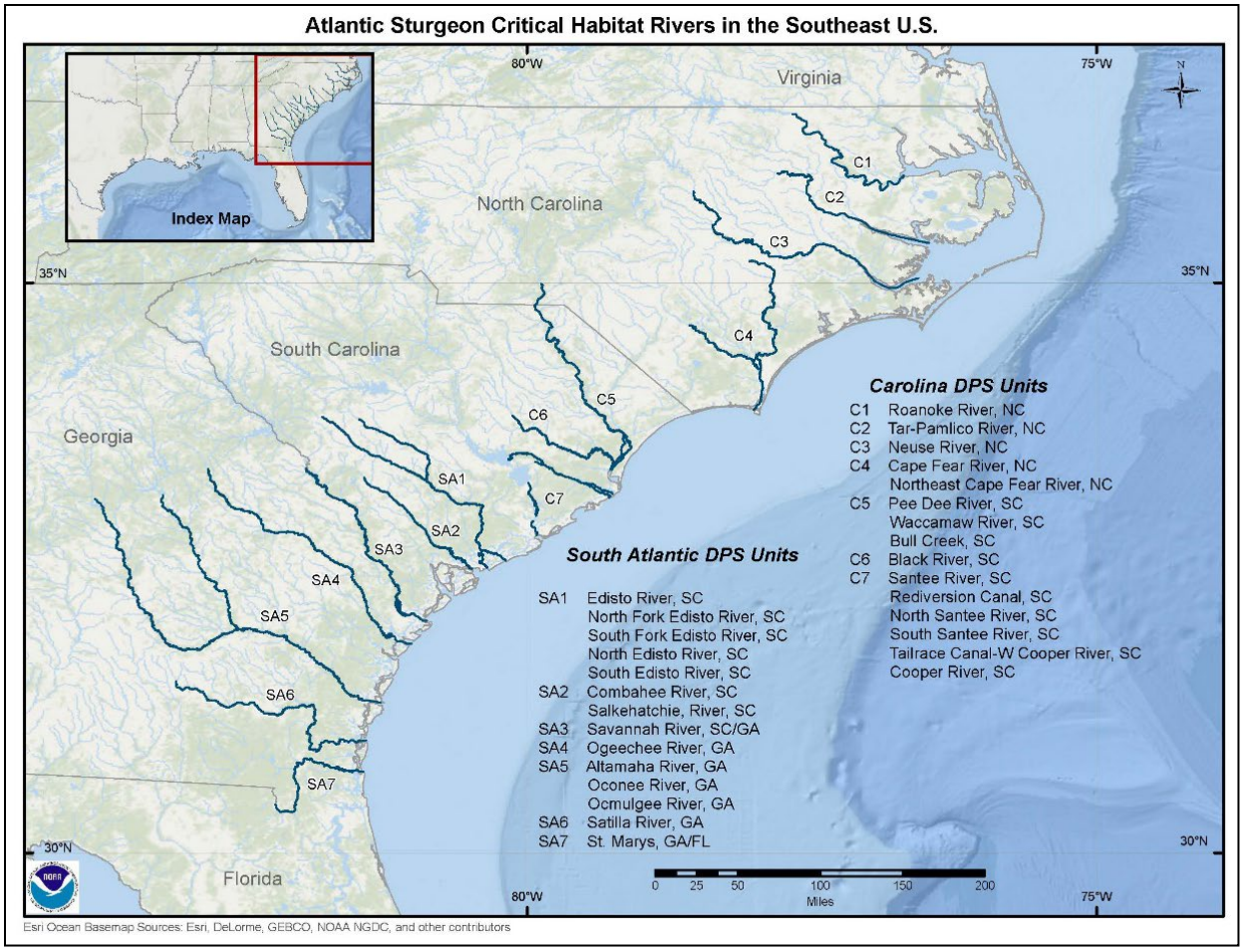

Figure 4-3 Southeast United States Atlantic Sturgeon Critical Habitat

Alternative 1 - Recommended Plan – No Action

The No Action plan would result in continued frequent flood events within the Neuse River basin that have some level of negative effects on threatened and endangered species and critical habitat which is located within tributaries and the Neuse River mainstem. The critical habitat is being negatively affected by streambank loss and incision, which is causing excess sedimentation within the water column and covering gravel or rocky areas along the river bottom which are essential for species such as the Atlantic sturgeon and the Neuse River waterdog which rely on this type of habitat for spawning or shelter. The negative effects are compounding from years of habitat loss that result from continued erosion issues caused by stream bank loss and incision, decreased water quality due to increased sedimentation and pollution, loss of habitat, and lower food abundance.

Alternative 2 - Structure Floodproofing

The impacts that could occur relating to any minor habitat loss due to tree/vegetation removal or ground disturbance needed to access property with respect to Alternative 2 would not be fully developed until any potential subsequent detailed design phase where each structure can be evaluated in further detail to determine which measure of Alternative 2 is best. It's assumed that since most of the impacts would be occurring on previously disturbed ground it is not likely new impacts would occur outside of the previously disturbed footprint of the structure site, but this would need to be evaluated during any potential subsequent detailed design phase. Any impacts to tree/vegetation trimming or removal or ground disturbance that would be needed for equipment to gain access to the site would be minor and temporary and the site around the property to be dry floodproofed would be allowed to regenerate after construction. Additionally, each structure to be floodproofed is expected to be completed in 90 days. The total estimated implementation time for Alternative 2 is 2.5 years for all structures in the project with 100 percent owner participation. Ground disturbing impacts from the construction of dry floodproofing at multiple structures would be minor and temporary within each of the identified areas.

The Atlantic sturgeon, Carolina madtom, Neuse River Waterdog, shortnose sturgeon, Atlantic pigtoe, Dwarf wedgemussel, Tar River spinymussel, and Yellow lance are federally listed as threatened or endangered and may be present in rivers and tributaries located in the Neuse River basin project area. However, these species occur well outside of the project area and would not be affected by the proposed action which would take place on high ground outside of the river and tributary areas where these species are most likely to occur. Additionally, the proposed action would not take place in any river or tributary so there would be no effect to the listed Critical Habitat for the Neuse River waterdog or Atlantic Sturgeon. Likewise, the federal and state listed, endangered red-cockaded woodpecker is a highly mobile species and is not currently known to roost or forage in the proposed project area vicinity which included currently inhabited homesites located within the floodplain. Also, tree cutting or land clearing is not being proposed as part of Alternative 2. Alternative 2 would have no effect to the red-cockaded woodpecker.

Moreover, the project would take place on previously disturbed ground where existing structures and homes are present with no additional clearing being proposed. Michaux's sumac generally is found in dry, rocky, or sandy soils, not indictive of the floodplain soils present within this project area; and in open cleared areas, free from tree overstory such as open fields, roadside ditches, and maintained utility right of ways. Although there is Michaux's Sumac documented in Wake County, the closest known areas of occurrence occur at William B. Umstead State Park and an area in Knightdale, NC, where both areas are located outside of our project area. Also, there are no known

occurrences of this plant within the other county project sites. Alternative 2 would have no effect on the endangered Michaux's Sumac. The monarch butterfly is a candidate species and not yet listed or proposed for listing. Currently, there are generally no Section 7 requirements for candidate species. However, since there are no new areas of clearing or construction proposed, Alternative 2 should have no effect on the monarch butterfly which relies on open fields and access to Milkweed (primarily Asclepias spp.) species plants in order to lay eggs.

Overall, structure dry floodproofing would have no effect on any ESA species or critical habitat found within the project area.

Alternative 3 – Property Buyouts

Property buyouts may result in minimal improvements to threatened and endangered species within the Neuse River basin by removing structures currently located within the floodplain and allowing the natural vegetation to regrow creating additional vegetated river buffer along with habitat in some areas. Natural river buffers are a known way to improve water quality by absorbing and filtering out nutrients and suspended sediments which could improve the river habitat which is considered critical habitat for the Carolina Madtom and the Atlantic Sturgeon. Riparian buffers also slow down the flow of water from a heavy rainfall, lessening the habitat reducing impacts caused by erosion from frequent flooding.

The Atlantic sturgeon, Carolina madtom, Neuse River Waterdog, shortnose sturgeon, Atlantic pigtoe, Dwarf wedgemussel, Tar River spinymussel, Yellow lance are federally listed as threatened or endangered and may be present in rivers and tributaries located in the Neuse River basin project area. However, these species are not likely to be adversely affected by Alternative 3 which would take place on high ground outside of the river and tributary areas where these species are most likely to occur. Additionally, Alternative 3 would not take place in any river or tributary so there would be no effect to the listed Critical Habitat for the Neuse River waterdog or Atlantic Sturgeon. Likewise, the federal and state listed, endangered red-cockaded woodpecker is a highly mobile species and is not currently known to roost or forage in the Alternative 3 vicinity areas which included currently inhabited homesites located within the floodplain. Also, tree cutting or land clearing is not being proposed as part of the buyout plan. This alternative is not likely to adversely affect the red-cockaded woodpecker. Moreover, the project would take place on previously disturbed ground where existing structures and homes are present with no additional clearing being proposed. Michaux's sumac generally is found in dry, rocky, or sandy soils, not indictive of the floodplain soils present within this project area, and in open cleared areas, free from tree overstory such as open fields, roadside ditches, and maintained utility right of ways. Although there is Michaux's Sumac documented in Wake County, the closest known areas of

occurrence occur at William B. Umstead State Park and an area in Knightdale, NC, both located outside of our project area. There are no known occurrences of this plant within the other county project sites. Alternative 3 would have no effect on the endangered Michaux's Sumac. The monarch butterfly is a candidate species and not yet listed or proposed for listing. Currently, there are generally no Section 7 requirements for candidate species. However, since there are no new areas of clearing or construction proposed, Alternative 3 should have no effect on the monarch butterfly which relies on open fields and access to Milkweed (primarily Asclepias spp.) species plants in order to lay eggs.

4.2.4. Essential Fish Habitat (EFH)

The National Marine Fisheries Service (NMFS) is responsible for enforcing the Magnuson-Stevens Fishery Conservation and Management Act (MSFCMA), (1996 amendments), which is intended to promote sustainable fisheries. To implement the MSFCMA, the NMFS and the eight regional Fishery Management Councils have identified and described EFH for each managed fish species. EFH can consist of both the water column (pelagic) and the underlying surface (seafloor) of a particular area. Areas designated as EFH contain habitat essential to the long-term survival and health of our nation's fisheries.

There are not any known habitats or areas identified as essential fish habitat (EFH) located directly within the project area. In compliance with Section 305(b)(2) of the MSFCMA, this report included an assessment of the potential effects of the proposed alternatives on nearby EFH. Correspondence received from NMFS on 17 June 2020 during scoping mentioned that there is an area downstream of New Bern, in the Neuse River and the associated creeks that provides essential fish habitat (EFH) for a number of NOAA-trust resource species, such as bluefish (*Pomatomus saltatrix*), summer flounder (Paralichthys dentatus), brown shrimp (*Farfantepenaeus aztecus*), and white shrimp (*Litopenaeus setiferus*).

Alternative 1 - Recommended Plan - No Action, Alternative 2 - Structure Floodproofing and Alternative 3 - Property Buyouts

There would be no impact to EFH associated with any of the three alternatives. Since none of the plans have structural elements that would alter any of the floodplain, the Neuse River or associated tributaries, there would be no change or impact to downstream EFH with any of the alternatives. Additionally, positive changes potentially gained from increased vegetation within the Neuse River Buffer or improved water quality from decreased erosion would be so minor in scale and extremely localized, it would be very unlikely to have any noticeable effect on EFH located downstream of New Bern.

4.3. Cultural Resources

Initial coordination was conducted with the NCOSA and the NCSHPO to discuss the study's goals, scope iterations, and proposed compliance with all cultural resources considerations under NEPA, as well as Section 106 of NHPA. Coordination to date included examination of data inventories in the area of potential effect (APE) as defined during the study's scoping period and consultation with the NCOSA, NCSHPO, ACHP, Capital Area Preservation, Wilson Historic Preservation Commission, the Cherokee Nation of Oklahoma, the Eastern Band of Cherokee Indians, and United Keetoowah Band of Cherokee Indians. A draft Programmatic Agreement (Appendix G – Cultural Resources) is proposed defining future investigation and compliance requirements. The Recommended Plan is the No Action Alternative, and therefore did not propose any modifications to the study area by USACE. For this reason, the Programmatic Agreement mentioned above is no longer necessary. Documentation of coordination to date with Tribal and cultural resource stakeholders is included in Appendix F (Correspondence).

Informal reconnaissance level cultural resource surveys of the upper Hominy Swamp Creek portion of the study area (near Wilson, NC) were conducted on 3 November 2021 during a multi-agency site visit that included representation from the NCOSA. Reconnaissance level survey recommendations are that Phase I surveys may be required during in any potential subsequent detailed design phase in areas subject to ground disturbing activity, however, the Recommended Plan, being the No Action alternative, did not propose ground disturbing activities, or modifications to existing standing structures.

Alternative 1 - Recommended Plan - No Action

Erosion in areas subject to high water velocities (e.g., streambanks) may be expected to increase. Where erosion is most severe, cultural resources, especially prehistoric archaeological resources, in the project area may eventually be lost. Over time, additional historic structures are likely to meet the NRHP requirements for eligibility evaluation. Future flooding effects may increase as compared to those currently realized due to expected increases in population and infrastructure, impervious surfaces in the watershed, and incidence and severity of storm events in the study area. Increased flooding may adversely impact historic structures. The No Action alternative may have negative impacts of ranging severity on cultural resources in the study area, due to variability in storm intensities and associated flooding and erosion.

Alternative 2 - Structure Floodproofing

Alternative 2 has the potential to cause adverse effects to historic properties; however, net effects of Alternative 2 would be positive. Referencing 36 CFR § 800.5, adverse

effects could be physical damage to all or part of a property, change of the character of a property's use or physical features, and introduction of visual elements that diminish significant historic features, etc. This alternative may have net positive impacts upon NRHP-eligible or -listed structures in the project area, although erosion-based impacts to archaeological resources are expected to remain similar to those of the No Action alternative. Any qualified historic structures would be protected rather than being continually subjected to flood risk. To ensure no adverse effects to historic properties or other cultural resources, dry floodproofing could conform to the Secretary of the Interior's Standards for Rehabilitation, published at 36 CFR Part 67, if necessary and as determined through consultation.

Alternative 3 – Property Buyouts

Property buyouts would include flood risk management in the form of acquisition of structures and associated lands for a total of 126 structures in Wayne and Johnston Counties, and the cities of Kinston, Goldsboro, and Wilson, North Carolina. Structures included in the buyout areas would be demolished or relocated from the property and the land would be returned to a natural state. At least 14 buildings, structures, and objects that are listed in, determined eligible, or potentially eligible for listing in the NRHP, and four historic districts either listed in, or determined potentially eligible for listing in, the NRHP, are also located within the proposed property buyout areas. This alternative would have negative impacts of ranging severity on cultural resources in the project area due to variability in storm intensities and associated flooding and erosion. Property buyouts alone would not change flood or erosion risk regarding archaeological resources or NRHP-eligible or -listed structures as compared to No Action conditions. Furthermore, this alternative may have significant negative impacts upon NRHP-eligible or -listed structures should demolition occur. Demolition of eligible or listed structures may require mitigation, to be coordinated with the NCSHPO and Advisory Council on Historic Preservation (ACHP).

4.4. Aesthetic and Recreational Resources

Hunting, fishing, bird, and wildlife watching are popular activities within the Neuse River basin and add millions of dollars to the economy through license fees and sales of equipment and supplies. These revenues are directly dependent on the ability to maintain and enhance the natural resources of North Carolina. According to the 2011 National Survey of Fishing, Hunting, and Wildlife-Associated Recreation in North Carolina, 1,307,000 residents identified as anglers, 317,000 residents identified as hunters, and 2,124,000 residents identified as wildlife watchers (USFWS, U.S. Census rev. 2018). North Carolina residents spent over $1.5 billion in the United States on fishing related activities during 2011; with the average angler spending $1,176. Hunters and wildlife watchers also reported spending about $2,017 per hunter and $586 per

wildlife watcher. With the Neuse River basin being a prime location for avid hunters, anglers, and bird/wildlife watching enthusiast, preserving natural lands, including wetlands, forest, and natural rivers are important as a resource for recreation.

In addition to hunting and fishing, the Neuse River basin offers many opportunities for other outdoor recreation activities such as hiking, camping, picnicking, wildlife photography, swimming, boating, and kayaking. Some larger parks located within the basin include Cliffs of the Neuse State Park, Neuse River Recreational Area within the Croatan National Forest, Falls Lake State Recreation Area, and William B. Umstead State Park. The Neuse River has not been designated as a “Wild and Scenic” river nor categorized in any manner by a federal or state entity.

Within the selected project area some examples of recreational areas include William B. Umstead State Park, located near Crabtree Creek in Raleigh, NC; Goldsborough Bridge Battlefield and Busco Beach, located in just off the Neuse River in Goldsboro, NC; Wilson Botanical Gardens, located in Wilson, NC; and Neuseway Nature Park, located in Kinston, NC. Additionally, there are many small community parks and recreational sports fields located within the various project areas.

Alternative 1 - Recommended Plan – No Action

There would be no effect to aesthetics or recreation with the No Action plan.

Alternative 2 - Structure Floodproofing

There could be a temporary negative effect to local aesthetics within the construction area where structures are being dry floodproofed. The negative effects would come from visual obstructions from construction fencing, construction signage, and sediment and erosion control silt fencing which would be installed around the project area temporarily during active construction activities. Additionally, recreation could be temporarily interrupted within the immediate project construction area where the dry floodproofing of 12 structures adjacent to Crabtree Creek in Raleigh, NC would take place. This interruption to both aesthetics and recreation would be localized to the construction area immediately adjacent to the 12 structures to be dry floodproofed and would be limited to 2.5 years during the construction period.

Alternative 3 - Property Buyouts

For Alternative 3 property buyouts, removing structures from the floodplain and allowing it to revegetate naturally would improve the aesthetics of the selected areas by increasing the natural areas available within the urban/suburban project area. Additionally, the added natural space may add corridors of increased biodiversity with the potential for low impact recreational opportunities within the floodplain such as hiking, walking and bird watching.

4.5. Socioeconomics

This section presents indicators of social vulnerability that can be used as qualitative metrics to evaluate the array of alternatives under the OSE account. These indicators include Health and Safety, Economic Vitality, Social Connectedness, Identity, Social Vulnerability and Resiliency, and Participation.

Demographic data is displayed in Section 2.7 for the study area. These statistics show that the study area has a similar age distribution, poverty rate, education level, and household size relative to the national average. Median household income, and median home value are slightly lower in the study area compared to the rest of the nation.

Alternative 1 – Recommended Plan – No Action

In the absence of a federal project, it is estimated that flood events would continue to impact the population at risk. Groups that would be disproportionately impacted by these flood events include those with lower median household incomes and larger household sizes, and the population living under the poverty line, as shown in Figures 2-10 and 2-13, respectively. Flood events would continue to impact local businesses, causing temporary closures and loss of wages.

Alternative 2 – Structure Floodproofing

Under Alternative 2, the risk of flooding would be reduced for structures that are floodproofed. The proposed measures would not cause disproportionately high and adverse impacts on minority populations or low-income populations, and there would be no induced flooding in any areas. Residents would remain in their current communities and economic growth would be sustained. Nationally, the total number of full-time equivalent jobs created is estimated at 117 with a total value exceeding $10 million. These regional economic impact estimates are described in more detail in Section 7 of Appendix B (Economics).

Alternative 3 – Property Buyouts

Under Alternative 3, the risk of flooding would be eliminated for homes that are bought out and removed from the floodplain. The proposed measures would not impact water surface elevations or cause induced flooding. This alternative would not cause disproportionately high and adverse impacts on minority or low-income populations. Local economies may experience economic transfers to other areas as residents move outside of the floodplain. Alternative 3 would result in an estimated 106 jobs created in the local economy and would result in an estimated increase in labor income of about $6 million in the local economy. These regional economic impact estimates are directly related to the costs spent on structure demolition and removal and are described in more detail in Section 7 of Appendix B (Economics).

4.5.1. Health and Safety

The health and safety of a community can be negatively impacted by flooding, and these effects can continue for many years after the event. Elderly individuals can be the most affected by flooding, especially in regard to their health, longevity, and safety. Studies have shown that older residents are more likely to experience depressive symptoms after natural disasters, especially when their community lacks cohesion because of these events (Chao, 2016). However, all individuals are affected by flooding disasters and may experience major psychological trauma that can include post-traumatic stress disorder, anxiety, depression, and worsened existing related psychological conditions (Fernandez et al. 2015, Goldmann et al. 2014, Hetherington et al. 2018).

Alternative 1 - Recommended Plan – No Action

Under the No Action alternative, flooding can present a serious hazard to residents' safety outside of psychological conditions. Flooding may continue to claim lives each year as people are unable to evacuate or climb to safety. When floodwaters threaten a community, local officials disseminate a warning to their residents who must first receive such a warning, understand its implications, and act quickly. It is generally assumed residents can get out of harm's way by evacuating (on foot, car, or likewise) or by climbing to higher elevation (like ascending to the second or third level of a home). Both options carry risks. Physical evacuation can lead to overcrowded roads, where fleeing residents are left trapped in their cars if floodwaters arrive. Climbing to a higher elevation may provide some level of safety from floodwaters, however residents are left stranded in their structure until the floodwaters receded. Further, elderly residents may have trouble climbing stairs/ladders that can offer protection from rising floodwaters. Under Alternative 1, risks associated with evacuation and negative impacts to health and safety would persist.

Alternative 2 – Structure Floodproofing

Under Alternative 2, the protected communities would likely be healthier and safer from impending floodwaters. Structure floodproofing measures designed to reduce damage to homes and their contents create a safer environment for the communities they help. Most importantly, these measures would keep residents above the floodwaters. Residents would not have to risk evacuating on foot or by car and getting trapped in moving waters. When homes are floodproofed, they are less likely to become inundated during a flood, preventing possible disease associated with post-flood structures (Ohl and Tapsell, 2000). Mental health and psychological safety would also be protected by these measures. Residents would be less likely to worry about rebuilding following a flood event. They would be less likely to worry about temporary relocations and the loss of their personal belongings while the floodwaters remain high.

Alternative 3 – Property Buyouts

Under Alternative 3, the protected communities would likely be healthier and safer from impending floodwaters. Removing structures and residents from the floodplain would eliminate flooding to these structures and prevent residents from getting caught by floodwaters in event of a flood-induced evacuation.

Mental health and psychological safety could be better or similar to the No Action plan. Residents would not need to worry about rebuilding following a flood event. However, residents may suffer stress or a sense of loss of community by leaving their communities and current homes.

4.5.2. Economic Vitality

Many of the reaches in the study area are characterized by high poverty rates and unemployment, as shown in tables and figures in Section 2.7. Flood events can increase poverty rates and unemployment when businesses are required to close due to floodwaters. This can result in individuals experiencing losses in income.

Alternative 1 - Recommended Plan - No Action

Under the No Action plan, disruption to the economy, business losses, and loss of wages may negatively impact the local economy for some time after flood events and contribute to a gradual deterioration of the economy (Cavallo et al. 2013). Further, many of the communities in the study area do not have large employers that give residents a reason to remain in the community. North Carolina's economy has maintained a strong growth rate, so residents may relocate to other areas within the state to avoid flooding and potential job losses. The communities they leave behind are

more likely to see stagnant growth as residents choose other regions with greater housing and occupational stability.

Residents who believe they are greatly affected by a flooding disaster are more likely to have a reduced perception of their community's recovery (Bergstrand et al. 2020). In this case, the effects of hazards within the physical environment translate into negative perceptions about the local economy. This can lead to a downward spiral among residents where they feel trapped in their community.

Alternative 2 - Structure Floodproofing

Under Alternative 2, residents have a reduced level of flood risk. This would allow them to stay in their community and work in their traditional occupations. By remaining in the community, they can create a positive attitude about their community's recovery and help their neighbors (Bergstrand and Mayer, 2020). The local economy is intrinsically tied to its members' health. When residents can remain in their occupations following a flood, they are likely to be healthier, both immediately and in the long run. Residents can contribute to their local economic growth and provide a quick restart to local production and consumption, thus helping the other members of their community.

Alternative 3 - Property Buyouts

Economic vitality under Alternative 3 in the immediate community would decrease. Local businesses may suffer when residents permanently relocate to another area and residential structures are acquired and demolished. Additionally, relocating residents may impact their jobs, and potentially cause individuals to choose jobs outside of their original communities. Local and regional economic growth may decline as a result of property buyouts and acquisitions.

4.5.3. Social Connectedness

Natural disasters including flood events influence the social structure of a community and impact the growth and sustainability of a community. Social connectedness determines how a community responds and recovers from a significant flood event.

Alternative 1 - Recommended Plan - No Action

Under the No Action alternative, flood events would persist. As communities deal with a disaster, they may lose or gain social connectedness, however, this can vary depending on the existing social structure of the community. Communities with many close bonds may have higher cohesion following a flood. At the individual level, those who remain in the community to volunteer and participate are more likely to experience positive community cohesion (Luden et al. 2019). However, residents who are marginalized or did not participate prior to a flood are not likely to remain in the community and help

build this community cohesion. In areas with many transient workers or impoverished residents, these effects would be especially pronounced.

Further, the level of existing organizations, such as volunteer groups, non-profits, and community outreach programs can help to mitigate the negative effects of flooding on social connectedness. This allows community members to connect as they begin the rebuilding process. Many of the impact areas within this study have a variety of these programs in place that could be a source of support following a flood. For example, the Crabtree Creek reach in Raleigh, NC, has several of these organizations including the Salvation Army, the Food Bank of Central and Eastern North Carolina, and Wake County Public Health Center. However, in areas with more persons living below the poverty level, there are fewer of these programs available.

Alternative 2 - Structure Floodproofing

Under Alternative 2, residents of flood-prone communities would be more likely to feel social connectedness after a flood because of the reduction in risk to individuals and their homes. While social connectedness can fray following a disaster, when residents team up to help each other out, they are more likely to feel like they belong to a part of a community. When residents' homes are protected from floodwaters, they are more likely to participate in the community and help their neighbors out. Residents can participate when they feel they are a part of the long-term community. If homes and residents' belongings are undamaged, they can help each other clean up debris and repair other damages caused by flooding.

Alternative 3 - Property Buyouts

Social connectedness is likely to be negatively impacted by Alternative 3. Residents in flood-prone communities that are forced to relocate and leave their communities may experience a loss of friendships, and a loss of a sense of belonging until they form bonds in their new communities.

4.5.4. Identity

Residents' identity with their community can suffer from the effects of flooding. Conversely, when residents are not subject to floodwaters and can remain in their communities, their identity within the community remains intact.

Alternative 1 - Recommended Plan - No Action

When residents are detached prior to a disaster, they are more likely to lose any identity they had with their community (Tapsell et al. 2002). However, in communities that have strong bonds prior to flooding, these ties are at risk of being frayed by stress and disagreement over post-disaster decisions. While a serious flooding event may cause

residents to question their identity to the community; living in a floodplain with the constant threat of flooding can cause detachment. The constant threat of flooding means community members are aware their home and/or place of work may be temporary, leading residents to view their position in the community as temporary. If residents develop this assumption, it becomes more difficult for community ties to develop, which could lead individuals to create a more cohesive identity within the community.

Alternative 2 - Structure Floodproofing

Similar to improvements in social connectedness, floodproofing of structures may increase residents' identity within the community allowing them to stay longer and contribute to the social fabric and economy. Structure floodproofing measures are likely to help residents feel that they are protected against potential flooding events, creating a sense of resiliency that is helpful following a flood (Redshaw et al. 2018). Because structure floodproofing visibly helps the members of the community with homes in the path of flooding, they are more likely to contribute to their community's well-being.

Alternative 3 - Property Buyouts

Similar to social connectedness, a sense of identity may be negatively impacted by Alternative 3. Residents whose homes are acquired and relocated to other communities may experience a loss of identity from leaving their communities and the homes they had previously lived in.

4.5.5. Social Vulnerability and Resiliency

Social vulnerability is the susceptibility of social groups to the adverse impacts of natural hazards. These impacts may include loss of life, injury, or disruption of livelihood. Resiliency determines how communities prepare for and respond to disruptions from natural hazards, including flood events.

Alternative 1 - Recommended Plan – No Action

Under the No Action alternative, socially vulnerable populations are especially affected by natural disasters and flooding events. As discussed previously, the elderly has an increased risk of developing depressive disorders from flooding events while at the same time, the elderly are more likely to struggle with evacuation and post-flood cleanup. Young children, while not as physically limited as elderly residents, may also experience psychological hardships because of damage caused by flooding events. The tables in Section 2.7 show the percent minority and households below the federal poverty line within the study area. These populations face more hardship when

rebuilding from disasters. Such communities are especially vulnerable to economic changes and social fraying.

Alternative 2 – Structure Floodproofing

The structure floodproofing plan would reduce the risk to socially vulnerable populations by reducing flood damages to certain homes within the study area. It would help these community members remain resilient in the face of flooding by providing them with a reduced level of flood risk they would not otherwise have. Elderly residents would feel safer in their current homes and reduce their level of concern over losing their homes and belongings which can take many years to replace. These floodproofing measures would allow residents in racial minority groups to feel more attached to their communities through increased safety measures. Outreach and education components of this alternative would better inform the public of their risks associated with flooding.

Alternative 3 – Property Buyouts

Property buyouts and acquisitions would remove the risk of flooding to homes that are selected for participation. Individuals who have high social vulnerability metrics, including the elderly, low-income, and minority populations, would benefit from the reduced risk of flooding. Outreach and education components of the alternative would better inform the public of their risks associated with flooding.

4.5.6. Participation

Civic participation is an indicator of community engagement and social cohesion and often measured by electoral participation. Participation in the community may be influenced by natural disasters, including flood events.

Alternative 1 - Recommended Plan – No Action

The development of flood damage reduction strategies offers opportunities for increasing local participation and creation of trust. Communities with high levels of participation from residents may be better off following a flood compared to communities with lower participation rates. One measure of community participation is voter turnout. Table 4-2 shows the voter turnout for counties within the study area.

Table 4-2 November 2020 Election Voter Turnout (source: North Carolina State Board of Elections)

County Name	Voter Turnout	County Name	Voter Turnout	County Name	Voter Turnout
Beaufort County	77%	Greene County	77%	Pamlico County	78%
Carteret County	82%	Johnston County	78%	Person County	79%
Craven County	73%	Jones County	75%	Pitt County	71%
Durham County	74%	Lenoir County	74%	Wake County	80%
Franklin County	79%	Nash County	76%	Wayne County	73%
Granville County	79%	Orange County	76%	Wilson County	72%

Higher voter turnout suggests community members are more invested in the outcomes of their local and regional events (Eagles and Erfle, 1989). Flooding within these areas can reduce community cohesion and residents' identity within the community, leading to a decrease in participation.

Alternative 2 – Structure Floodproofing

Alternative 2 is the likely plan to induce higher community participation through floodproofing measures. When community members feel they are better protected from flooding, they are less likely to feel like temporary or transient members of the community. Because of this, the community members can get more involved when they see they have a long-term future within their current communities. Communities with structure floodproofing measures could see higher participation in terms of voter turnout, as residents take interest in measures that affect their local community.

Alternative 3 – Property Buyouts

Under Alternative 3, participation in existing communities would likely decline as residents move outside of the flood-prone communities. Residents near the acquired structures may be less inclined to get involved when they see their neighbors leaving the community. Participation in local elections and community measures would decline.

4.5.7. Summary of Social Vulnerability

This OSE analysis describes adverse effects from flooding for the future No Action alternative as well as the beneficial social effects from Alternatives 2 and 3. Public health and safety are negatively affected by flooding under the future without-project condition. The study area in North Carolina has a long history of flooding – one that has the potential to impact and harm its citizenry. Alternative 2 would mitigate this impact by reducing the likelihood of flood damage and impacts from floodwater inundation. Economic vitality would also be adversely affected from flooding under the No Action alternative. Community cohesion, participation, and identity would be negatively impacted under the No Action alternative. Finally, social vulnerability would be at risk under the No Action plan and individuals vulnerable to economic loss would feel greater stress from flooding. Under Alternative 2, individuals would be less likely to lose employment, income, and be impacted by stress related to flood events.

Under Alternative 3, economic vitality, social connectedness, identity, and community participation would be negatively impacted since residents would be leave their homes and move to other communities. The health and safety of the community would be positively impacted since residents would be physically removed from flood-prone areas. Highly vulnerable populations including the elderly, low income, and minority populations, would be moved to communities with lower flood risk and not experience the difficulties of recovering from repeated flood events.

4.6. Cumulative Effects

The Federal Executive Branch's Council on Environmental Quality defines cumulative impact as "the impact on the environment that results from the incremental impact of an 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" (40 CFR 1508.7, National Environmental Policy Act of 1969, as amended).

Similarly, the ACHP, an independent federal agency established by NHPA of 1966, oversees the implementation of the Section 106 process and requires undertakings to consider cumulative effects. "Adverse effects may include reasonably foreseeable effects caused by the undertaking that may occur later in time, be farther removed in distance or be cumulative" (36 CFR Part 800.5).

4.7. Identification of Significant Resources

During the scoping process no potentially significant cumulative impact issues are identified. The most significant issue identified during scoping is the need for improved water quality in the mainstem of the Neuse River by reducing frequency of flood flows and sedimentation from erosion entering into the Neuse River. The scoping process

established the geographic focus areas for the project area, species of interest located in the area and critical habitat and identified other actions affecting resources and the surrounding ecosystem. The geographic project area considered for this cumulative effects analysis is the Neuse River basin with the specific proposed project focus areas surrounding the population centers of Raleigh, Goldsboro, and Wilson. The time frame for this analysis is 50 years. During scoping, the following resources or issues of concern were identified:

- Wetlands
- Anadromous fish critical habitat
- Floodplains
- Endangered and threatened species
- Wildlife habitat

4.8. Past Actions

Past actions within the Neuse River basin include the Goldsboro, Neuse River, NC Federal Project, which was authorized by the Flood Control Act of 1941. This project was constructed shortly after authorization and included a cutoff channel, 12 feet deep, 20 feet wide, and about 6,400 feet long across the bend in the Neuse River south of Goldsboro, NC. The primary purpose of the Neuse River cutoff was to alleviate flooding along a 7.1 mile stretch of the Neuse River to agricultural and urbanized areas in Goldsboro, NC. The Neuse River cutoff project was recently modified under the authority of Section 1135 of the Water Resources Development Act of 1986 for the improvement of ecosystem restoration at the cutoff and main channel. Construction was completed in 2021. Operation and maintenance of the modified project is now the responsibility of the non-Federal sponsor, the City of Goldsboro.

Another past action in the analysis area is the Falls Lake Dam and Reservoir. Falls Dam is located in the upper Neuse River immediately upstream of the village of Falls in Wake County, NC, approximately 198 miles upstream from New Bern, NC, 47 miles above Smithfield, NC and about 10 miles north of Raleigh, NC. The main body of the lake is in Wake and Durham counties, but some of the embayments extend into Granville County. The Falls Lake project is authorized for flood control, water supply, water quality and recreation. Falls Lake Dam is an earthen structure having a top elevation of 291.5 feet, msl and an overall length of 1,915 feet. The height above the streambed is 92.5 feet. Falls Lake extends 28 miles up the Neuse River to just above the confluence of the Eno and Flat Rivers. At the top of the conservation pool at elevation 251.5 feet msl, the length of the shoreline is about 175 miles, and the lake

covers an area of 12,410 acres. Falls Lake Project and Dam is operated and maintained by the USACE (https://epec.saw.usace.army.mil/neuse.htm).

4.9. Present Actions

There are no other identified alternatives which are either implementable nor economically viable under federal regulations, policy and/or guidelines. Therefore, No Action is the Recommended Plan for the Neuse River Basin study at the time of the study termination.

4.10. Reasonably Foreseeable Future Actions

Currently, there are no known reasonably foreseeable future actions planned in the proposed project areas or surrounding areas in the described portion of the Neuse River that would contribute to cumulative impacts.

4.11. Alternative Plans Cumulative Impacts Analysis and Determination

Since no federal action is recommended, there are no environmental impacts to any significant resources nor adverse impacts to culturally significant historic properties caused by federal action.

Potential impacts of evaluated actions in the final basinwide alternatives array are qualitatively discussed below in Table 4-3.

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Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
Geology and Sediment		Continued erosion and sedimentation caused by flood events.		During construction proper sediment and erosion control measures, including approved seeding and silt fencing would be required. After construction continued erosion and sedimentation similar to No Action would be expected.		Erosion and sedimentation could occur, proper sediment and erosion control measures, including approved seeding and silt fencing would be required.
Wetlands and Floodplains		No impacts.		No changes to existing hydrology in floodplain, wetland and floodplain impacts would be avoided.		Insignificant, negligible change to existing wetlands found within the project area.
Water Quality		Continuing negative effects to water quality by erosion issues and increased suspended sediments and runoff related to frequent high flooding events within the basin.		Alt. 2 would not reduce erosion, sedimentation or stormwater runoff within the basin and therefore is not expected to impact water quality.		Minimal improvements to water quality within the Neuse River basin by removing structures currently located within the floodplain and allowing the vegetation to grow creating additional vegetated buffer in some areas.
HTRW		Alt. 1 would not adversely impact hazardous and toxic materials located in the proximity of proposed project area, nor would it		Alt. 2 would not adversely impact hazardous and toxic materials located in the proximity of proposed project area, nor would it produce		Alt. 3 would not adversely impact hazardous and toxic materials located in the proximity of proposed project area, nor would it

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
HTRW (Continued)		produce new hazardous and toxic materials within the Neuse River basin.		new hazardous and toxic materials within the Neuse River basin.		produce new hazardous and toxic materials within the Neuse River basin.
Air Quality		The No Action alternative would not involve construction or any other actions that could potentially increase emissions or contribute to increased greenhouse gases.		Temporary, minor localized impacts associated with construction and heavy equipment. No permanent air quality or greenhouse gas impacts associated with Alternative 2 and no air quality permits would be required.		Temporary, minor localized impacts associated with construction and heavy equipment. No expansive air quality impacts with Alt. 3 and no air quality permits would be required.
Prime & Unique Farmland		No prime or unique farmland soils would be altered as part of this project.		No prime or unique farmland soils would be altered as part of this project.		No prime or unique farmland soils would be altered as part of this project.
Noise		No Impact		Temporary, minor localized impacts associated with construction and heavy equipment, all work would be executed during standard daylight working hours, each structure taking approximately 3 months to complete. No significant, long-term increases in noise levels are expected.		Temporary, minor localized impacts associated with construction and heavy equipment, all work during standard daylight working hours, each structure taking approximately 1-2 months to complete. No significant, long-term increases in noise levels are expected.

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
Climate Change		The No Action alternative would continue to experience current and projected effects from climate change that is equivalent to FWOP conditions.		Temporary and isolated increases in greenhouse gases may be technically attributed to climate change. However, scale of Alt. 2 is insignificant with respect to global climate change drivers and therefore, would not affect nor be affected by climate change.		Climate change would not affect nor be affected by Alt. 3, similar to Alt. 2. Removal of structure and return of floodplain to an undeveloped condition may reduce man-made influences to climate change such as excess temperature related to infrastructure and greenhouse gases.
Sea Level Change		Sea level change is not expected to change the current riverine flooding characteristics of the project areas. For the No Action alternative, the existing identified vulnerable infrastructure would remain at risk for flooding but would not be impacted by sea level change.		Components of Alt. 2 appear to fall beyond the footprint of sea-level change impact that would occur mostly downstream in the Neuse; therefore, under Alt. 2, the sea-level change impacts would be similar to Alt. 1.		Alt. 3 outside the footprint of sea-level change impact that would occur mostly downstream in the Neuse; therefore, under Alt. 3, the sea-level change impacts would be similar to Alt. 1.

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)						
Environmental Quality (EQ) Resource		**Alternative 1. Recommended Plan - No Action**		**Alternative 2. Dry Floodproofing**		**Alternative 3. Property Buyouts**
Vegetation		No Action plan would result in continued frequent flood events within the Neuse River Basin that have some level of negative effects on vegetation. The negative effects are compounding from years of stream bank loss that result from continued erosion issues and stream incision in some parts of the basin. Invasive species would continue to grow and exist throughout the basin and the project areas.		Although no cutting or trimming of vegetation is planned at this stage of the study, Alt. 2 did not include replanting of any native species at the dry floodproofing site so there could be the potential for additional invasive species to regrow within the dry floodproofing areas which could have a long-term negative impact to surrounding native vegetation.		Invasive species could potentially regrow in the buyout areas where homes or structures are removed from the floodplain property, the current Alt. 3 did not include replanting of any native species at the buyout site after structure removal. The potential for additional invasive species to regrow within the buyout areas would have a long-term negative impact to surrounding native vegetation.

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
Wildlife		The No Action plan would result in continued frequent flood events within the Neuse River basin that have some level of negative effects on wildlife. The negative effects are compounding from years of habitat loss that result from continued erosion issues caused by stream bank loss and incision, decreased water quality due to increased sedimentation and pollution, loss of habitat, and lower food abundance.		Any impacts to tree/vegetation trimming or removal or ground disturbance that would be needed for equipment to gain access to the site would be minor and temporary and the site around the property to be dry floodproofed would be allowed to regenerate after construction. Each structure to be completed in 90 days (total implementation period 2.5 years) keeping any impacts minor and temporary within each of the identified areas. Impacts of any noise or air quality effects from the construction would be minor and temporary to local wildlife within each of the identified areas.		Property buyouts may result in minimal improvements to habitat for wildlife within the Neuse River basin by removing structures currently located within the floodplain and allowing the vegetation to regrow creating additional cover and foraging area for fauna. There could be temporary minor negative impacts to wildlife with associated construction noise and air quality effects during the actual removal of any structure on the property estimated to take 1-2 months per structure. Total implementation period estimated at 2 years.

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
Threatened and Endangered Species (TES)		Continued frequent flood events within the Neuse River basin to have some level of negative effects from years of habitat loss that result from continued erosion issues caused by stream bank loss and incision, decreased water quality due to increased sedimentation and pollution, loss of habitat, and lower food abundance.		Any impacts to tree/vegetation trimming or removal or ground disturbance that would be needed for equipment to gain access to the site would be minor and temporary and the site around the property to be dry floodproofed would be allowed to regenerate after construction. Construction to be completed in 90 days (total implementation period 2.5 years) keeping any impacts minor and temporary within each of the identified areas. There are no identified impacts to TES or CH with Alt. 2.		Property buyouts may result in minimal improvements to threatened and endangered species within the Neuse River basin by removing structures currently located within the floodplain and allowing the vegetation to regrow creating additional vegetated river buffer along with habitat in some areas. Positive improvement for riparian buffers which also slow down the flow of water from a heavy rainfall, lessening the habitat reducing impacts caused by erosion from frequent flooding.
Essential Fish Habitat (EFH)		Positive changes potentially gained from increased vegetation within the Neuse River Buffer or improved water quality from decreased erosion would be so minor		Positive changes potentially gained from increased vegetation within the Neuse River Buffer or improved water quality from decreased erosion would be so minor in scale and extremely localized,		Positive changes potentially gained from increased vegetation within the Neuse River Buffer or improved water quality from decreased erosion would be so minor in scale and

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)

Environmental Quality (EQ) Resource		Alternative 1. Recommended Plan - No Action		Alternative 2. Dry Floodproofing		Alternative 3. Property Buyouts
Essential Fish Habitat (EFH) (Continued)		in scale and extremely localized, it would be very unlikely to have any noticeable effect on EFH located downstream of New Bern.		it would be very unlikely to have any noticeable effect on EFH located downstream of New Bern.		extremely localized, it would be very unlikely to have any noticeable effect on EFH located downstream of New Bern.
Cultural Resources		Negative impacts of ranging severity due to variability in storm flooding and erosion.		Net positive impacts upon NRHP-eligible or -listed structures in the project area, although erosion-based impacts are expected to remain similar to those of the No Action alternative. Dry floodproofing would conform to the Secretary of the Interior's Standards for Rehabilitation, published at 36 CFR Part 67.		Negative impacts of ranging severity due to variability in storm intensities and associated flooding and erosion; significant negative impacts upon NRHP-eligible or -listed structures should demolition occur.

Table 4-3 Qualitative EQ Account Evaluation of Final Basinwide Alternatives Array (Continued)						
Environmental Quality (EQ) Resource		**Alternative 1. Recommended Plan - No Action**		**Alternative 2. Dry Floodproofing**		**Alternative 3. Property Buyouts**
Aesthetics and Recreation		No Impact, no new construction within Neuse River basin so there would be no changes to the current aesthetics or the available land to use for recreation.		Temporary and localized impacts to aesthetics and recreation. Impacts would be expected to be localized to the project area construction zone located around 12 structures to be dry floodproofed along Crabtree Creek, Raleigh, NC. The impacts would also be expected to be temporary and limited to the 3 month expected construction period.		No Impact, no new construction within Neuse River basin so there would be no changes to the current aesthetics or the available land to use for recreation.
Socioeconomics		Continued negative impacts to health and safety, economy, and local social communities from frequent flood events		Positive outcomes for social and health of residents' lives. Additional positive benefits to local economies and social communities.		Positive outcomes for social and health of residents' lives. Negative benefits to local economies and social communities.

Chapter 5 THE RECOMMENDED PLAN

5.1. Plan Details

The Recommended Plan for the Neuse River Basin Flood Risk Management Study is Alternative 1, No Action. Alternative 2 is the only alternative determined to be economically feasible and designated the National Economic Development (NED) plan. This alternative is a nonstructural plan of dry floodproofing of 12 structures, 10 of which are multi-family residential apartment buildings, located adjacent to Crabtree Creek in Raleigh, NC. However, this alternative did not ultimately meet the planning screening acceptability criteria shown in Table 3-21, based on the following issues.

Alternative 2 potentially conflicted with the following federal and local regulations:

- FEMA NFIP Technical Bulletin 3 dated January 2021 – Requirements for the Design and Certification of Dry Floodproofing Non-Residential and Mixed-Use Buildings), Section 1.3. and
- City of Raleigh Stormwater Design Manual, dated 22 July 2022, (Chapter 7, Section 7.7)

Implementation of a flood risk management plan that potentially conflicted with Federal, state and local regulations could negatively impact a community's, or certain property owners' ability to participate in the National Flood insurance Program (NFIP) and other federally funded flood emergency disaster recovery programs.

Additionally, since dry floodproofing measures associated with Alternative 2 would only be intended to reduce flood damage, a detailed Emergency Evacuation Plan (EEP) for affected residents would be required as a critically needed component to successfully implement Alternative 2. Even with the EEP, implementation of Alternative 2 could potentially increase the risk of loss of life given that an EEP would generally not have the authority to implement nor enforce mandatory evacuation of residents.

Therefore, if they refused to evacuate their residences under any circumstances, even if recommended by law enforcement, residents' ingress and egress would be severely restricted during a flood event. As a result, residents would be placed at a heightened risk if floodwaters overtopped the design flood level creating the need for immediate rescue and emergency assistance.

There are no other identified alternatives which are either implementable nor economically viable under federal regulations, policy and/or guidelines. Therefore, No Action is the Recommended Plan for the Neuse River Basin study.

Since no federal action is recommended, there are no environmental impacts to any significant resources nor adverse impacts to culturally significant historic properties caused by federal action.

5.2. Views of the Non-Federal Sponsor

The non-Federal sponsor, the North Carolina Department of Environmental Quality, did not object to the Recommended Plan of no federal action.

5.3. Environmental Justice

Background and Definitions

Executive Order (EO) 12898, dated February 11, 1994, mandates that "each federal agency shall make achieving environmental justice part of its mission by identifying and addressing, as appropriate, disproportionately high and adverse human health or environmental effects of its programs, policies, and activities on minority populations and low-income populations."

The Council on Environmental Quality (CEQ) has oversight of the federal government's compliance with EO 12898 and NEPA. CEQ, in consultation with the U.S. Environmental Protection Agency (EPA) and other affected agencies, developed NEPA guidance for addressing requirements of the EO 12898 (CEQ, 1997). This guidance was developed to further assist federal agencies with their NEPA procedures so that environmental justice (EJ) concerns are effectively identified and addressed.

The CEQ has also identified six general principles for consideration in identifying and addressing EJ in the NEPA process which include: (1) area composition (demographics); (2) data (concerning cumulative exposure to human health or environmental hazards); (3) interrelated factors (recognizing the interrelated cultural, social, occupational, or economic factors); (4) public participation; (5) community representation; and (6) tribal representation.

The following definitions are used by the CEQ in guidance on key terms of EO 12898:

- Low-income population: Low-income populations in an affected area should be identified with the annual statistical poverty thresholds from the Bureau of the Census' Current Population Reports, Series P-60 on Income and Poverty. In identifying low income populations, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a set of individuals (such as migrant workers or Native Americans), where either type of group experiences common conditions of environmental exposure or effect.

- Minority: Individual(s) who are members of the following population groups: American Indian or Alaskan Native; Asian or Pacific Islander; Black, not of Hispanic origin; or Hispanic.

- Minority population: Minority populations should be identified where either: (a) the minority population of the affected area exceeds 50 percent or (b) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population or other appropriate unit of geographic analysis. In identifying minority communities, agencies may consider as a community either a group of individuals living in geographic proximity to one another, or a geographically dispersed/transient set of individuals (such as migrant workers or Native American), where either type of group experiences common conditions of environmental exposure or effect. The selection of the appropriate unit of geographic analysis may be a governing body's jurisdiction, a neighborhood, census tract, or other similar unit that is to be chosen so as not to artificially dilute or inflate the affected minority population. A minority population also exists if there is more than one minority group present and the minority percentage, as calculated by aggregating all minority persons, meets one of the above-stated thresholds.

- Disproportionately high and adverse human health effects: When determining whether human health effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

    - Whether the health effects, which may be measured in risks and rates, are significant (as employed by NEPA), or above generally accepted norms. Adverse health effects may include bodily impairment, infirmity, illness, or death.
    - Whether the risk or rate of hazard exposure by a minority population, low-income population, or Indian tribe to an environmental hazard is significant (as employed by NEPA) and appreciably exceeds or is likely to appreciably exceed the risk or rate to the general population or other appropriate comparison group.
    - Whether health effects occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards.

- Disproportionally high and adverse environmental effects: When determining whether environmental effects are disproportionately high and adverse, agencies are to consider the following three factors to the extent practicable:

- Whether there is or would be an impact on the natural or physical environment that significantly (as employed by NEPA) and adversely affects a minority population, low-income population, or Indian tribe. Such effects may include ecological, cultural, human health, economic, or social impacts on minority communities, low-income communities, or Indian tribes when those impacts are interrelated to impacts on the natural or physical environment.
- Whether environmental effects are significant (as employed by NEPA) and are or may be having an adverse impact on minority populations, low-income populations, or Indian tribes that appreciably exceeds or is likely to appreciably exceed those on the general population or other appropriate comparison group.
- Whether the environmental effects occur or would occur in a minority population, low-income population, or Indian tribe affected by cumulative or multiple adverse exposures from environmental hazards (Ibid. Appendix A (Hydrology and Hydraulics)).

Analysis and Conclusions

Since no federal action is the Recommended Plan, there are no expected adverse impacts to EJ populations.

Chapter 6 COMPLIANCE WITH ENVIRONMENTAL REQUIREMENTS

The draft IFR/EA was prepared in accordance with the 1969 version of the Council on Environmental Quality (CEQ) regulations (40 Code of Federal Regulations (CFR) parts 1500-1508). Additionally, this study began prior to the implementation of the updated CEQ NEPA 2020 regulations.

The relationship of the draft Recommended Plan to federal laws and policies is described below and summarized in Table 6-1.

Table 6-1 The Relationship of the Draft Recommended Plan to Federal Laws and Policies

Title of Public Law or Executive Order	Compliance Status*	Section Addressed
Clean Air Act of 1972, As Amended	Full Compliance	4.1.3.2
Clean Water Act of 1972, As Amended	Full Compliance	4.1.2.2
Magnuson-Stevens Fishery Conservation and Management Act	Full Compliance	4.2.4
Protection of Wetlands, E.O. 11990	Full Compliance	4.1.2.1
Invasive Species, E.O. 13112	Full Compliance	4.2.1
Floodplain Management, E.O. 11988	Full Compliance	4.1.2.1
Fish and Wildlife Coordination Act of 1958, As Amended	Full Compliance	4.2.3
Endangered Species Act of 1973	Full Compliance	4.2.3
National Historic Preservation Act of 1966, As Amended	Full Compliance	4.3
Federal Actions to Address Environmental Justice and Minority and Low-Income Populations, E.O. 12898	Full Compliance	5.3
Federal Coastal Zone Management Act of 1972	Full Compliance	6.6

*Full compliance if the study was not terminated and the NEPA process was completed.

6.1. National Environmental Policy Act (NEPA)

n accordance with NEPA, the Wilmington District provided a scoping letter by email on 29 May 2020, to tribal, local, state, and federal resource agencies and interested parties for a 30-day comment period. Additionally, a virtual scoping meeting was conducted on 7 July 2020. Comments were received from USFWS, USEPA, NMFS, ACHP,

NCSHPO, NCWRC, NC Division of Coastal Management (NCDCM), NCDMF, NC Division of Parks, Pitt County, Jones County, Cherokee Tribe of Oklahoma, and American Rivers.

Concerns voiced were predominantly related to construction of new dams/reservoirs or large structural water control features such as levees or channel modifications. Additional concerns included the impacts to existing cultural resources, wetlands, fish and wildlife, and natural habitat adjacent to the river. All identified agency and stakeholder concerns were considered during the development of the draft IFR/EA. The draft IFR/EA was released to the public and resource agencies for a 30-day review from 26 April to 26 May 2022. Formal views of the public, agencies, stakeholders, and tribes were obtained on the draft IFR/EA released for review and comment on 26 April 2022. Also, a public information meeting was held on 10 May 2022 where multiple stakeholders and the public participated. Comments received on the draft IFR/EA and USACE responses are included in Appendix I (Public and Agency Comments and Responses).

6.2. Clean Water Act of 1972, as Amended

6.2.1. Section 401 of Clean Water Act of 1972

The NCDWR was included in the scoping and 30-day review of the draft IFR/EA as part of the feasibility planning phase of this study. Since there are no direct impacts to jurisdictional bodies of water or wetlands associated with the draft Recommended Plan, a Section 401 water quality certification is not required.

6.2.2. Section 404 of Clean Water Act of 1972

Pursuant to Section 404 of the Clean Water Act, the effects associated with the discharge of fill material into waters of the United States are evaluated in accordance with Section 404(b)(1) (P.L. 95-217). Since there are no direct impacts associated with fill in jurisdictional bodies of water or wetlands associated with the draft Recommended Plan, a Section 404 (b)(1) analysis is not required.

6.3. Magnuson-Stevens Fishery Conservation and Management Act (Essential Fish Habitat (EFH))

Potential project effects on EFH species and their habitats have been evaluated and are addressed in Section 4.2.4 of this document. The USACE determined that the draft Recommended Plan would not have a significant adverse effect on such resources. The draft IFR/EA was submitted to the NMFS along with a letter requesting review and EFH concurrence. NMFS HCD sent concurrence via email on 19 July 2022 that the draft

Recommended Plan is very unlikely to adversely affect EFH and an EFH consultation is not required by the Magnuson-Stevens Fishery Conservation and Management Act.

6.4. Fish and Wildlife Coordination Act of 1958, as Amended

The Fish and Wildlife Coordination Act, as amended (16 U.S.C. 661, *et seq*), requires that USACE coordinate and obtain comments from the USFWS, the NMFS, where applicable, and appropriate State fish and wildlife agencies.

Coordination with NMFS, NCDMF, NCWRC, and USFWS was conducted throughout the study process. Coordination included receiving written scoping comments, a virtual scoping meeting, and an onsite field visit to Hominy Swamp Creek where, at one point during the feasibility study, multiple channel bench features were being evaluated as part of a structural measure; however, this measure was ultimately determined to be not economically feasible and removed from further consideration.

6.5. Section 7 of the Endangered Species Act of 1973

Pursuant to Section 7 of the Endangered Species Act, the USACE is in communication with the U.S. Fish and Wildlife Service (USFWS) during the development of the Neuse River Basin Flood Risk Management study. The USACE determined that the draft Recommended Plan would have no effects on endangered species or critical habitats, and received USFWS concurrence by letter dated 25 May 2022 and a follow up email dated 21 July 2022.

It is not anticipated that implementation of the draft Recommended Plan would have any impacts that would require Section 7 consultation with NMFS for impacts to ESA marine species covered by the NMFS Office of Protected Resources. The NMFS Office of Protected Resources received a copy of the draft IFR/EA during the 30-day public review and provided no comments.

6.6. Section 106 of the National Historic Preservation Act of 1966, as Amended

Consultation with the NCSHPO and the ACHP occurred iteratively as the Recommended Plan evolved based upon updated information. A draft Programmatic Agreement (PA) was prepared and coordinated among the NCOSA, NCSHPO, ACHP, Capital Area Preservation organization, and Wilson Historic Preservation Commission prior to identification of the No Action alternative as the Recommended Plan. As a result, detailed surveys of historic structures are not necessary, and a PA is no longer required.

No federally recognized North Carolina Indian Tribes had areas of interest overlapping with the study area; however, the Eastern Band of Cherokee Indians, the Cherokee Nation of Oklahoma, and the United Keetoowah Band of Cherokee Indians were invited to participate in the Section 106 Programmatic Agreement process as concurring parties. See Appendix G (Cultural Resources) for a copy of the draft Programmatic Agreement and Appendix F (Correspondence) for associated Section 106 correspondence.

6.7. North Carolina Coastal Zone Management Program

One previous element included in the draft Recommended Plan (stream gage installation) would have been installed within Craven County which is a designated coastal county in North Carolina. Pursuant to the Federal Coastal Zone Management Act of 1972, as amended (P.L. 92-583), federal activities are required to be consistent, to the maximum extent practicable, with the federally approved coastal management program of the State in which their activities would occur. A federal consistency was sent to the North Carolina Division of Coastal Management (NCDCM) on 15 March 2022. NCDCM concurrence with the federal consistency was received on 25 May 2022. This stream gage feature was ultimately removed from the draft Recommended Plan due to redundancy with another area stream gage that was identified during the public and agency review process.

Chapter 7 SUMMARY OF AGENCY AND PUBLIC INVOLVEMENT

7.1. Cooperating Agencies

Pursuant to Section 1005 of WRRDA 2014, the USACE requested that the other agencies serve as cooperating agencies during the planning process. On 26 June 2020, a cooperating agency letter was mailed out to NMFS, USFWS, EPA, and FEMA. As noted in the letter, invited agencies were considered a coordinating agency unless correspondence was received to state otherwise. The NMFS sent a letter dated 15 July 2020 to the USACE Wilmington District stating that their organization did not have the resources or staffing to be a cooperating agency on the Neuse River Basin Flood Risk Management study. Other agencies did not respond, so they are cooperating agencies. These letters are included in Appendix F (Correspondence).

7.2. Public and Agency Coordination Prior to Development of the Draft IFR/EA

During the first year of the feasibility study, specifically between September and November 2020, ten separate onsite and/or virtual information gathering events within the Neuse River basin study area were held with town, city, county, and state officials. These events contributed to the study by providing existing information about past flood risk studies, mapping, and other technical data. Concurrent discussions with officials from at least six (6) other counties located along the perimeter of the basin validated the level of flood risk from tributaries of the Neuse River is minor primarily because development is located outside the 1% AEP flood level.

Three virtual public involvement meetings were held between March and April 2021. These meetings individually focused on the eastern, central, and western portions of the Neuse River basin, confirmed strong public interest in this study and provided opportunities to discuss potential measures that could be evaluated to reduce flood risk.

Additionally, a draft Programmatic Agreement regarding compliance with Section 106 of the National Historic Preservation Act was developed in coordination with the NCOSA, NCSHPO, ACHP, Capital Area Preservation, Wilson Historic Preservation Commission, the Cherokee Nation of Oklahoma, the Eastern Band of Cherokee Indians, and United Keetoowah Band of Cherokee Indians. However, as a result of the Recommended Plan being No Action, a PA is no longer required. See Appendix G (Cultural Resources) for a copy of the draft Programmatic Agreement and Appendix F for associated Section 106 correspondence.

7.3. Coordination of the Draft IFR/EA Document

Four additional focused virtual meetings were held with officials of communities where initial flood risk management measures were proposed as part of the draft Recommended Plan and draft IFR/EA. Participating counties and communities included Wayne and Johnston Counties, and the cities/towns of Goldsboro, Wilson, and Raleigh, all in North Carolina. Feedback from these meetings has been incorporated as applicable into this Technical Report and Appendix F (Correspondence) and Appendix I (Public and Agency Comments and Responses).

7.4. Recipients of the Draft IFR/EA Document

Tribes

Eastern Band of Cherokee Indians
Cherokee Nation of Oklahoma
United Keetoowah Band of Cherokee Indians

Federal Agencies

Advisory Council on Historic Preservation
U.S. Environmental Protection Agency
U.S. National Marine Fisheries Service
U.S. Fish and Wildlife Service
U.S. Department of Agriculture - National Resources Conservation Service

State Agencies

N.C. Department of Environmental Quality
N.C. Department of Transportation
N.C. Division of Coastal Management
N.C. Division of Emergency Management Resources
N.C. Division of Marine Fisheries
N.C. Division of Water Resources
N.C. Office of State Archaeology
N.C. State Historic Preservation Office
N.C. Wildlife Resources Commission
N.C. Office of Recovery and Resiliency
North Carolina State University

Local Governments

Craven County, County Manager
City of New Bern, City Manager
Jones County, County Manager
Town of Pollocksville, Mayor
Town of Trenton, Mayor
Lenoir County, County Manager
City of Kinston, City Manager
Town of Seven Springs, Mayor
Town of Grifton, Mayor
Pitt County, County Manager
Wilson County, County Manager
City of Wilson, City Manager
Wayne County, County Manager
City of Goldsboro, City Manager
Johnston County, County Manager
Town of Smithfield, City Manager
Wake County, County Manager
City of Raleigh, City Manager and Director of Public Works
Durham County, County Manager
City of Durham, City Manager and Director of Public Works

Elected Officials

Rep. Butterfield, NC-1
Rep. Ross, NC-2
Rep. Murphy, NC-3
Rep. Price, NC-4
Rep. Manning, NC-6
Rep. Rouzer, NC-7
Sen. Burr, NC
Sen. Tillis, NC

Conservation Groups/Recreation Groups

American Rivers
The Nature Conservancy
National Audubon Society
National Wildlife Federation
Sierra Club

Chapter 8 CONCLUSIONS

The flood risk management problems and needs of the study area have been reviewed and evaluated with regard to the Federal and non-Federal interests with consideration of engineering, economic, environmental, social, and cultural resources concerns. The conclusions of the study are summarized as follows:

a) The Neuse River basin is susceptible to major damage from multiple causes including riverine flooding, plus coastal storm surge and sea level rise in the tidally influenced downstream portion of this basin.

b) Due to the complex dynamic of this tidally influenced area, including the city of New Bern, detailed analyses of this portion of the basin are not included in this study. This unique area should be separately evaluated under a new study action.

c) For the non-tidally influenced area of this basin, generally northwest of the city of New Bern to the basin's headwaters, no significant Life-Safety risk is estimated for any reach evaluated during this study.

d) Alternative 2, a nonstructural plan of dry floodproofing of 12 structures located adjacent to Crabtree Creek in Raleigh, NC, including 10 multi-family residential apartment buildings, is the only economically feasible plan and is identified as the National Economic Development (NED) plan. However:

- This alternative did not ultimately meet the planning screening acceptability criteria due to potential conflicts with federal and local floodplain management regulations, and
- If residents refused to evacuate their residences under any circumstances, even if recommended by law enforcement, residents' ingress and egress would be severely restricted during a flood event. As a result, residents would be placed at a heightened risk if floodwaters overtopped the design flood level creating the need for immediate rescue and emergency assistance.

e) There are no other identified alternatives which are either implementable nor economically viable under federal regulations, policy and/or guidelines. Therefore, No Action is determined to be the Recommended Plan for the Neuse River Basin Study.

f) Since no federal action is recommended, there are no environmental impacts to any significant resources nor adverse impacts to culturally significant historic properties caused by federal action.

g) The non-Federal sponsor, the North Carolina Department of Environmental Quality, did not object to the Recommended Plan of no federal action.

h) While there is no federal interest found for implementation of a flood risk management plan, there are potential opportunities for a non-Federal entity to pursue additional analysis with the Corps to further define flood risk within the basin. One example could be further assessment of the multi-building apartment complex along Crabtree Creek in southeastern portion of the city of Raleigh (Alternative 2) to conduct a Planning Assistance to States (PAS) study, Floodplain Management study (FPMS) or Continuing Authorities Program (CAP) study. This is a potentially socially vulnerable area subject to flood damage where the flood risk could endanger the residents. These programs could also be used to develop educational materials for the public describing basinwide flood risk based on the analyses to date, including socially vulnerable communities.

i) Based on coordination to date with the non-Federal sponsor, this report is expected to be used to inform the Neuse River resilience study being conducted by the NCDEQ Division of Mitigation Services.

Chapter 9 POINT OF CONTACT

Any comments or questions regarding this Technical Report should be addressed to the U.S. Army Corps of Engineers, Wilmington District, 69 Darlington Avenue, Wilmington, NC 28403, ATTN: Jason Glazener, Lead Planner.

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Chapter 10 REFERENCES

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Chapter 11 LIST OF PREPARERS

The professionals listed in Table 11-1 provided major support in developing and preparing the *Draft Neuse River Basin Flood Risk Management Integrated Feasibility Report and Environmental Assessment, North Carolina*.

Table 11-1 List of Preparers for Draft IFR/EA

Name	Project Delivery Team Role
	Plan Formulator
	Environmental and EA Preparation
	Cultural Resources
	Section 106 Programmatic Agreement
	Engineering Technical Lead/Hydrology and Hydraulics
	Economics
	Cost Engineer
	Design
	Geotechnical
	Real Estate
	Geographic Information System
	Project Manager
Name	**First District Quality Control Team Role**
	Chief, Planning and Environmental Branch
	Chief, Environmental Resources Section
	Chief, Water Resources Section
	Hydraulic Engineer
	Chief, Economics and Planning Quality Review
	Chief, Technical Support Section
	Chief Design and General Engineering Section
	Chief, Geotechnical and Dam Safety Section
	Geologist
	Chief, Programs and Project Management Branch
	Chief, Management and Disposal Branch, Real Estate
	Archeologist

The professionals listed in Table 11-2 provided major support in developing and preparing this *Neuse River Basin Flood Risk Management Technical Report, North Carolina*.

Table 11-2 List of Preparers for the Technical Report

Name	Project Delivery Team Role
	Plan Formulator
	Environmental and EA Preparation
	Cultural Resources
	Section 106 Programmatic Agreement
	Engineering Technical Lead/Hydrology and Hydraulics
	Economics
	Cost Engineer
	Design
	Geotechnical
	Real Estate
	Geographic Information System
	Project Manager
Name	**Second District Quality Control Team Role**
	Chief, Planning Branch
	Senior Plan Formulator
	Chief, Environmental Resources Section
	Chief, Water Resources Section
	Hydraulic Engineer
	Chief, Economics and Planning Quality Review
	Chief, Technical Support Section
	Chief Design and General Engineering Section
	Chief, Geotechnical and Dam Safety Section
	Geologist
	Chief, Programs and Project Management Branch
	Chief, Management and Disposal Branch, Real Estate
	Archeologist

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