US Army Corps of Engineers ®
Wilmington District

DETAILED PROJECT REPORT AND ENVIRONMENTAL ASSESSMENT

GREENVILLE UTILITIES COMMISSION, NC

SECTION 14 EMERGENCY STREAMBANK AND SHORELINE EROSION PROTECTION PROJECT

Emergency Streambank and Shoreline Erosion Protection
Section 14 of the Flood Control Act of 1946, as amended

November 2022

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EXECUTIVE SUMMARY

This Detailed Project Report and Environmental Assessment (DPR/EA) presents the findings of the "Greenville Utilities Commission (GUC), NC Section 14 Emergency Streambank and Shoreline Erosion Protection Study", and has been prepared by the U.S. Army Corps of Engineers – Wilmington District in partnership with the GUC to document the plan formulation process and potential environmental effects associated with the implementation of emergency streambank and shoreline erosion protection alternatives for the project site. The geographic scope of the GUC, NC Section 14 study consists of the implementation site along the northern shoreline of the Tar River in the immediate vicinity of the GUC water treatment plant, located in the City of Greenville, NC. Additionally, positive impacts from the project extend to areas of Pitt and Greene counties which are provided water supply from the plant.

The overall goal of the project is to provide long-term protection and stabilization for the embankment along the Tar River adjacent to the GUC water treatment plant in order to reduce risk to the adjacent water intake infrastructure. Section 14 of the Flood Control Act of 1946, as amended, is a Continuing Authorities Program (CAP) focusing on relatively smaller water resource-related projects not requiring specific Congressional authorization. The Section 14 program is designed for protection of essential, properly maintained public facilities in imminent threat of damage or failure from natural streambank and shoreline erosion processes. The drinking water intake system is a key element of the regions drinking water operations, is an essential public service to over 140,000 citizens (GUC 2022), and is maintained as such. The GUC is the non-Federal sponsor for this feasibility study. The GUC provides electric, water, sewer and natural gas services to the City of Greenville and portions of Pitt and Greene Counties. GUC is owned by the citizens of Greenville but operates under a separate charter issued by the N.C. General Assembly and is an eligible non-Federal sponsor.

This DPR/EA develops and discusses potential solutions as a guide to Federal and non-Federal partnership in a protection project. This DPR/EA provides a description and discussion of the existing conditions in the project area, and the array of alternative plans evaluated, including their benefits, costs, and environmental effects. This report also identifies, evaluates, and recommends a solution (the Tentatively Selected Plan) that best meets the planning objective of managing the risk of damage to the GUC water intake system posed from adjacent shoreline erosion along the Tar River over a 50-yr period of analysis (2023-2072).

The Tentatively Selected Plan (Stone (Riprap) Slope Protection) will provide stabilization with a layer of stone (riprap) placed over a layer of bedding stone and geotextile along approximately 300 linear feet of streambank. The riprap will tie into the

top of the existing embankment and will cover the streambank down to the channel bottom with a built up revetment protecting the toe. The existing streambank and surrounding area would be cleared of vegetation as well as the existing failing erosion protection measures. The streambank would be graded to a 2H:lV slope for placement of the streambank slope protection. Below the ordinary high water line, backfill material consisting of NCDOT #57 stone would be placed over a geotextile layer, graded, and compacted as required to provide a smooth sloped surface for the placement of the stone. Above the ordinary high water line, backfill material consisting of satisfactory fill (earth) material would be placed on the existing cleared streambank, graded, and compacted as required to provide a smooth sloped surface for placement of the stone slope protection. Toe protection would be placed along the toe of the stream bottom. The stone toe protection would be placed to a distance of approximately eleven (11) feet to eighteen (18) feet from the toe and to a height of approximately 6 feet above the stream bottom. Materials staging and construction access would take place in previously disturbed areas and is available via an existing access road. Vegetative clearing not to exceed one acre may be required to accommodate necessary equipment. Estimated construction time is 4-6 months.

The Direct Construction Cost of the Tentatively Selected Plan is $1,376,000 (does not include real estate, detailed design and construction management costs). Total Project Costs, including detailed design and construction management, are $1,841,000. The figure of $1,841,000 is used as the basis for cost sharing. The project will be designed and constructed through the USACE Continuing Authorities Program. The Federal cost-share for the Tentatively Selected Plan is $1,196,000, which is 65% of $1,841,000. The non-Federal cost-share of 35% is $644,000. In addition to the design and construction costs, the feasibility phase costs are $150,000 and cost-shared at $125,000 Federal and $25,000 non-Federal, which brings the Fully Funded Federal Cost to $1,321,000. The non-Federal sponsor fully supports the Tentatively Selected Plan.

1.0 STUDY AUTHORITY

The proposed project, protection of a municipal drinking water intake system, is located within and adjacent to the Tar River in the City of Greenville, North Carolina (Figure 1.1) and is being pursued under the authority of Section 14 of the Flood Control Act of 1946 (PL 79-526), as amended, for emergency streambank and shoreline erosion protection for public facilities and services. Applicable paragraph(s) used to determine eligibility in U.S. Army Corps of Engineers (USACE) Engineering Pamphlet (EP) 1105-2-58: paragraph 29(a) states "This program is designed to implement projects to protect public facilities and facilities owned by non-profit organizations that are used to provide public services that are open to all on equal terms. These facilities must have been properly maintained but be in imminent threat of damage or failure by natural erosion processes on stream banks and shorelines, and are essential and important enough to merit Federal participation in their protection." The subject drinking water intake system is a key element of the regions drinking water operations, is an essential public service to over 140,000 citizens (GUC 2022), and is maintained as such. The Greenville Utilities Commission (GUC) water treatment plant is not a Federal facility or a private property. It is under imminent threat of damage or failure from continuing shoreline erosion at the site, and therefore qualifies under the Section 14 program. The non-Federal sponsor for this study, the GUC, strongly supports a partnership with the USACE to protect the system through the Section 14 authority, as stated in a letter from GUC officials (Appendix A).

Section 14 is under the Continuing Authorities Program (CAP), which focuses on water resource-related projects of relatively smaller scope, cost and complexity than USACE projects conducted under the General Investigations program. The Continuing Authorities Program is a delegated authority to plan, design, and construct certain types of water resource and environmental restoration projects without specific Congressional authorization. Additional information on this program can be found in USACE 2019, Engineer Pamphlet (EP) 1105-2-58.

The feasibility study was carried out in a manner consistent with the USACE Environmental Operating Principles (EOPs). The principles are consistent with the National Environmental Policy Act (NEPA); the Army's Environmental Strategy with its four pillars (prevention, compliance, restoration, and conservation); and other environmental statutes that govern USACE activities. Finally, the implementation framework proposed as part of the study will facilitate a collaborative effort by fully engaging individuals, agencies, and local groups in identifying, planning, and implementing shoreline protection efforts. Total study costs were $150,000 and cost-shared by USACE and the GUC as outlined in section 9.0 of this report.

2.0 NON-FEDERAL SPONSOR AND PURPOSE AND NEED FOR ACTION

The GUC is the non-Federal sponsor for this feasibility study. The GUC provides electric, water, sewer and natural gas services to the City of Greenville and 75% of Pitt County. The GUC is owned by the citizens of Greenville but operates under a separate charter issued by the N.C. General Assembly.

Based on a request from the GUC, USACE staff conducted a site visit on July 8, 2020 to the GUC Water Treatment Plant to investigate streambank erosion adjacent to the plant's water intake infrastructure. Resulting from the site investigation was a determination that the Section 14 Authority was an avenue for USACE assistance.

The GUC water treatment plant is located along the Tar River from which it pulls water through intake structures into the treatment plant. The plant has two 30-inch water intake pipes on the Tar River at their water treatment plant serving a population of approximately 140,000 along with industrial demands (GUC 2022). The average water demand is 14.1 MGD with a peak of 18.6 MGD. Streambank erosion has been occurring adjacent to the intake structures. In 2011, the GUC implemented a streambank stabilization project to address this issue. That previously constructed project is currently in poor condition with visible failure of the articulating concrete mat erosion protection. The steel cables connecting the individual concrete mats together have rusted and broken with the loss of mats and erosion of the earthen riverbank. Scour holes have developed along the revetment at the intake pipes. The end sections have failed with erosion of the riverbank at each end of the revetment. This threatens the continued operation of the water intakes and water supply to the GUC service region.

Repair and stabilization of the riverbank at the water intakes on the Tar River is needed to prevent loss of water supply due to potential collapse of the riverbank and damage to the water intake pipes and intake structure. The current condition the riverbank is too unstable to allow safe access to maintenance equipment to clear debris and sediment from the water intakes. Maintenance has to be performed from more expensive barges. Quick emergency repairs are not possible from the riverbank. Should the riverbank fail and damage the water intakes the GUC has only three days of emergency water supply storage. The biggest threat is embankment collapse onto the intake structures, damaging the structures or cutting the lines. This would put over 140,000 citizens at risk of losing valuable water resources which would jeopardize public health and fire flow protection.

The purpose of this study is to provide long-term protection and stabilization for the embankment along the Tar River adjacent to the GUC water treatment plant.

3.0 LOCATION OF STUDY AREA AND ENDANGERED FACILITY

The study area is located near the City of Greenville, North Carolina. Greenville is located in Pitt County in eastern NC and has a population of approximately 90,000. The service area of the endangered facility includes both Pitt and Greene counties. The facility is located along the Tar River, approximately 3 miles upstream from the City of Greenville (Figure 3-1). The water treatment plant's water intake infrastructure is located within the left bank or northern side of the river, as shown in Figure 3-2. Congressional representation for the area includes the following:

Senator Richard Burr (R)
Senator Thom Tillis (R)
Congressional District: NC3 – Greg Murphy (R)
NC 1 – George "G.K." Butterfield Jr. (D)

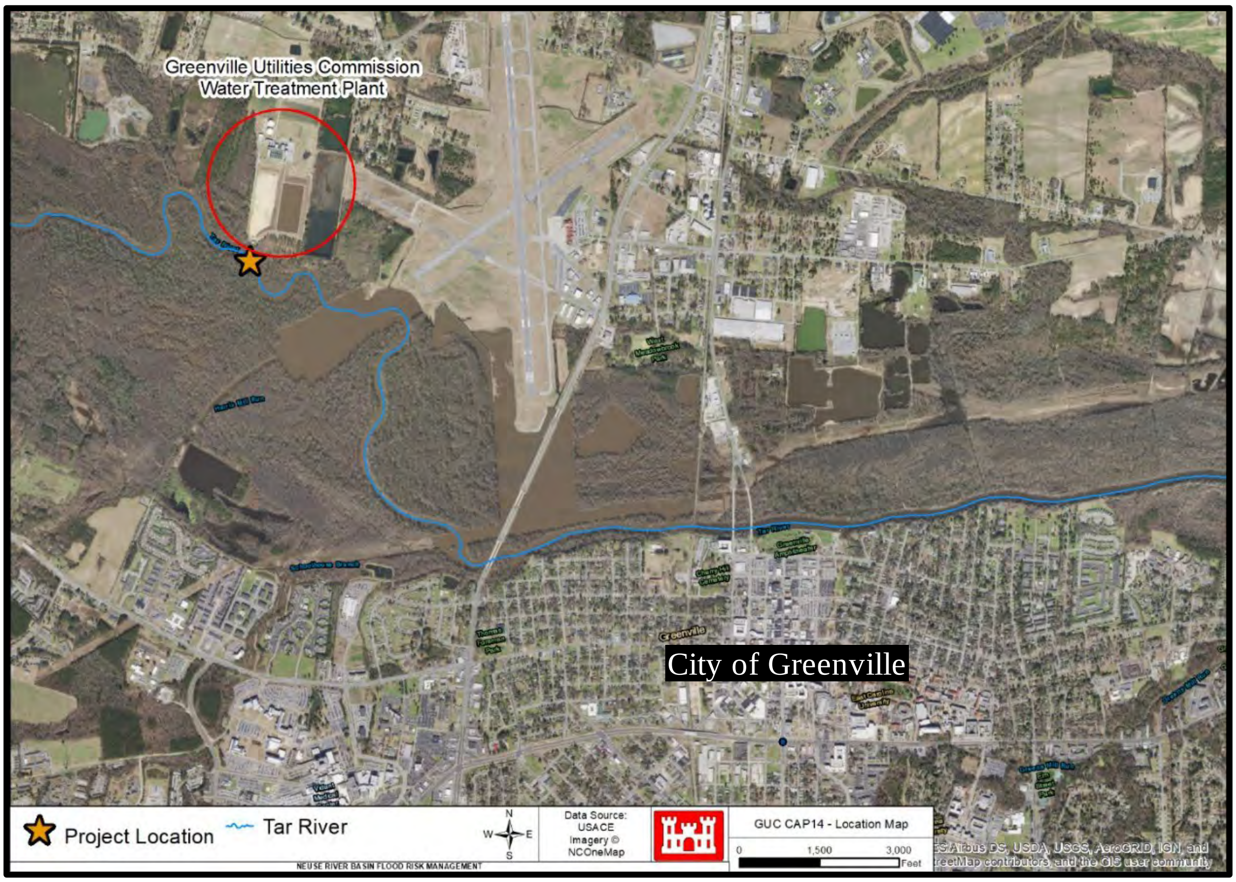

Figure 3-1. Location of Project Site in relation to the City of Greenville, NC

Figure 3-2. Location of Endangered Critical Public Facility

4.0 EROSION ASSESSMENT

There are a number of natural processes causing the continued erosion along the left riverbank of the Tar River in the project area. These natural factors include riverine-based storm events, in addition to wind, wave, and tides associated with coastal-based storm events. Based on input from the GUC, the predominate factors that induce erosion in the project area are associated with how quickly water levels rise and fall against the riverbank. Riverbank erosion has been a persistent issue adjacent to the intake structures (figure 4-1). The problem was significant enough that in 2011, the GUC implemented a riverbank stabilization project to address this issue.

Figure 4-1. Riverbank erosion prior to 2011 project.

Since 2011, erosion has continued in spite of the previous erosion protection project. The GUC staff describe a situation of visually apparent degradation worsening on a month-by-month basis (figure 4-2). The biggest threat is embankment collapse onto the intake structures, damaging the structures or cutting the lines.

Figure 4-2. 2011 project in state of degradation (photo: USACE site visit 2020).

5.0 PLAN FORMULATION AND EVALUATION OF ALTERNATIVES

5.1 Alternatives Considered

USACE Engineer Pamphlet (EP) 1105-2-58 paragraph 29(d) directs that "… given the narrow geographic focus, low cost of these projects, and the imminent threat to the facilities, the formulation and evaluation will focus on the least-cost alternative solution. The least-cost alternative plan is considered to be justified if the total cost of the proposed alternative is less than the costs to relocate the threatened facility."

As follows, the project delivery team (PDT) initially identified the study problem and opportunities in partnership with the non-Federal sponsor, the GUC. A study objective was identified, as well as study constraints:

Problem Statement: Natural streambank erosion is threatening imminent damage to the Greenville, NC regional drinking water intake system.

Opportunities:

- Reduce risk of interrupted water service to the public

Objective:

- Identify an alternative to manage the risk of damage to the GUC water intake system posed from adjacent shoreline erosion along the Tar River over a 50-yr period of analysis (2023-2072).

Constraints:

- Any Federally recommended protection project must cost less than relocating the threatened facility out of harm's way.

Additional Considerations:

- To avoid impacts to anadromous fishes, no in-water work will occur between February 1 and September 30.

The Project Delivery Team (PDT) considered a range of possible actions, or measures, to meet the study objective while managing constraints. Several of these measures were screened out during preliminary investigation.

The PDT used basic evaluation and screening criteria for each of the measures considered, as follows:

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. EP 1105-2-58 paragraph29(d) directs that "formulation and evaluation will focus on the least-cost alternative solution"
Acceptability	Is the plan feasible from all angles (legally, financially, environmentally, politically)? In essence, is there a red flag that would prevent its implementation?

5.2 Measures initially considered and screened

The following measures were considered by the PDT early in the plan formulation process, but were screened out for varying reasons prior to any cost analysis.

Flow Diversion Structure with supplemental riprap:

This alternative included a flow diversion structure that more effectively directed flow through the natural riverbend within the project area. Complex modeling would be required to avoid unintended consequences, as the structure may act differently during varying flow conditions, resulting in potential negative consequences. Some level of supplemental riprap would be required to accompany the flow diversion structure if implemented. Considering the proximity of the raw water intake structures and associated piping, as well as the amount of physical modification required for the natural channel, this alternative did not provide a practical solution. Due to technical concerns, this alternative did not meet the Effectiveness criteria.

Articulating Concrete Block Protection:

This alternative included an articulated concrete block design that would replace the existing, failing armor. Due to the historical failing performance of the existing protection using this same methodology, and concerns of maintenance and resiliency to the combined riverine and coastal-based erosion, this alternative was screened based on the Effectiveness criteria.

Sandbag Protection:

This protection measure was considered due to the potentially significant cost savings. However, because sandbags are not durable and are easily damaged, this alternative would merely serve as a temporary solution. Therefore, this alternative would not meet the study objective to provide long-term protection and stabilization and was screened based on the Effectiveness criteria.

High Performance Turf Reinforcement Matting:

This measure included construction of a high-performance turf reinforcement Matting atop the area of eroded riverbank. This design involved a thin, synthetic layer of non-biodegradable material, such as polypropylene, that replaced the existing, failing articulated concrete block armor. Due to concerns of structural durability given the riverine and coastal-based hydraulic loading that the project area was subjected to on a relatively frequent basis, this measure was not considered a complete alternative on its own, and would need the addition of supplemental armoring. This measure was screened based on the Completeness criteria.

5.3 Alternatives carried forward for additional consideration

The following alternatives were carried forward for further consideration, including preliminary costs assessments for comparison purposes. Cost estimates were developed using the same line items for Total Direct Construction Costs (not to include real estate, detailed design and construction management costs).

No Action Alternative:

Under the No Action Alternative, the USACE would not construct streambank protection to address existing erosion near the intake structures of the GUC water treatment plant. Previous attempts by the non-Federal sponsor to address the issue have not been successful. With No Action, erosion is expected to continue with potential collapse of portions of the embankment into the adjacent stream. This increases risk to the integrity of the intake system and operations of the water treatment plant. No federal construction costs are incurred with this alternative. The No Action alternative is carried forward for comparative purposes.

Relocation:

USACE EP 1105-2-58 paragraph 29(d) states that "The least-cost alternative plan is considered to be justified if the total cost of the proposed alternative is less than the costs to relocate the threatened facility." Therefore, relocation of the threatened water intake system was investigated for economic justification purposes. This alternative included relocation of the raw water intake infrastructure away from the eroding riverbank, involving complete decommissioning of existing raw water intake screens within the project area and the associated pipe network that fed into the water treatment plant. This action would eliminate the need for emergency erosion protection. Cost estimates for relocation of the threatened infrastructure were primarily based on actual construction costs incurred in 2013 from the construction of a second intake structure. These costs do not include the cost of obtaining a replacement site or removal costs of the intake system from its current location, and were obtained from a signed financial closeout document provided by the GUC to the North Carolina Division of Water Quality (Appendix C). Construction costs were approximately $4.6 million in 2013. It is assumed that costs from 2013 would be escalated to current costs and include removal costs as well. Based upon this information, it is assumed that costs for relocating the threatened infrastructure would substantially exceed $4,500,000.

Stone (Riprap) Slope Protection:

This alternative included the construction of a riprap revetment to replace the existing, failing, articulated concrete block armor along the riverbank. The total length of revetment extended beyond the existing armoring to appropriately tie into the natural riverbank. Proposed earthwork modified the natural streambank such that the riprap revetment would be placed at a 2H:1V slope. This alternative also included additional stone placed along the riverbank toe to account for potential toe scour. Riprap slope protection would be sustainable with a minimal level of maintenance, primarily for occasional repairs to maintain revetment integrity. This alternative would be technically feasible in that the structure is a proven and commonly used method of streambank stabilization for locations with similar conditions. Initial rough order of magnitude (ROM) cost estimate for comparative purposes was $980,000.

Gabion Baskets

This alternative included the use of Gabion Baskets to replace the existing, failing, articulated concrete block armor along the riverbank. This alternative involved relatively smaller sized stone encased in a series of stacked wired cages to act as a buffer between the natural streambank soils and erosive flows from the Tar River. A concern over this alternatives ability to provide adequate toe scour protection was a consideration. The initial ROM cost estimate for comparative purposes was $2,170,000.

Steel Sheet Pile Bulkhead

This alternative includes the construction of a steel sheetpile bulkhead within the area of eroded riverbank. The bulkhead would extend beyond the existing articulated concrete block armor to appropriately tie into high ground. The structure's design elevation was set to the approximate top of riverbank. During the assessment of this alternative, a concern was identified of the risk of requiring the depth of the steel sheetpile to extend below the raw water intake pipe network. A more detailed analysis would have been required to confirm this. However, preliminary cost estimates of this alternative resulted in it not being the least-cost, so further analysis was not conducted. Initial ROM cost estimate for comparative purposes was $1,675,000.

High Performance Turf Reinforcement Matting combined with Rip Rap:

This alternative included construction of a High-Performance Turf Reinforcement Matting atop the area of eroded riverbank. This design involved a thin, synthetic layer of non-biodegradable material, such as polypropylene, that replaced the existing, failing articulated concrete block armor. Due to concerns of structural durability given the riverine and coastal-based hydraulic loading that the project area was subjected to on a relatively frequent basis, this alternative would also be supplemented by rock rip rap. Initial ROM cost estimate for comparative purposes was $1,100,000.

5.4 Comprehensive Benefits Analysis of the Four 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 GUC, NC CAP 14 study falls into category 7(e)(3), 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 are 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 partner and consider the views of the public and stakeholders.

USACE Engineer Pamphlet (EP) 1105-2-58 paragraph 29(d) directs in relation to the CAP 14 authority that "… given the narrow geographic focus, low cost of these projects, and the imminent threat to the facilities, the formulation and evaluation will focus on the least-cost alternative solution. The least-cost alternative plan is considered to be justified if the total cost of the proposed alternative is less than the costs to relocate the threatened facility."

Given the narrow focus and streamlined formulation process of the CAP 14 Authority, the PDT conducted a commensurate comprehensive benefits analysis.

To meet the 5 January 2021 Policy Directive, meaningful factors were identified for each of the 4 accounts to be evaluated on how they would be impacted by each alternative in the final array (Table 5-1). Methods of evaluation are primarily qualitative.

National Economic Development (NED)	Regional Economic Development (RED)
Project Costs	Jobs
Ability to Meet Study Objective	Labor Income
	Value Added
Other Social Effects (OSE)	**Environmental Quality (EQ)**
Health and Safety	Habitat Change
Social Vulnerability and Resiliency	Threatened & Endangered Species Risk
	Cultural Resources Sites

Table 5-1 Factors Evaluated for the Four Benefit Accounts

The following paragraphs summarize the evaluation of the final array of alternatives against the four Accounts. Table 5-2 on the following page presents the evaluation results.

Plan which maximizes NED: Stone (Riprap) Slope Protection – Using preliminary rough-order-of-magnitude cost estimates for comparison purposes, the stone (riprap) slope protection alternative provided the benefits of protection at the least cost of $980,000. This compares with high performance turf reinforcement matting combined with riprap ($1,100,000), steel sheetpile bulkhead ($1,675,000), and gabion baskets ($2,170,000).

Plan which maximizes RED: Gabion Baskets – Using preliminary rough-order-of-magnitude cost estimates for comparison purposes, the gabion baskets alternative would provided the most RED benefits when considering local/regional jobs created and labor income associated with the implementation of this project, as it has the highest implementation costs ($2,170,000) as compared with the other alternatives.

Plan which maximizes OSE: All plans would provide equal benefit. To evaluate the impacts of each of the final alternative against the OSE account, a qualitative ranking system was used of High/Medium/Low, with "High" having the greatest OSE benefits, and "Low" the lowest OSE benefits. All plans would provide equal benefit to the population served, as each of them would equally reduce social vulnerability and increase health and safety, and resiliency by reducing the risk of interruption to public drinking water services. An Environmental Justice assessment is located in section 11.0.

Plan which maximizes EQ: High Performance Turf Reinforcement Matting with Riprap. To evaluate the impacts of each of the final alternative against the EQ account, a qualitative ranking system was used of High/Medium/Low, with "High" having the greatest OSE benefits, and "Low" the lowest OSE benefits. The high performance turf reinforcement matting with riprap was the only alternative ot received a "High' ranking due to its natural and nature-based features. The steel sheetpile bulkhead alternative received a "Low" ranking due to it's removal of habitat along the streambank. All other alternatives received a "Medium" ranking

Table 5-2. Evaluation fo the Four Accounts

	FOUR ACCOUNTS			
ALTERNATIVE	**NED**	**RED**	**OSE**	**EQ**
No Action	N/A	N/A	Low	Low
Relocation	$4,500,00	$4,500,000	Medium	Medium
Stone (riprap)	$980,000	$980,000	Medium	Medium
Gabion Baskets	$2,170,000	$2,170,000	Medium	Medium
Steel Sheetpile Bulkhead	$1,675,000	$1,675,000	Medium	Low
High Performance Turf Matting w/ riprap	$1,100,000	$1,100,000	Medium	High

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
2. A plan that maximizes net total benefits across all benefit categories ***(Stone (Riprap) Slope Protection).*** This alternative was selected for this category rather than High Performance Turf Matting with riprap because the NED account was given more weight than the EQ account considering the study Authority.
3. A plan that maximizes net benefits consistent with the study purpose (NED for this study) ***(Stone (Riprap) Slope Protection)***
4. For flood-risk management studies, a nonstructural plan ***(Not applicable)***

* There is no locally preferred plan

5.5 Screening of Final Array and Selection of Plan

Table 5-2. Provides a screening matrix of all alternatives considered.

Table 5-2. Alternatives Screening

Alternatives Considered	Screening Criteria: Completeness	Effectiveness	Efficiency (least cost*)	Acceptability	Notes
Relocation of Intake Infrastructure	Yes	Yes	**No**	Yes	Considered as an alternative to a Federal project. Screened based on Efficiency criteria using existing GUC-provided cost data for relocation, and compared with PDT rough-order of-magnitude (ROM) alternative costs.
Gabion Baskets w/ rip rap	Yes	Yes	**No**	Yes	Not the least-cost alternative. Does NOT meet Efficiency criteria.
Stone (Riprap) Slope Protection	Yes	Yes	Yes	Yes	**Tentatively Selected Plan –** meets all screening criteria and is least-cost alternative
Flow Diversion Structure	**No**	**No**	N/A	Yes	Screened out due to practical engineering concerns/unintended consequences
Flow Diversion Structure plus rip rap	Yes	**No**	N/A	Yes	Technical engineering concerns associated with unintended consequences. Does NOT meet Effectiveness criteria.
Articulating Concrete Block Protection	Yes	**No**	N/A	Yes	This method is currently failing at the site. Does NOT meet Effectiveness criteria due to technical concerns.
Steel Sheetpile Bulkhead	Yes	Yes	**No**	Yes	T&E Species impacts were a consideration. Not the least-cost alternative. Does NOT meet Efficiency criteria.
High Performance Turf Reinforcement Matting	**No**	Yes	N/A	Yes	Significant durability concerns would require supplemental stone rip rap. Does NOT meet Completeness criteria.
High Performance Turf Reinforcement Matting plus rip rap	Yes	Yes	**No**	Yes	Not the least-cost alternative. Does NOT meet Efficiency criteria.
Sandbags	Yes	**No**	Yes	Yes	Screened out due not meeting objective of long-term protection (50yr) / Does NOT meet Effectiveness criteria.

5.6 Tentatively Selected Plan

Relative to the other alternatives considered, the Stone (Riprap) Slope Protection is the least-cost alternative and meets all screening criteria. Considering all evaluation criteria, the Stone (Riprap) Slope Protection is considered the Tentatively Selected Plan. The GUC has expressed acceptance of the Stone (Riprap) Slope Protection as their locally-preferred alternative.

Tentatively Selected Plan Description: This plan will provide stabilization with a layer of stone (riprap) placed over a layer of bedding stone along approximately 305 linear feet of streambank. The riprap will tie into the top of the existing embankment and cover the streambank down to the channel bottom with a built up revetment protecting the toe. The existing streambank and surrounding area would be cleared of vegetation and old erosion protection measures. The cleared material will be taken offsite to an approved disposal facility. Above the ordinary high water line, backfill material consisting of satisfactory fill (earth) material would be placed on the existing cleared streambank, graded to a 2H:lV slope, and then compacted as required for placement of the streambank slope protection. These new backfill materials used for grading will be in accordance with the Unified Soil Classificaiton System ASTM D2487 and will be free from roots and other organic matter, trash, debris, frozen material, and stones larger than 3 inches in any dimension. Once the foundation material is in place, the streambank will be covered with slope protection measures that consist of a 1’ layer of bedding stone (NCDOT #57 stone) and a 25.5" thick layer of NCDOT Class I riprap placed over a layer of geotextile and graded fill slope. Below the ordinary high water line, backfill material consisting of NCDOT #57 stone would be placed over a geotextile layer, and compacted as required to provide a smooth sloped surface for the placement of the stone protection. A toe protection revetment will be built up along the toe of the stream bottom. Riprap placement would cover 0.25 acres of upland area and 0.25 acres of benthic habitat (i.e., submerged bank and river bottom). In total, riprap placement would cover 0.5 acres. The design will accommodate flow vanes which already exist adjacent to the construction area. Materials staging and construction would take place in previously disturbed areas. Vegetative clearing not to exceed one acre may be required to accommodate necessary equipment. Estimated construction time is 4-6 months. A typical cross section is shown in figure 5-1. A plan view of the Tentatively Selected Plan is shown in figure 5-2. A conceptual rendering is shown in figure 5-3.

Civil/Site Description: Access to the project site is currently via an access road that runs the length of the project. Materials staging would take place in the open areas at the top of the embankment as directed by the facility. Construction access is available via the existing access road. The project site is located on the embankment of the Tar River downstream of the intake. Currently this site has an articulated block system that has failed due to undermining. Additionally there are flow weirs in the channel along the bank that must be incorporated into the design. A Type 2 DOT Turbidity Curtain will be installed during in-water material placement and a silt fence will be installed on the upland perimeter of the construction activities and along most improved access roads. Post construction landscaping to restore disturbed areas and fill slopes is estimated to be approximately 0.3 acre.

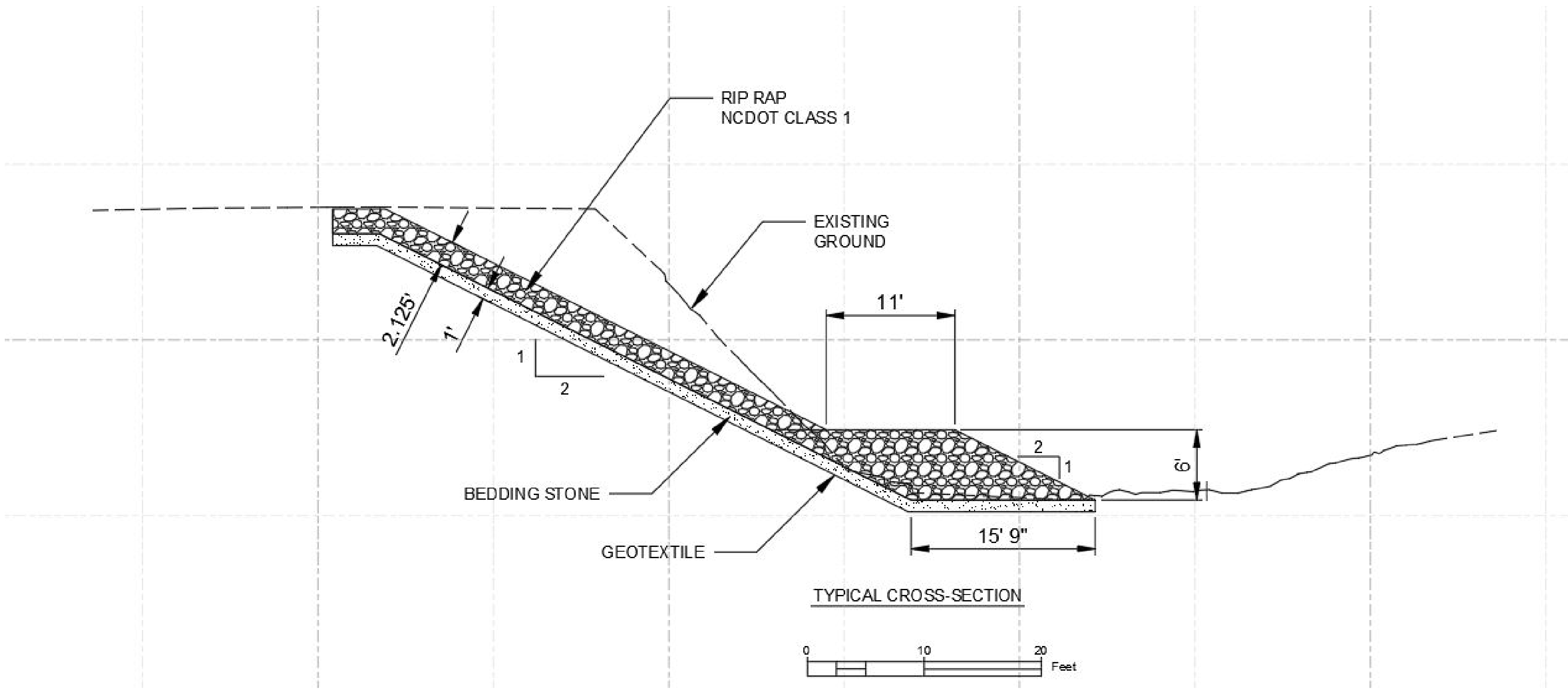

Figure 5-1. Typical cross section of Recommended Plan

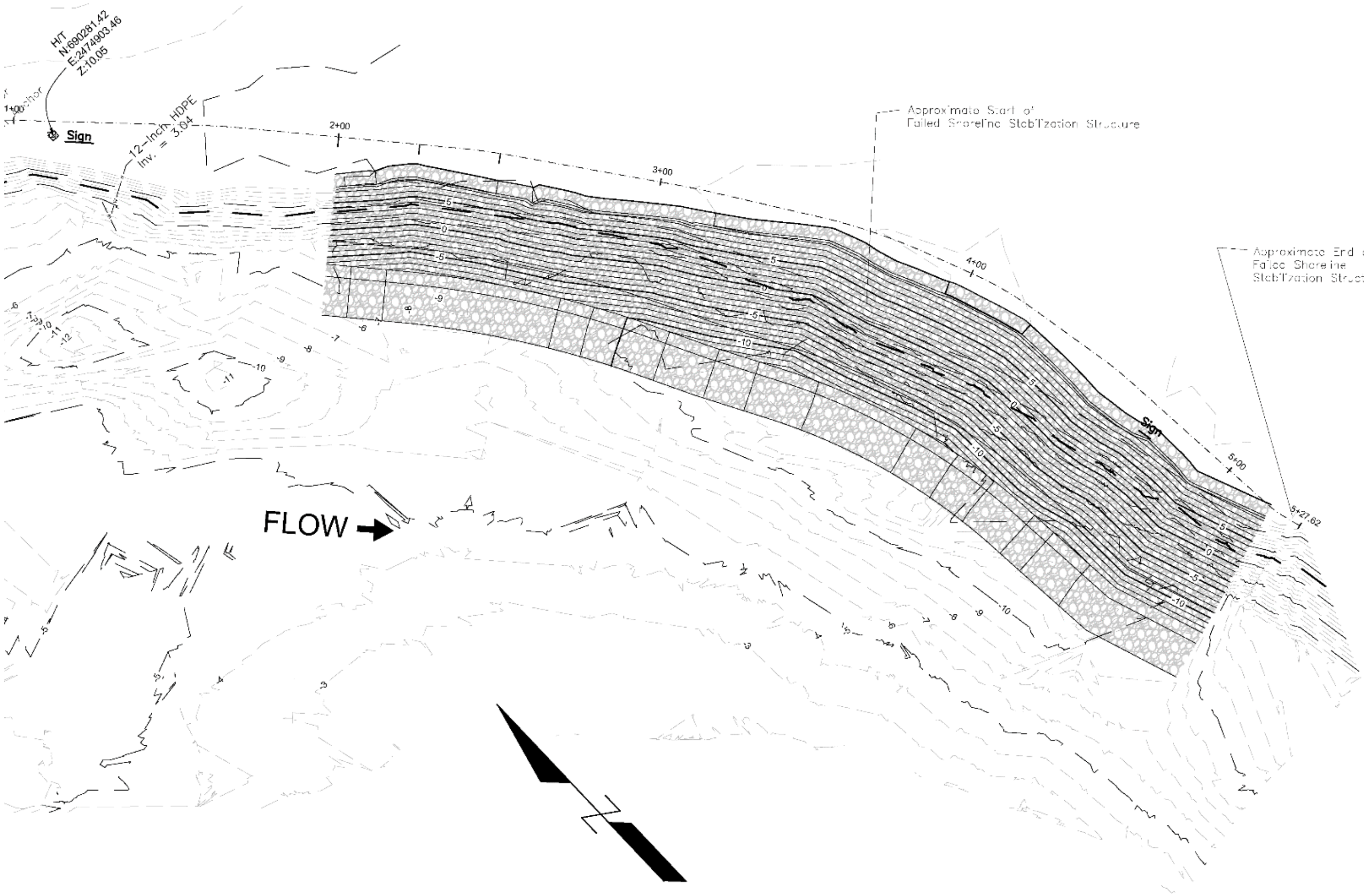

Figure 5-2. Footprint of Tentatively Selected Plan

Figure 5-3. Conceptual Rendering of Tentatively Selected Plan

6.0 EXISTING AND FUTURE-WITHOUT PROJECT CONDITIONS, AND IMPACTS OF THE PROPOSED ACTION AND NO ACTION

6.1 Sediments

Pitt County is in the Coastal Plain physiographic province, in the eastern part of North Carolina. Soil topography in Pitt County is considered nearly level to sloping. The nearly level soils are found in the eastern and southeastern parts of the County. The more sloping soils are found in the County's western portions and generally south of Tar River and its tributaries. All soils are naturally acidic, and base saturation is less than 35%. Natural fertility of soils is mostly low or very low. Suitable amounts of lime and fertilizer are generally required to increase the content of calcium, magnesium, phosphorus, and potassium in soils to allow for agricultural use. The content of organic matter in soils is also considered generally low or very low, except where soils are very wet and water has retarded oxidation. The City of Greenville is the approximate geographical center of the county (USDA 1974).

Soils at the proposed project area are mapped as Alaga loamy sand, banded substratum (AgB) and Bibb complex (Bb) (see figure 6-1). AgB is a somewhat excessively drained, sandy soil on broad, high divides of uplands and stream terraces. Infiltration in this soil type is rapid, and runoff is slow. Bb soils are poorly drained, nearly level soils on flood plains and in upland draws and depressions. Bb soils have a surface layer of fine sandy loam which is underlain by very friable fine sandy loam. Infiltration in Bb soils is moderate, and runoff is slow. Both mapped soil types typically terminate 6 feet deep (USDA 2022).

Figure 6-1. Soils present in and surrounding the proposed project area.

A subsurface investigation was conducted by Schnabel Engineering South, P.C. in 2008 as part of water intake upgrades in the project area. The boring logs from the associated report found that the topsoil layer was less than 1 foot deep, followed by alluvium consisting of mostly silt (ML) with sand down to 12 feet below the surface. Laboratory tests of the silt showed up to 81% passing a #200 sieve. From 12 to 39 feet below the surface was sand (SP) with 26% passing a #200 sieve. From 39 to 70 feet below the surface was clay (CL) with 76% passing a #200 sieve. There were no laboratory data defining particle sizes greater than the #200 sieve, though the logs describe some sand as being medium (not passing a #40 sieve) and coarse (not passing a #10 sieve). The United Soil Classification System (USCS) describes sand particle sizes to be between 0.075 and 4.75 mm. Not passing the #200 sieve indicates particles lager than 0.075 mm.

Construction impacts of the tentatively selected plan to sediments would result from the minimal excavation and grading of the streambank in the project area, allowing for proper riprap placement. These impacts are considered to be temporary and minimal, and further reduced by implementing appropriate erosion control measures during construction. It is expected that implementation of the tentatively selected plan would result in an overall reduction in erosion at the proposed project area, and improve stabilization of the Tar River oxbow bend nearest Greenville Water Treatment Plant water intake infrastructure.

The No Action alternative would allow the riverbank near the intake structures to remain vulnerable to additional erosion and threaten plant's infrastructure. The current riverbank revetment is in poor condition and the articulating concrete mat is failing and the erosion that is occurring behind the mat would continue.

6.2 Water Quality and Wetlands

Waters in and near the proposed project area are classified as WS-IV with a supplemental classification of NSW (NCDEQ 1992). Water Supply IV (WS-IV) waters serve drinking, culinary, or food processing purposes. In the project area, specifically, Tar River waters are also considered in a Critical Area (CA) meaning risk of pollution is greater due their <1/2 mile proximity to water supply intakes. Nutrient Sensitive Waters (NSW) are a supplemental classification intended for waters needing additional nutrient management due to being subject to excessive growths of microscopic or macroscopic vegetation (NCDEQ 2022).

Wetlands are absent from the proposed project area, which consists of a steep-sloping, eroded streambank largely devoid of vegetation as observed during multiple site visits in 2022. High water events have further deteriorated the bank such that the oxbow bend of the Tar River continues to migrate northward.

The tentatively selected plan is expected to have favorable long-term effects on water quality in, and downstream of, the project area by decreasing erosion and subsequent turbidity introduced to the Tar River following high water events. Additionally, the tentatively selected plan will prevent bank sloughing / failure and preclude damage to critical water supply infrastructure. Appropriate sedimentation and erosion control measures that equal or exceed the most recent version of the “North Carolina Erosion and Sediment Control Planning and Design Manual” (NCDEQ 2013) will be designed, installed, and maintained properly to assure compliance with the appropriate turbidity standards, although temporary increases in turbidity may occur during construction. These measures include a Type 2 DOT Turbidity Curtain to be used during in-water material placement, and silt fence use on the upland perimeter of construction activity and along most improved access roads (Appendix C).

All proposed work, construction activity, and contractor actions would be in compliance with the conditions of Nationwide Permit (NWP) 13 and all regional conditions for Nationwide Permits in the Wilmington District. The TSP would comply with Executive Order 11990, which directs federal agencies to take action to minimize the destruction, loss or degradation of wetlands, and to preserve and enhance the natural and beneficial values of wetlands. A Section 401 (Public Law 92-500 and Public Law 95-217) water quality general certification (GC) (#4245) will be acquired prior to implementation of the proposed action. The USACE will request written approval from the North Carolina Division of Water Resources (DWR) confirming that GC #4245 is applicable. No work will begin until DWR has either formally approved use of GC #4245 or issued a water quality certificate that covers this project. All proposed work would be in compliance with the conditions of the appropriate water quality general certificate.

Additionally, the NCDWR has established riparian buffer rules protecting vegetated areas adjacent to intermittent and perennial streams, lakes, reservoirs, ponds, estuaries, and modified natural streams. The project area is subject to the Tar-Pamlico Buffer rules designed to protect riparian zones. Buffer rules will be assessed as part of Section 401 coordination.

The no action alternative would allow for continued streambank erosion in the project area, resulting in increased turbidity as compared to nearby reaches of the Tar River. Additionally, potential bank failure under the no action alternative may damage water intake structures or associated transmission infrastructure. This would place over 140,000 citizens at risk of losing critical water resources, jeopardizing public health and fire protection abilities.

6.3 Floodplains

In the vicinity of Greenville, NC, the Tar River is characterized by a wide floodplain, primarily on the south side of the river. The proposed project area in its entirety is located within the AE flood zone as defined by the Federal Emergency Management Agency (FEMA) (Figure 6-2) (NCDPS 2022).

The tentatively selected plan would not impact floodplains at or adjacent to the proposed project area. In compliance with Executive Order 11988, which directs federal agencies to avoid long and short term adverse impacts associated with the occupancy and modification of floodplains and to avoid direct or indirect support of floodplain development whenever practical, no practical alternative exists to the proposed stabilization of the north bank of Tar River near water supply infrastructure. Every effort will be taken to minimize potential harm to or within the floodplain by reducing the amount of material placed in the floodplain to only that which is required to protect the bank. Due to the limited size and scope of the recommend plan, implementation is unlikely to result in adverse impacts to the adjacent floodplain. Any proposed action within the established floodway/floodplain will comply with state/local floodplain protection standards. Effects of the tentatively selected plan associated with Tar-Pamlico Buffer rules

The No Action alternative would not result in any impacts to wetlands or floodplains.

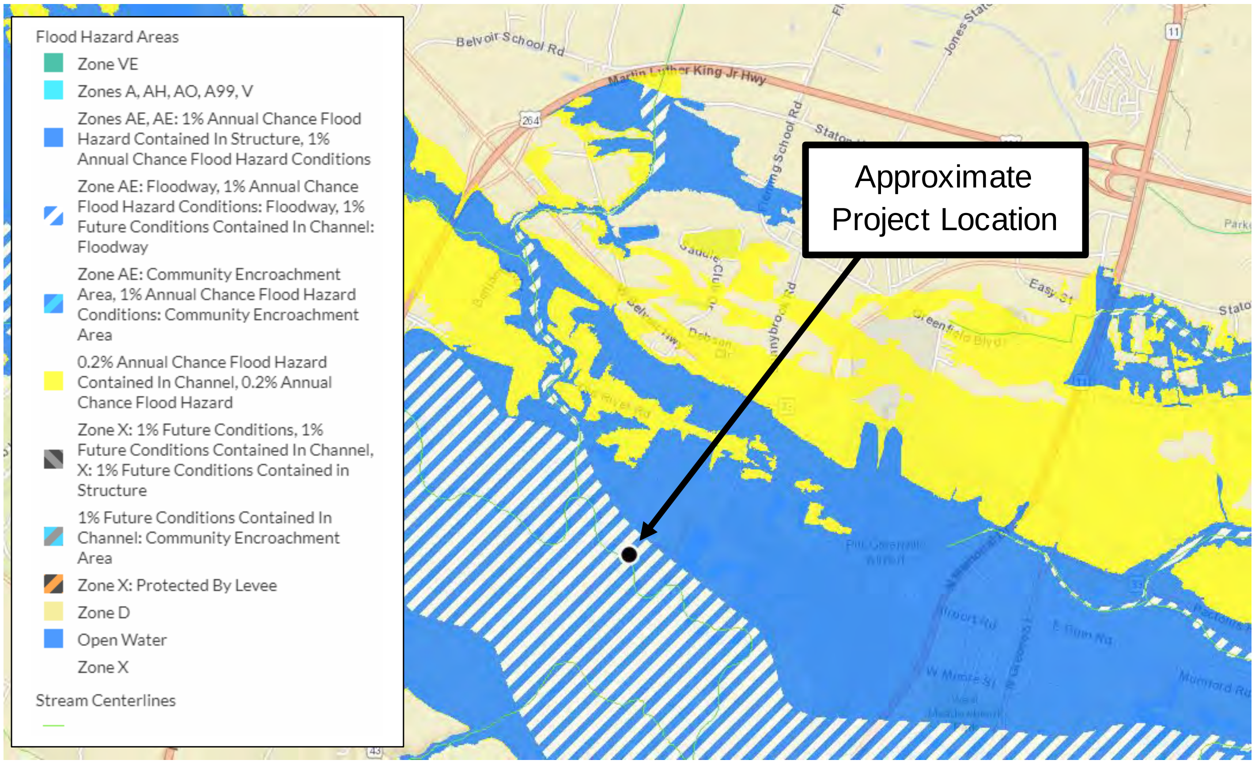

Figure 6-2. Floodplain map at and surrounding proposed project area.

6.4 Hazardous and Toxic Materials

The United States Environmental Protection Agency's (USEPA) Envirofacts website was queried to identify the presence of EPA-regulated facilities within one mile of the proposed project area. The Envirofacts website contains information collected from regulatory programs and other data relating to environmental activities with the potential to affect air, water, and land resources in surrounding areas. Forty-eight sites were reported within a one mile radius however, there was only one site in the immediate vicinity of the proposed project area. This site was identified as the Greenville Water Treatment Plant immediately north of the proposed project area (USEPA 2022).

Multiple on-site inspections of the project area and surroundings have been performed by USACE, Wilmington District staff in 2022. Based on these site visits and an investigation of historic aerial photographs, no evidence of improperly managed hazardous and/or toxic materials, or indicators of those materials were present in the proposed project area.

The tentatively selected plan would not affect hazardous and toxic materials in the proposed project area, nor would it produce hazardous and toxic materials. On the contrary, the proposed action is expected to help minimize streambank erosion in the proposed project area and offer protection to water intake infrastructure.

Similarly, the No Action alternative would not affect hazardous and toxic materials in the proposed project area, nor would it produce hazardous or toxic materials.

6.5 Cultural Resources

The North Carolina State Historic Preservation Office's (SHPO) HPOWEB Map Service was queried to identify known cultural resources in and near the project area. This service provides information such as cultural resources sites listed on the National Register, sites designated as Local Landmarks, and other data useful in considering potential impacts to cultural resources. No cultural resources are known to exist in the proposed project area, or along roadways to be used during construction (Figure 6-3) (NCDNCR 2022b).

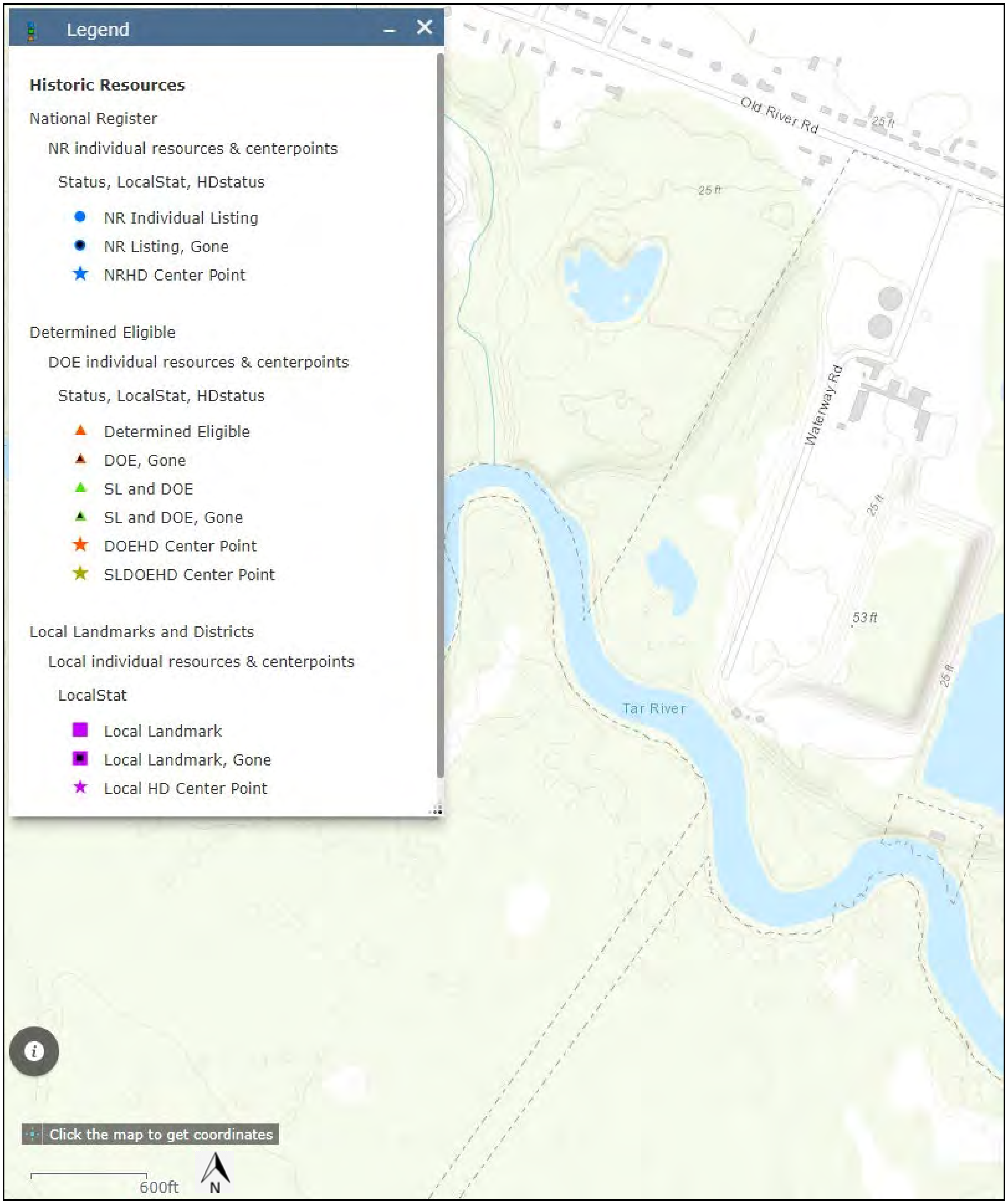

Figure 6-3. Known cultural resources located at and surrounding proposed project area.

The proposed project area is immediately adjacent to a previously disturbed area, the Greenville Water Treatment Plant, which is not known to be associated with, or itself be, a culturally-significant resource. Furthermore, considering severe streambank erosion in the proposed project area, the minimal excavation and clearing involved during construction, and the relatively small, proposed project area, it is unlikely that any cultural resources will be affected by the tentatively selected plan. Materials staging areas and construction traffic will be in previously disturbed areas as well. The proposed action will have no effect on historic properties or cultural resources and would provide protection to the streambank from future erosive events. By letter dated February 2, 2022, referencing project number ER 22-0162, the SHPO concurred with the USACE's effects determination. Should any cultural resources be discovered during implementation of the tentatively selected plan, construction would be temporarily suspended, and the SHPO would be contacted.

The no action alternative would allow for continued streambank erosion, which may endanger any unidentified cultural resources in the proposed project area.

6.6 Air Quality

The proposed project area, located in Pitt County, NC, is in attainment with both State and Federal National Ambient Air Quality Standards parameters (Figures 6-4 and 6-5) (NCDEQ 2011, USEPA 2012). The tentatively selected plan would not affect the attainment status of the project area or region.

Air quality would be temporarily and insignificantly affected by the tentatively selected plan. Emissions are expected from equipment used during construction, and any other support equipment which may be on or adjacent to the proposed project area. Increases in dust emissions would occur during construction, but these impacts would be short-term, only occuring while construction is active, and would not impact overall air quality. Any proposed project-related emissions are not expected to contribute significantly to direct or indirect emissions and would not impact air quality in the project area. A State Implementation Plan conformity determination is not required since the proposed project area is in attainment for all criteria pollutants.

Figure 6-4. North Carolina 8-hour Ozone nonattainment area boundaries

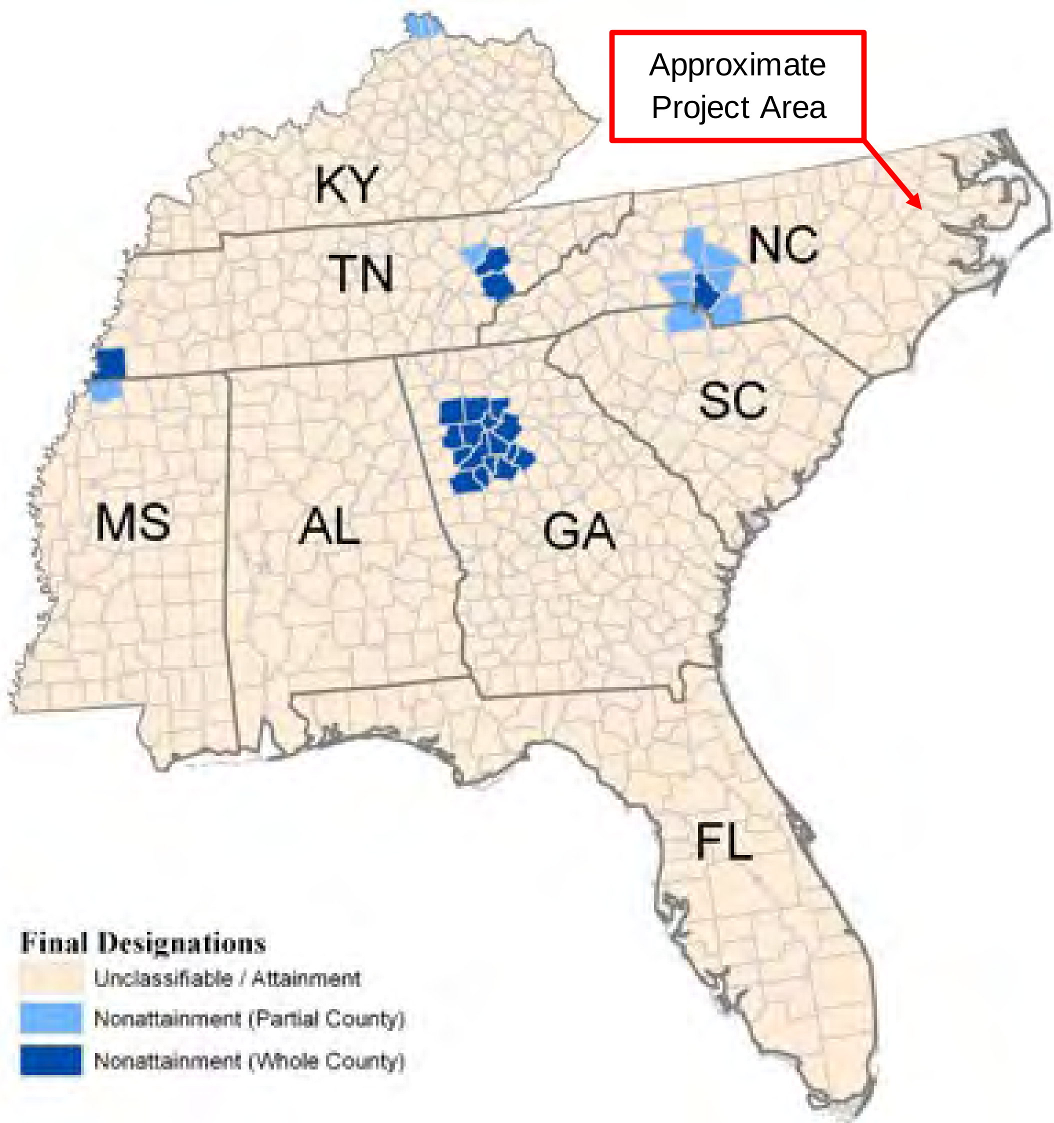

Figure 6-5. EPA ground-level ozone standards.

The no action alternative would not contribute to emissions and would not impact air quality, although construction activity associated with State-installed emergency rip rap may affect air quality in a manner similar to that of the proposed action.

6.7 Noise

Noise levels vary in Pitt County, NC. In the proposed project area vicinity, noise levels are typically associated with industrial operations, air travel, and local agricultural activity. Noise levels may be temporarily elevated during construction in the proposed project area, with expected duration of 4-6 months during daylight hours. In accordance with the published Noise Control Ordinance of Pitt County, NC (Pitt County 2022), construction activity associated with the tentatively selected plan is expected to comply with all published noise ordinances.

The no action alternative would have no impacts on Noise.

6.8 Benthic Resources

The benthic community in the vicinity of the proposed project area has been rated “excellent” by the North Carolina Department of Environmental Quality’s Division of Water Resources’ Biological Assessment Branch (NCDEQ 2007b). Specifically, benthic sampling occurred at Station OB163 which is located in the Tar River approximately one mile northwest of the proposed project area.

The tentatively selected plan would have negligible impacts on benthic resources in the proposed project area as the majority of construction-related disturbance would occur in the upland portion of the project area. Additionally, material excavation would be minimal, if any. NCDOT #57 stone would be placed on the eroding streambank from the waterline to the stream bed at which point, NCDOT Class II rip rap would be placed on the streambed and extend westward for approximately 12 feet. The proposed project area lies on the northward (outer) bank of an oxbow bend of the Tar River, which experiences higher water velocities and increased erosive forces as compared to the river’s opposite bank. Due to these relatively higher water velocities, severe bank erosion, and benthic survey results (NCDEQ 2007), it is not expected that there exists a thriving benthic community in the immediate project area. However, construction of the tentatively selected plan would permanently alter the predominant benthic habitat from a highly eroded sandy habitat to a rocky habitat (riprap) in the immediate project area and bury existing benthic fauna, temporarily disrupting benthic community composition. In total, 0.25 acres of sandy habitat would be permanently covered by riprap. Construction of the tentatively selected plan would stabilize sediments in the most eroded portions of the proposed project area and provide hard structure for utilization by benthic organisms and other aquatic fauna. Impacts to benthic community composition in areas surrounding construction activities would be short-lived.

The no action plan would allow for continued streambank erosion in the project area, potentially altering benthic habitat regularly following extreme weather and flow events.

6.9 Fisheries Resources

Fisheries resources in waters upstream the proposed project area have been surveyed by North Carolina Department of Environmental Quality's Division of Water Resources' Biological Assessment Branch (NCDEQ 2007a). Fish community collection sites are typically located at bridge crossings or other public access points on second, third, and fourth order streams where backpack electrofishing methods can be safely and efficiently applied. The nearest site upstream of the project area is station OF57, located approximately 7 miles northwest of the project area in Tyson Creek at the SR 1255 road crossing. The nearest site downstream of the project area is station OF31, located approximately 2.5 miles east of the project area in Parker Creek at the NC 33 road crossing. At each collection site, reports summarizing results are unavailable. For this reason, assessing fisheries resources in the project area vicinity is difficult; however, in the Tar River and Upper Pamlico River, game fishes including striped bass, largemouth bass, sunfish, and white and yellow perch are common (NCWRC 2022).

The tentatively selected plan will involve in-water placement of material, which will have minimal and short-lived impacts on fisheries resources, primarily by temporarily increasing turbidity during construction and by alteration of benthic habitat from sandy sediment to rock structure (riprap). Short-lived turbidity increases and construction activity in the proposed project area may temporarily displace fish species; however, these mobile species are capable of foraging in similar, nearby waters for the duration of the project and are not expected to be negatively impacted by the proposed action. To further avoid potential impacts to anadromous fish species such as striped bass, an in-water work moratorium will be established between February 1 and September 30.

The no action plan would allow for continued streambank erosion in the project area, potentially altering localized turbidity and forage substrate for fishes.

6.9.1 Essential Fish Habitat

The Magnusson-Stevens Fishery Conservation Act of 1976 governs marine fisheries resources and provides for protection of essential fisheries habitat (EFH). No EFH exists at or in areas surrounding the proposed project area (NOAA 2022). The tentatively selected plan and no action alternative will not result in any impacts to essential fish habitat.

6.10 Terrestrial Resources

Erosion and failed erosion control measures at the proposed project site has eliminated much of the streambank vegetation, leaving an eroded steep slope with minimal to no vegetation remaining. Vegetation above the eroded zone is comprised of predominately regularly mowed grasses, vines, and hardwood trees such as bald cypress (*Taxodium distichum*), water oak (*Quercus nigra*), river birch (*Betula nigra*), sweet gum (*Liquidambar styraciflua*) and various pine species (*Pinus spp.*). As streambank erosion continues in the project area, especially following storm events, riparian vegetation continues to become increasingly scarce.

The tentatively selected plan would require grading of the streambank, principally by material placement, to a contour of 2H:1V. Clearing of grasses, vines, and trees, not to exceed one acre, will be required to allow for equipment operation. This clearing will be minimized as to retain as much existing riparian vegetation as practicable. Additionally, 0.25 acres of previously disturbed terrestrial habitat will be permanently covered with riprap. No other impacts to terrestrial resources are expected, and all disturbed bare ground areas would be re-vegetated with grasses or other native plants upon project completion.

Under the no action, continued streambank erosion and associated vegetation loss would persist.

6.11 Threatened and Endangered Species, and Species of Concern

The tentatively selected plan has been reviewed for compliance with the Endangered Species Act of 1973, as amended (ESA). According to the United States Fish and Wildlife Service' Information for Planning and Consultation Service (IPaC) (USFWS 2022), six species known to exist in Greene County, NC are given special consideration under the ESA (Appendix D). The Atlantic Sturgeon is also listed under the ESA but is under the purview of the National Marine Fisheries Service. Additionally, the proposed project area overlaps with designated critical habitat for the Atlantic sturgeon and Neuse River waterdog.

The North Carolina Department of Environment and Natural Resources' Natural Heritage Program identifies 102 species, animal assemblages, and natural communities meriting special consideration in Pitt County, NC (NCDNCR 2022a).

The species featured in Table 6-1 were considered in the development and documentation of the proposed action.

Table 6-1. ESA and State-listed species potentially present in project area.

Federally / State Listed Species				
Common Name	**Scientific Name**	**Responsible Agency**	**Status**	**Effects Determination**
American Alligator	*Alligator mississippiensis*	USFWS	FSAT	NE
Atlantic Pigtoe	*Fusconaia masoni*	USFWS	FT	MANLAA
Atlantic Sturgeon	*Acipenser oxyrhynchus oxyrhynchus*	NFMS	FE	NE
Bald Eagle	*Haliaeetus leucocephalus*	USFWS	BGEPA	NE
Eastern Lampmussel	*Lamsilis radiata*	NCWRC	ST	MANLAA
Monarch Butterfly	*Danaus plexippus*	USFWS	FC	NE
Roanoke Slabshell	*Elliptio roanokensis*	NCWRC	SSC	MANLAA
Neuse River waterdog	*Necturus lewisi*	USFWS	FT	MANLAA
Tar River Spinymussel	*Parvaspina steinstansana*	USFWS	FE	MANLAA
Tidewater Mucket	*Leptodea ochracea*	NCWRC	ST	MANLAA
West Indian Manatee	*Trichechus manatus*	USFWS	FT	NE

FC - Federal Candidate
FE - Federal Endangered
FSAT - Federal Similarity of Appearance (Threatened)
SSC - State Special Concern
ST - State Threatened
TF - Federal Threatened
BGEPA - Bald and Golden Eagle Protection Act

NE - No Effect
MANLAA - May Affect, Not Likely to Adversely Affect
MALAA - May Affect, Likely to Adversely Effect

Several birds of conservation concern and migratory birds may be present in the project area and vicinity. Following coordination with the USFWS, a bald eagle survey was conducted in Aprill 2022 encompassing all areas within a 660 ft radius of the area of concern (i.e., proposed project footprint), as depicted in Figure 6-6. A 660 ft radius buffer accounts for adequate project distance from an active eagle nest, should an eagle nest be present in the vicinity. The survey was conducted by boat and on foot, on both banks of the Tar River. No bald eagles or bald eagles were observed. Additionally, Greenville Water Treatment Plant staff had not reported any sightings of bald eagles in the area in several years.

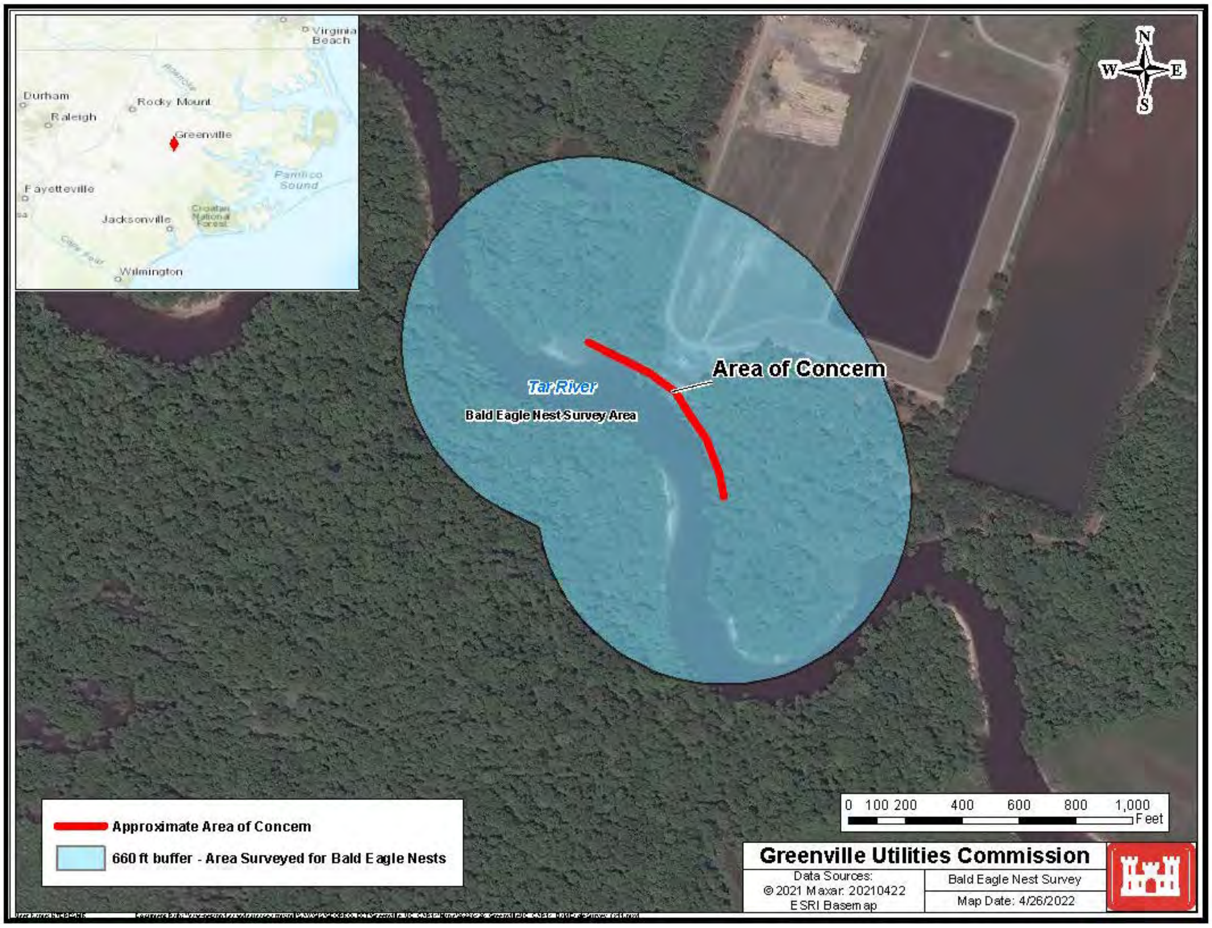

Figure 6-6. Bald eagle survey area.

Species featured in Table 6-1 may be present in the project area. Clams and mussels are largely sessile and those in the immediate project footprint may be buried during construction; however, other animal species in the project vicinity are mobile and could likely avoid impacts associated with construction activity, should they be present. Similarly, it is unlikely that any plants given special consideration by the Natural Heritage Program would be affected by proposed construction. Affected upland areas are heavily disturbed and/or maintained.

The tentatively selected plan will have no effect on the Federally listed American alligator, Bald Eagle, Monarch butterfly, or West Indian manatee. Although the American Alligator may be present in the project area, it is mobile and will not be affected by construction activity. Bald eagles are currently absent from the project area. The Monarch butterfly may be seen in western portions of North Carolina during its annual migration, but is unlikely to be encountered in the project area. The West Indian

Manatee is also unlikely to be encountered in the project area due to the project area's inland distance from the Atlantic ocean and its relatively northern latitude.

The tentatively selected plan may affect but is not likely to adversely affect the following Federal / State listed threatened or endangered species or other species of concern: Atlantic Pigtoe, Atlantic Sturgeon, Eastern Lampmussel, Roanoke Slabshell, Neuse River Waterdog, Tar River Spineymussel, Tidewater Mucket. Effects to mollusks and the Neuse River Waterdog may be realized as temporary increases in localized turbidity associated with in-water construction activity, alteration of benthic habitat from sandy bottom to riprap, and burial during construction; however, riprap may provide favorable substrate for mollusks such as freshwater clams and mussels. The Neuse River Waterdog typically prefers leaf beds and quiet waters, which are absent from the immediate project area. Additionally, implementation of the tentatively selected plan will reduce long-term turbidity and erosion in the project area. Based upon known spawning run patterns, it is unlikely that Atlantic Sturgeon would be encountered during in-water construction. To avoid potential impacts to Atlantic Sturgeon, an in-water work moratorium will be established between February 1 and September 30; therefore, the tentatively selected plan will have no effect on Atlantic Sturgeon. Additionally, primary constituent elements for Atlantic sturgeon critical habitat including, but not limited to, suitable spawning sites, aggregation areas, and preferred flow regime are absent from the project area (USFWS 2016).

The tentatively selected plan will not include destruction or adverse affects to designated critical habitat for the Atlantic Sturgeon or Neuse River Waterdog.

The no action alternative would allow for continued streambank erosion, which may displace aquatic threatened and endangered species, and other species of concern, by degrading water quality.

6.12 Aesthetic and Recreational Resources

The Tar River empties into Pamlico Sound. The relatively flat topography of Pitt County affords the Tar River a moderate degree of sinuosity and a relatively unconstrained floodplain. With few exceptions, including the Greenville Water Treatment Plant, the River's banks are bordered by woodlands and natural areas with pleasing aesthetic qualities. Primary recreational opportunities present in the proposed project vicinity are recreational shoreline and small craft fishing, hunting, and hiking.

The tentatively selected plan is not expected to significantly impact aesthetic or recreational resources. Construction would be restricted to the immediate proposed project area and would provide stabilization to the eroding streambank. Any impacts related to construction, including noise, presence of construction equipment, and potential effects to roadway traffic circulation associated with equipment or material transport would be temporary and short-lived. Although the proposed project area would be covered in riprap, a maintained bank is congruent with other landuse in the project area and would be an aesthetic improvement as compared to current conditions (bank erosion and failing existing protection measures). The tentatively selected plan would not adversely impact any scenic views or adversely impact recreation in the proposed project area.

The no action alternative would not directly impact aesthetic and recreational resources in the proposed project area; continued bank erosion may detract from recreational opportunities and the aesthetic value of lands at and downstream of the proposed project area.

6.13 Socioeconomic Resources

For information regarding socioeconomic resources in the vicinity of proposed project area, to include environmental justice, please see Section 11.0 Environmental Justice Assessment.

6.14 Cumulative Impacts

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 foreseeably 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).

Over multiple years, storms and other high water events in the Tar River watershed have resulted in successive severe erosion events on the northward (outer) bank of an oxbow bend of the Tar River nearest critical water supply infrastructure associated with the Greenville Water Treatment Plant. Continued erosion in the proposed project area may ultimately result in damage to water intake or associated transmission infrastructure, and be detrimental to human and environmental health at and in areas served by the Water Treatment Plant.

The tentatively selected plan would armor approximately 305 linear feet of the Tar River bank with riprap to prevent continued erosion and bank sloughing, endangering critical water supply infrastructure. Streambanks abutting the proposed project area are, and would remain, unarmored. The proposed action is expected to have minimal impact on overall functionality and quantity of riparian vegetation and available wildlife habitat in the proposed project area.

The selected alternative would have no appreciable adverse impact on environmental resources in the proposed project area or the Tar River watershed, and may provide environmental benefits by stabilizing the streambank.

Following construction of the proposed action, water supply infrastructure associated with the Greenville Water Treatment Plant is expected to remain protected from erosion caused by scouring of the northern Tar River bank following storm and other high water events for a period of 50 years and is not expected to alter any ecological function or community structure in the project vicinity (i.e., within a five mile radius of the project area). Additionally, no known future actions are expected to be constructed by other agencies / organizations in the project vicinity during the expected 50-year life of the proposed action.

6.15 Conclusion

Based on findings described in this report, it is in the federal interest to implement the tentatively selected plan for emergency streambank erosion control at the Greenville Water Treatment Plant. The proposed action will meet the objective of protecting vulnerable water supply infrastructure. Table 6-2 details significant environmental factors and impacts taken into consideration. Project construction will result in long-term impacts to benthic habitat and terrestrial vegetation (not to exceed one acre) and short-term impacts to benthic community composition, fish species habitat, water quality, air quality, and noise levels in the project area. Overall benefits of the tentatively selected plan, however, include a long-term reduction in streambank erosion and turbidity in the project area and protection of critical water supply infrastructure.

Table 6-2. Comparison of environmental impacts associated with Tentatively Selected Plan and No Action alternative.

Project Area Resource	Impacts of TSP: Stone (Riprap) Slope Protection	Impacts of No Action Alternative
Sediments	Temporary impacts from excavation, grading, and material placement during construction. Expected to result in an overall reduction in erosion at the proposed project area and improve bank stabilization.	Continued streambank erosion in the project area, resulting in increased turbidity. Potential bank failure under the no action alternative may damage water intake structures or associated transmission infrastructure.
Water Quality	Temporary elevation in turbidity during construction. Expected to have favorable long-term effects on water quality in, and downstream of, the project area by decreasing erosion and subsequent turbidity introduced to the Tar River following high water events	Continued streambank erosion, and associated elevated turbidity in and downstream of the proposed project area. Potential bank failure under the no action alternative may damage water intake structures or associated transmission infrastructure.
Wetlands and Floodplains	No impacts.	No impacts.
Hazardous and Toxic Materials	No impacts.	No impacts
Cultural Resources	No impacts.	Continued streambank erosion, which may endanger any unidentified cultural resources in the proposed project area.
Air Quality	Temporary increases in emissions during construction.	No impacts
Noise	Temporary increases in noise during construction. Construction would comply with the published Noise Control Ordinance of Pitt County, NC.	No impacts.
Benthic Resources	Permanent habitat alteration from sandy bottom to hard structure and temporary community composition disruption in proposed project footprint. Long-term sediment stabilization in the proposed project area and introduction of hard structure for utilization by benthic organisms and other aquatic fauna.	Continued streambank erosion, potentially altering benthic habitat regularly following extreme weather and flow events.
Fisheries Resources	Temporary increased turbidity and temporary species displacement during construction. Alteration of benthic habitat from sandy sediment to rock structure.	Continued streambank erosion, potentially altering localized turbidity and forage substrate for fishes.
Terrestrial Resources	Vegetation clearing (grasses, vines, and trees) and grading to accommodate required equipment during construction. Disturbed areas would be re-vegetated with grasses or other native plants upon project completion.	Continued streambank erosion and associated vegetation loss.
Threatened and Endangered Species, and Species of Concern	Construction activity may affect but is not likely to adversely affect multiple threatened and endangered species, or other species of concern. Critical habitat will be unaffected.	Continued streambank erosion may displace aquatic threatened and endangered species and other species of concern by degrading water quality.
Aesthetic and Recreational Resources	Impacts related to construction, including noise, presence of construction equipment, and potential effects to roadway traffic circulation associated with equipment or material transport would be temporary and short-lived. A maintained bank is congruent with other landuse in the project area and would be an aesthetic improvement as compared to current conditions.	Continued streambank erosion may detract from the aesthetic value.

7.0 CLIMATE CHANGE CONSIDERATIONS

ER 1100-2-8162, Incorporating Sea Level Change (SLC) in Civil Works Programs, provides regulations and guidance for incorporating direct and indirect physical effects of projected future sea level change to USACE Civil Works projects. Consideration of potential relative sea level change is required in every USACE coastal activity as far inland as the estimated tidal influence, including studies that calculate backwater profiling with the ocean as the downstream boundary condition.

NOAA's "Sea Level Rise Viewer" (https://coast.noaa.gov/) was used to determine the impacts of SLC. Present day MHHW extends up the mouth of the Tar River to near the Edgecombe and Pitt County border. Four MHHW scenarios that included sea level rise were assessed within the tool, 1-ft sea level rise, 2-ft sea level rise, 6-ft sea level rise, and 8-ft sea level rise. Based on a comparison of the encroaching water depth footprint between the different sea level rise scenarios, no GUC WTP infrastructure would be impacted by the increased MHHW. For reference, the USACE Sea-level Change Curve Calculator for the Beaufort, NC gauge #8656483 resulted in the following projections for year 2073: Low Curve is 0.66-ft, Intermediate Curve is 1.27-ft, and High Curve is 3.12-ft.

The USACE Sea Level Tracker (https://climate.sec.usace.army.mil/slr_app/) was used to visualize the variability of coastal water levels at the Beaufort, NC Gage, and compare the different USACE sea level change scenarios. Results of the tracker tool include historical gauge records through year 2021. Notably, there has been an apparent upward trend of both 5- and 19-year MSL moving averages since the mid-2000's. This pitch upward may suggest convergence with the High SLC curve in the near future.

A qualitative climate change analysis was performed as required by U.S. Army Corps of Engineers (USACE) Engineering and Construction Bulletin (ECB) 2018-14, "Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects." This analysis captured current and projected future climate change trends that are applicable to the GUC study area. Findings of these assessments revealed increasing temperatures though was unable to definitively show an increasing or decreasing trend in precipitation, based on observed data. Assessment of future projections also showed an increasing temperature trend as well as also suggesting an increasing trend in precipitation. Overall, there were no significant trends evident in observed streamflow throughout the study basin while more uncertainty was associated with projected future streamflow trends, particularly with higher streamflow projections. Refer to Appendix B Hydrology and Hydraulics, Section 7 for more details of the climate change analysis performed as part of this report.

8.0 HYDRAULIC ANALYSIS

Appendix B documents the hydrologic and hydraulic analysis and includes a summary of the design considerations on the Tentatively selected Plan.

Erosion mechanisms that are occurring within the project area and potential solutions were assessed using Hydrologic Engineering Center's (CEIWR-HEC) River Analysis System (HEC-RAS) software, version 6.2. In accordance of Engineering Manual 1110-2-1601, Hydraulic Design of Flood Control Channels, HEC-RAS was utilized to riprap protection associated with the Tentatively selected Plan. The HEC-RAS Hydraulic Design Functions, Riprap Calculator contains the methodologies prescribed in EM 1110-2-1601, Chapter 3, and used 1-dimension, steady-state hydraulic results. A sensitivity analysis was also conducted that includes the use of field-measured streamflow velocity values as provided by the Greenville Utilities Commission.

8.1 HEC-RAS

The project HEC-RAS model was based on the current 2022 Effective FEMA model for Tar River in Pitt County. A series of refinements and improvements were made to the FEMA model which included georeferencing of existing cross sections as well as insertion of new cross sections based on recent bathymetric surveying by USACE and Greenville Utilities Commission. Simplified calibration of flows and water surface elevation within the HEC-RAS was achieved by using the nearby, downstream USGS streamflow gage at Greenville, NC.

8.1.1 RIPRAP CALCULATOR

Riprap was sized following procedures in EM 1110-2-1601, which is based on critical flow velocity within the Tar River channel. Two methods of determining average channel velocity were used due to the presence of field measurements within the project area. The first method was based on the aforementioned HEC-RAS hydraulic model to calculate velocity and is the preferred method within EM 1110-2-1601. The second method determined velocity from field measurements within the channel (Schnabel, 2008). Safety factors assumed for the first and second methods were 1.4 and 1.2, respectively. It was determined that conditions that produce the critical flow velocity would occur at near channel capacity or bankfull condition. Modeling showed that interaction with the surrounding inundated floodplain of the Tar River resulted in lower velocities for the project area.

The HEC-RAS method resulted in a critical flow velocity of approximately 5 feet per second within the project area and recommended a riprap gradation equivalent to EM 1110-2-1601 gradation #1. The second method, based on field-measured flow velocities resulted in a critical flow velocity of approximately 7 feet per second within the project area and recommended a riprap gradation equivalent of EM 1110-2-1601 gradation #3. EM 1110-2-1601 gradation #3 is as follows:

D15(min) = 5.98 in. / W15(min) = 10.67 lbs.

D15(max) = 7.88 in. / W15(max) = 24.50 lbs.

D30 = 7.32 in. / W30 = 19.61 lbs.

D50(min) = 8.80 in. / W50(min) = 34.02 lbs.

D50(max) = 10.01 in. / W50(max) = 50.12 lbs.

D90 = 10.56 in. / W90 = 58.87 lbs.

D100(min) = 11.03 in. / W100(min) = 67.05 lbs.

D100(max) = 15.00 in. / W100(max) = 168.74 lbs.

The resulting velocities from the two methods described above produced different recommendations of riprap sizes for the project site. Method #1 calculated relatively low averaged channel velocities and consequently resulted in choosing the smallest EM 1110-2-1601 gradation #1 curve. Method #1 corresponding stone size readily available at a local quarry was NCDOT Class B. Method #2, based on higher average velocities measured within the channel, resulted in choosing EM 1110-2-1601 gradation #3 curve. Method #2 corresponding stone size readily available a local quarry was NCDOT Class 1. Generally, it is uncommon to recommend riprap sizing be determined based solely on field observations as it carries uncertainty related to limited observation points. However, due to the emergency streambank stabilization nature of this study authority and method #2 producing relatively larger stone size, it is recommended that NCDOT Class 1, or an equivalent readily available stone be placed along the Tar River left bank at the project site.

8.2 FINAL RIPRAP SIZE RECOMMENDATIONS

The Recommended Plan (Stone (Riprap) Slope Protection) would consist of a layer of stone (Riprap) placed over a layer of bedding stone along approximately 350 linear feet of streambank and extending from the top of the existing streambank in the oxbow bend of Tar River to the embankment toe. The streambank would be cleared and graded to a 2H:lV slope for placement of the streambank slope protection. Below the ordinary high water line, backfill material consisting of NCDOT #57 stone would be placed over a geotextile layer, graded, and compacted as required to provide a smooth sloped surface for the placement of the stone. Above the ordinary high water line, backfill material consisting of satisfactory fill (earth) material would be placed on the existing cleared streambank, graded, and compacted as required to provide a smooth sloped surface for placement of the stone slope protection. (Satisfactory materials comprise any materials classified by ASTM D2487 as GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, and

CL-ML. Satisfactory materials for grading shall be free from roots and other organic matter, trash, debris, frozen material, and stones larger than 3 inches in any dimension.) The streambank slope protection measures would consist of a 1' layer of bedding stone (NCDOT #57 stone) and a 25.5" thick layer of NCDOT Class I riprap placed over a layer of geotextile and graded fill slope. Toe protection will be placed along the toe of the stream bottom.

9.0 DETAILED COST ESTIMATE FOR RECOMMENDED PLAN

RECOMMENDED PLAN, "STONE (RIPRAP) SLOPE PROTECTION"
GREENVILLE, NC SECTION 14 EMERGENCY STREAMBANK
AND SHORELINE EROSION PROTECTION PROJECT

ESTIMATED TOTAL PROJECT COSTS (FULLY FUNDED)
(all costs include contingency in accordance with Appendix C)

	2024 Q3 Price Level Prices
Direct Construction Costs	$1,376,000
Real Estate Costs	$3,000
Detailed Design (from DI phase)	$279,000
Supervision and Administration	$183,000
TOTAL PROJECT COST	$1,841,000

ESTIMATED FEDERAL COST:	$1,196,650 (65%)
ESTIMATED NON-FEDERAL COST:	$644,350 (35%)
Subtotal:	$1,841,000
FEASIBILITY STUDY COST:	$150,000 ($125k Fed / $25k non-Fed)
TOTAL COST WITH STUDY:	$1,991,000

10.0 ECONOMIC JUSTIFICATION FOR RECOMMENDED PLAN

ER 1105-2-100 Appendix C, Section III, F-23 states that the least cost alternative plan is considered to be justified if the total costs of the proposed alternative are less than the costs to relocate the threatened facility. With the estimated costs of relocation at greater than $4,600,000 and the protection cost of the Recommended Plan at approximately $1,841,000, it is determined that the Recommended Plan of Stone (Riprap) Slope Protection is economically justified.

11.0 ENVIRONMENTAL JUSTICE ASSESSMENT

Background and Definitions

Executive Order 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 US Environmental Protection Agency (EPA) and other affected agencies, developed NEPA guidance for addressing requirements of the EO (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 (recognize 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 the EO:

- 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 will 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.

Analysis and Conclusions

USACE conducted an EJ analysis by determining whether EJ populations are present and whether the proposed action would result in a disproportionately high and/or adverse effect on these populations.

For purposes of the EJ analysis, the area of effect is the area which is served by the public utility which is being protected (figure 11-1). Using the Center for Disease Control (CDC) Social Vulnerability Index (SVI) by census tract, the Tentatively Selected Plan would have positive impacts on the following populations:

***Minority Population*:** Varies from low to high, but most proposed areas of impact received a CDC CVI ranking exceeding 0.5 for the minority status and language category, signifying that 50% of the tracts in North Carolina are less vulnerable than these identified tracts based on minority & English-speaking status.

***Per Capita Income*:** The majority of the population that is affected is in the “Highest Vulnerability” category.

***SVI Overall Percentile ranking*:** The majority of the population that is affected is in the “Highest Vulnerability” category.

Impacts to the above populations due to the Tentatively Selected Plan are anticipated to be positive as a result of protecting operations which provide their drinking water. There are no expected significant adverse impacts to EJ populations due to the implementation of this project.

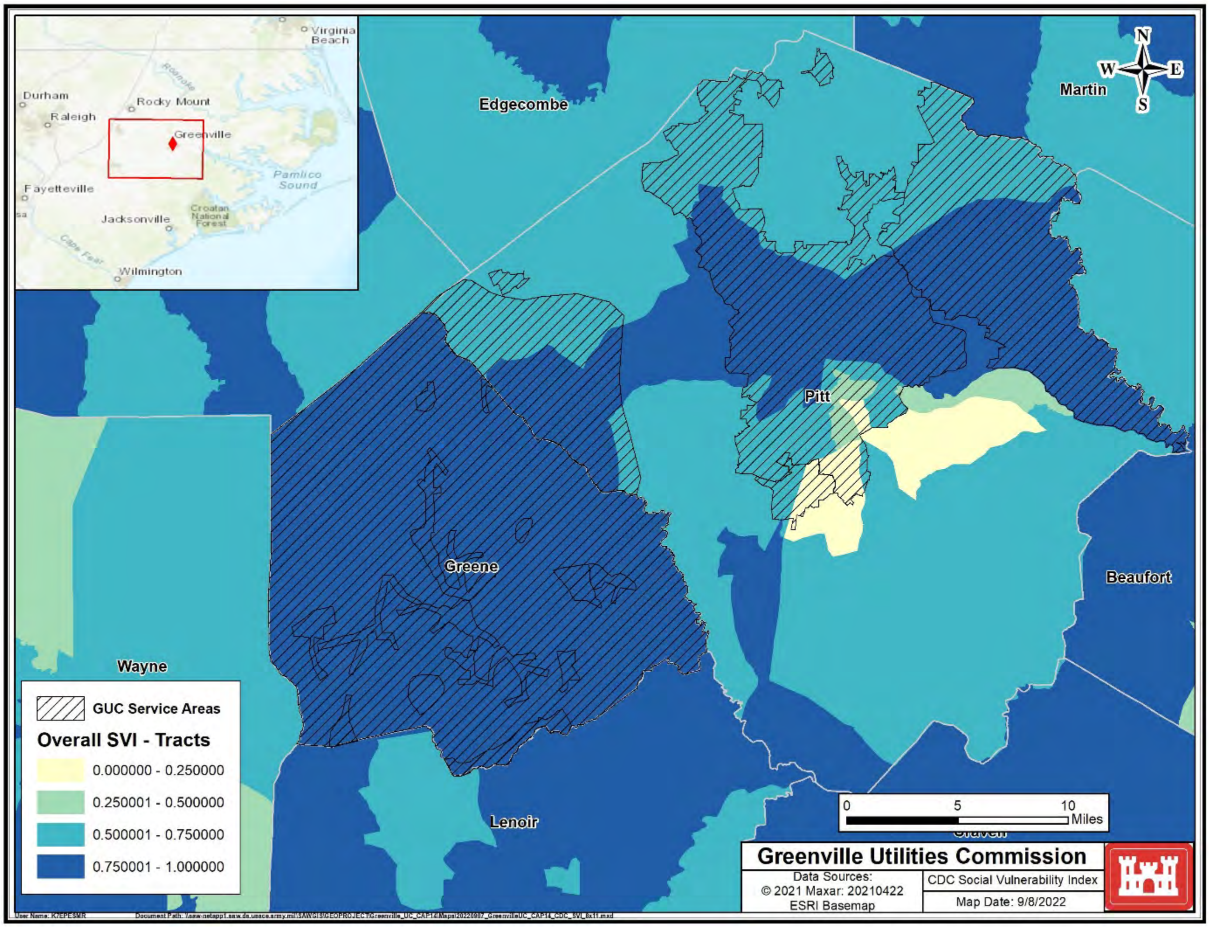

Figure 11-1. Map CDC SVI Index overlayed with the GUC service area. The dark blue represents the overall "highest vulnerability" where the populations are more vulnerable than at least 75% of other populations in North Carolina.

12.0 REAL ESTATE REQUIREMENTS

The lands required for the Greenville Utilities Commission Section 14 Project are owned in fee by the Greenville Utilities Commission (GUC). In 2011, the GUC implemented a streambank stabilization project. However, continued riverbank erosion of the Tar River has created a direct threat to the continued operation of the water intakes and water supply to the GUC service region.

Based on the current design, no additional real estate will be required for the construction of this project. All proposed access and staging areas will be located on lands owned in fee by the GUC. However, should additional requirements become necessary, the appropriate standard estate will be determined based on the need and the GUC will be responsible for obtaining the estate identified at that time over such lands. The estimated Federal and Non-Federal Real Estate administrative costs are as follows:

Federal	$500
Non-Federal	$1,500

Prior to advertisement for construction, the GUC will provide Real Estate Division an executed Authorization for Entry for Construction and Attorneys Certificate of Authority shown in section 11.1. Once received by Real Estate Division, a Real Estate Certification Letter will be provided to the Wilmington Districts Project Management and Contracting Divisions.

13.0 SUMMARY COORDINATION, PUBLIC VIEWS, AND COMMENTS

In response to an email inquiry, a site visit was conducted on July 8, 2020 to investigate the erosion concern at the GUC water treatment plant. As a result of the site visit, a letter was sent to the USACE Wilmington District dated August 21, 2020 requesting assistance under the CAP 14 authority. The study initiated when Federal funds were received in November of 2021.

Since initiation of the Section 14 study, coordination with the Sponsor and Agencies has occurred via teleconference, emails, letter exchange, and on-site meetings. Coordination to date has included Pitt County, the City of Greenville, the Greenville Utilities Commission, the US Environmental Protection Agency, the NC State Historic Preservation Office, the NC Division of Water Quality, the NC Division of Marine Fisheries, the NC Wildlife Resources Commission, the National Marine Fisheries Service, the US Fish and Wildlife Service, the Friends of Greenville Greenways, the North Carolina Black Alliance, and Sound Rivers. Specifically, regarding feedback opportunities, a project scoping letter was distributed to all identified stakeholders on February 23, 2022 requesting preliminary project review and comment. Comments were received from the the NC State Historic Preservation Office, the NC Wildlife Resources Commission, the US Environmental Protection Agency, and the US Fish and Wildlife Service. In general comments concerned potential impacts to air quality, water quality and hydrodynamics, terrestrial and aquatic resources, threatened and endangered species, and environmental justice.

14.0 PLAN IMPLEMENTATION

13.1 Non-Federal Responsibilities

The GUC, as stated in a letter and resolution dated 21 August 2020 (Appendix A), has expressed support for the project and has agreed to accept the role of non-Federal sponsor in the event of approval of a final Detailed Project Report. The GUC has statutory authority under the Federal Water Resources Development Law of 1969 (G.S. 143-215.38 et.seq.) to make binding commitments to carry out the non-Federal responsibilities related to USACE projects, including making cash contributions to projects. In order to implement the Tentatively Selected Plan, the GUC, as the non-Federal sponsor, would be responsible for the following:

1. Without cost to the U.S. Government, provision of legally sufficient title to real estate for all necessary land, easements, rights-of-way, and access routes necessary for project construction and subsequent operation and maintenance. Land provisions would include:

    a. construction site to accommodate all emergency streambank and shoreline erosion protection features to be constructed, and

    b. temporary staging area of acceptable location and acreage for contractor's use during construction period. Staging area will be a previously disturbed site.

2. In accordance with ER 1105-2-100 the non-Federal sponsor is responsible for a minimum of 35 percent of total project costs to a maximum of 50 percent of total project costs during the design and implementation period for the Section 14 authority. In accordance with the terms of the PPA, the non-Federal sponsor must pay 5 percent of total project costs in cash, provide all LERRD required for the project, participate in the Project Coordination Team, perform necessary non-Federal audits, and perform investigations necessary to identify the existence and extent of hazardous substances on LER required for the project. If the value of the non-Federal sponsor's contributions listed above is less than 35 percent of total project costs, the non-Federal sponsor must pay additional cash so that its contributions equal 35 percent of total project costs. The amount of cash contribution is currently estimated to be $644,000 of the total $1,841,000. This cash amount will vary depending on the actual real estate costs and in-kind services. The GUC has stated its intent by letter dated August 21, 2020 (Appendix A), to accept the non-Federal sponsor's responsibilities as defined in a Project Partnership Agreement, should the project report be approved.

3. Funding of 100% of the cost of Annual Operation and Maintenance required to keep the project in viable condition to satisfy its design function. This funding would not be provided for during the initial implementation of the project, but

would become a yearly responsibility of the non-Federal sponsor upon completion of the construction phase.

4. Satisfy all provisions of the Project Partnership Agreement (PPA) regarding non-Federal sponsor responsibilities in implementing the project.

14.2 Federal Responsibilities

In order to implement the Recommended Plan, the USACE would provide the Federal share of project cost, to equal project first cost less the total non-Federal share, not including Annual Operation and Maintenance expenses. The Federal share of project cost is currently estimated to be $1,196,000 which is 65% of Total Project Costs (not including Feasibility Phase costs). Federal expenditures shall not exceed $5 million for flood control (Section 14) purposes at any single locality for any one fiscal year. The USACE would also provide the following:

1. Review and certification of Real Estate provisions.
2. Design and Implementation of the project.
3. Contracting for project construction.
4. Supervision and Administration of project construction.

14.3 In-kind Contributions

In-kind contributions are work performed by and/or materials provided by the non-Federal sponsor pursuant to an executed agreement for which the sponsor receives a credit toward its share of total project costs (excluding the required 5 percent cash contribution for this project) if the work (and materials) is determined to be integral to the project. At this time, the non-Federal sponsor does not intend to provide any in-kind contributions for this project.

14.4 Project Partnership Agreement (PPA)

After approval of a final Detailed Project Report for this Greenville Utilities Commission, NC Section 14 project, a Project Partnership Agreement (PPA) would be executed. A PPA is a legally binding agreement between the USACE and a non-Federal sponsor (in this case, the GUC) for construction of a water resources project, in this case, the GUC Emergency Streambank and Shoreline Erosion Protection Project. The PPA would describe the project and the responsibilities of the USACE and the GUC in the cost sharing and execution of project work.

14.5 Sponsor Views

The GUC has expressed support for this project and has agreed, by letter dated August 21, 2020, to accept the role of non-Federal sponsor in event of approval of a final feasibility report. The GUC's preference among the alternatives (i.e., the "Locally-Preferred Plan") is the Stone (Riprap) Slope Protection. After a full review process, this Tentatively Selected Plan will become the Recommended Plan.

15.0 RECOMMENDATIONS

Based on the evaluation and screening process, the Stone (Riprap) Slope Protection emerged as the single alternative that best meets the planning objective of managing the risk of damage from erosion to the GUC water intake system over a 50-yr period of analysis (2023-2072) while meeting the planning evaluation criteria of completeness, effectiveness, efficiency and acceptability. This alternative is economically justified as the least-cost alternative and would be more economical than relocating the infrastructure. Therefore, the Stone (Riprap) Slope Protection was selected as the Federally-Preferred Alternative. The GUC has expressed its support for the project, and is willing and capable of accepting the role of non-Federal Sponsor, as stated in their letter dated August 21, 2020. In addition, the GUC has expressed acceptance that the Federally-Preferred Alternative is their Locally-Preferred Alternative.

The Stone (Riprap) Slope Protection, as both Federally-Preferred and Locally-Preferred Alternative, is therefore selected as the Tentatively Selected Plan. It is further recommended that implementation of the project proceed, with plans and specifications, execution of a PPA and construction contract, and construction of the Stone (Riprap) Slope Protection. Any comments or questions regarding this Integrated Feasibility Report and Environmental Assessment should be addressed to the U.S. Army Corps of Engineers, Wilmington District, 69 Darlington Avenue, Wilmington, NC 28403, ATTN: Jason Glazener, Lead Planner.

16.0 REFERENCES

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Greenville Utilities

August 21, 2020

U.S. Army Corps of Engineers
Wilmington District
69 Darlington Avenue
Wilmington, NC 28403

Dear Colonel Bennett:

The Greenville Utilities Commission (GUC) Water Treatment Plant was commissioned in 1983 at a capacity of 12 Million Gallons a Day (MGD) to provide safe drinking water to our customers. Today, GUC treats an average of 14 MGD with peak demands of 18.5 MGD serving over 140,000 customers in our service area. The water treatment plant current capacity is 22.5 MGD. In addition, GUC has been providing surface water to five wholesale communities since 2011 due to restrictions imposed by the Central Coastal Plain Capacity Use Area Rule. To increase the reliability of water supply to the water plant, a redundant set of intake screens, piping, and manifold were installed in 2010 to ensure sufficient water could be withdrawn from the Tar River and treated to provide safe water that is essential for public health. The redundant intakes allow water to be withdrawn from the river and pulled into the raw water pump station through two thirty-inch pipes that were installed through the riverbank.

A project was completed in 2011 to stabilize the riverbank using the ArmorFlex revetment system and Iowa training vanes. The riverbank has seen significant erosion behind the ArmorFlex system increasing the potential of damage to the raw water intake lines coming from the intake screens. If the riverbank collapsed and severed the lines, then over 140,000 customers would be at risk of losing a valuable resource which would jeopardize public health and fire flow protection. In addition, the screens have also been covered by river sediment due to many high river events since 2011. Dredging contractors have removed an average of 4,000 cubic yards of material since 2016 to keep sediments from covering screens.

The riverbank needs to be stabilized to ensure an adequate amount of water is available for public health protection. Greenville Utilities Commission is willing and able to partner with the U.S. Army Corps of Engineers under the Section 14 Authority to address the problem.

Respectfully Submitted,

Randall D. Emory, PE
Director of Water Resources

cc: Anthony C. Cannon, General Manager/CEO
David W. Springer, PE, Assistant Director of Water Resources
D. Anthony Whitehead, Water Quality Manager
Julius E. Patrick, Water Treatment Plant Superintendent

PO Box 1847
Greenville, NC
27835
www.guc.com

Your Local Advantage

Greenville Utilities Commission Continuing Authorities Program, Section 14 Feasibility Study

Appendix B. Hydrology and Hydraulics

US Army Corps
of Engineers

August 2022

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1 Introduction

This hydrology and hydraulics appendix serves as documentation of the engineering evaluation process for the Greenville Utilities Commission (GUC) Final Integrated Feasibility Report. The Continuing Authorities Program (CAP) project is authorized by Section 14 of the Emergency Streambank and Shoreline Protection, Flood Control Act of 1946, as amended. This report is in response to a request from the Greenville Utilities Commission that the U.S. Army Corps of Engineers provide assistance in addressing riverbank erosion problems at their Water Treatment Plant. Riverine and coastal storm damages that originate from the Tar River, including erosion causing riverbank instability and failure, threatens GUC infrastructure that is critical to ensuring safe, useable water is available for public use. This appendix describes the development of existing conditions (EC) and future without project (FWOP) conditions in addition to the formulation, refinement, and design of structural study measures and alternative plans. This Engineering Appendix is in accordance with ER 1110-2-115 (USACE, 1999), provides assumptions of underlying hydrology and hydraulic uncertainty in accordance with ER 1105-2-101 (USACE 2019b), and includes an assessment of climate change of the study area and potential effects of such change by ECB 2018-14 (USACE, 2018).

1.1 Vertical Datum

All elevations in this repot are referenced to the North American Vertical Datum of 1988 (NAVD88) unless otherwise noted.

2 Background

2.1 Location

The GUC Water Treatment Plant (WTP) is located along the Tar River, approximately 3 miles upstream from the City of Greenville, NC, in Pitt County (Figure 1). The plant's infrastructure is situated within the left overbank or northern side of the Tar River and is inside the extents of the Federal Emergency Management Agency (FEMA) effective flood zone designated "AE" (Figure 2). Based on FEMA Map Number 3720467900J, panel effective date 1/2/2004, portions of the facility are also within the FEMA Regulatory Floodway (Figure 3). This reach of the Tar River is characterized by shallow channel bottom gradients and tend to be sluggish in flow, and swamp and marshes are predominant.

Figure 1. Location Map 1

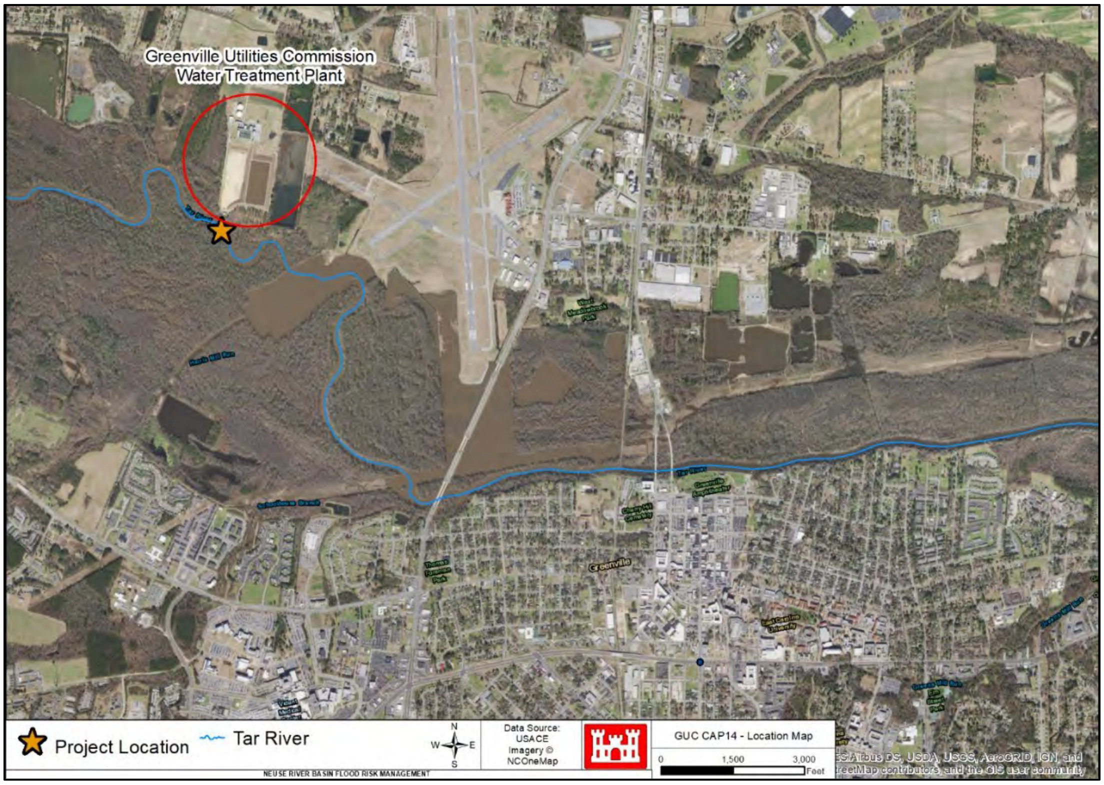

Figure 2. Location Map 2

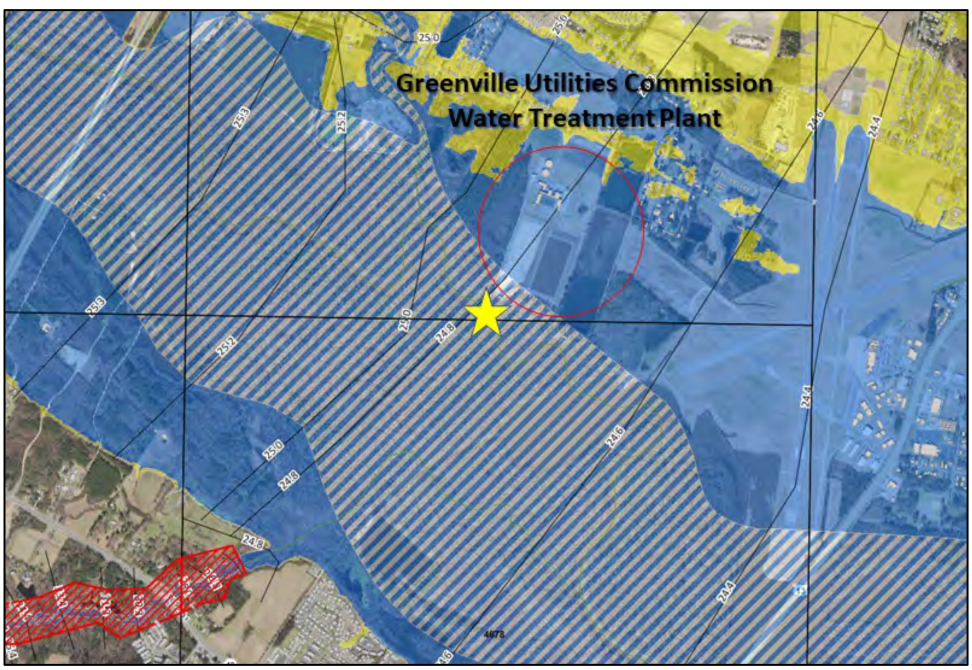

Figure 3. NCFRIS Screenshot – Project Area

2.2 Infrastructure at Risk

The GUC WTP utilizes two sets of raw water intake structures that pull water from the Tar River into their facility for treatment. The structures are placed near the thalweg of the Tar River and is in proximity to the left side channel riverbank (Figure 4). Each set is comprised of two individual intake screens that takes advantage of the river's natural flow velocity to allow water to be pulled into a pipe network that converges to a pump station, located further away from the left channel bank. The total pipe length from intakes to pump station is roughly 500 linear feet.

Figure 4. Infrastructure at Risk

2.3 Existing Remediation

The natural riverbank nearest the intake structures has historically been subjected to frequent overtopping flow from the Tar River. This has resulted in erosion of approximately 120 linear feet of riverbank in the area of the intakes (Figure 5, Figure 6). In 2013, a length of articulated concrete block armor was placed atop the eroded streambank (Figure 7). The design allowed for topsoil to be placed within the mat's open cells to promote natural vegetated cover (Figure 8). The mat footprint was to extend from the top of bank to cover about 40 horizontal feet of the riverbank at a 2H:1V slope. The mat's toe would tie into a series of intermittent flow vanes. These vanes were designed to deflect erosive wave action away from the riverbank and encourage the main flow path of the river to remain near the intake locations. Lastly, the design called for aggregate to be placed at the toe tie-in section.

Figure 5. Riverbank erosion, 2011 – Pre-Remediation

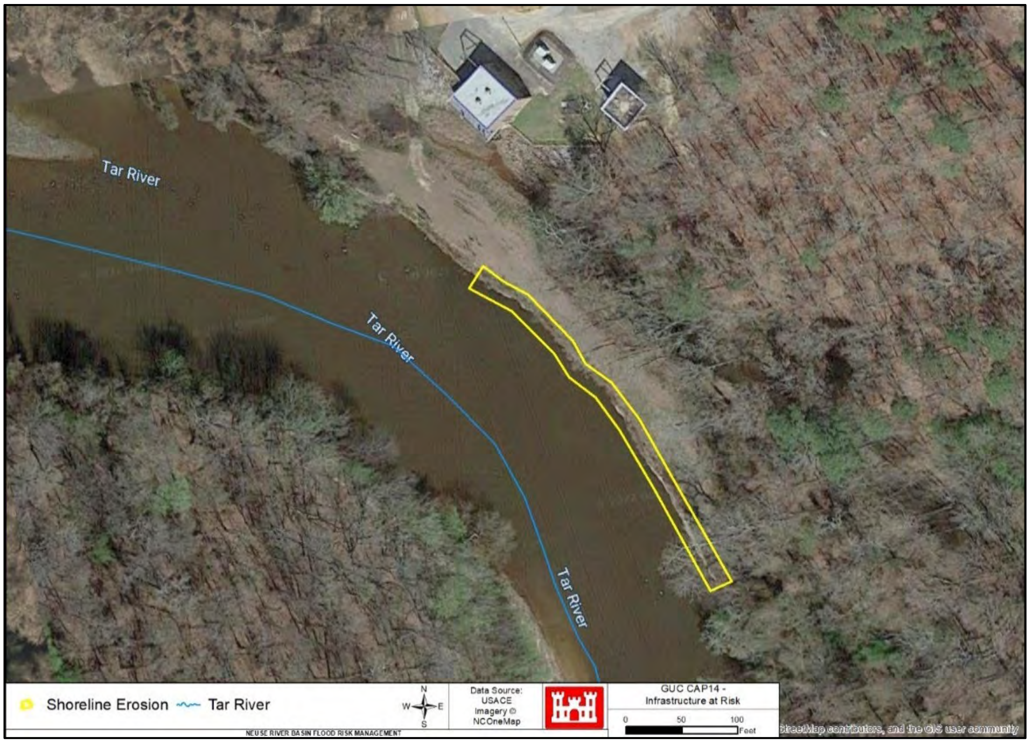

Figure 6. Shoreline Erosion

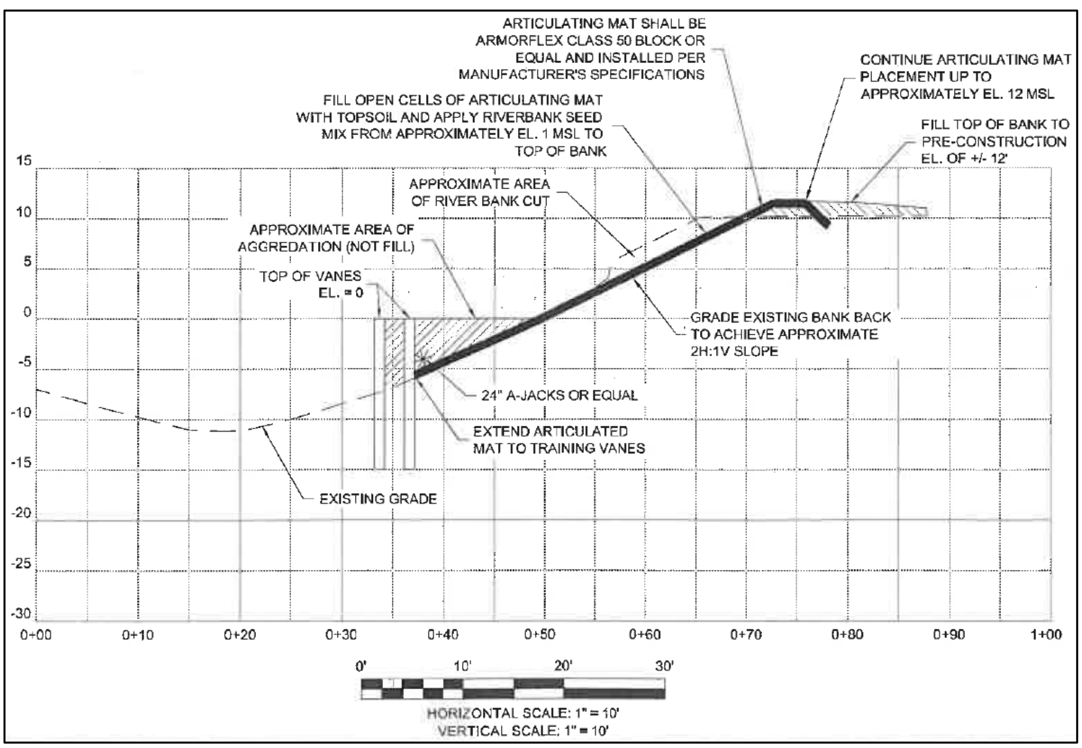

Figure 7. Existing Articulated Concrete Block Design

Figure 8. Newly Completed Construction of Articulated Concrete Block Armor

Between completion of the articulated concrete block armor and current year, 2022, significant portions of the design have failed. Segments of the mat cell have separated, breaking apart the steel wire mesh that had originally kept it together (Figure 9). With dislodged concrete cells collapsing into the channel, the riverbank's natural soils were once again exposed to erosion from the Tar River. This has ultimately resulted in conditions similar to pre-remediation. Furthermore, the nature in which the armor failed, large segments of connected concrete and steel wire, pose a threat to damage the intake structures, should they completely disconnect and fall on top of the intake screens (Figure 10).

Figure 9. USACE Site Visit 2020

Figure 10. USACE Site Visit 2022

2.4 Problem Statement

Natural streambank erosion is threatening imminent damage to the Greenville, NC regional drinking water intake system.

Riverbank erosion has been a persistent issue adjacent to the intake structures. In 2011, GUC implemented a riverbank stabilization project to address this issue. However, the existing riverbank erosion protection on the Tar River where the water intakes are located is failing. This is a direct threat to the continued operation of the water intakes and water supply to the GUC service region. The existing riverbank revetment is in poor condition and the articulating concrete mat is failing with erosion occurring behind the mat. The steel cables that once connected the individual concrete mats together have rusted and broken, rendering the disconnected mats ineffective as erosion protection for the earthen riverbank. Scour holes have developed along the revetment at the intake pipes. The end sections have failed, with erosion of the riverbank at each end of the revetment.

GUC staff describe a situation of visually apparent degradation worsening on a month-by-month basis. The biggest threat is embankment collapse onto the intake structures, damaging the structures or cutting the lines. This would put over 140,000 citizens at risk of losing valuable water resources and would jeopardize public health and fire flow protection.

2.5 Objective

The study objective is to provide emergency riverbank erosion protection to ensure uninterrupted water services to the public.

3 Alternatives

This section details the formulation and assessment of measures to provide emergency riverbank protection within the project area. A method of analysis and means of screening was based on assessment iterations due to the need to narrow down the number of proposed measures. Early assessment iterations focused on leveraging available existing reporting, data, and modeling to determine measure viability. Later iterations involved a more detailed assessment approach that included quantitative modeling to determine measure viability. This assessment resulted in the selection of Alternative 3, riprap revetment, being carried forward. The design was optimized to ensure it will meet the erosion projection objective to the extent that the cost constraints of CAP would allow.

3.1 Alternative 1

Alternative 1 included relocation of raw water intake infrastructure away from the eroding riverbank. This alternative involved complete decommissioning of existing raw water intake screens within the project area and associated pipe network that fed into the water treatment plant. This action would eliminate the need for emergency erosion protection. However, due to relocation cost data provided by GUC, this alternative was not a practical solution that would meet the planning objective.

3.2 Alternative 2

Alternative 2 included the use of Gabion Baskets to replace the existing, failing, articulated concrete block armor along the riverbank. This alternative involved relatively smaller sized stone encased in a series of stacked wired cages to act as a buffer between the natural streambank soils and erosive flows from the Tar River. Due to cost data and concerns of providing adequate toe scour protection, this alternative was not a practical solution that would meet the planning objective.

3.3 Alternative 3

Alternative 3 included the construction of a Riprap revetment to replace the existing, failing, articulated concrete block armor along the riverbank. The total length of revetment extended beyond the existing armoring to appropriately tie into the natural riverbank. Proposed earthwork modified the natural streambank such that the riprap revetment would be placed at a 2H:1V slope. This alternative also included additional stone placed along the riverbank toe to account for potential toe scour. This is the only solution that is both practical and sustainable and would meet the planning objective.

3.4 Alternative 4

Alternative 4 included a flow diversion structure that more efficiency directed flow through the nature riverbend within the project area. Due to the proximity of the raw water intake structures and associated piping as well as amount of physical modification required for the natural channel, this alternative did not provide a practical solution that would meet the planning objective.

3.5 Alternative 5

Alternative 5 included an articulated concrete block design that would replace the existing, failing armor. Due to the historical performance of the existing protection and concerns of maintenance and resiliency to the combined riverine and coastal-based erosion, this alternative did not provide a practical solution that would meet the planning objective.

3.6 Alternative 6

Alternative 6 included construction of a steel sheetpile bulkhead within the area of eroded riverbank. The bulkhead would extend beyond the existing articulated concrete block armor to appropriately tie into high ground. The structure’s design elevation was set to the approximate top of riverbank. Due to cost data and concern of the required penetration depth of the steel sheetpile extending below the raw water intake pipe network, this alternative did not provide a practical solution that would meet the planning objective.

3.7 Alternative 7

Alternative 7 included construction of a High-Performance Turf Reinforcement Matting atop the area of eroded riverbank. This design involved a thin, synthetic layer that replaced the existing, failing articulated concrete block armor. Due to concerns of structural durability given the riverine and coastal-based hydraulic loading that the project area was subjected to on a relatively frequent basis, this alternative did not provide a practical solution that would meet the planning objective.

3.8 Alternative 8

Alternative 8 included installation of sandbags within the area of eroded riverbank. Due to the inability for a sandbag design to provide a long-term solution and overall concerns of durability and maintenance, this alternative did not provide a practical solution that would meet the planning objective.

3.9 Selected Alternative

Optimization of Alternative 3 resulted in a design consisting of construction of a riprap revetment that keyed into top-of-bank and offered toe scour protection, while also accommodating the existing flow vanes.

This alternative involves placing a continuous rock revetment along approximately 300 feet of riverbank, adjacent to the raw water intake infrastructure. The elevation of the revetment crest would match the existing ground elevation, a range from roughly 10.0-ft to 10.5-ft, NAVD88. The design details are discussed in Section 5.

4 Pertinent Data

4.1 Imagery

Historical imagery was made readily available from Google Earth and NC OneMap. This dataset included aerial imagery for dates that captured conditions seen over the past ~20 years, from 1998 to 2020. A qualitative assessment of visual change in overbank conditions affirmed the high frequency in which the project area is exposed to overtopping flow from the Tar River in addition to showing continual riverbank degradation over time.

Figure 11. Google Earth Historical Imagery

4.2 Land Cover

The most current (2019) National Land Cover Database (NLCD) was used to characterize Land Use in the project area (Figure 12). NLCD 2019 provided a raster of descriptive land cover types at a 30-meter resolution and enables hydrologic characterization at a subbasin-level.

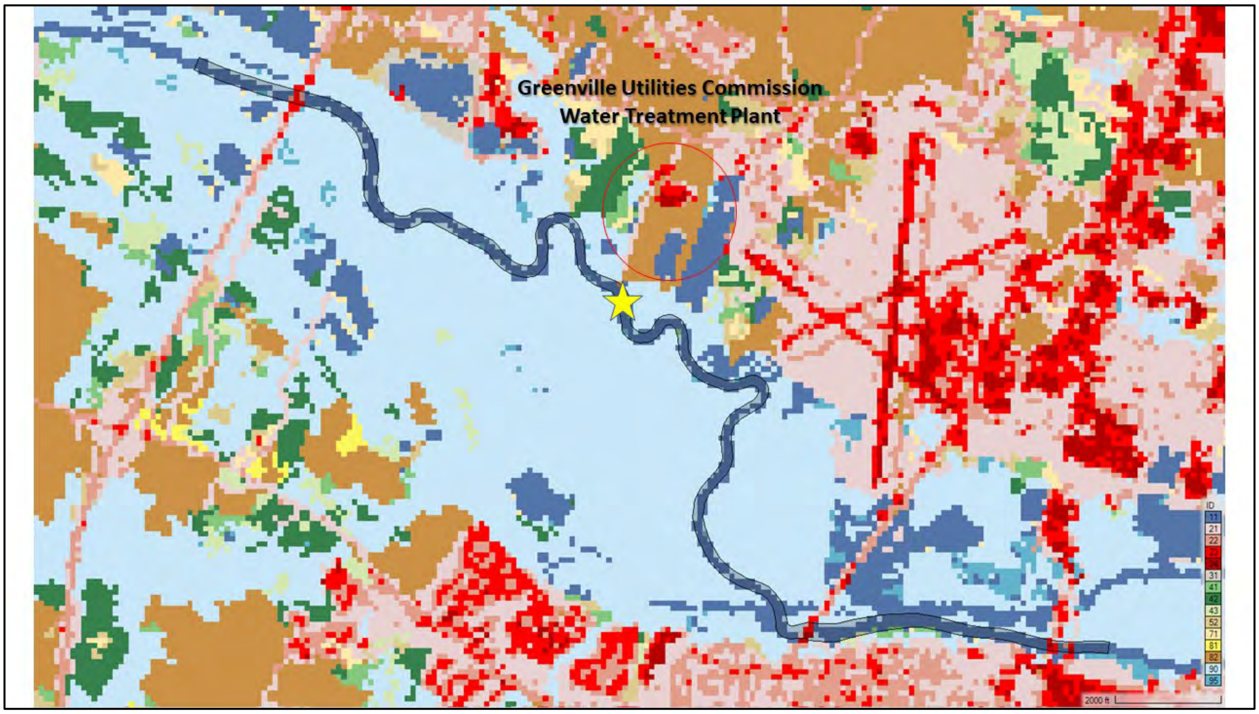

Figure 12. Project Area Land Cover – NLCD 2019

Table 1. NLCD 2019 Land Cover Classification

Open Water
Developed - Open Space
Developed - Low Intensity
Developed - Medium Intensity
Developed - High Intensity
Barren Land (Rock/Sand/Clay)
Deciduous Forest
Evergreen Forest
Mixed Forest
Pasture/Hay
Cultivated Crops
Woody Wetlands
Emergent Herbaceous Wetlands

4.3 Topography

Several sources for topography were used based on the need to capture overbank conditions (overland) as well as in-channel conditions (underwater). This information combined with aerial imagery was utilized to layout, analyze, and compute quantities for the riprap revetment design.

Two primary sources of overland terrain data were the State of North Carolina's Light Detection and Ranging (LiDAR) dataset and a recent ground-based survey conducted by USACE as part of this CAP study. The North Carolina LiDAR collection includes Quality Level 2 (QL2) LiDAR as defined by USGS (Table 2). This dataset is approximately 8 years old and was considered appropriate to represent existing conditions (Figure 13). The USACE survey was specific to the project area with the intent to capture as accurate as possible top of riverbank elevations and nearest adjacent high ground.

Table 2. LiDAR Quality Level Requirements

QUALITY LEVEL	DATA SOURCE	VERTICAL ACCURACY RMSEz (cm)	NOMINAL PULSE SPACING (NPS) meters	NOMINAL PULSE SPACING (NPD) points per square meter	DIGITAL ELEVATION MODEL (DEM) cell size (meters)
QL0	**Lidar**	**5 cm**	**<= 0.35 m**	**>= 8 pts/square meter**	**0.5 m**
QL1	**Lidar**	**10 cm**	**<= 0.35 m**	**>= 8 pts/square meter**	**0.5 m**
QL2	**Lidar**	**10 cm**	**<= 0.71 m**	**>= 2 pts/square meter**	**1 m**
QL3	Lidar	20 cm	<= 0.35 m	>= 0.5 pts/square meter	2m
QL4	Imagery	139 cm	N/A	N/A	5 m
QL5	IfSAR	185 cm	N/A	N/A	5 m

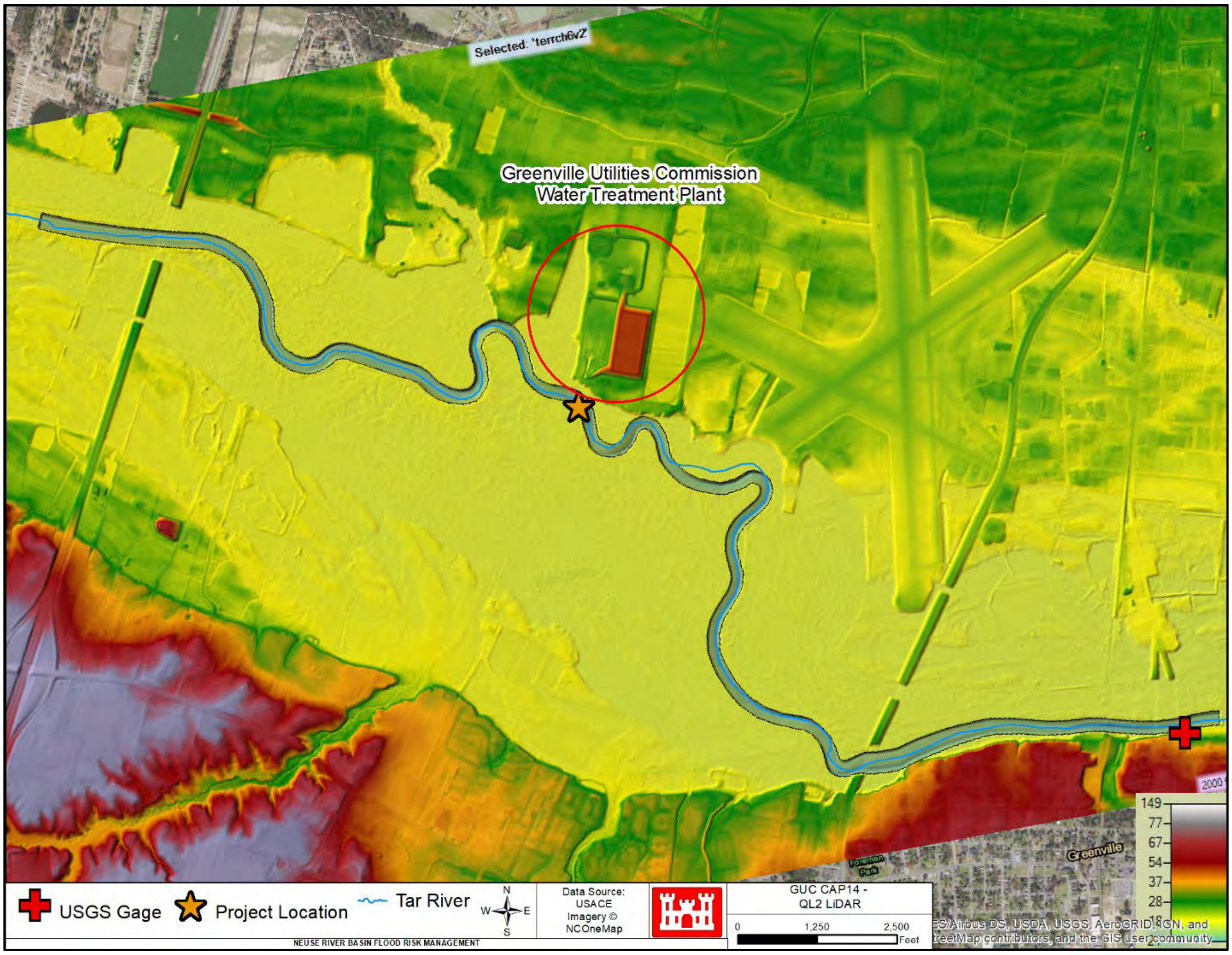

Figure 13. Project Area QL2 LiDAR

For underwater, or bathymetric, data needs, several sources were leveraged. The underlying, largest extent of the project area was included in the hydraulic modeling as part of FEMA's National Flood Insurance Program (NFIP). FEMA effective mapping in this region of the Tar River is based on a HEC-RAS model, version 3.1, originally developed in the early 2000's. As such, the model was not georeferenced. Approximate locations of hydraulic cross sections that include channel bathymetry of the Tar River were provided by the North Carolina Floodplain Mapping Program (Figure 14).

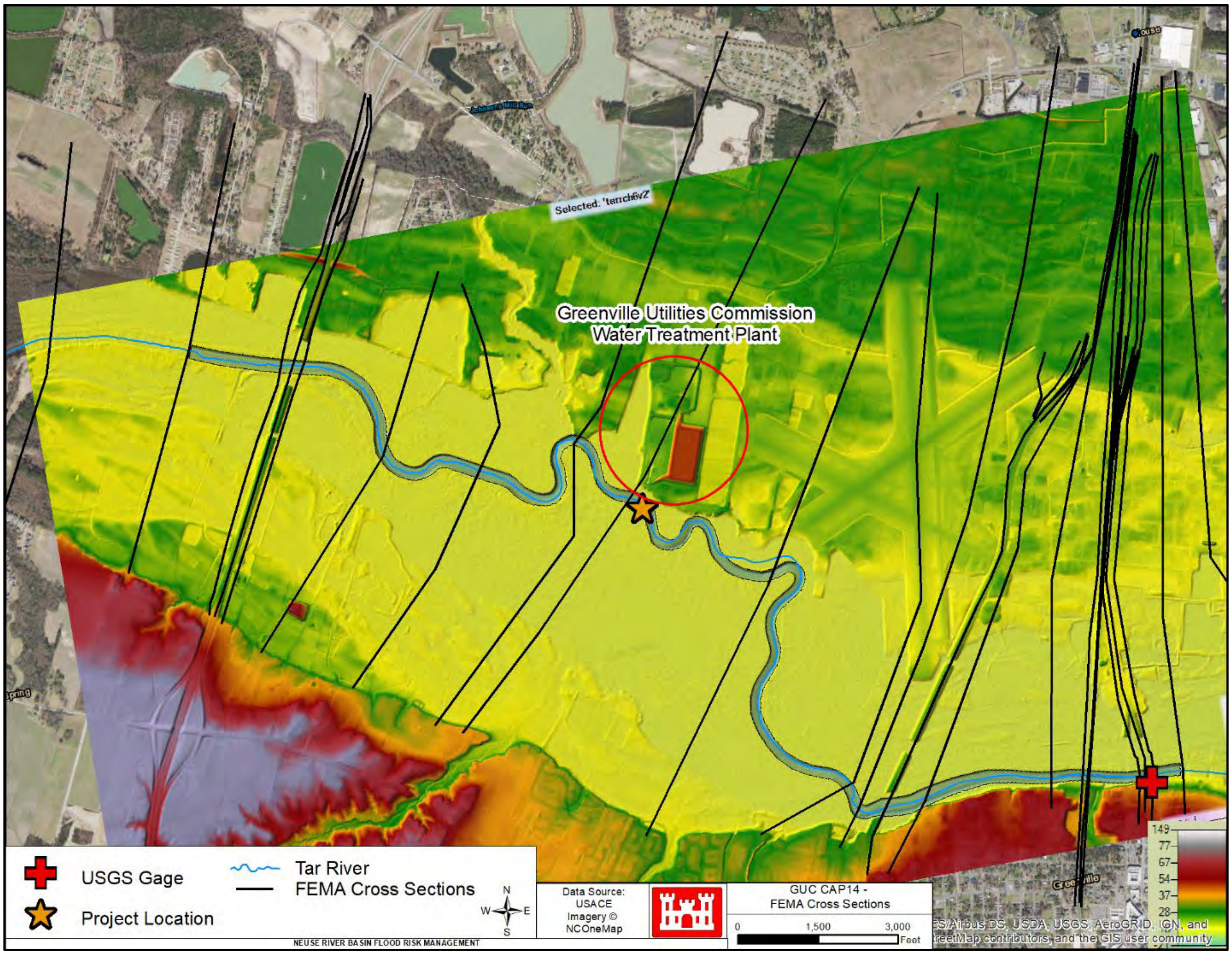

Figure 14. FEMA Cross Sections

Another source of bathymetry was provided by GUC, in the form of a 2008 sedimentation survey. This survey was part of an investigation of water velocities at the raw water intake structures. It included bathymetric surveys, water velocity measurements, and sediment sampling. Nine bathymetric channel profiles were taken that extended upstream and downstream of the project area. Two of the nine profiles fall within the immediate project area (Figure 15).

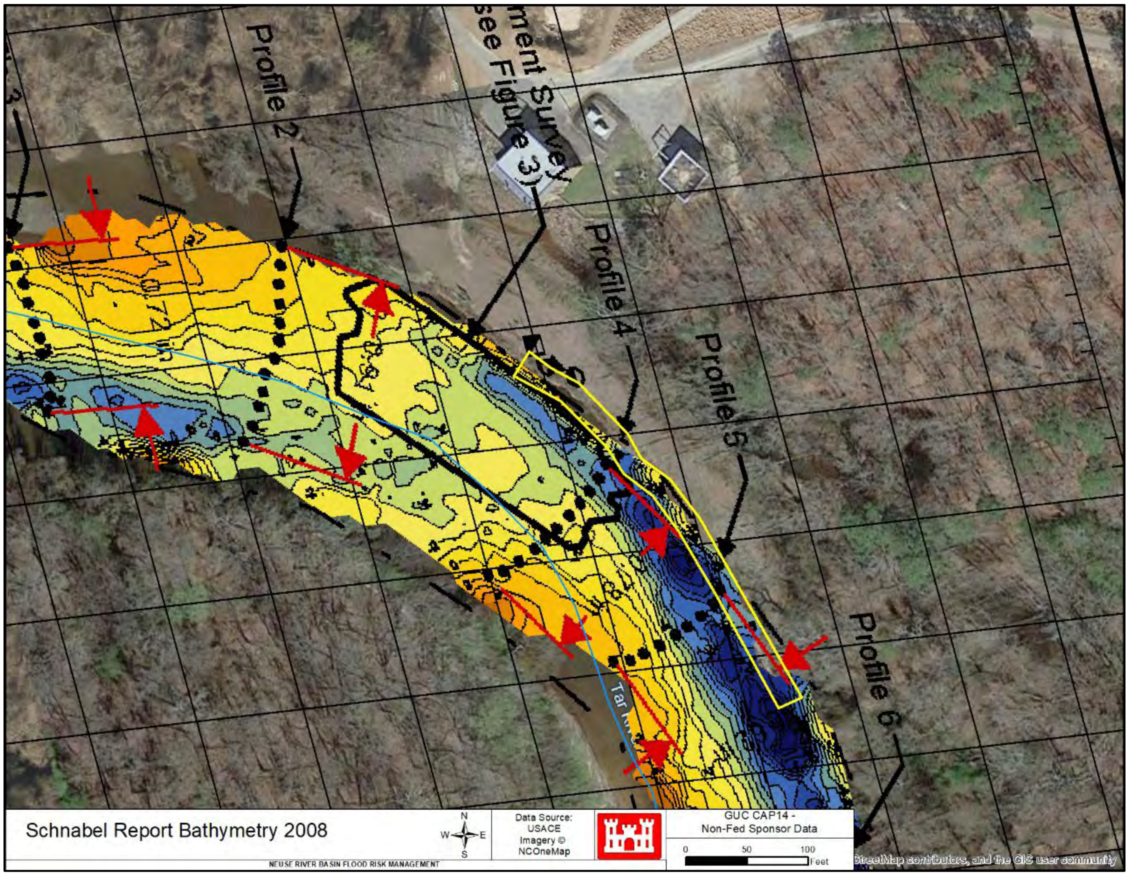

Figure 15. Survey Data Provided by Sponsor, Dated 2008

The last source of bathymetric data was based on a USACE survey conducted as part of this CAP study. This effort included the overland survey mentioned earlier in this section. The survey included multiple cross-sectional profiles as well as several parallel to the river's flow path (Figure 16).

Figure 16. Survey Data Provided by USACE, Dated 2022

4.4 Streamflow

Streamflow records of the Tar River were used to analyze the project conditions and formulate engineering solutions. The USGS Tar River at Greenville, NC (ID 02084000) streamflow station was exclusively used to represent flow conditions within the project area due its proximity to the GUC WTP (Figure 17). The streamflow station is location approximately 3 river miles downstream of the raw water intake structures and eroded riverbank. The station captures unregulated discharge (cfs) and stage (ft) with a drainage area of 2,660 square miles. Its datum is about 3.5 feet below NAVD88 datum. USGS notes that the station is affected by both astronomical and wind tides that originate from the Pamlico Sound. Although the exact station location has shifted 200 to 800 feet upstream of its current location throughout its period of record, surface-water records date back to 1905. The station's POR extreme was Hurricane Floyd in September 1999 with a maximum discharge of 73,000 cfs and a maximum gage height of 29.72 feet.

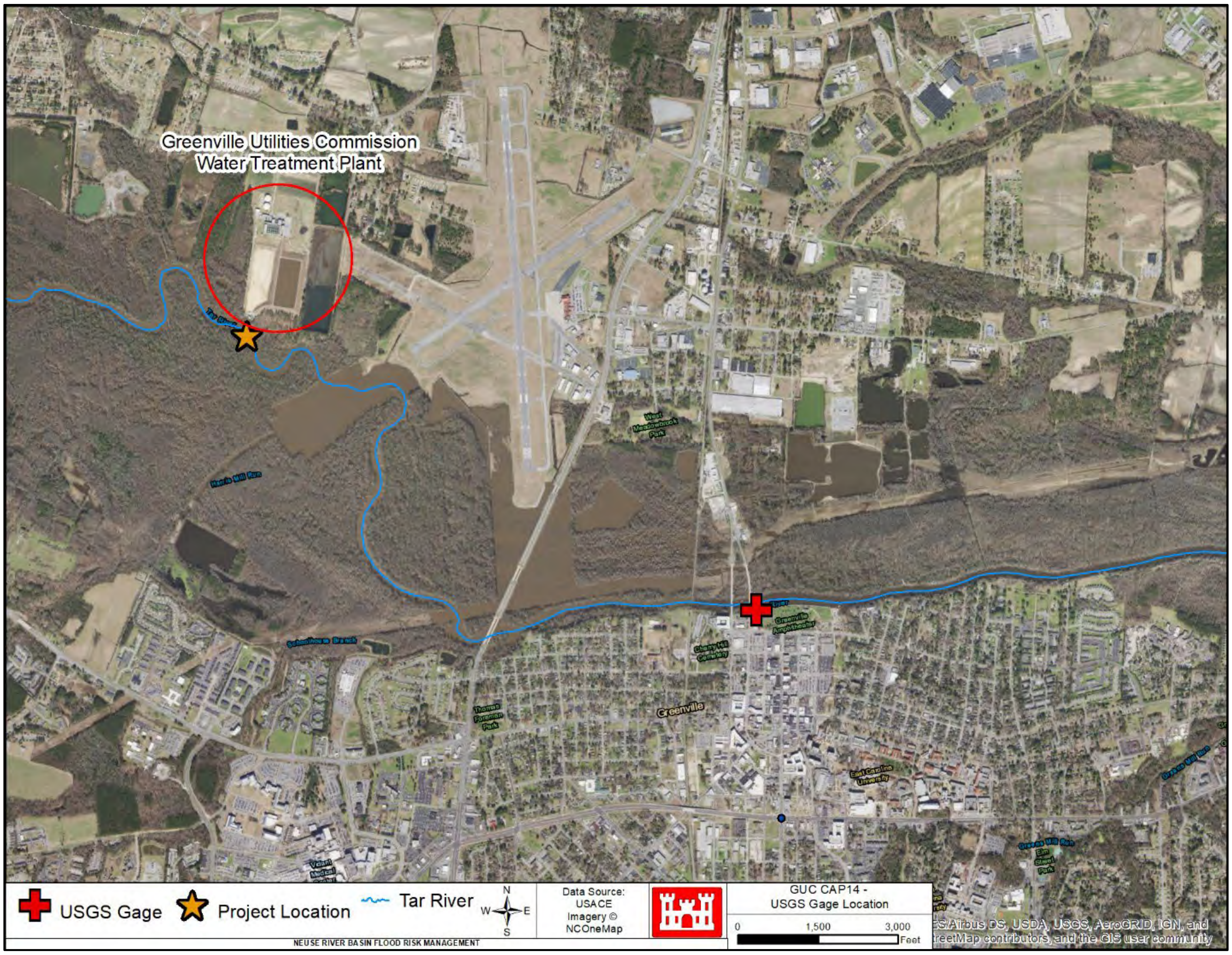

Figure 17. USGS 02084000 Tar River at Greenville Gage

5 Riprap Revetment Analysis and Design

5.1 Erosion Mechanism

There are a number of natural processes causing the continued erosion along the left riverbank of the Tar River. These natural factors include riverine-based storm events, in addition to wind, wave, and tides associated with coastal-based storm events. Based on input from GUC, the predominate factors that induce erosion in the project area are associated with how quickly water levels rise and fall against the riverbank. This input suggested that riverine-based flooding mechanism may play the larger role in causing erosion. With this in mind, use of HEC-RAS modeling to determine critical flow velocities was deemed appropriate. Input data required to run HEC-RAS included initial upstream flow data, overland and bathymetric topographic data, and downstream boundary condition data. The following methodology was followed to calculate the input data, and ultimately the final velocity values.

1. Develop stage-discharge relationship at the project based on streamflow station records and measurements taken simultaneously at both locations during USACE survey. Multiple site visits were conducted to determine a reasonable delta in river profile water surface elevations. This established relationship was considered appropriate given the emergency natural of this CAP, Section 14 project.
2. HEC-RAS model geometry was based on existing FEMA cross sections as well as new placement of cross sections near the eroded riverbank based on USACE bathymetric survey (Figure 18). Hydraulic structure data was based on the FEMA effective model.

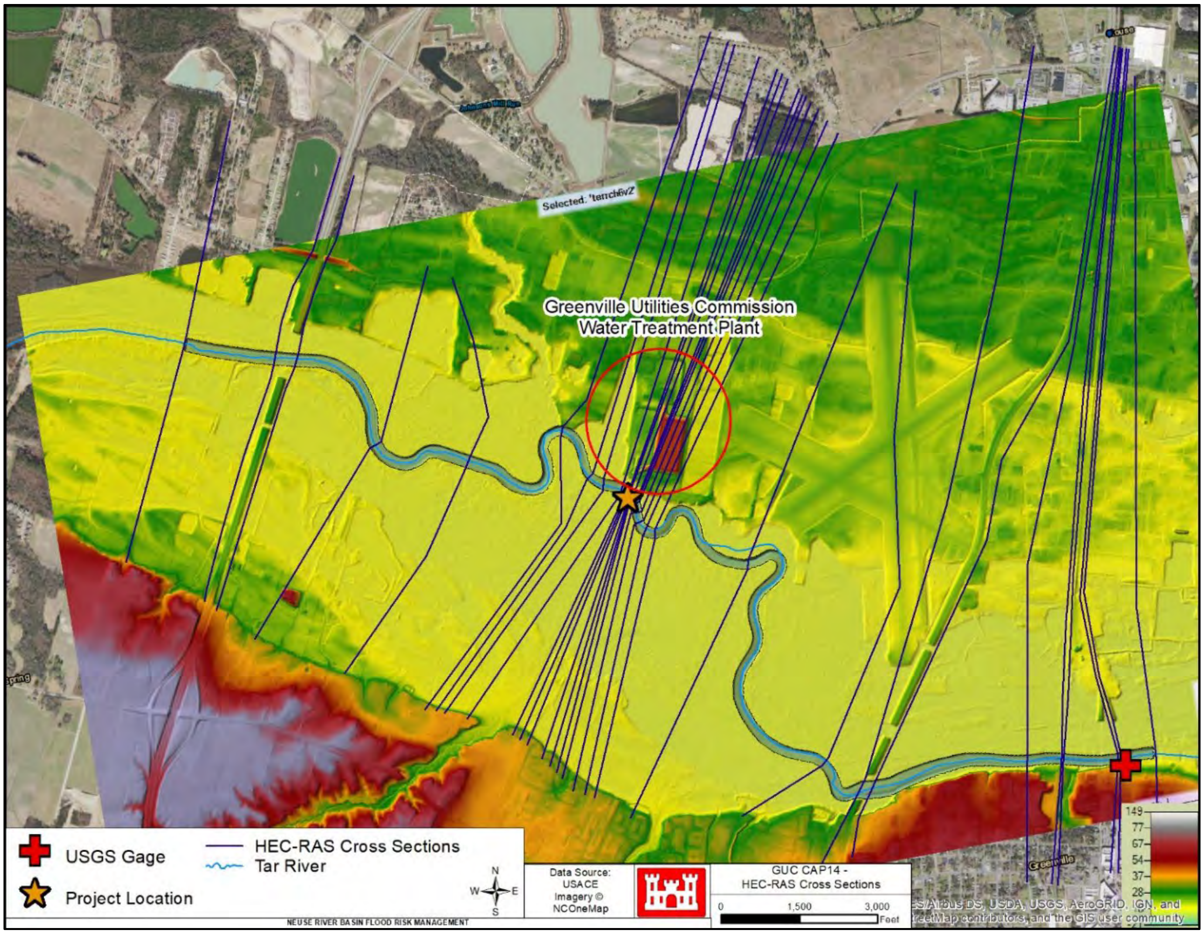

Figure 18. Project HEC-RAS Cross Sections

3. Initial Manning's N values were based on the FEMA effective HEC-RAS model. Insertion and adjustments were then made based on review of aerial imagery given the age of the original model and changes in land use over time. Finally, values were adjusted during model calibration to the USGS streamflow station, given the stage-discharge relationship established in step 1.
4. Upstream model boundary was set sufficiently far enough away from eroded riverbank as to not inadvertently influence modeled velocities. Downstream model boundary location was set to the approximate USGS streamflow station, roughly 3 river miles below the project area. The downstream boundary condition method was set to the USGS streamflow station rating curve. Choice of this method was consistent with step 1.
5. A suite of flows was input at the upstream beginning of the HEC-RAS model. This suite was modeled to capture velocity characteristics of the Tar River within the project area during low, typical, channel-capacity, and significant overbank flooding. Comparison of modeled output would provide insight on what flow scenario produced the highest, critical velocity.

5.2 Riprap Revetment Design

Riprap was sized following procedures in EM 1110-2-1601, which is based on critical flow velocity within the Tar River channel. Two methods of determining average channel velocity were used due to the presence of field measurements within the project area. The first method described below was based on development of a HEC-RAS hydraulic model to calculate velocity and is the preferred method within EM 1110-2-1601. The second method determined velocity from field measurements within the channel (Schnabel, 2008). Consideration of results from these two methods are presented below and a final recommendation of riprap size is presented.

5.2.1 Method #1: Hydraulic Model-Derived Velocity

HEC-RAS, version 6.2 was used to determine the appropriate riprap size classification. The program follows the procedure in EM 1110-2-1601 (USACE, 1924) for cases where velocity and depth are given. Riprap was sized by the following equation:

$$D_{30} = S_f C_s C_V C_T d\left[\left(\frac{\gamma_W}{\gamma_S - \gamma_W}\right)^{1/2} \frac{V}{\sqrt{K_1 g d}}\right]^{2.5} \qquad \text{eq. 1}$$

where

D_{30}= riprap of size which 30 percent is finer by weight
S_f= safety factor
C_s= stability coefficient for incipient failure, 0.3 for angular rock
C_V= vertical velocity distribution coefficient, 1.0 for straight channels
C_T= thickness coefficient, 1.0
d= local depth of flow
γ_W= unit weight of water
γ_S=unit weight of stone
V= V_{ss}, local depth averaged side slope velocity
K_1= side slope correction factor
g= gravitational constant

Values for the equation variables above were based on a cross section (XS 68951) located upstream of the river bend and was approximately 1,000 feet upstream of the design section (XS 67957). Hydraulic model results showed that velocities were maximized during near bankfull conditions (8,000 cfs) and that for higher flows overbank inundation actually decreased channel velocities. Local depth averaged side slope velocity (Vss) was 5.2 fps with a local depth of flow (d) of 11.0 ft. Unit weight of stone (γ_S) was 165 lb/cf. Side slope correction factor was set to 1.0 due to a design side slope angle of 26.6 deg (2H:1V). A 1.4 safety factor was used (EM recommends a minimum value of 1.1) to account for potential irregularities in velocity within the river.

A D30 size of 1.8 inches was calculated. EM 1110-2-1601 recommends a minimum riprap gradation D30 of 4.44 inches (EM1601 #1). EM 1110-2-1601 gradation #1 consists of the following stone size and percent finer by weight:

D15(min) = 3.49 in. / W15(min) = 2.13 lbs.

D15(max) = 4.74 in. / W15(max) = 5.32 lbs.

D30 = 4.44 in. / W30 = 4.38 lbs.

D50(min) = 5.30 in. / W50(min) = 7.46 lbs.

D50(max) = 5.98 in. / W50(max) = 10.67 lbs.

D90 = 6.36 in. / W90 = 12.86 lbs.

D100(min) = 6.68 in. / W100(min) = 14.93 lbs.

D100(max) = 9.00 in. / W100(max) = 36.45 lbs.

In general, EM 1110-2-1601 gradations call for more restrictive gradation bands than what is typically available at local quarries. For convenience, the standard NCDOT riprap classifications for stone readily available near the project area are given in the table below:

Table 3. NCDOT Standard Riprap Classifications

TABLE 1042-1
ACCEPTANCE CRITERIA FOR RIP RAP AND STONE FOR EROSION CONTROL

Class	Required Stone Sizes, inches		
	Minimum	Midrange	Maximum
A	2	4	6
B	5	8	12
1	5	10	17
2	9	14	23

No more than 5.0% of the material furnished can be less than the minimum size specified nor no more than 10.0% of the material can exceed the maximum size specified.

Notably, NCDOT gradations are given by simplified dimension and not by weight. Therefore, care was taken in choosing a NCDOT riprap classification that would produce gradation bands similar to those in EM 1110-2-1601. As shown in the table above, NCDOT riprap Class B appeared to meet D50 and D100 requirements of EM 1110-2-1601 gradation #1.

5.2.2 Method #2: Field Measurement-Derived Velocity

The HEC-RAS average channel velocity used in determining Vss in method #1 was approximately 3.6 fps for bankfull conditions (8,000 cfs). This value did not seem to be representative of the field measurements taken as part of the Schnabel Bathymetry and Water Velocity Studies (April 2008). Review of the effective FEMA hydraulic model also appeared not to be representative (Vavg <3 fps). The Schnabel study measured velocities about 3 feet below the water surface during a flow event that based on USGS 02084000 Tar River at Greenville was near bankfull condition (7,400 cfs). Twenty-one field measurements of velocities near the upstream cross section (XS 68951) resulted in an average velocity of about 7 fps with a range of 1-11 fps. Attempts in HEC-RAS calibration to the field measurements resulted in unreasonable manning's n values and energy gradient slopes. Therefore, method #2 is based solely on field-measured data. Based on a Vavg of 7 fps at 8,000 cfs, and a slight safety factor reduction to 1.2 that reflected more confidence in velocity measurements, a D30 size of 7.5 inches was calculated. A D30 of 7.5 inches falls within EM 1110-2-1601 gradation #3, which is as follows:

D15(min) = 5.98 in.	/	W15(min) = 10.67 lbs.
D15(max) = 7.88 in.	/	W15(max) = 24.50 lbs.
D30 = 7.32 in.	/	W30 = 19.61 lbs.
D50(min) = 8.80 in.	/	W50(min) = 34.02 lbs.
D50(max) = 10.01 in.	/	W50(max) = 50.12 lbs.
D90 = 10.56 in.	/	W90 = 58.87 lbs.
D100(min) = 11.03 in.	/	W100(min) = 67.05 lbs.
D100(max) = 15.00 in.	/	W100(max) = 168.74 lbs.

Based on average velocity measurements from the Schnabel study and from the NCDOT riprap classification table above, NCDOT riprap Class 1 appeared to meet D50 requirements but slightly overestimated D100 requirements.

5.2.3 Final Riprap Size Recommendation

The resulting velocities from the two methods described above produced different recommendations of riprap sizes for the project site. Method #1 calculated relatively low averaged channel velocities and consequently resulted in choosing the smallest EM 1110-2-1601 gradation #1 curve. Method #1 corresponding stone size readily available at a local quarry was NCDOT Class B. Method #2, based on higher average velocities measured within the channel, resulted in choosing EM 1110-2-1601 gradation #3 curve. Method #2 corresponding stone size readily available a local quarry was NCDOT Class

1. Generally, it is uncommon to recommend riprap sizing be determined based solely on field observations as it carries uncertainty related to limited observation points. However, due to the emergency streambank stabilization nature of this study authority and method #2 producing relatively larger stone size, it is recommended that NCDOT Class 1 stone be placed along the Tar River left bank at the project site.

5.2.4 Layer Thickness

EM 1110-2-1601 calls for stone to be contained with a riprap layer, a thickness no less than 1.5 x the spherical diameter of the upper limit W50 stone or 1.0 x the spherical diameter of the upper limit W100 stone. Therefore, a layer thickness of 17 inches is recommend based on NCDOT Class 1 stone.

*The thickness determined above should be increased by 50-percent when the riprap is placed underwater to provide for uncertainties associated with this type of placement. Therefore, a layer thickness of 25.5 inches is recommended for underwater placement.

5.2.5 Revetment Top Protection

Placement of riprap is recommended to extend to top of bank. A level surface equal to the layer thickness is recommended past the top of bank and is to be keyed into natural ground.

5.2.6 Revetment End Protection

The upstream and downstream ends of riprap revetment are to be extended to areas of noneroding velocities and relatively stable banks. As design velocities were calculated to be relatively low, primary identification of revetment end protection should be based on location of stable bank. This is anticipated to extend at a minimum beyond the existing articulating block footprint.

5.2.7 Revetment Toe Scour Estimation

Local scour was estimated following procedures in EM 1110-2-1601 and using HEC-RAS, version 6.2. The Hydraulic Design (HD) Riprap and Scour Calculator within HEC-RAS was used to determine the range of estimated scour depths. Manual hydraulic data inputs required by the scour calculator include the following:

Radius of Curvature = 575 feet

D50 of Bed Material = 0.16 millimeters (Schnabel, 2008)

Bend Severity = Severe

The scour calculator included a suite of empirical simple scour calculators, that take an ensemble approach to scour calculations. Engineering judgment was then used to determine the maximum likely scour depth. Scour calculator results for four different Bend Scour methods are as follows:

Maynord = 10.8 feet

Zeller = 2.9 feet

Thorne = 14.2 feet

USACE Curve = 12.9 feet

Maximum bend scour depths ranged from 2.9 feet to 14.2 feet, with mean and median values of 10.2 feet and 11.9 feet, respectively. With a maximum estimated bend scour depth of 2.9 feet, Zeller appeared as an outlier. However, it is anticipated that some methods are more likely to generate similar results because they have similar structure. Therefore, the mean value of 10.2 feet across the four methods would be used to assist in final recommended bend scour depth. As this average was closest to the Maynord value, it was chosen to represent the maximum bend scour depth, at 10.8 feet. A safety factor 1.1 was applied to the recommended bend scour depth, resulting in a final value of 11.9 feet.

5.2.8 Revetment Toe Protection

Toe protection would be provided by placing launchable stone at the toe of the bank (Figure 19).

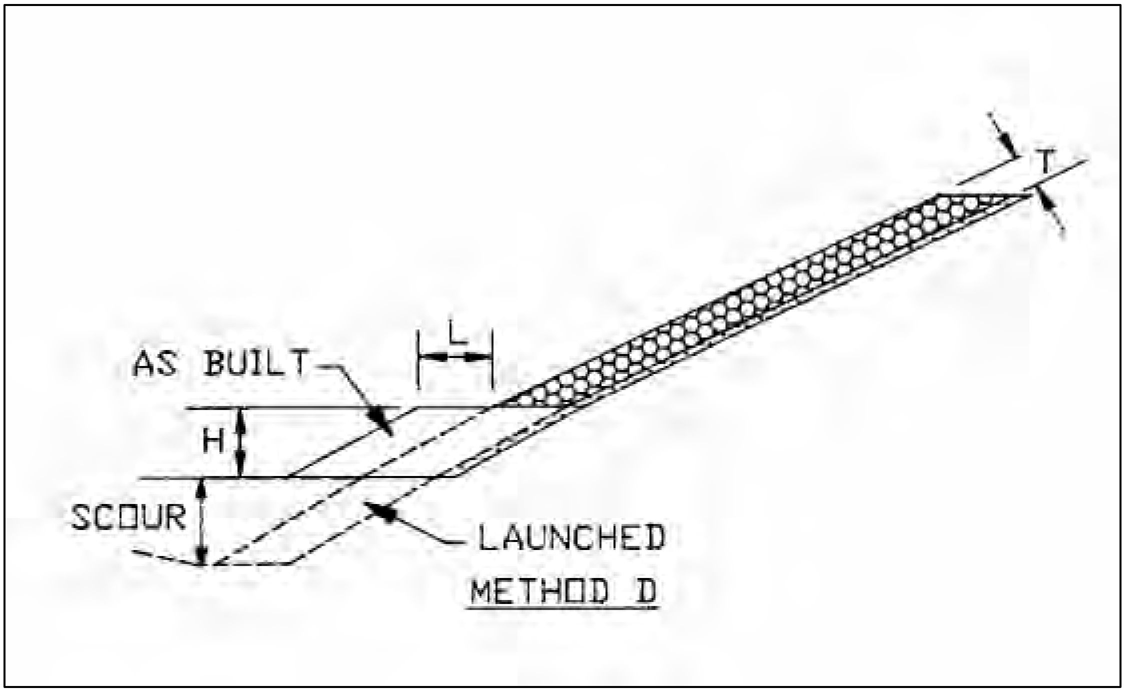

Figure 19. Revetment Toe Protection – Launchable Stone

The portion of Tar River within the project area was characterized by incurring gradual scour in regular bendways, thus, the height of the stone section before launching would be 2.5 to 4.0 times the bank protection thickness, or 5.3 feet to 8.5 feet. Per EM 1110-2-1601, Table 3-2, with a vertical launch distance of 11.9 feet and assumed underwater placement, stone volume for the riprap launching section was increased by 50-percent. The following equation was used to calculate volume of launchable stone required per linear foot of protection:

Volume = (Table 3-2 factor) * (thickness of the bank revetment) * (scour depth) * (5^1/2)

where

Table 3-2 factor = 1.5

Thickness of bank revetment = 25.5 inches (2.125 feet)

Scour depth = 11.9

The volume per linear foot of protection was calculated to be 84.8 cubic feet/ft. A safety factor of 1.1 was then applied. The final value was 93.3 cubic feet/ft.

6 Sea Level Change

ER 1100-2-8162, Incorporating Sea Level Change (SLC) in Civil Works Programs, provides regulations and guidance for incorporating direct and indirect physical effects of projected future sea level change to USACE Civil Works projects. Consideration of potential relative sea level change is required in every USACE coastal activity as far inland as the estimated tidal influence, including studies that calculate backwater profiling with the ocean as the downstream boundary condition.

Using the USACE Sea-Level Change Curve Calculator (Version 2019.21) historical rates and future rates are calculated for the Beaufort, NC Gage 8656483 (Figure 20, Figure 21). This site has 54 years of record based on the current 2017 accepted datum status (listed POR from 1953 to 2007). The current accepted NOAA relative sea level trend rate along with its 95% confidence intervals for the Beaufort, NC Gauge 8656483 is 3.36 +/- 0.34 mm/yr (Figure 22). For reference, the absolute global sea level rise is believed to be 1.7-1.8 millimeters/year, or roughly half of the relative rise predicted at the Beaufort, NC gauge. Interannual variation at this site is shown in Figure 23. According to ER 1100-2-8162, these historical and future rates are then used by the calculator to produce three curves which are the *USACE Low Curve*, *USACE Intermediate Curve*, and the *USACE High Curve*. The *USACE Low Curve* is calculated using the historic rate of sea-level change for each given location. The *USACE Intermediate Curve* is computed from the modified National Research Council (NRC) Curve I considering both the most recent Intergovernmental Panel on Climate Change (IPCC) projections and modified NRC projections with the local rate of vertical movement added. The *USACE High Curve* is computed from the modified NRC Curve III considering both the most recent IPCC projections and modified NRC projections with the local rate of vertical land movement added. The results for Beaufort, NC gage can be found in Figure 24 and Table 4 in both graphical and tabular form for each curve. The project base year was specified as 2023, and the analysis projected out 100 years. The results of the calculator for the year 2073 are as follows: Low Curve is 0.66-ft, Intermediate Curve is 1.27-ft, and High Curve is 3.12-ft. Results for year 2123 are as follows: Low Curve is 1.10-ft. Intermediate Curve is 2.63-ft, and High Curve is 7.47-ft.

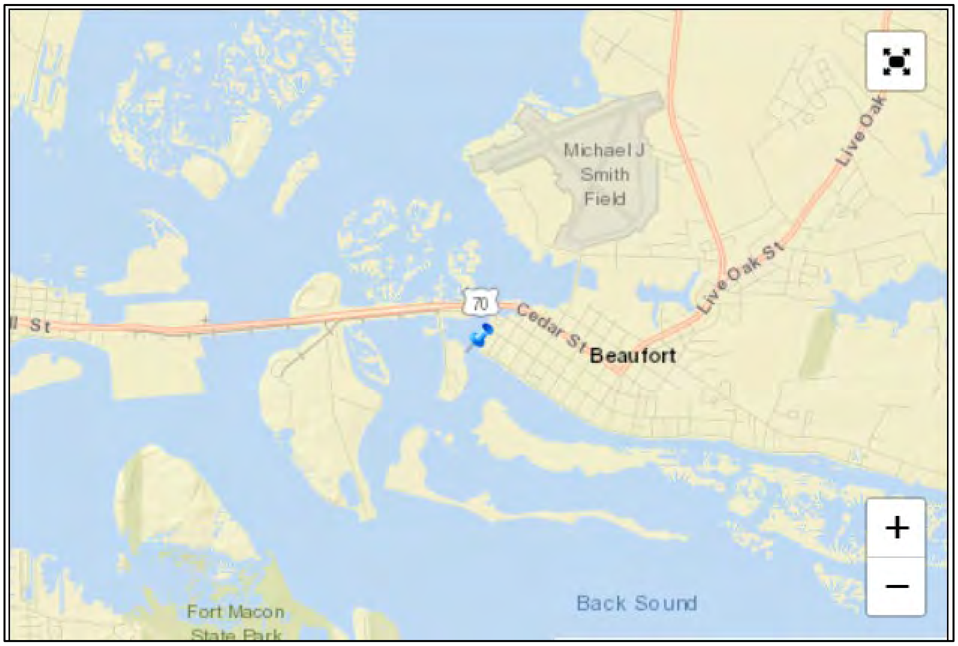

Figure 20. Location of Beaufort, NC Gage 8656483

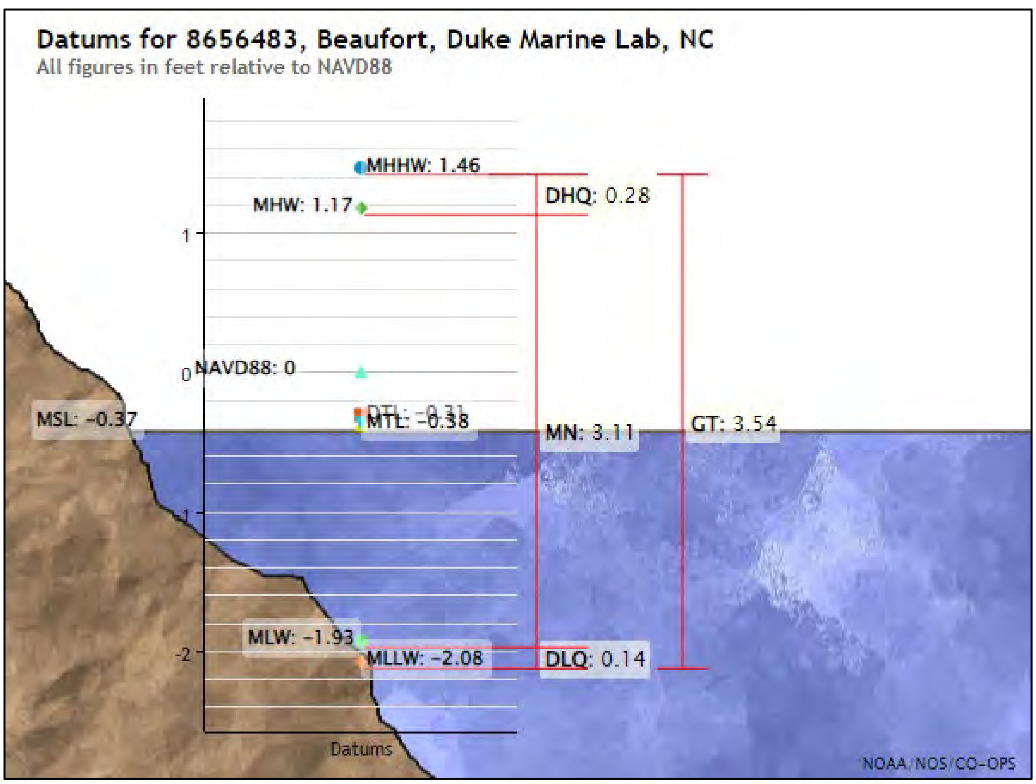

Figure 21. Beaufort, NC Gauge 8656483 Datum Information

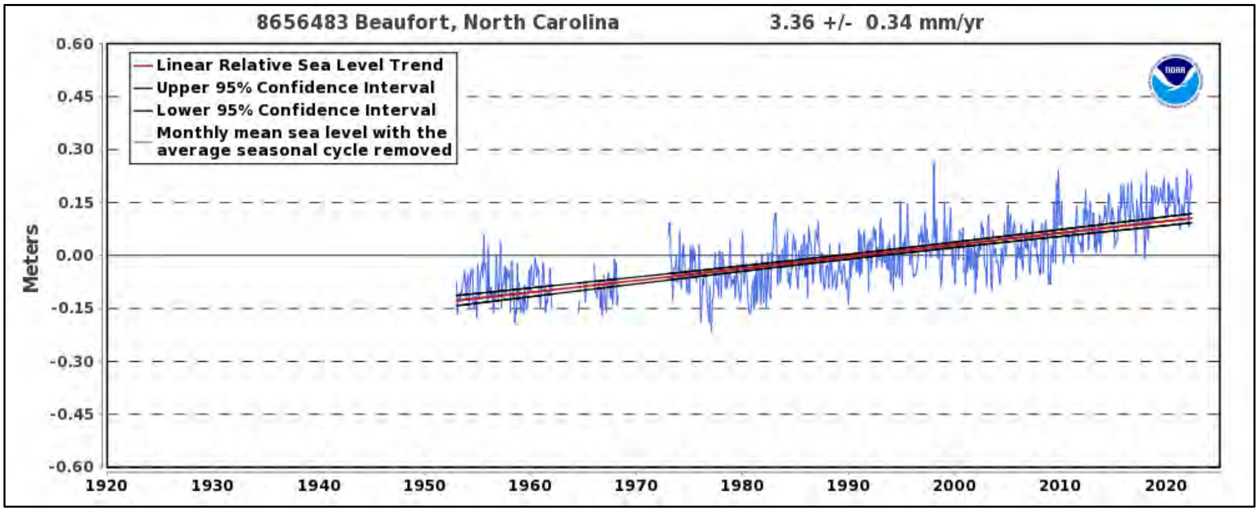

Figure 22. Beaufort, NC Gauge 8656483 Relative Sea Level Trend

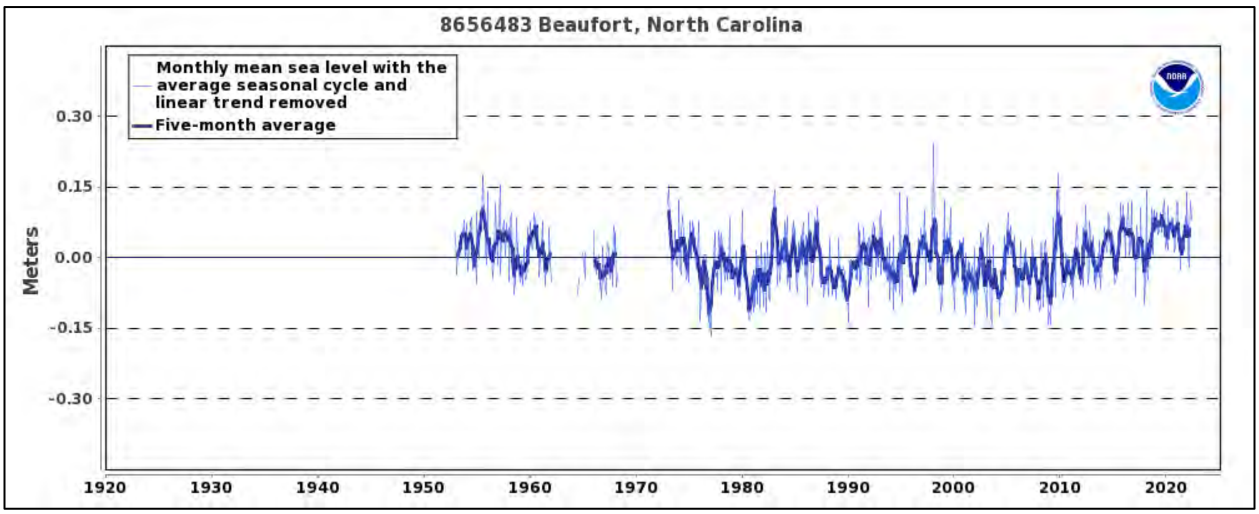

Figure 23. Beaufort, NC Gauge 8656483 Interannual Variation

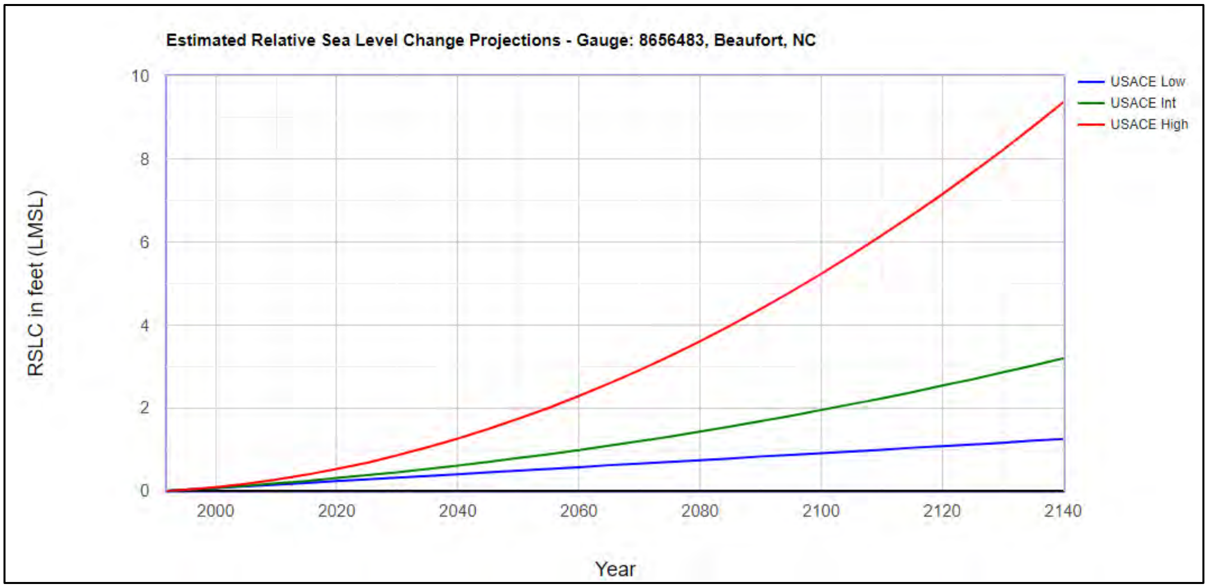

Figure 24. Estimated Relative Sea Level Change Projection Curves Beaufort, NC Gage 8656483

Table 4. Estimated Relative Sea Level Change Projection Tabular Data Beaufort, NC Gage 8656483

8656483, Beaufort, NC
NOAA's 2006 Published Rate: 0.00843 feet/yr
All values are expressed in feet relative to LMSL
Gauge Status: Compliant

Year	USACE Low	USACE Int	USACE High
1992	0.00	0.00	0.00
1995	0.03	0.03	0.03
2000	0.07	0.07	0.09
2005	0.11	0.12	0.17
2010	0.15	0.18	0.27
2015	0.19	0.24	0.39
2020	0.24	0.31	0.53
2025	0.28	0.38	0.68
2030	0.32	0.45	0.86
2035	0.36	0.53	1.05
2040	0.40	0.61	1.26
2045	0.45	0.70	1.49
2050	0.49	0.79	1.74
2055	0.53	0.88	2.00
2060	0.57	0.98	2.29
2065	0.62	1.09	2.59
2070	0.66	1.20	2.91
2075	0.70	1.31	3.25
2080	0.74	1.43	3.61
2085	0.78	1.55	3.99
2090	0.83	1.68	4.39
2095	0.87	1.81	4.80
2100	0.91	1.95	5.23
2105	0.95	2.09	5.69
2110	0.99	2.23	6.16
2115	1.04	2.38	6.65
2120	1.08	2.54	7.15
2125	1.12	2.69	7.68
2130	1.16	2.86	8.22
2135	1.21	3.02	8.79
2140	1.25	3.20	9.37

The USACE Sea Level Tracker (https://climate.sec.usace.army.mil/slr_app/) was used to visualize the variability of coastal water levels at the Beaufort, NC Gage, and compare the different USACE sea level change scenarios. Results of the tracker tool include historical gauge records through year 2021 (Figure 25). Notably, there has been an apparent upward trend of both 5- and 19-year MSL moving averages since the mid-2000's. This pitch upward may suggest convergence with the High SLC curve in the near future.

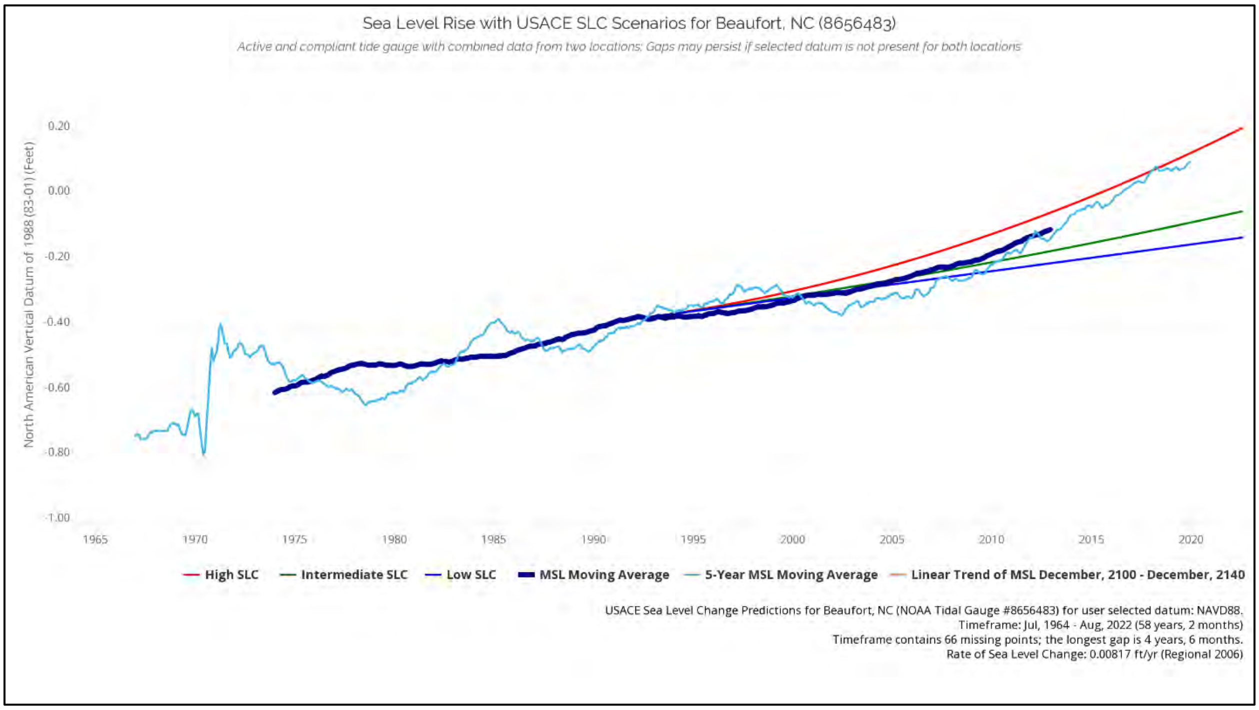

Figure 25. USACE Sea Level Tracker for Beaufort, NC (8656483) through Year 2021

NOAA's "Sea Level Rise Viewer" (https://coast.noaa.gov/) was used to determine the impacts of SLC. Present day MHHW extends up the mouth of the Tar River to near the Edgecombe and Pitt county border (Figure 26). Four MHHW scenarios that included sea level rise were assessed within the tool, 1-ft sea level rise (Figure 27), 2-ft sea level rise (Figure 28), 6-ft sea level rise (Figure 29), and 8-ft sea level rise (Figure 30). Based on a comparison of the encroaching water depth footprint between the different sea level rise scenarios, no GUC WTP infrastructure would be impacted by the increased MHHW.

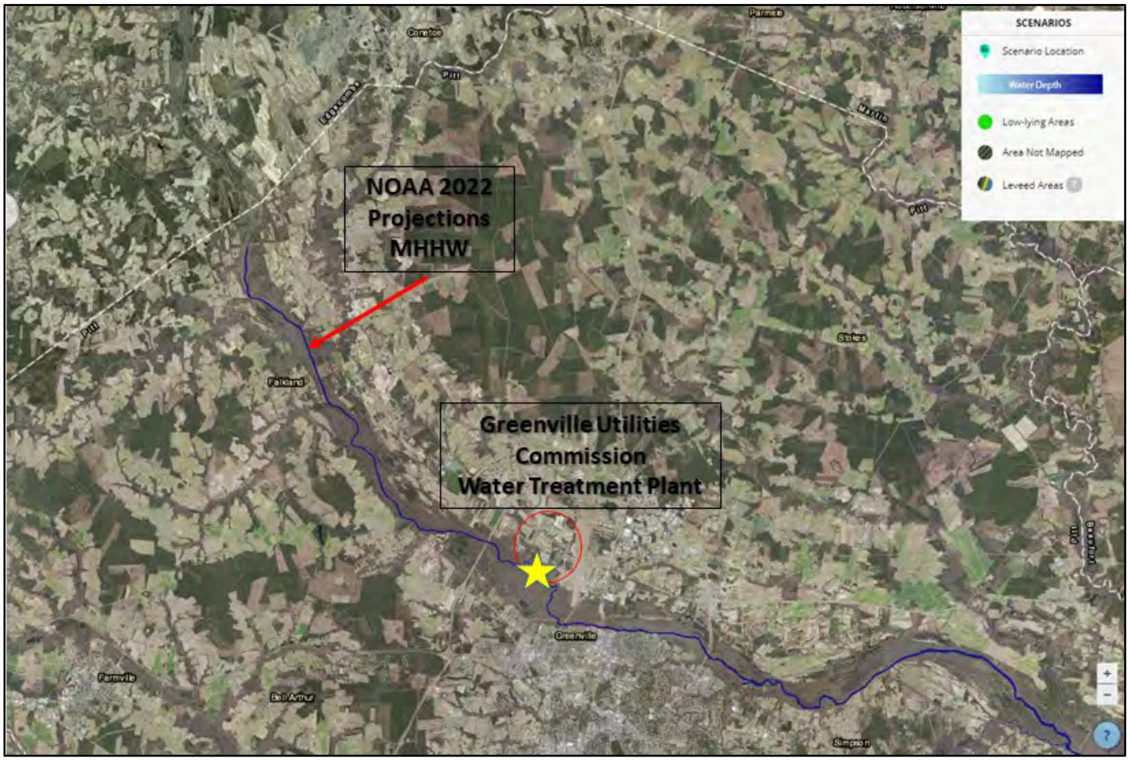

Figure 26. NOAA Sea Level Rise Viewer – 2022 MHHW Projections

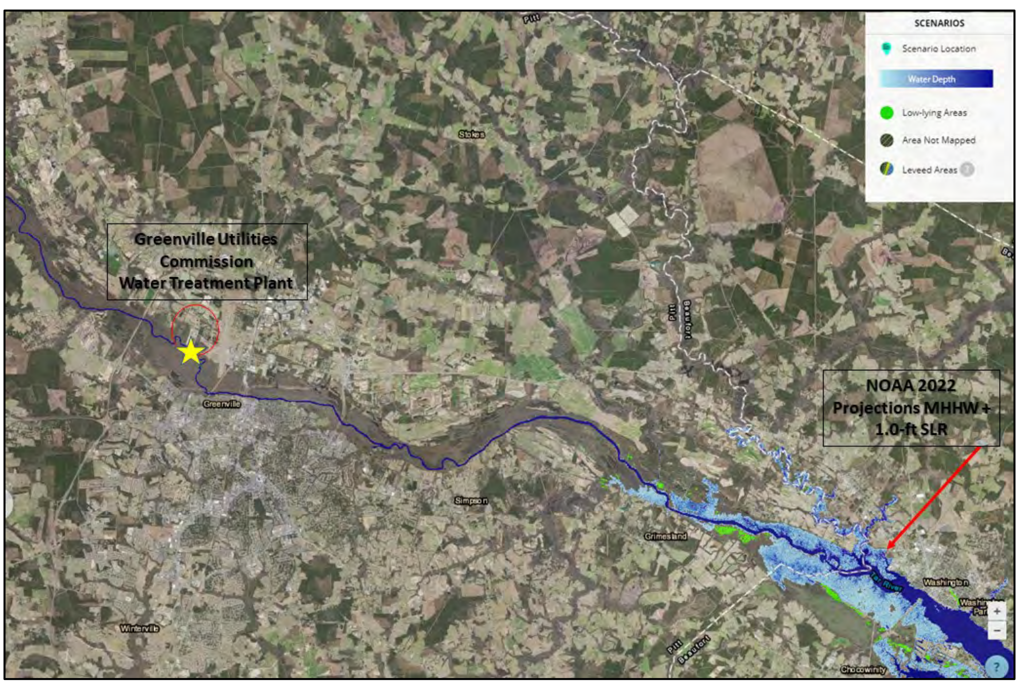

Figure 27. NOAA Sea Level Rise Viewer – 2022 MHHW Projections + 1.0-ft Sea Level Rise

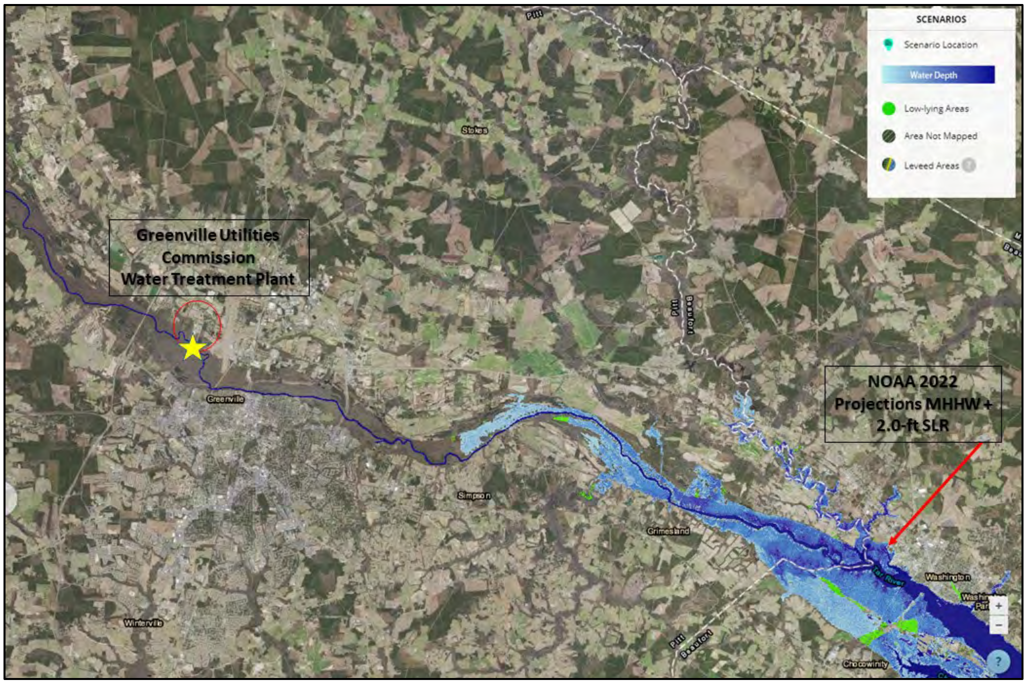

Figure 28. NOAA Sea Level Rise Viewer – 2022 MHHW Projections + 2.0-ft Sea Level Rise

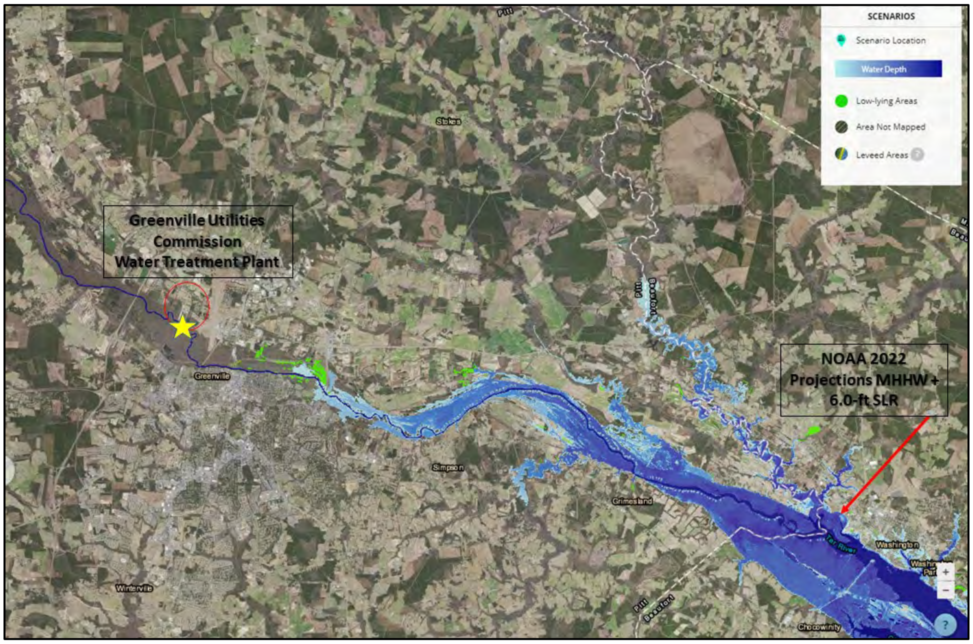

Figure 29. NOAA Sea Level Rise Viewer – 2022 MHHW Projections + 6.0-ft Sea Level Rise

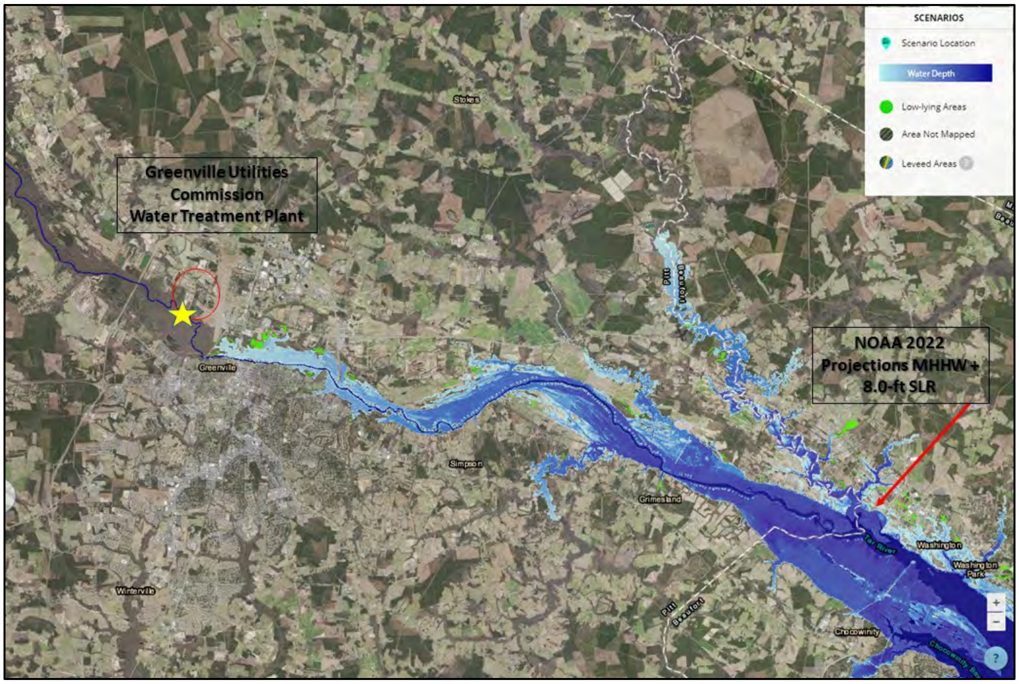

Figure 30. NOAA Sea Level Rise Viewer – 2022 MHHW Projections + 8.0-ft Sea Level Rise

6.1 SLC Impacts to Infrastructure and Project Adaptability

Engineer Technical Letter (ETL) 1100-2-1, Procedures to Evaluate Sea Level Change: Impacts, Responses, and Adaptation, provides guidance for a qualitative analysis to determine the risk of potential SLC. A qualitative matrix was developed to evaluate SLC impacts to infrastructure and critical resources in the project area (Table 5). This matrix shows the resources on which the study area depends, and the vulnerability of each resource from potential SLC. The common driving factor for SLR vulnerability was inundation within the project area caused by higher tailwater conditions. While results from the NOAA Sea Level Rise Viewer showed the project area to be outside of the area influenced by SLR, there may be risk related to model and natural uncertainty that has been incorporated into the tool.

Table 5. Qualitative Sea Level Rise Matrix

Critical Resources in Project Area	Density of Resource*	Resource and Risk Description	Risk from SLR*
Federal and local levees and floodwalls	0	No levees or floodwalls located within the project area.	0
Federal and local pump stations, flood gates, drainage network, etc.	1	1 GUC WTP pump station building. Intake pipes will be inundated more often due to higher tailwater.	1
River, channel, lake exposure	1	Tar River. Near channel capacity and overbank flows will occur more often due to higher tailwater	1
Potential area of impact	0	Project area falls outside of the potential impact area.	0
Commercial and industrial infrastructure	1	GUC WTP raw water intake structures and pump station	1
Transportation infrastructure	0	There are no bridges within the project area.	0
Utilities, sewage, communication networks	0	There are no utilities, sewage, or communication networks within the project area.	0
Private infrastructure	0	There is no private infrastructure within the project area.	0
Evacuation routes	0	There are no evacuation routes within the project area.	0
Environmental and habitat areas	1	There are overbank marshes and wetlands within the project area. Will be inundated more often due to higher tailwater.	1
Potential for impacts at adjacent navigation, coastal storm damage, or ecosystem projects	1	Pamlico and Tar Rivers Navigation project. Will be inundated more often due to higher tailwater.	1

*3 = high, 2 = medium, 1 = low, 0 = none

6.2 Sea Level Change Conclusion

Sea level change is a growing concern in estuary and coastal regions of North Carolina. In order to ensure projects are adaptable to changing conditions related to SLC, structural components of the project should ideally be flexible to modifications and be able to accommodate re-assessments of SLC at later dates within the assumed project life span. To maintain riverbank erosion protection level of this project's components, as well as reduce the frequency of flooding due to overtopping, the riprap revetment structure can be retrofitted by increasing the length and height of protection by adding larger stone.

7 Climate Change Analysis

This qualitative assessment of climate change impacts is required by U.S. Army Corps of Engineers (USACE, "the Corps") Engineering and Construction Bulletin (ECB) 2018-14, "Guidance for Incorporating Climate Change Impacts to Inland Hydrology in Civil Works Studies, Designs, and Projects." This assessment documents the qualitative effects of climate change on the hydrology in the region. The ECB 2018-14 analysis is targeted at identifying potential impacts and risks to the GUC CAP, Section 14 Feasibility Study due to climate change.

USACE projects, programs, missions, and operations have generally proven to be robust enough to accommodate the range of natural climate variability over their operating life spans. However, recent scientific evidence shows that in some places and for some impacts relevant to USACE operations, climate change is shifting the baseline about which that natural climate variability occurs and may be changing the range of that variability as well. This is relevant to USACE because the assumptions of stationary climate conditions and a fixed range of natural variability, as captured in the historic hydrologic record may no longer apply. Consequently, historic hydrologic records may no longer be appropriately applied to carry out hydrologic assessments for flood risk management in watersheds such as the Tar-Pamlico Basin.

7.1 Tar-Pamlico Basin Description

The Tar-Pamlico River basin is the fourth largest river basin in North Carolina and is one of only four river basins whose boundaries are located entirely within the state. The Tar River originates in north central North Carolina in Person, Granville and Vance counties and flows southeasterly until it reaches tidal waters near Washington and becomes the Pamlico River. The river empties into the Pamlico Sound. The Pamlico River is a tidal estuary that flows into the Pamlico Sound. Major tributaries of the Tar River include Fishing Creek, Swift Creek, Little Fishing Creek, Town Creek, Conetoe Creek, Chicod Creek, Tranters Creek and the Pungo River. Based on the 2011 National Land Cover Data, the Tar-Pamlico River Basin's estimated developed area is ~7%, agriculture ~29%, wetlands ~23% grassland/scrub ~12% and forest ~27%. Development and population growth centers around Greenville, Rocky Mount, Washington and in rural areas within commuting distance to Raleigh.

The Tar River Basin begins in the Piedmont of North Carolina and extends 215 miles southeast through the Coastal Plan and flows to the Pamlico Sound estuary. The basin covers about 6,100 square miles. The basin encompasses all or part of 18 counties. Major population centers in the study area include the cities of Louisburg, Rocky Mount, Greenville, Tarboro, and Princeville, NC.

7.2 Tar-Pamlico Basin Gage Data

The Tar-Pamlico Basin has 13 stream gage sites, of which 8 are located along the Tar River mainstem (Table 6).

Table 6. Summary of Available USGS gages located in the Tar-Pamlico Basin

USGS NO.	Gage Name and Location	DA, mi^2	Latitude	Longitude	Water Quality Data	Start of Record	Latest Record
02081500	Tar River near Tar River, NC	165	36.1942	-78.5831	Yes	1939	2020
02081747	Tar R at Us 401 At Louisburg, NC	435	36.0931	-78.2961	Yes	1934	2020
02082000	Tar River near Nashville, NC	708	35.8493	-77.9305	Yes	1929	1970
02082506	Tar R Bl Tar R Reservoir near Rocky Mount, NC	784	35.9006	-77.8656	Yes	1971	2012
02082585	Tar River at Nc 97 At Rocky Mount, NC	933	35.9547	-77.7872	No	1977	2020
02082770	Swift Creek at Hilliardston, NC	173	36.1122	-77.9200	Yes	1924	2020
02082950	Little Fishing Creek near White Oak, NC	178	36.1833	-77.8761	Yes	1960	2020
02083000	Fishing Creek near Enfield, NC	530	36.1506	-77.6931	Yes	1910	2020
02083500	Tar River at Tarboro, NC	2,222	35.8944	-77.5331	Yes	1897	2020
02083800	Conetoe Creek near Bethel, NC	72	35.7760	-77.4622	Yes	1955	2002
02084000	Tar River at Greenville, NC	2,697	35.6167	-77.3728	Yes	1887	2020
02084160	Chicod Cr at SR1760 Near Simpson, NC	42	35.5617	-77.2308	Yes	1976	2020
02084472	Pamlico River at Washington, NC	3,200	N/A	N/A	Yes	1999	2020

7.3 Literature Review

7.3.1 Observed Trends

7.3.1.1 Literature Review of Observed Climate Changes

The Tar-Pamlico River Basin is located in Water Resource Region (i.e., HUC-2 watershed) number 03, the South Atlantic-Gulf Region.

7.3.1.2 Temperature

A number of studies focusing on observed trends in historical temperatures were reviewed for this report. These include both national scale studies inclusive of results relevant to Water Resources Region 03 and regional studies focusing more specifically and exclusively on the area. Results from both types of studies are discussed below.

A 2009 study by Wang et al. examined historical climate trends across the continental United States. Gridded (0.5 degrees x 0.5 degrees) mean monthly climate data for the period 1950 – 2000 were used. The focus of this work was on the link between observed seasonality and regionality of trends and sea surface temperature variability. The authors identified positive statistically significant trends in recent observed mean air temperature for most of the U.S. (Figure 31). For the South Atlantic-Gulf Region, mixed results are presented. A positive, but small, warming trend is identified for most of the area in the spring and summer. For the fall months, the southern portion of the area is shown to be warming while some cooling is shown in the northern portion of the area. For the winter months, the divide appears to be more east-west, with warming in the east and cooling in the western portion of the area. A later study by Westby et al. (2013), using data from the period 1949 – 2011, moderately contradicted these findings, presenting a general winter cooling trend for the entire region for this time period. The third NCA report (Carter et al., 2014) presents historical annual average temperatures for the southeast region. Their southeast study region is larger than, but inclusive of the South Atlantic-Gulf Region. For this area, historical data generally shows warming of average annual temperatures in the early part of the 20th century, followed by a few decades of cooling, and is now showing indications of warming. However, though a seasonal breakdown is not presented, the NCA report cites an overall lack of trend in mean annual temperature in the region for the past century. Details on statistical significance are not provided.

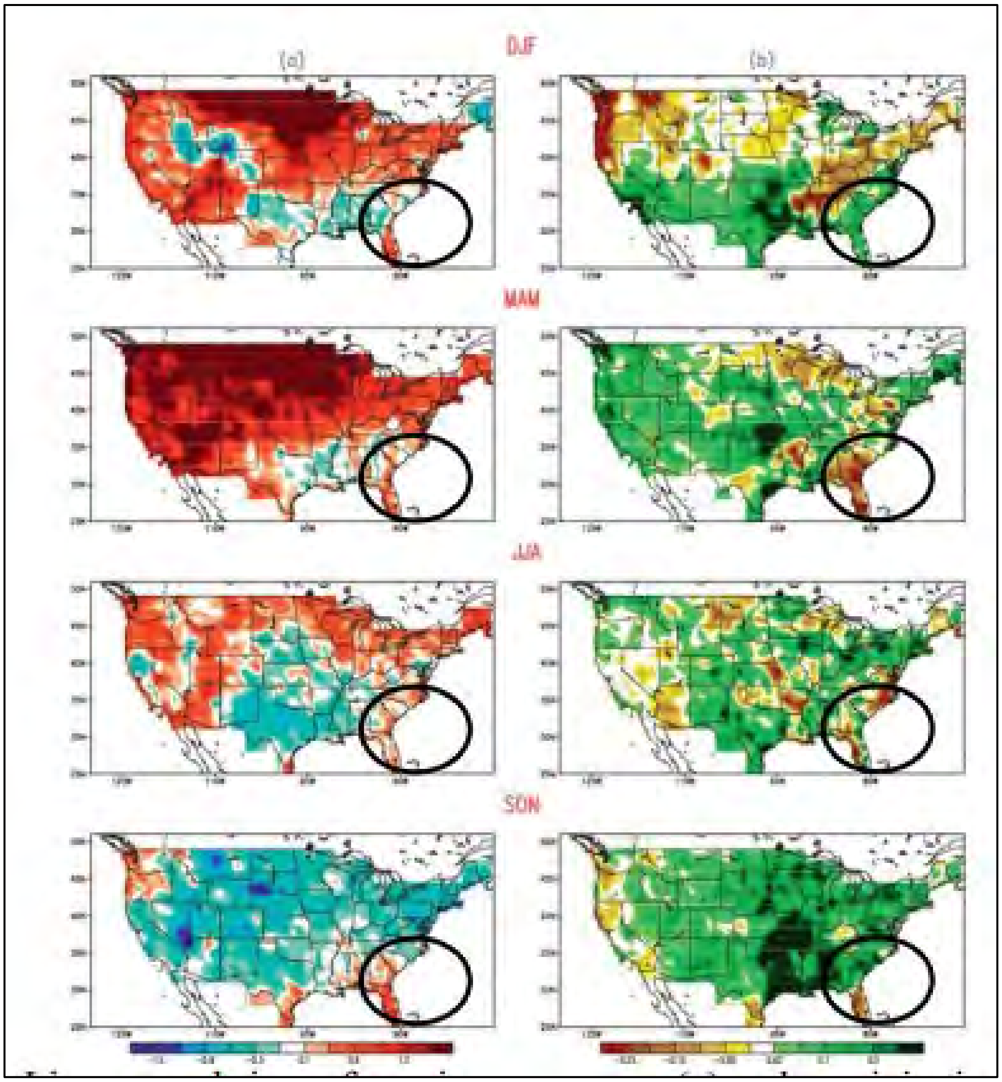

Figure 31. Linear trends in surface air temperature (a) and precipitation (b) over the United States, 1950 – 2000. The South Atlantic-Gulf Region is within the black oval (Wang et al., 2009)

A 2012 study by Patterson et al. focused exclusively on historical climate and streamflow trends in the South Atlantic region. Monthly and annual trends were analyzed for a number of stations distributed throughout the South Atlantic-Gulf Region for the period 1934 – 2005. Results (Figure 32) identified a largely cooling trend for the first half of the historical period and the period as a whole. However, the second half of the study period (1970 – 2005) exhibits a clear warming trend with nearly half of the stations showing statistically significant warming over the period (average increase of 0.7 ºC). The circa 1970 "transition" point for climate and streamflow in the U.S. has been noted elsewhere, including Carter et al. (2014). Trends in overnight minimum temperatures (Tmin) and daily maximum (Tmax) temperatures for the southeast U.S. were the subject of a study by Misra et al. (2012). Their study region encompasses nearly the full extent of the South Atlantic-Gulf Region and used data from 1948 to

2010. Results of this study show increasing trends in both Tmin and Tmax throughout most of the study region. The authors attribute at least a portion of these changes to the impacts of urbanization and irrigation.

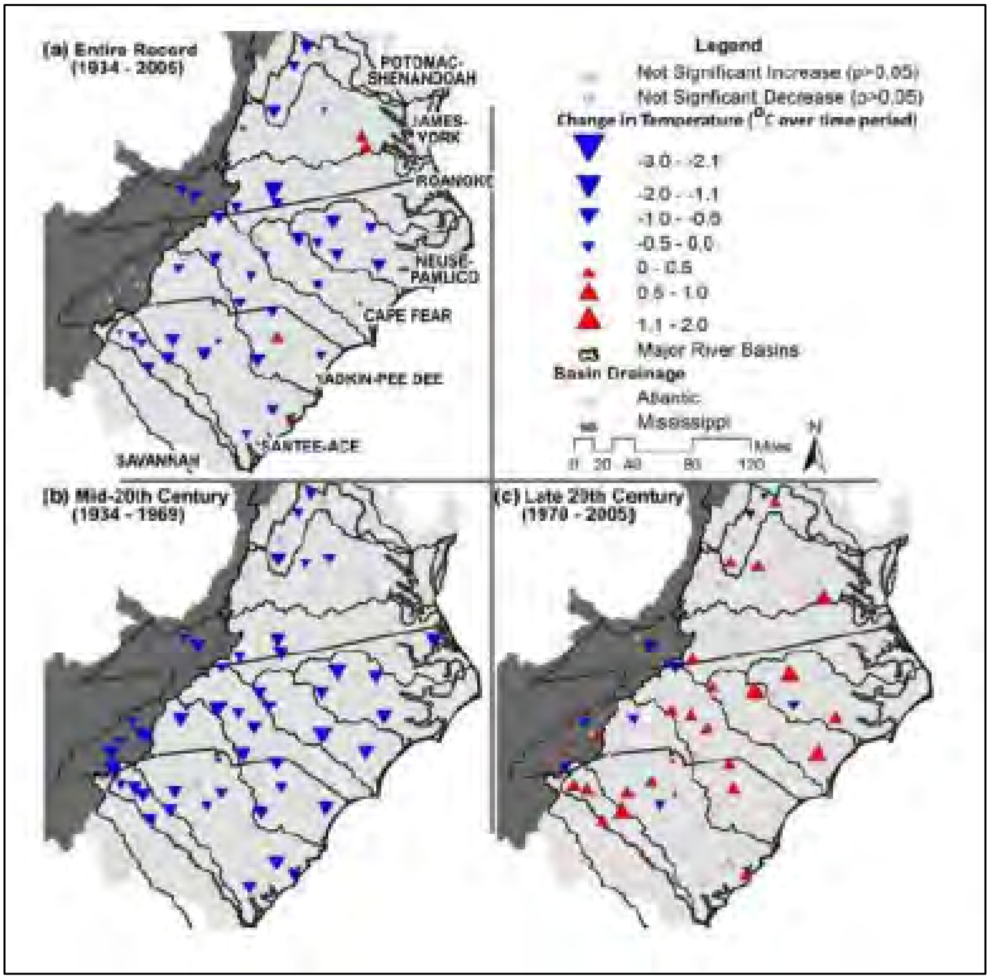

Figure 32. Historical annual temperature trends for the South Atlantic Region, 1934 – 2005. Triangles point in the direction of the trend, size reflects the magnitude of the change. Blue indicates a decreasing temperature trend. Red indicates an increasing temperature trend (Patterson et al., 2012)

In North Carolina specifically the temperatures have risen more than 1oC since the beginning of the 20th century (NCEI, 2022). Winter average temperatures have been increasing with the 2015-2020 period exceeding the levels of the 1930's and 1950's. Summer average temperatures in the 2005-2020 period have been the warmest on record.

7.3.1.3 Precipitation

Palecki et al. (2005) examined historical precipitation data from across the continental United States. They quantified trends in precipitation for the period 1972 – 2002 using NCDC 15- minute rainfall data. For the South Atlantic-Gulf Region, statistically significant increases in winter storm intensity (mm per hour) and fall storm totals were identified for the southernmost portion of South Atlantic-Gulf Region. Additionally, a statistically significant decrease in summer storm intensity was identified for the northern portion of the area.

A 2011 study by McRoberts and Nielsen-Gammon used a new continuous and homogenous data set to perform precipitation trend analyses for sub-basins across the United States. The extended data period used for the analysis was 1895 – 2009. Linear positive trends in annual precipitation were identified for most of the U.S (Figure 33). For the South Atlantic-Gulf Region, results were mixed with some areas showing mild decreases in precipitation and others showing mild increases. No clear trend for the area is evident from these results.

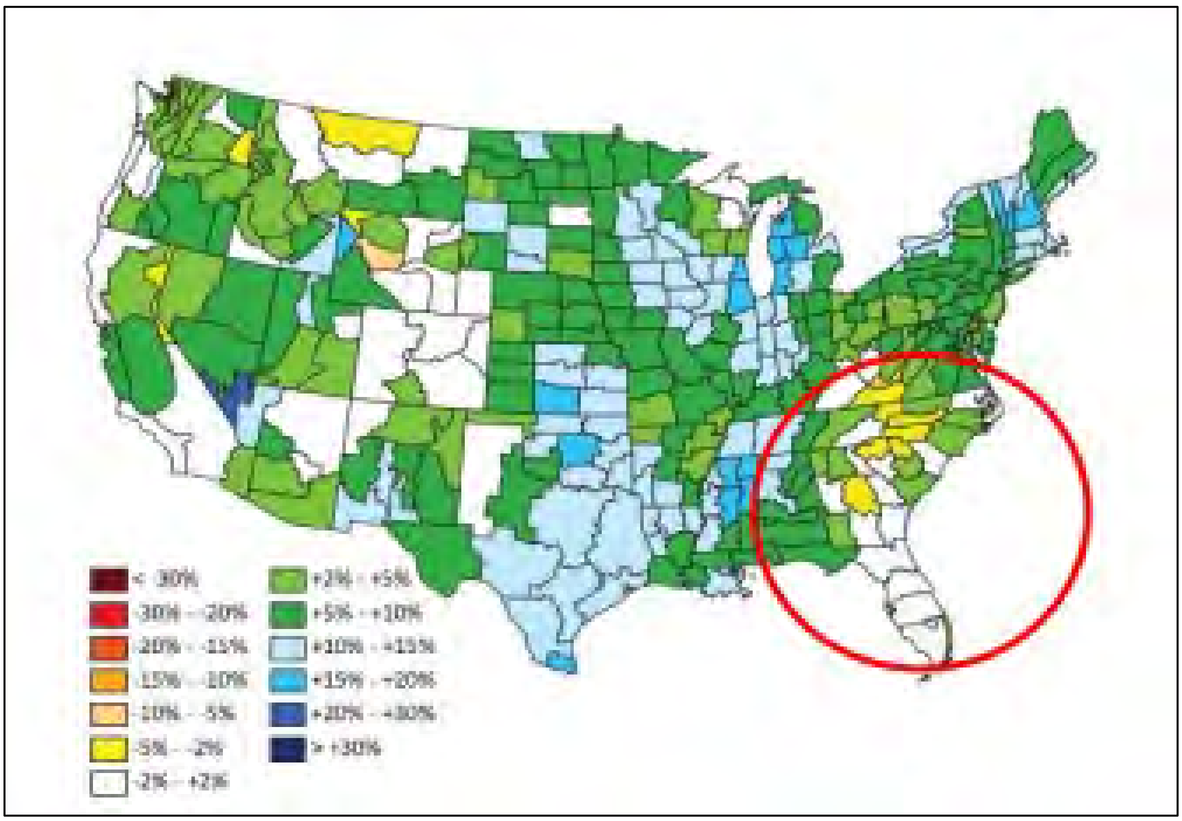

Figure 33. Linear trends in annual precipitation, 1895 – 2009, percent change per century. The South Atlantic-Gulf Region is within the red oval (McRoberts and Nielsen-Gammon, 2011).

Changes in extreme precipitation events observed in recent historical data have been the focus of a number of studies. Studies of extreme events have focused on intensity, frequency, and/or duration of such events. Wang and Zhang (2008) used recent historical data and downscaled Global Climate Models (GCMs) to investigate changes in extreme precipitation across North America. They focused specifically on the changes in the frequency of the 20-year maximum daily precipitation event. The authors looked at both historical trends in observed data and trends in future projections. Statistically significant increases in the frequency of the 20-year storm event were quantified across the southern and central U.S., in both the recent historical data and the long-term future projections (described below). For the South Atlantic-Gulf Region, significant changes in the recurrence of this storm were identified for the period 1977 – 1999 compared to the period 1949 – 1976. An increase in frequency of approximately 25 to 50% was quantified.

In North Carolina (at the Coweeta Laboratory), changes in precipitation variability have been observed (Laseter et al., 2012) (Figure 34). These changes include wetter wet years and dryer dry years compared to the middle of the 20th century. As an example, the wettest year on record occurred in 2009 at Coweeta, and only two years earlier (2007) the driest year on record was observed. This pattern of change is supported by the NCA report (Carter et al., 2014), which states that, “summers have been either increasingly dry or extremely wet” in the southeast region. This assessment is based on analysis of data dating back to the turn of the 20th century.

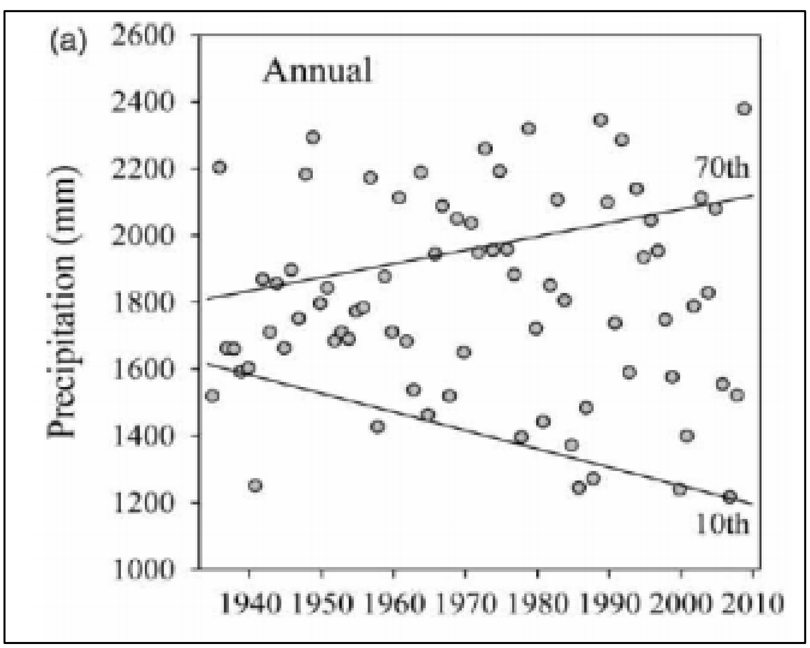

Figure 34. Total annual precipitation at Coweeta Laboratory (North Carolina). Lines show modeled 10th and 90th quantiles as a function of time, 1940 – 2010. (Laseter et al., 2012).

A 2012 study by Patterson et al. focused exclusively on the South Atlantic Region, investigating historical climate and streamflow trends. Monthly and annual trends were analyzed for a number of stations distributed throughout the South Atlantic-Gulf Region for the period 1934 – 2005. Results identified little, if any, patterns of precipitation change in the area over this period. Some sites showed increasing trends, others showed decreasing trends. Overall, and for the full period of record, more sites exhibited mild increases in precipitation than decreases.

In North Carolina there is no overall trend in annual precipitation, but precipitation is generally higher in the summer months (NCEI, 2022).

7.3.1.4 Hydrology

Kalra et al. (2008) found statistically negative trends in annual and seasonal streamflow for a large number of stream gages in the South Atlantic-Gulf Region, analyzed in aggregate, for the historical period 1952 – 2001. This study also identified a statistically significant stepwise change occurring in the mid-1970s, concurrent with the warming climate "transition" period previously noted in Section 2.1, Temperature. These findings are supported by a regional study by Small et al. (2006). This study, using HCDN data for the period 1948 – 1997, identified statistically significant negative trends in annual low flow for multiple stations distributed throughout the South Atlantic-Gulf Region (but even more stations exhibited no significant trend at all).

The Patterson et al. (2012) study also observed a "transition" period occurring around 1970, as well as identified significant decreasing trends in streamflow in the South Atlantic-Gulf Region for the period 1970 – 2005 (Figure 35). Results were mixed for an earlier time period (1934 – 1969), with some decreasing and some increasing trends. These results again highlight the noted transition period of the 1970s.

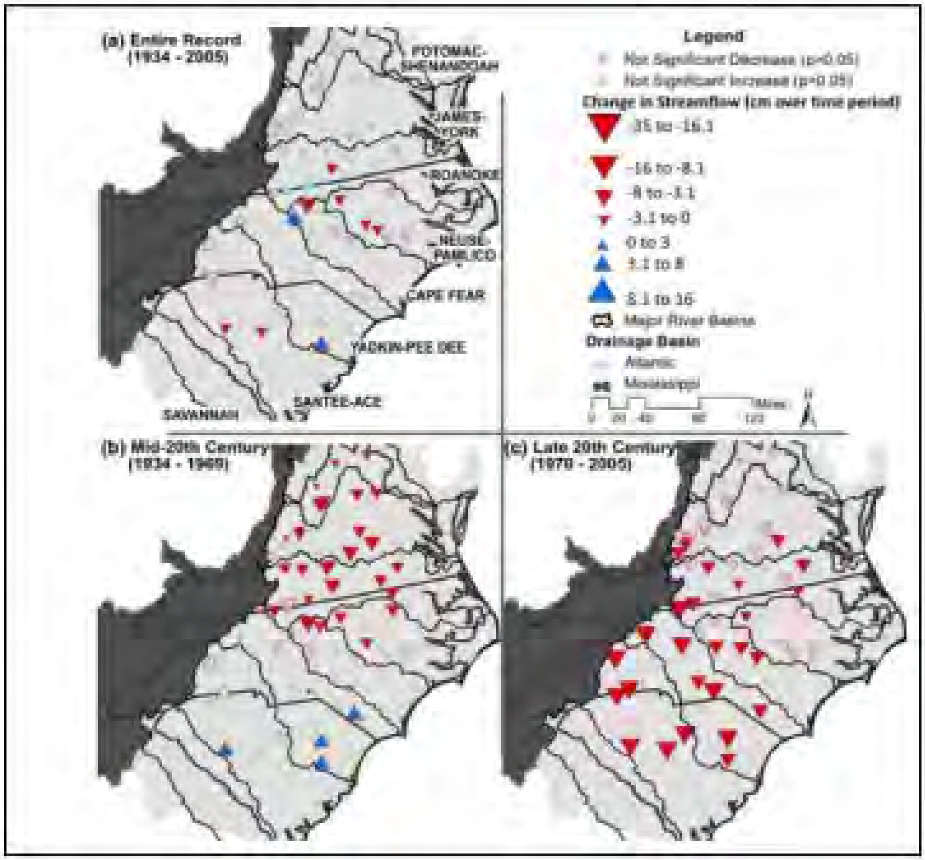

Figure 35. Observed changes in annual streamflow, South Atlantic Region, 1934 – 2005. Triangles point in the direction of the trend, size reflects the magnitude of the change. Blue indicates a decreasing streamflow trend. Red indicates and increasing streamflow trend. (Patterson et al., 2012).

7.3.2 Future Trends

7.3.2.1 Literature Review of Project Climate Changes

While historical data is essential to understanding current and future climate, non-stationarity in the data (i.e., a changing climate) dictates the use of supplemental information in long-term planning studies. In other words, the past may no longer be a good predictor of the future (Milly et al., 2008). Consequently, the scientific and engineering communities are actively using computer models of the Earth's atmosphere and associated thermodynamics to project future climate trends for use in water resources planning efforts. Although significant uncertainties are inherent in these model projections, the models, termed global climate models (GCMs), are widely accepted as representing the best available science on the subject, and have proven highly useful in planning as a supplement to historical data. A wealth of literature now exists on the use of GCMs across the globe.

7.3.2.2 Temperature

Elguindi and Grundstein (2013) present results of regional climate modeling of the U.S. focused on the Thornthwaite climate type – a measure of the combination of relative temperature and precipitation projections. For the South Atlantic-Gulf Region, results show a shift from primarily warm wet or warm moist climate type in the latter decades of the 20th century to a much larger proportion of hot moist or hot dry climate type areas by the period 2041 – 2070 (Figure 36).

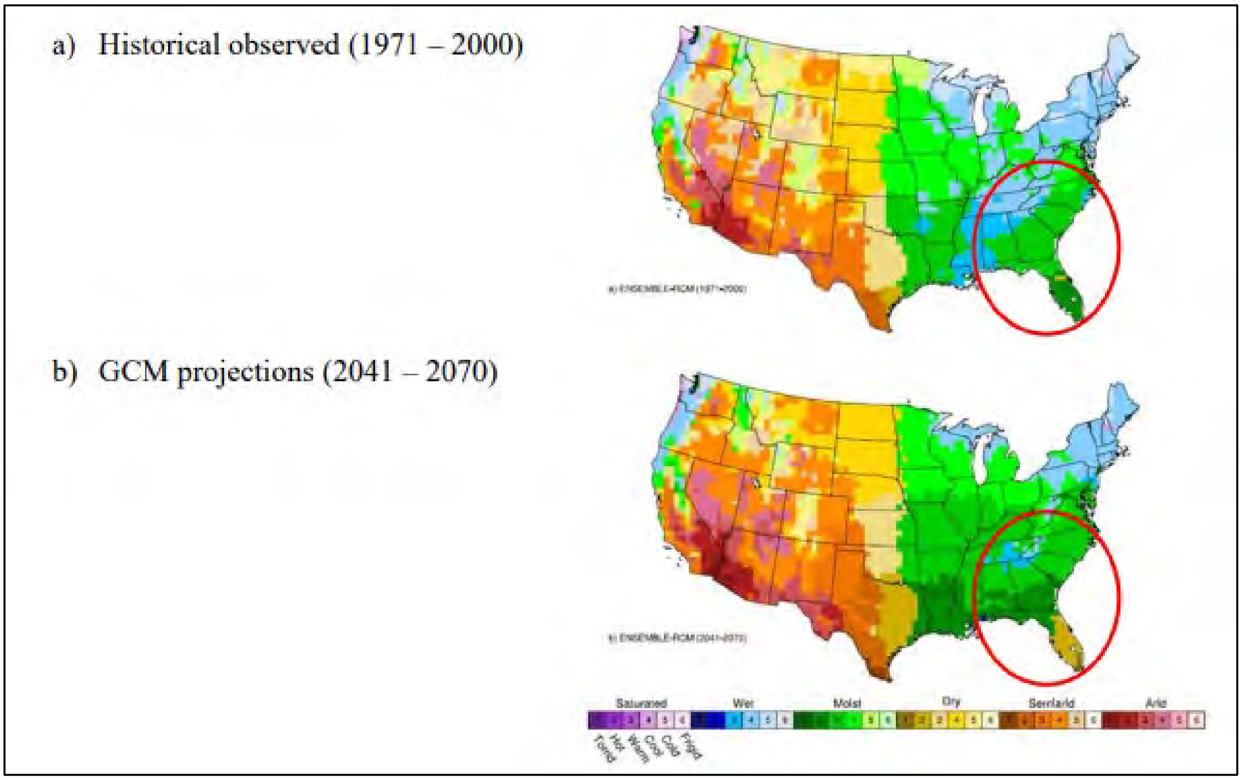

Figure 36. Revised Thornthwaite climate types projected by regional climate models. The South Atlantic-Gulf Region is within the red oval (Elguindi and Grundstein, 2013)

Projections of changes in temperature extremes have been the subject of many recent studies performed at a national scale. A 2006 study by Tebaldi et al. applied nine GCMs at a global scale focused on extreme precipitation and temperature projections. Model projections of climate at the end of the century (2080 – 2099) were compared to historical data for the period 1980 – 1999. For the general southeastern U.S., inclusive of the South Atlantic-Gulf Region, the authors identified small increases in the projected extreme temperature range (annual high minus annual low temperature), a moderate increase in a heat wave duration index (increase of 3 to 4 days per year that temperatures continuously exceeds the historical norm by at least 5 ºC), and a moderate increase in the number of warm nights (6 to 7% increase in the percentage of times in the year when minimum temperature is above the 90th percentile of the climatological distribution for the given calendar year), compared to the baseline period. NCEI, 2022 predicts temperatures in North Carolina will continue to rise (Figure 37).

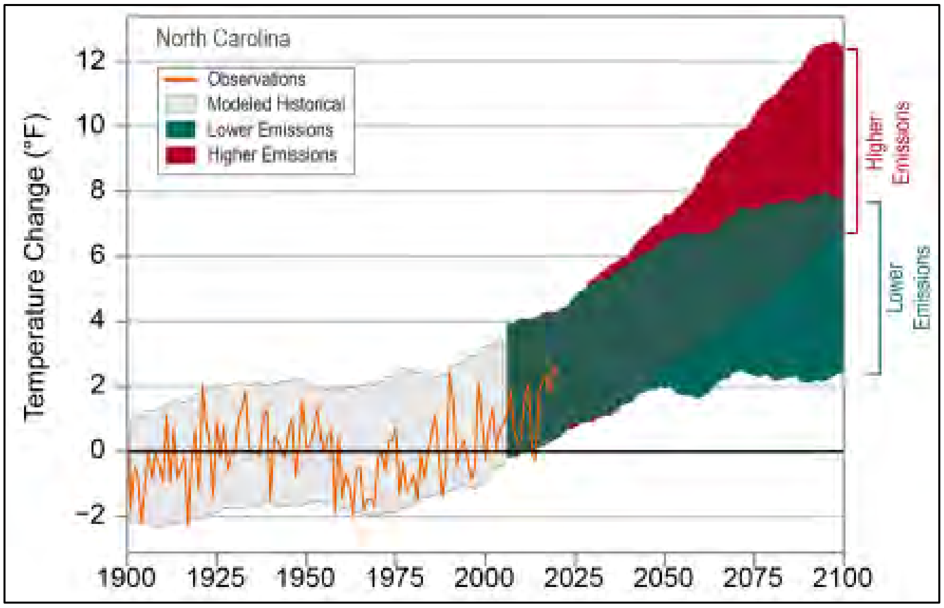

Figure 37. Projected annual average air temperature, North Carolina, 1995–2100. (NCEI, 2022)

7.3.2.3 Precipitation

Future projections of extreme events, including storm events and droughts, are the subject of studies by Tebaldi et al. (2006), Wang and Zhang (2008), Gao et al. (2012), and Wang et al. (2013a). The first authors, as part of a global study, compared an ensemble of GCM projections for the southeast U.S. and a 2090 planning horizon with historical baseline data (1980 – 1999). They report small increases in the number of high (> 10 mm) precipitation days for the region, the number of storm events greater than the 95th percentile of the historical record, and the daily precipitation intensity index (annual total precipitation divided by number of wet days). In other words, the projections forecast small increases in the occurrence and intensity of storm events by the end of the 21st century for the general study region. In addition to the historical data trend analyses by Wang and Zhang (2008) described above, these authors also used downscaled GCMs to look at potential future changes in precipitation events across North America. They used an ensemble of GCMs and a single high emissions scenario (A2) to quantify a significant increase (c. 30 to 50%) in the recurrence of the current 20-year 24-hour storm event for their future planning horizon (2075) and the general South Atlantic-Gulf Region (Figure 38). The projected increases in storm frequency presented by Wang and Zhang appear to be more significant than those projected by Tebaldi et al. (2006), but there is agreement on the general trend.

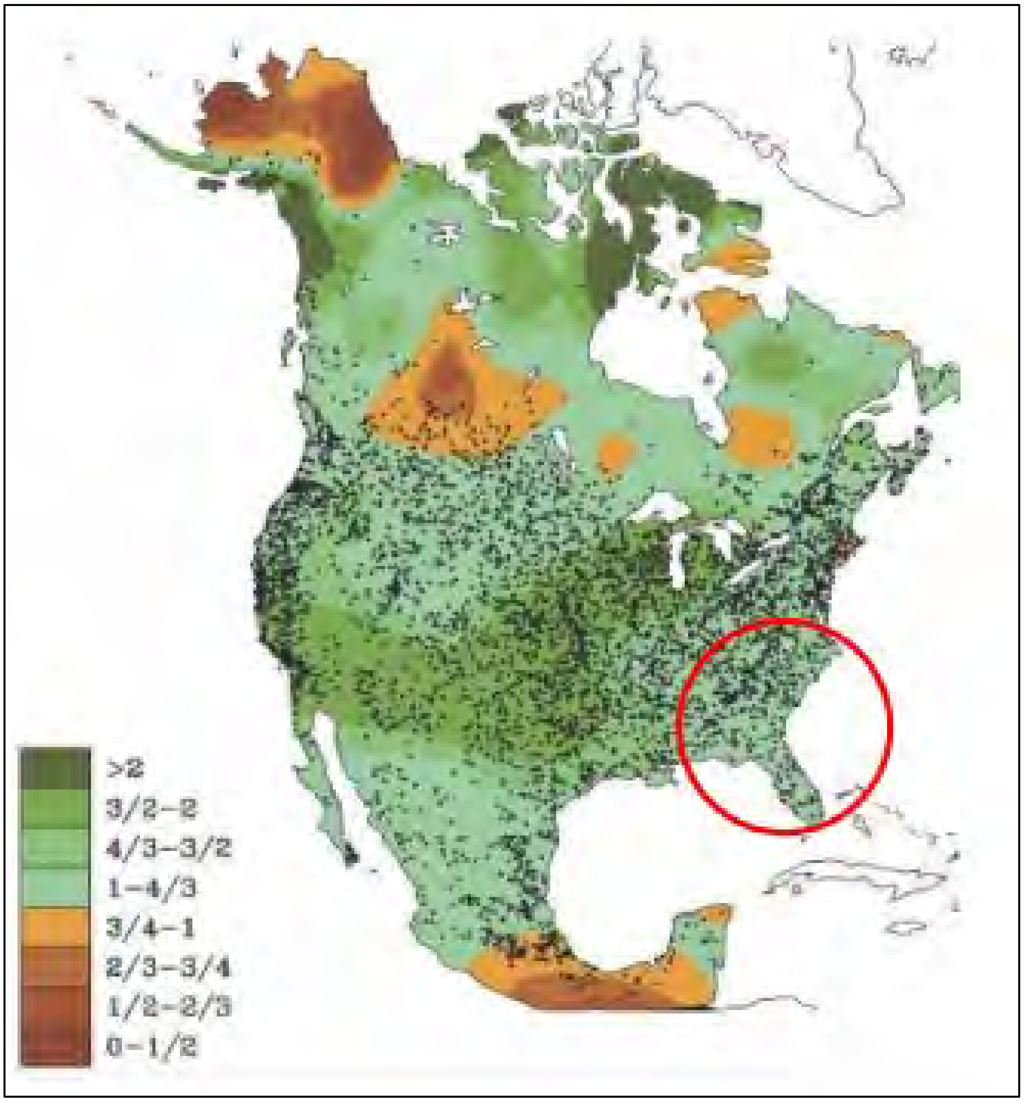

Figure 38. Projected risk of current 20-year 24-hour precipitation event occurring in 2070 compared to historical (1974). A value of 2 indicates this storm will be twice as likely in the future compared to the past. Black dots show the locations of stations. The South Atlantic Gulf Region is within the red oval (Wang and Zhang, 2008).

NCEI 2022 projects an increase in precipitation in North Carolina, primarily in the winter and spring, as well as an increase in hurricane-associate storm intensity and rainfall rates.

7.3.2.4 Hydrology

Study projections from Hagemann et al. (2013) for the general South Atlantic-Gulf Region show an overall decrease in runoff by approximately 200 mm per year for their future planning horizon (2071 – 2100) compared to the recent historical baseline (1971 – 2000) (Figure 39), assuming an A2 emissions scenario.

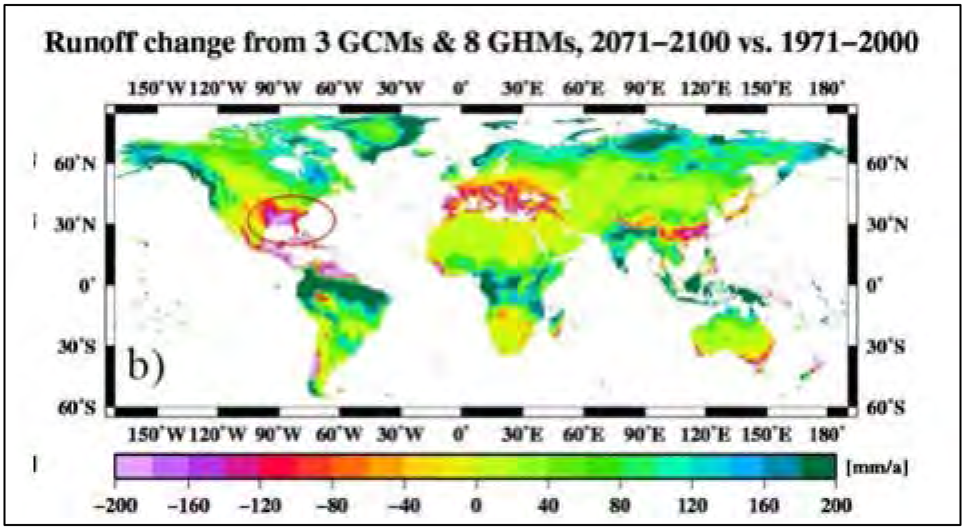

Figure 39. Ensemble mean runoff projections (mm/year) for A2 greenhouse gas emissions scenario, changes in annual runoff, 2085 vs. 1985. The South Atlantic-Gulf Region is within the red oval (Hagemann et al., 2013).

Wu et al. (2014), used the full suite of CMIP3 GCM projections in combination with a lumped rainfall-runoff model to projects future streamflow changes for Coweeta Laboratory, a watershed in North Carolina. The results suggest a likely increase in winter streamflow, however it shows mixed results for other seasons.

No clear consensus was found in projected streamflow changes in the South Atlantic-Gulf Region. Some studies point toward small increases in flow, others point toward small decreases in flow.

7.3.3 Summary of Literature Review

A January 2015 report conducted by the USACE Institute for Water Resources (USACE 2015b) summarizes the available climate change literature for this region, covering both observed and projected changes (Figure 40).

The results presented in this review indicate a small upward trend in temperature and a small downward trend in streamflow in the South Atlantic-Gulf Region, particularly since the 1970s. Both temperature and streamflow show majority consensus within the literature. Studies on precipitation show mixed results but with more findings showing an upward, rather than downward, pattern over the past 50 to 100 years. There is a high consensus that future average and maximum temperatures are forecasted to have a large increase. There is no consensus on precipitation averages and streamflow trends in the future, with contradicting predictions. Precipitation extremes however are predicted to have a small increase in the future based on a majority consensus.

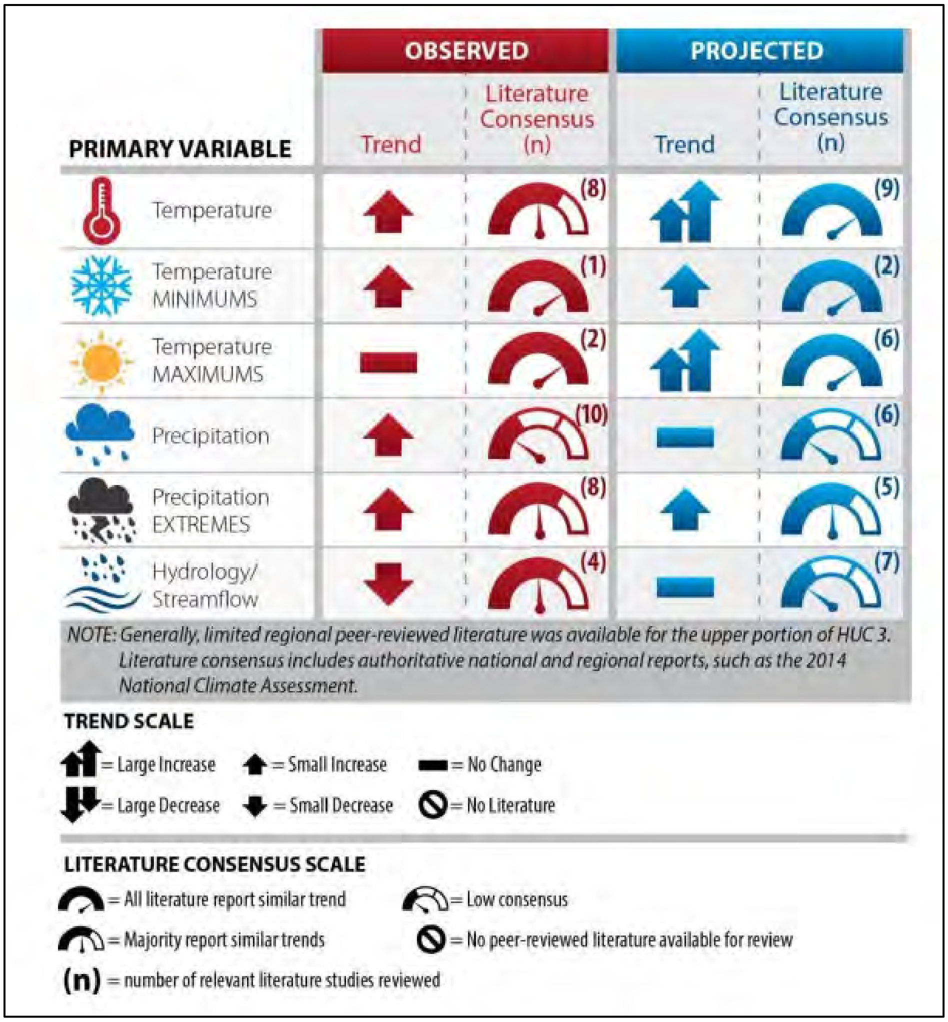

Figure 40. Summary Matrix of Observed and Project Climate Trends

The general consensus in the recent literature points toward small increases in annual temperature in the South Atlantic-Gulf Region over the past century, particularly over the past 40 years. While much of the area is located within the so-called “warming hole” identified by various researchers (including Carter et al., 2014), recent studies have demonstrated significant warming for other parts of the area (particularly northern portions) since the 1970s. Annual precipitation totals have become more variable in recent years compared to earlier in the 20th century. Evidence has also been presented, but with limited consensus, of small increasing trends in the magnitude of annual and seasonal precipitation for parts of the study area. These results are seemingly contradicted by a number of studies that have shown decreasing trends in streamflow throughout the area, particularly since the 1970s. This paradox is discussed by Small et al. (2006), who attribute it largely to seasonal differences in the timing of the changes in precipitation vs. streamflow. The study authors evaluated watersheds that experienced minimal water withdrawals and/or transfers. Results presented here also suggest that increasing temperatures may also play a role in decreasing streamflows, despite the lack of corresponding precipitation decline.

There is strong consensus in the literature that air temperatures will increase in the study area, and throughout the country, over the next century. The studies reviewed here generally agree on an increase in mean annual air temperature of approximately 2 to 4 ºC by the latter half of the 21st century for the South Atlantic-Gulf Region. The largest increases are projected for the summer months. Reasonable consensus is also seen in the literature with respect to projected increases in extreme temperature events, including more frequent, longer, and more intense summer heat waves in the long-term future compared to the recent past. Projections of precipitation in the study area are less certain than those associated with air temperature. Results of the studies reviewed here are roughly evenly split with respect to projected increases vs. decreases in future annual precipitation. This is not unexpected as, according to the recently released NCA (Carter et al., 2014); the southeast region of the country (inclusive of the South Atlantic-Gulf Region) appears to be located in a "transition zone" between the projected wetter conditions to the north and dryer conditions to the west. There is, however, moderate consensus among the reviewed studies that future storm events in the region will be more intense and more frequent compared to the recent past. Similarly, clear consensus is lacking in the hydrologic projection literature. Projections generated by coupling GCMs with macro-scale hydrologic models in some cases indicate a reduction in future streamflows but in other cases indicate a potential increase in streamflows in the study region. Of the limited number of studies reviewed here, results are approximately evenly split between the two.

7.4 Observed Trends in Current Climate and Climate Change

7.4.1 Climate Hydrology Assessment Tool

The Climate Hydrology Assessment Tool (CHAT) developed by USACE and was utilized to examine trends in observed annual peak streamflow for various gage locations (Table 6). The CHAT tool is used to fit a linear regression to the peak streamflow data in addition to providing a p-value indicating the statistical significance of a given trend.

A summary of the regression trends and their statistical significance is shown in Table 7 below. Individual graphical output for all gages and period of record data analyzed is shown in Figure 41 through Figure 48. Every gage that was analyzed via CHAT did not have a statistically significant linear trend. A few of the gages were not within the CHAT and the Tar River at Greenville, NC gage did not have the 30-year period of record needed to perform the analysis, so it was not analyzed either. There were no statistically significant trends detected in either gage that would indicate significant changes in observed streamflow due to climate change, long-term natural climate trends, or land use/land cover changes. These results will be further analyzed and checked with the nonstationarity detection tool in the next section.

Table 7. Summary of Observed Streamflow Trends in Annual Peak Streamflow using CHAT

Gage Number	Gage Name and Location	POR for CHAT	POR for NSD	POR Note	Regression Slope	P-Value	Trend Direction	Significance
02081500	Tar River near Tar River, NC	1940-2014	1940-2014	Complete	8.477	0.645	Upward	Insignificant
02081747	Tar R at US 401 at Louisburg, NC	1964-2014	1964-2014	Complete	42.442	0.314	Upward	Insignificant
02082000	Tar River near Nashville, NC	N/A	N/A	Not in CHAT or NSD	N/A	N/A	N/A	N/A
02082506	Tar River below Tar R Reservoir near Rocky Mount, NC	N/A	N/A	Not in CHAT or NSD	N/A	N/A	N/A	N/A
02082585	Tar River at NC 97 at Rocky Mount, NC	1977-2014	1977-2014	Complete	-5.974	0.939	Downward	Insignificant
02082770	Swift Creek at Hilliardston, NC	1964-2014	1964-2014	Complete	25.847	0.409	Upward	Insignificant
02082950	Little Fishing Creek near White Oak, NC	1960-2014	1960-2014	Complete	9.582	0.807	Upward	Insignificant
02083000	Fishing Creek near Enfield, NC	1915-2014	1915-2014	Complete	-8.263	0.556	Downward	Insignificant
02083500	Tar River at Tarboro, NC	1895-2014	1906-2014	Complete	-15.017	0.564	Downward	Insignificant
02083800	Conetoe Creek near Bethel, NC	N/A	N/A	Not in CHAT or NSD	N/A	N/A	N/A	N/A
02084000	Tar River at Greenville, NC	1997-2014	1997-2014	Length not sufficient	N/A	N/A	N/A	N/A
02084160	Chicod Creek at SR1760 near Simpson, NC	1976-2014	1976-2014	Complete, minus gap (1988-91)	39.246	0.07	Upward	Insignificant
02084472	Pamlico River at Washington, NC	N/A	N/A	Not in CHAT or NSD	N/A	N/A	N/A	N/A

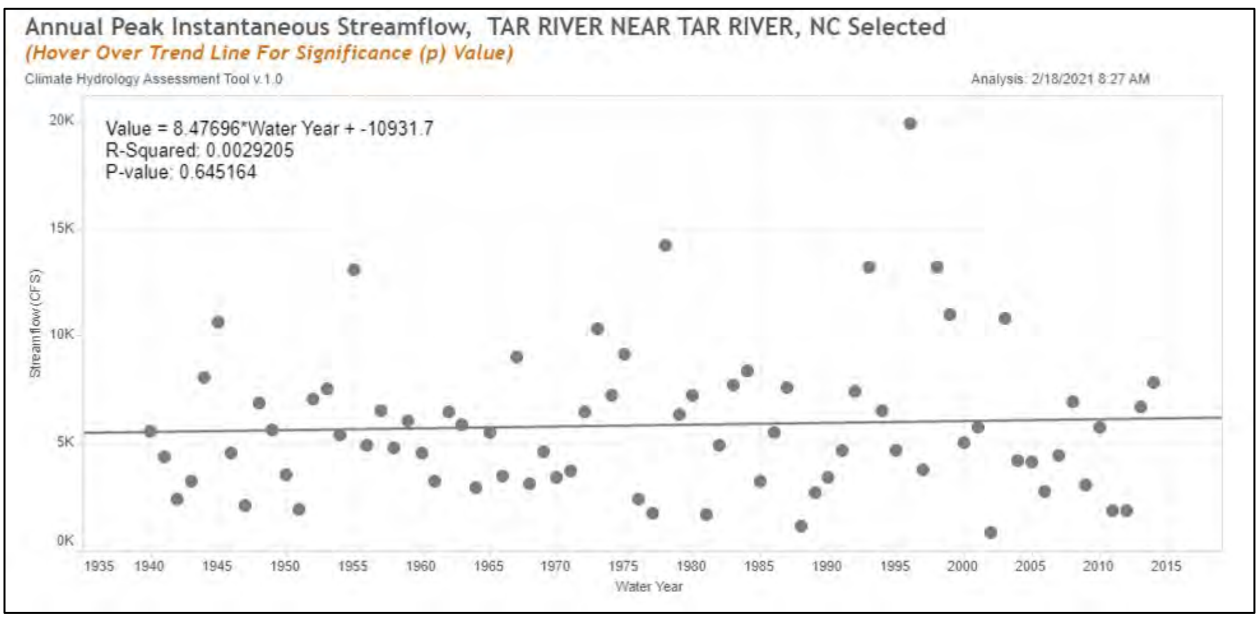

Figure 41. CHAT Results for Gage 02081500 Tar River near Tar River, NC

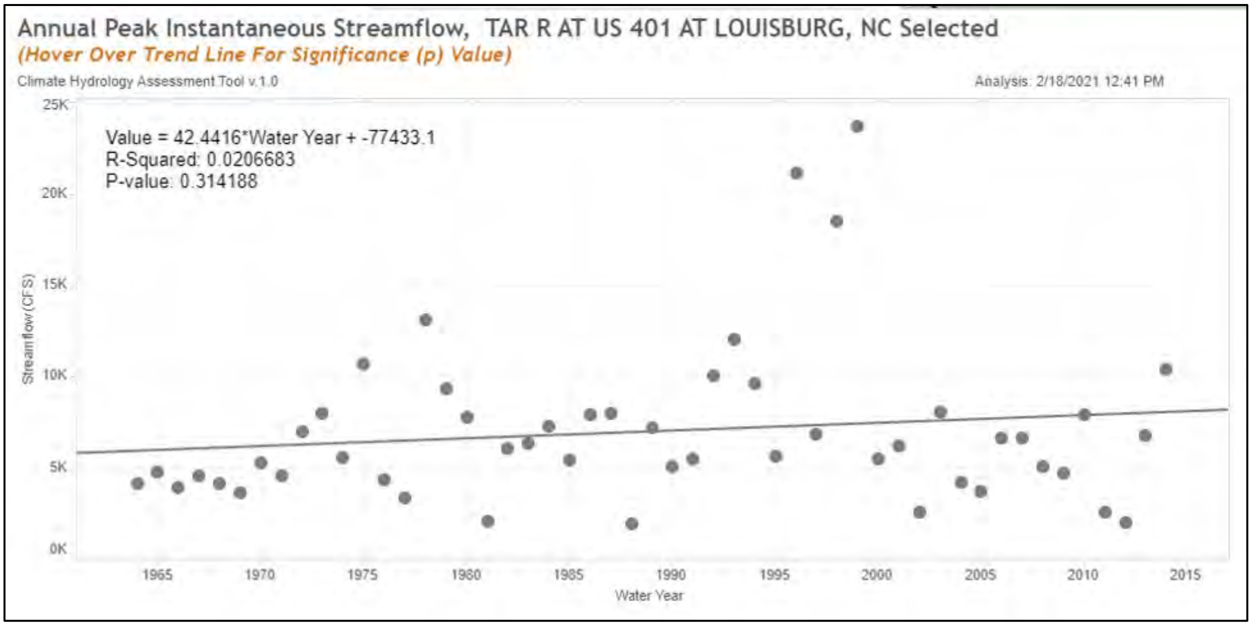

Figure 42. CHAT Results for Gage 02081747 Tar River at US 401 at Louisburg, NC

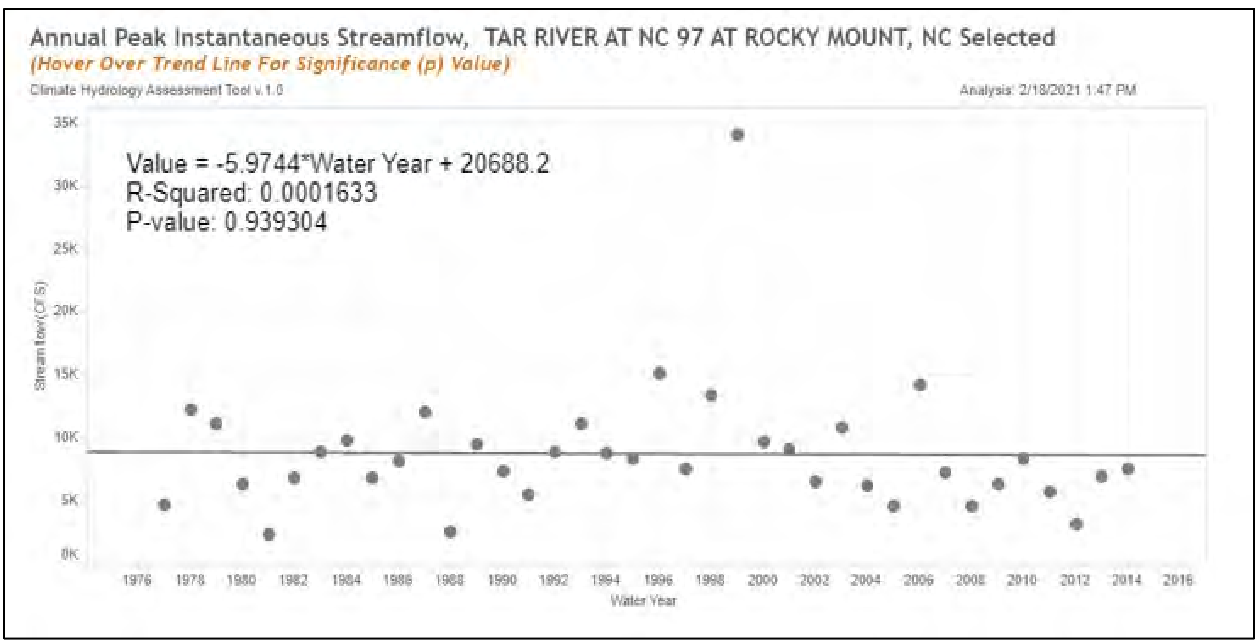

Figure 43. CHAT Results for Gage 02082585 Tar River at NC 97 at Rocky Mount, NC

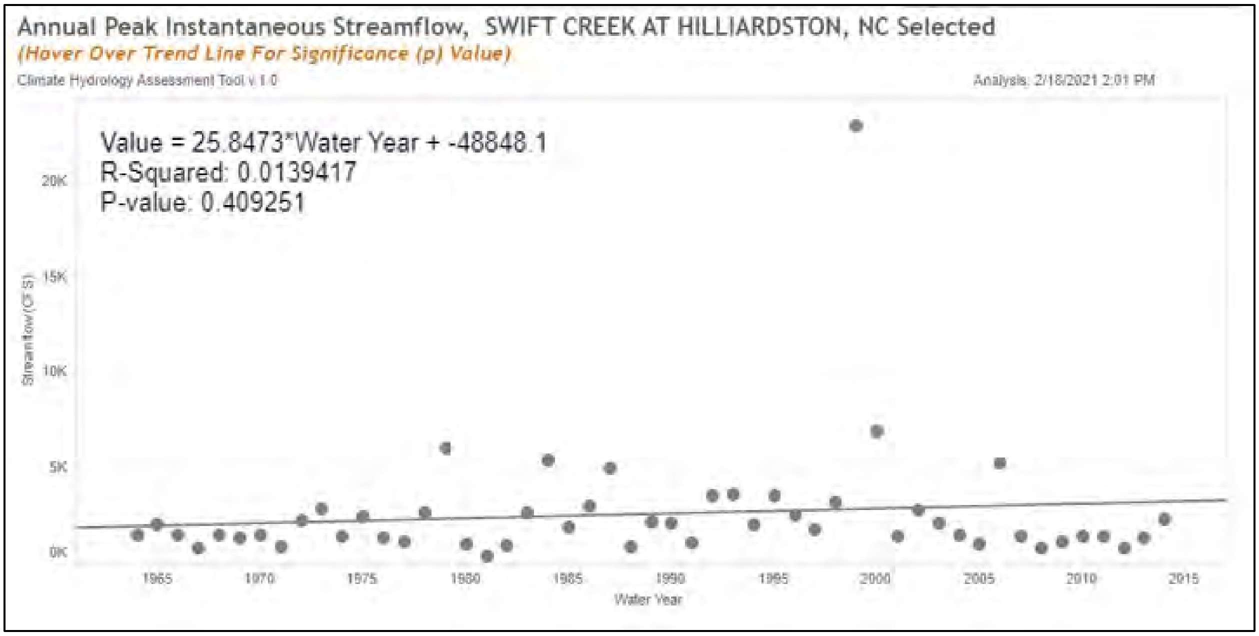

Figure 44. CHAT Results for Gage 02082770 Swift Creek at Hilliardston, NC

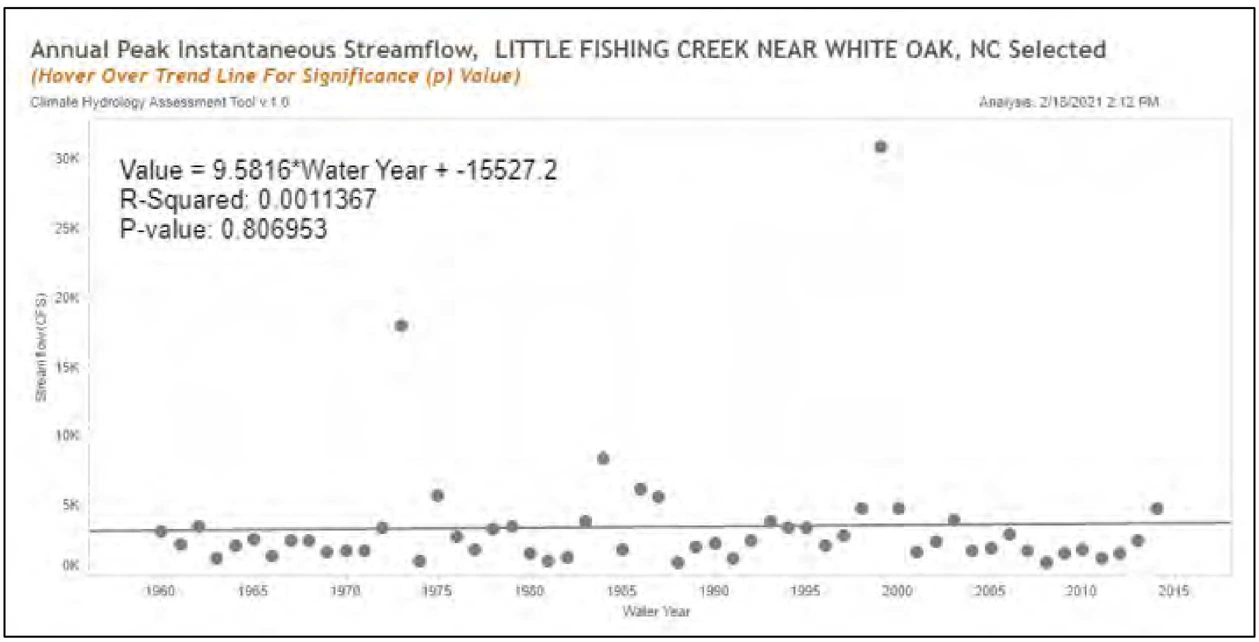

Figure 45. CHAT Results for Gage 02082950 Little Fishing Creek near White Oak, NC

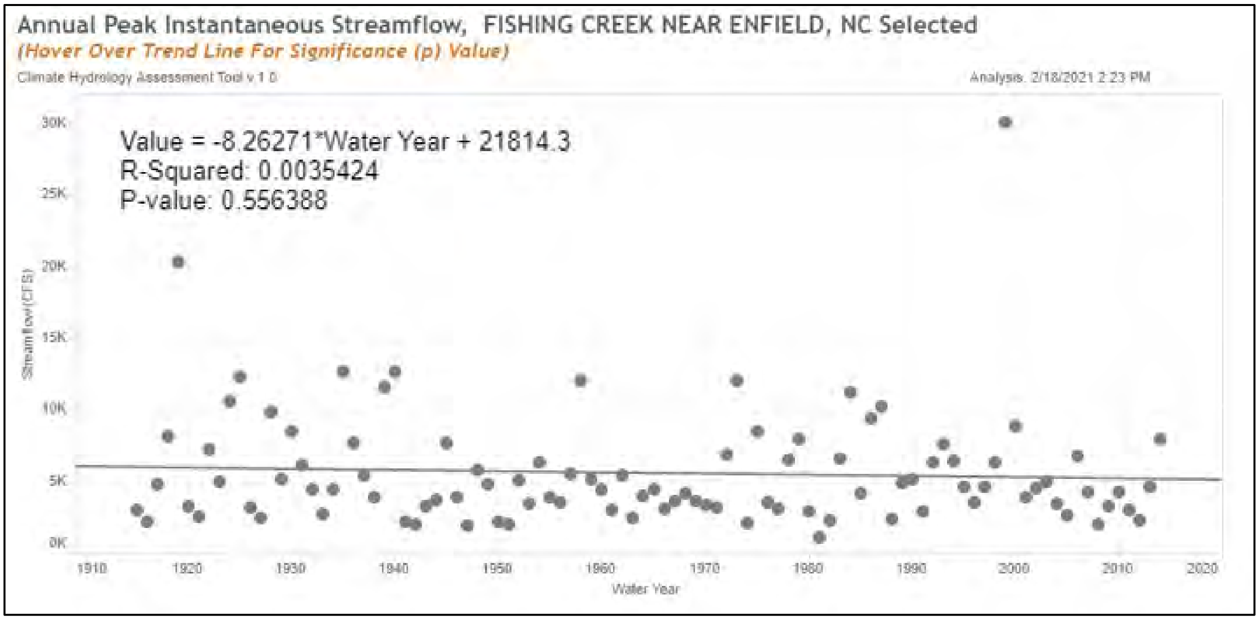

Figure 46. CHAT Results for Gage 02083000 Fishing Creek near Enfield, NC

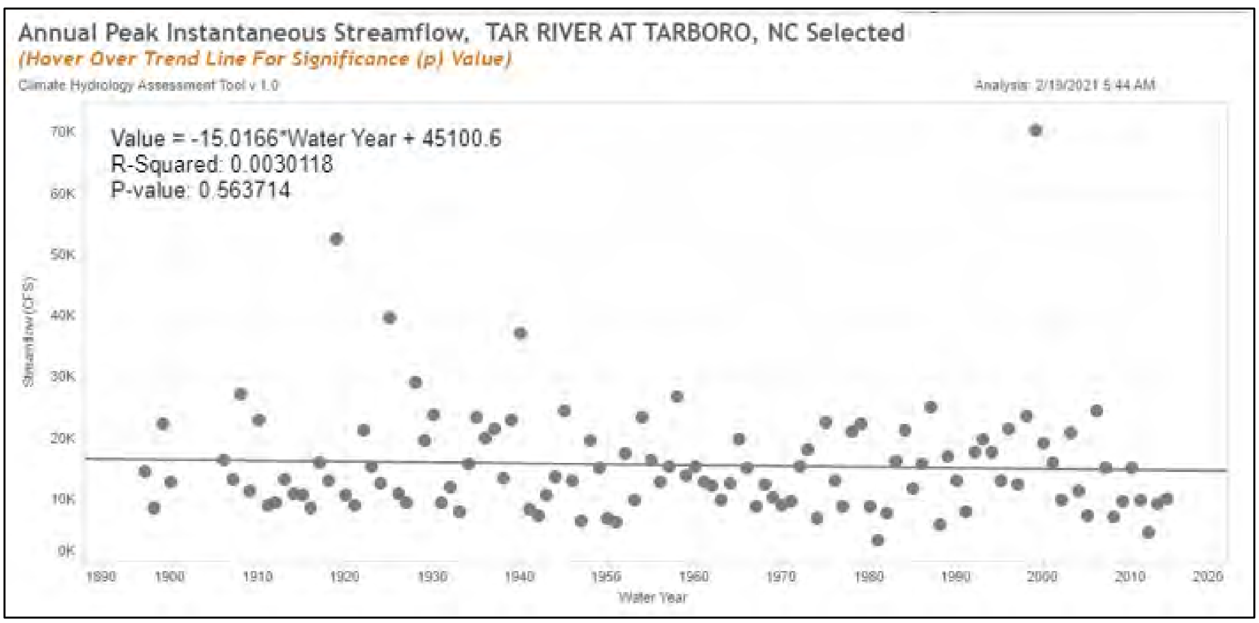

Figure 47. CHAT Results for Gage 02083500 Tar River at Tarboro, NC

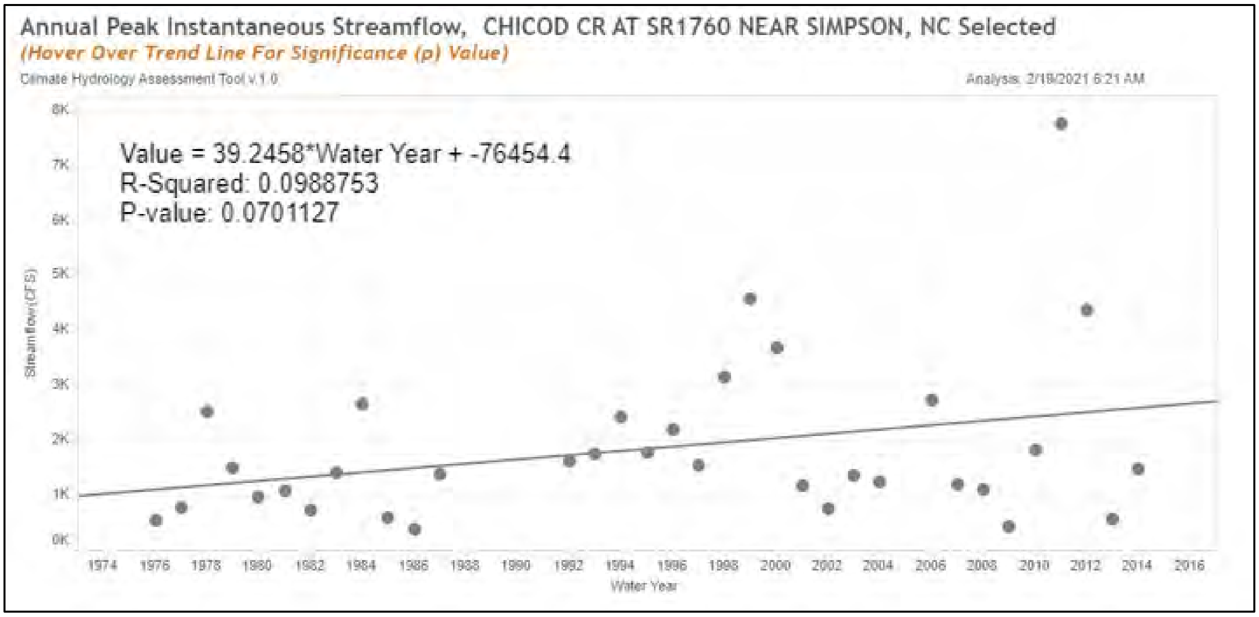

Figure 48. CHAT Results for Gage 02084160 Chicod Creek at SR1760 near Simpson, NC

7.4.2 Nonstationarity Detection Tool

The USACE Nonstationarity Detection (NSD) Tool was used to assess whether the assumption of stationarity, which is the assumption that the statistical characteristics of a time-series dataset are constant over the period of record, is valid for a given hydrologic time-series dataset. Nonstationarities are detected through the use of 12 different statistical tests which examine how the statistical characteristics of the dataset change with time (Engineering Technical Letter (ETL) 1100-2-3, Guidance for Detection of Nonstationarities in Annual Maximum Discharges; Nonstationarity Detection Tool User Manual, version 1.2). Abbreviations of the 12 statistical tests are shown in Table 8.

Table 8. NSD Statistical Test Abbreviations

Nonstationarity Detection Method Abbreviation	Statistical Test Name
CVM	Cramer-Von-Mises (CPM)
KS	Kolmogorov-Smirnov (CPM)
LP	LePage (CPM)
END	Energy Divisive Method
LW	Lombard Wilcoxon
PT	Pettitt
MW	Mann-Whitney (CPM)
BAY	Bayesian
LM	Lombard Mood
MD	Mood (CPM)
SLW	Smooth Lombard Wilcoxon
SLM	Smooth Lombard Mood

A nonstationarity can be considered "strong" when it exhibits consensus among multiple nonstationarity detection methods, robustness in detection of changes in statistical properties, and a relatively large change in the magnitude of a dataset's statistical properties. Many of the statistical tests used to detect nonstationarities rely on statistical change points, these are points within the time series data where there is a break in the statistical properties of the data, such that data before and after the change point cannot be described by the same statistical characteristics. Similar to nonstationarities, change points must also exhibit consensus, robustness, and significant magnitude of change.

A summary of the NSD results can be found in Table 9. Only one stream gage produced a nonstationarity and it is the 020817747 Tar R at US 401 at Louisburg, NC gage. The NSD calculated that a consensus of distribution occurred in 1971 by the CVM and KS methods, but the calculations presented no robustness. All other gages either did not have enough data to perform an analysis or the data that was found on USGS was not recent enough to be feasible for the analysis.

Table 9. Summary of Observed Streamflow Trends in Annual Peak Streamflow using NSD

Gage Number	Gage Name and Location	POR for CHAT	POR for NSD	POR Note	Consensus	Robustness	Conclusion
02081500	Tar River near Tar River, NC	1940-2014	1940-2014	Complete	No	No	None
02081747	Tar R at US 401 at Louisburg, NC	1964-2014	1964-2014	Complete	Yes	No	CVM & KS in 1971
02082000	Tar River near Nashville, NC	N/A	N/A	Not in CHAT or NSD (ended in 1970)	N/A	N/A	N/A
02082506	Tar River below Tar R Reservoir near Rocky Mount, NC	N/A	N/A	Not in CHAT or NSD (ended in 2010)	N/A	N/A	N/A
02082585	Tar River at NC 97 at Rocky Mount, NC	1977-2014	1977-2014	Complete	No	No	None
02082770	Swift Creek at Hilliardston, NC	1964-2014	1964-2014	Complete	No	No	None
02082950	Little Fishing Creek near White Oak, NC	1960-2014	1960-2014	Complete	No	No	None
02083000	Fishing Creek near Enfield, NC	1915-2014	1915-2014	Complete	No	No	None
02083500	Tar River at Tarboro, NC	1895-2014	1906-2014	Complete	No	No	None
02083800	Conetoe Creek near Bethel, NC	N/A	N/A	Not in CHAT or NSD (ended in 2001)	N/A	N/A	N/A
02084000	Tar River at Greenville, NC	1997-2014	1997-2014	Length not sufficient	N/A	N/A	N/A
02084160	Chicod Creek at SR1760 near Simpson, NC	1976-2014	1976-2014	Complete, minus gap (1988-91)	No	No	None
02084472	Pamlico River at Washington, NC	N/A	N/A	Not in CHAT or NSD (length not sufficient)	N/A	N/A	N/A

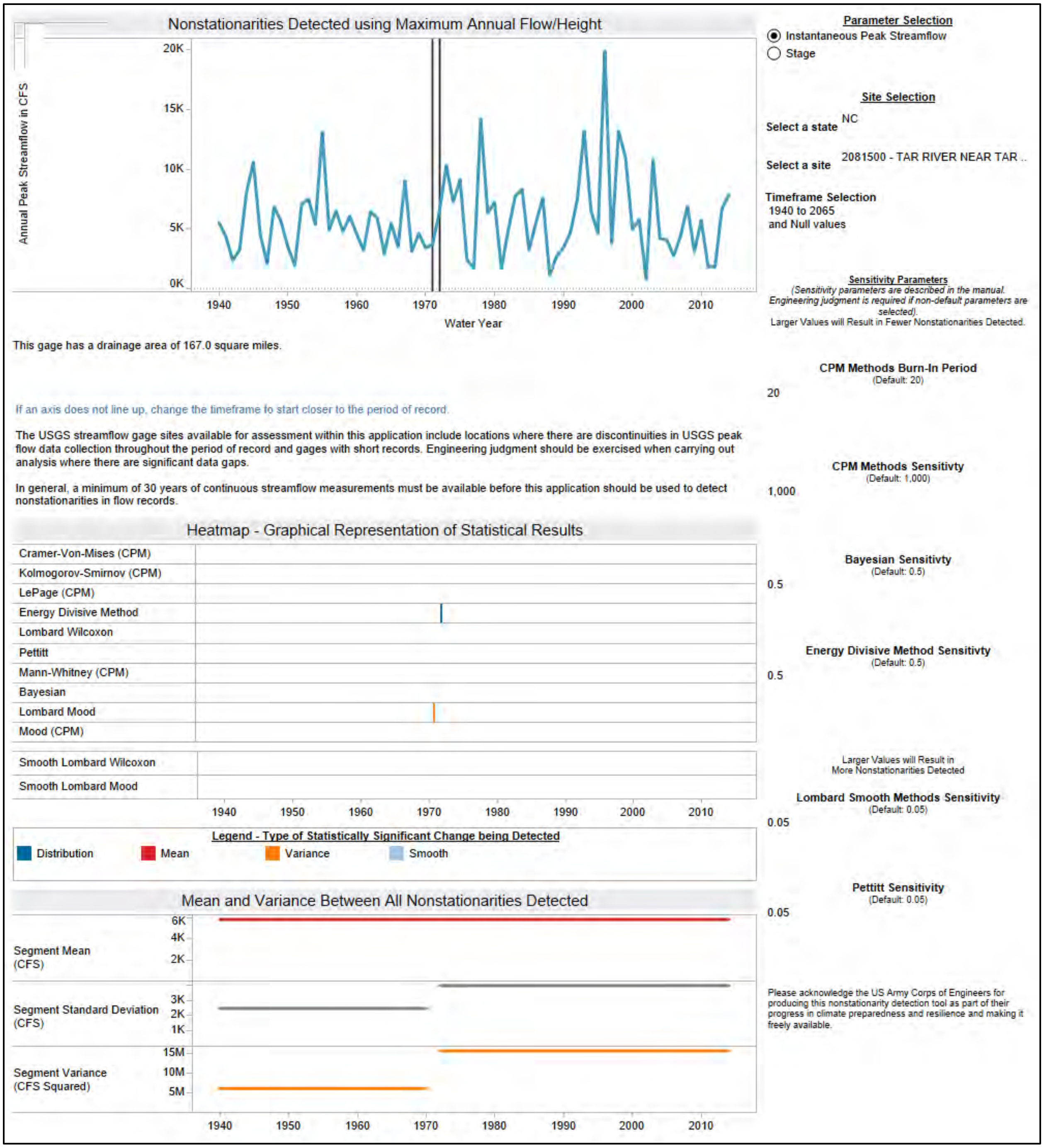

Figure 49. Nonstationarity Detection Results for Gage 02081500 Tar River near Tar River, NC

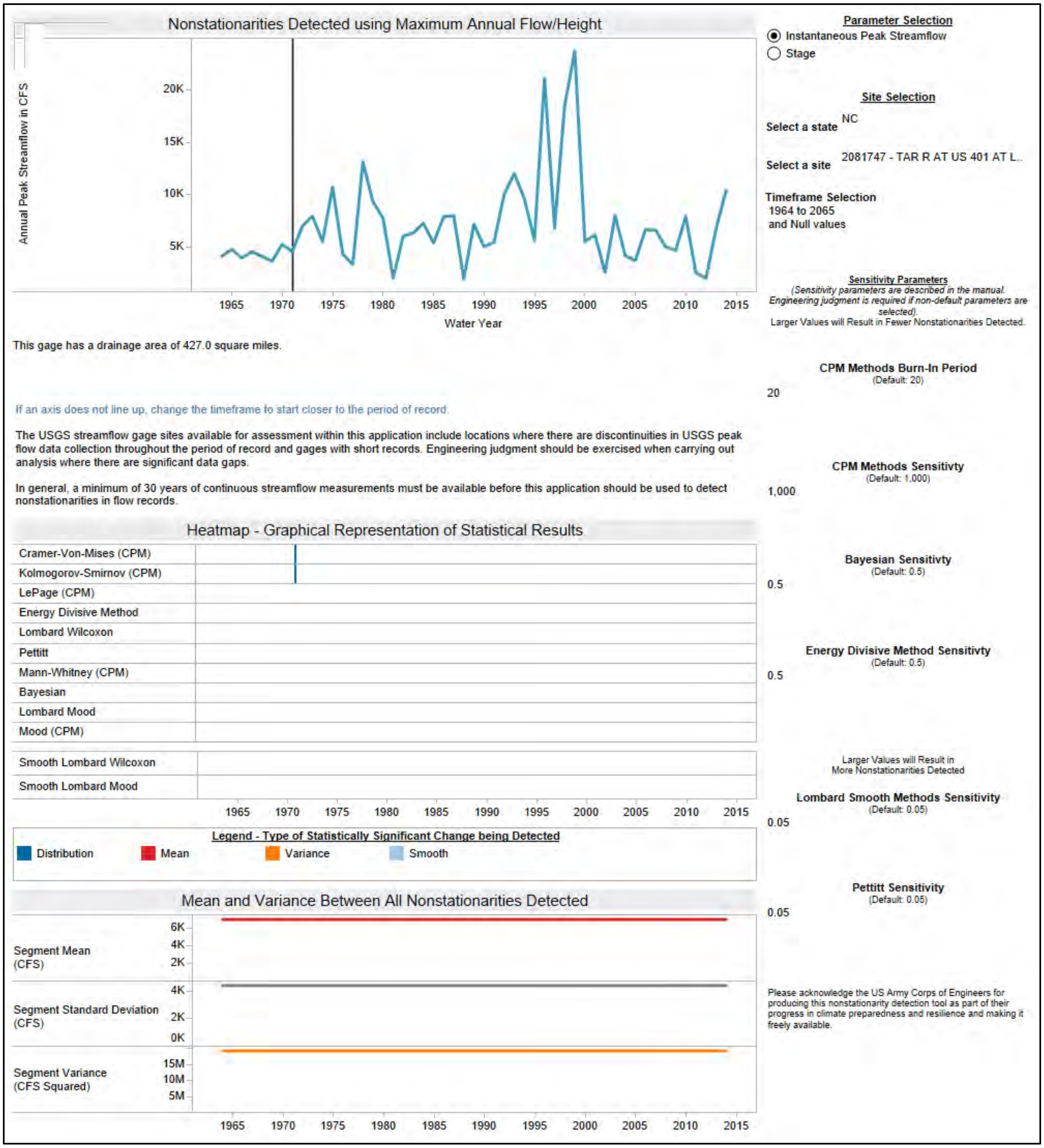

Figure 50. Nonstationarity Detection Results for Gage 02081747 Tar River at US 401 at Louisburg, NC

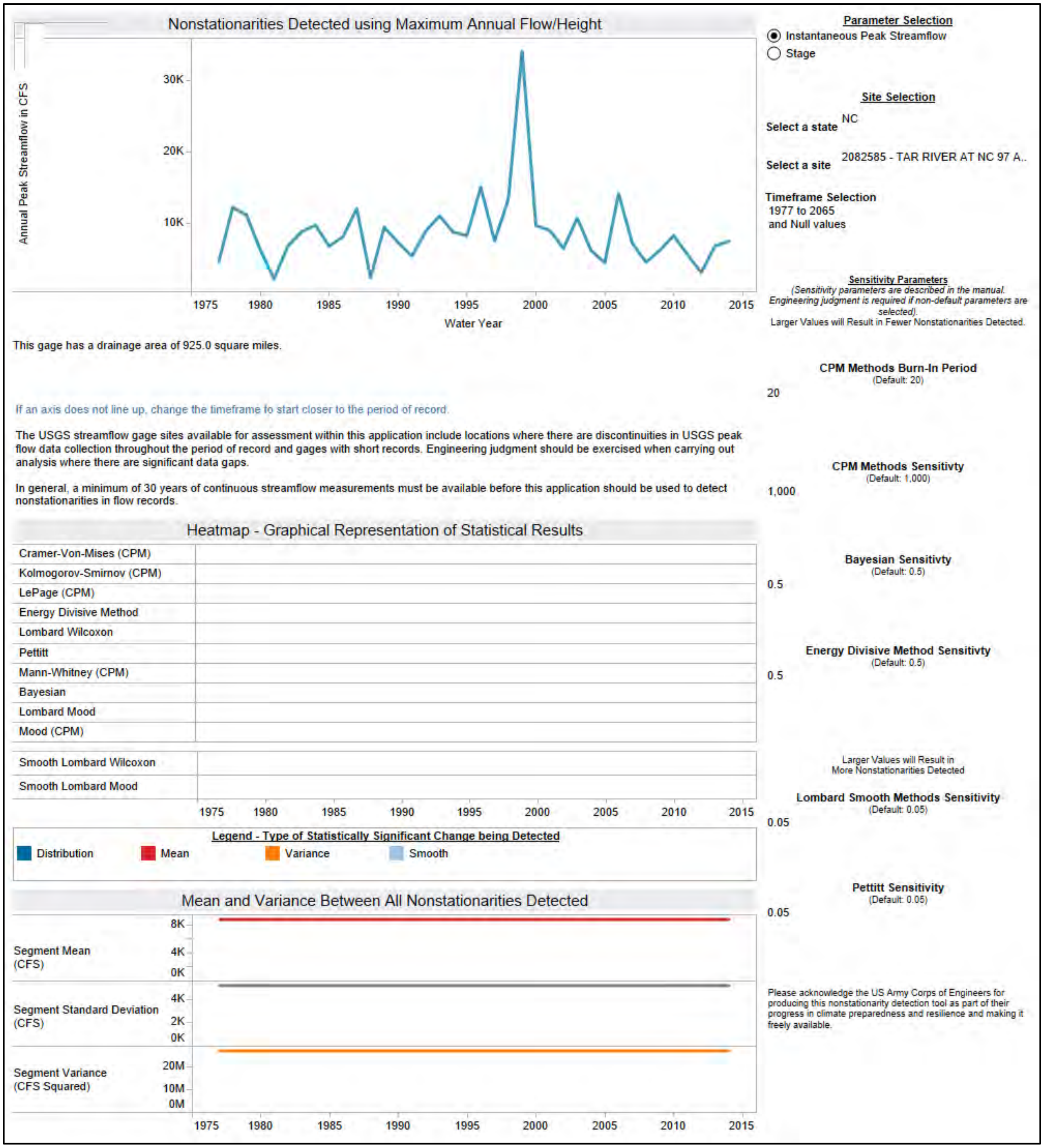

Figure 51. Nonstationarity Detection Results for Gage 02082585 Tar River at NC 97 at Rocky Mount, NC

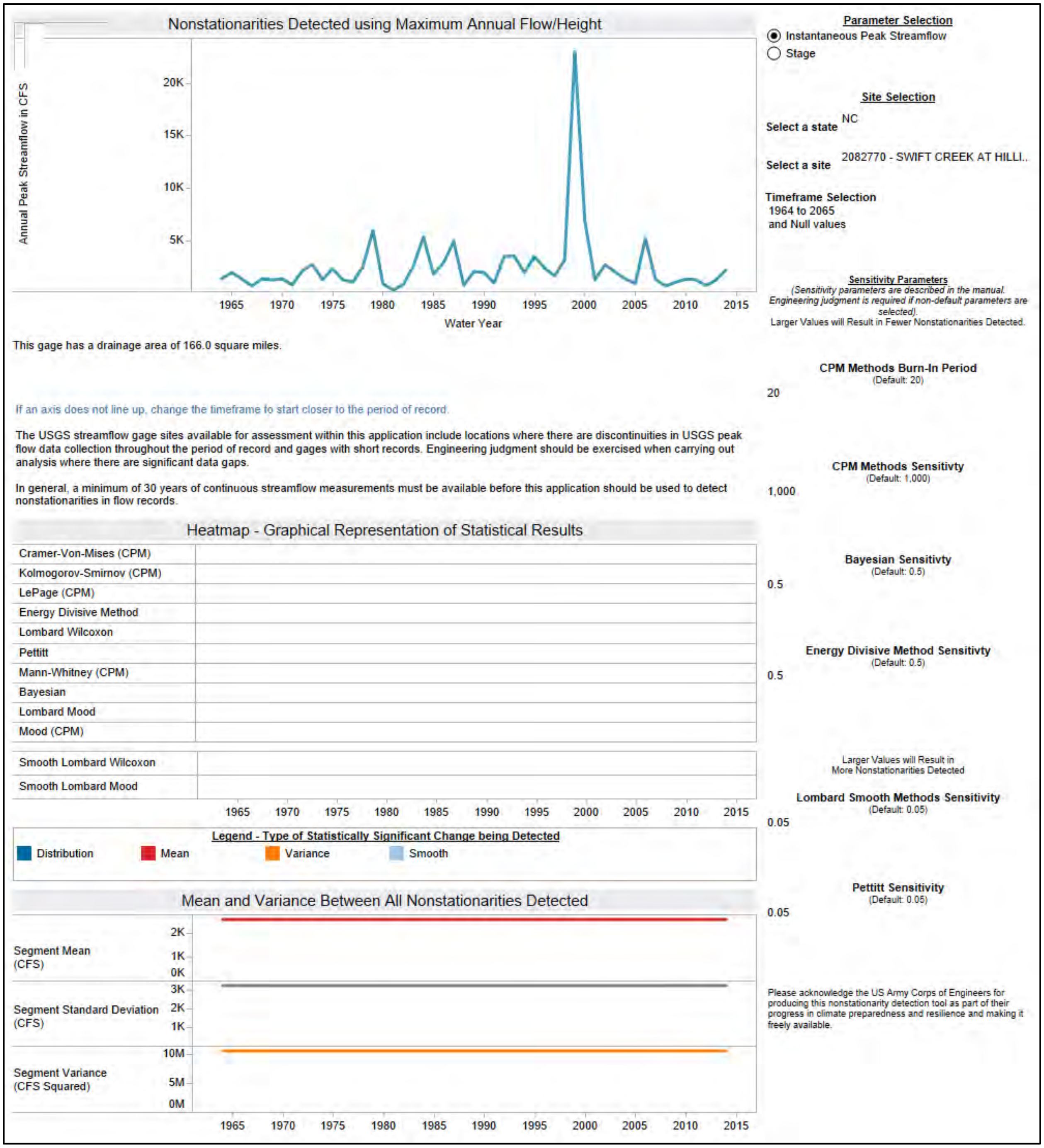

Figure 52. Nonstationarity Detection Results for Gage 02082770 Swift Creek at Hilliardston, NC

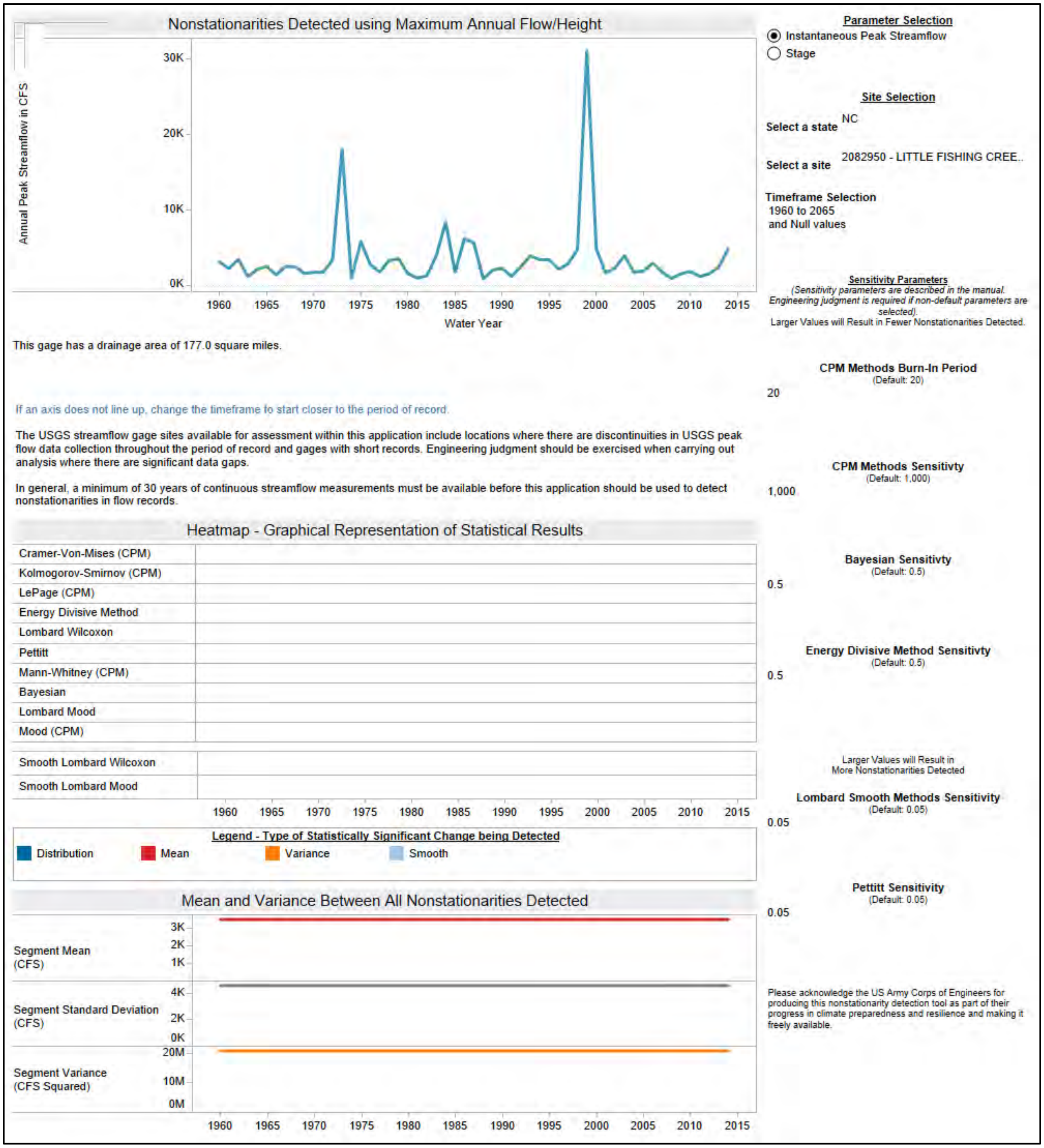

Figure 53. Nonstationarity Detection Results for Gage 02082950 Little Fishing Creek near White Oak, NC

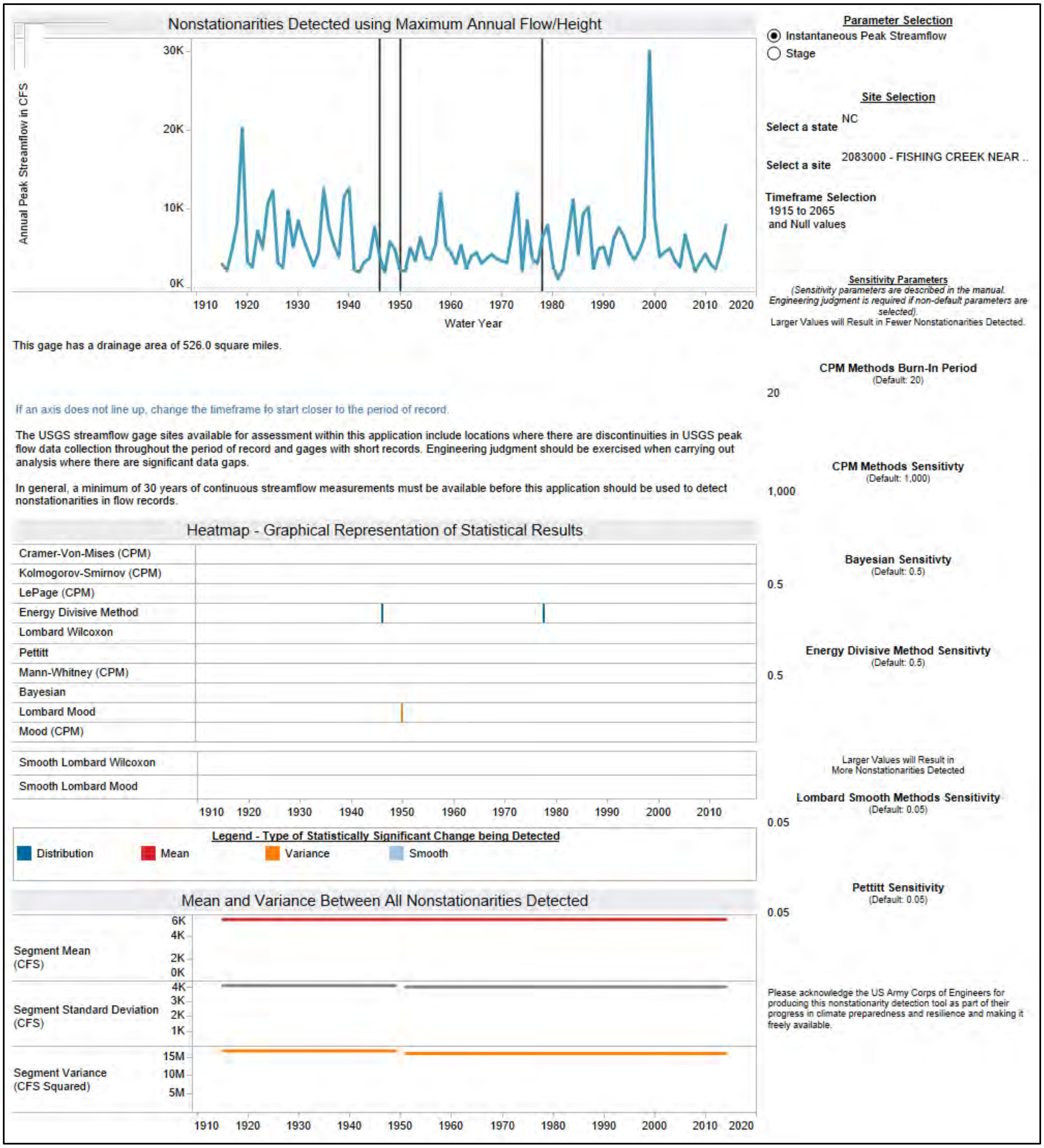

Figure 54. Nonstationarity Detection Results for Gage 02083000 Fishing Creek near Enfield, NC

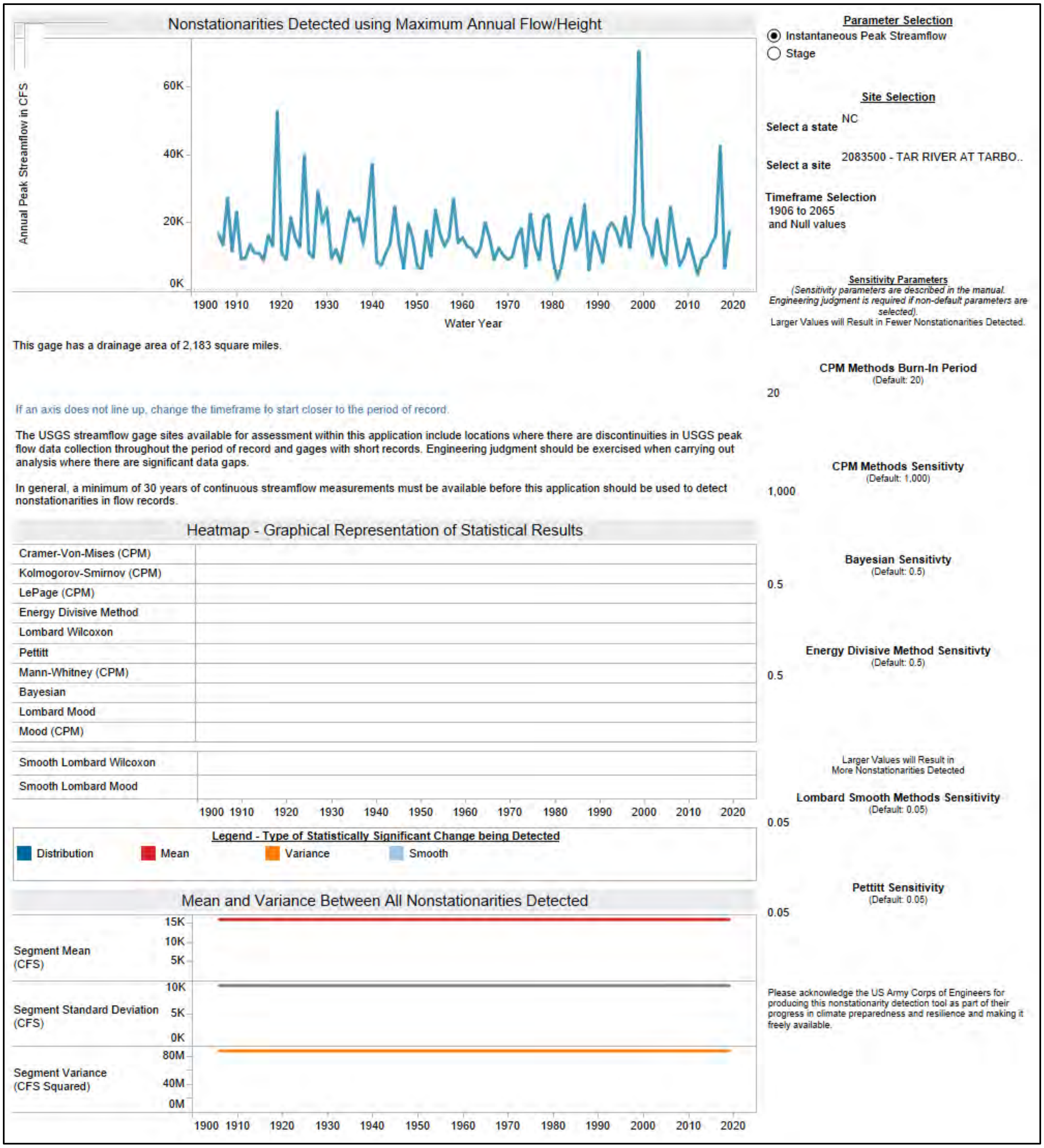

Figure 55. Nonstationarity Detection Results for Gage 02083500 Tar River at Tarboro, NC

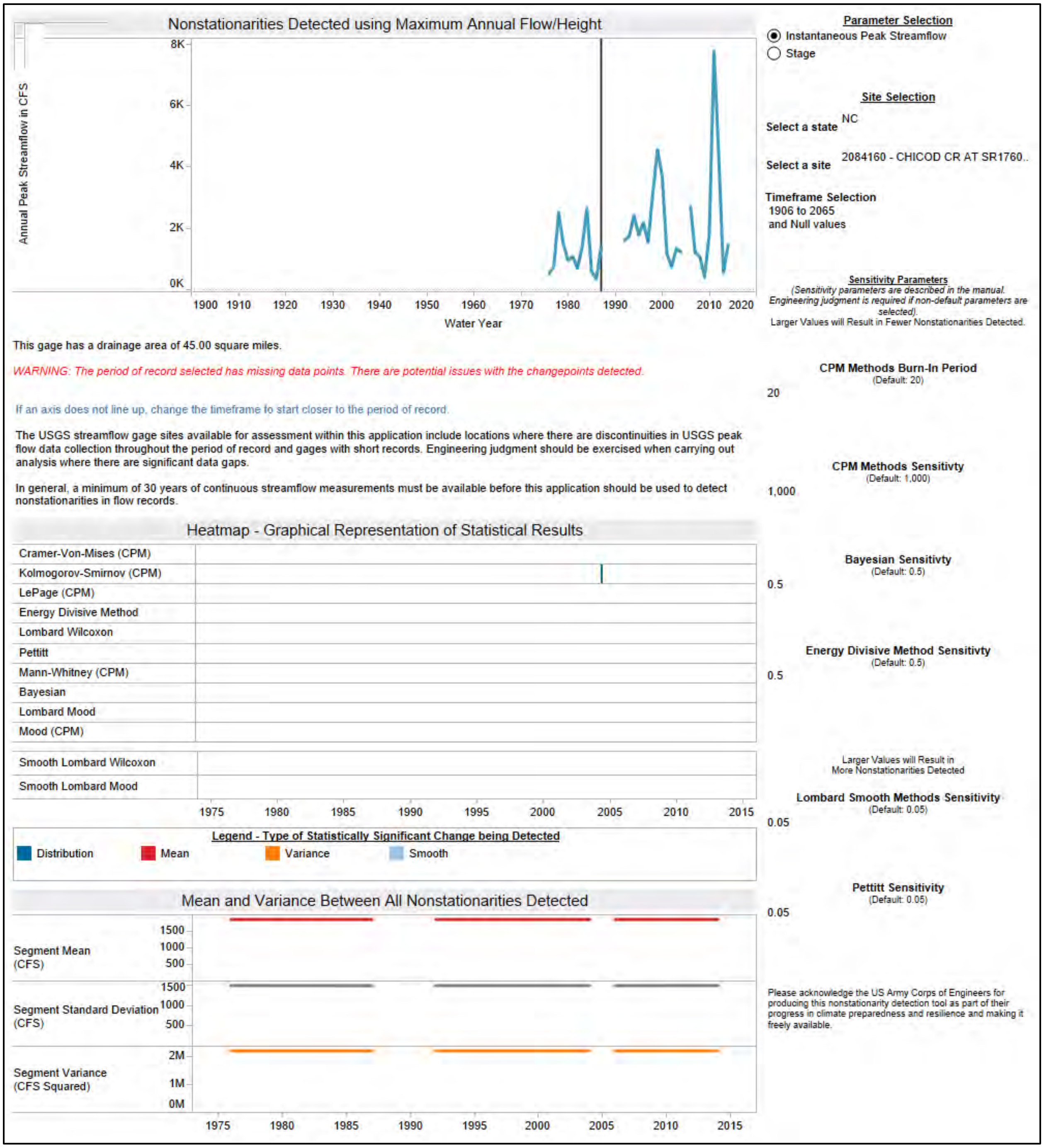

Figure 56. Nonstationarity Detection Results for Gage 02084160 Chicod Creek at SR 1760 near Simpson, NC

7.5 Projected Trends in Future Climate and Climate Change

7.5.1 Climate Hydrology Assessment Tool

The USACE Climate Hydrology Assessment Tool (CHAT) was used to assess projected, future trends within the Neuse-Pamlico watershed, HUC-0302. The tool displays the range of projected annual maximum monthly streamflows from 1950 - 2099, with the projections from 1950 – 1999 representing hindcast projections and 2000 – 2099 representing forecasted projections.

Figure 57 displays the range of projections for 93 combinations of CMIP5 GCMs and RCPs produced using BCSD statistical downscaling. These flows are simulated using an unregulated VIC hydrologic model at the outlet of HUC 0302 Neuse-Pamlico. It should be noted that the hindcast projections do not replicate historically observed precipitation or streamflow and should therefore not be compared directly with historical observations. This is in part because observed streamflows are impacted by regulation, while the VIC model used to produce the results displayed in Figure 57 is representative of the unregulated condition.

Upon examination of the range of model results, there is a clear increasing trend in the higher projections, whereas the lower projections appear to be relatively stable and unchanging through time. The spread of the model results also increases with time, which is to be expected as uncertainty in future projection increases as time moves away from the model initiation point. Sources of variation and the significant uncertainty associated with these models include the boundary conditions applied to the GCMs, as well as variation between GCMs and selection of RCPs applied. Each GCM and RCP independently incorporate significant assumptions regarding future conditions, thus introducing more uncertainty into the climate changed projected hydrology. Climate model downscaling and a limited temporal resolution further contribute to the uncertainty associated with CHAT results. There is also uncertainty associated with the hydrologic models. The large spread of results shown in Figure 57 highlights current climatic and hydrologic modeling limitations and associated uncertainty.

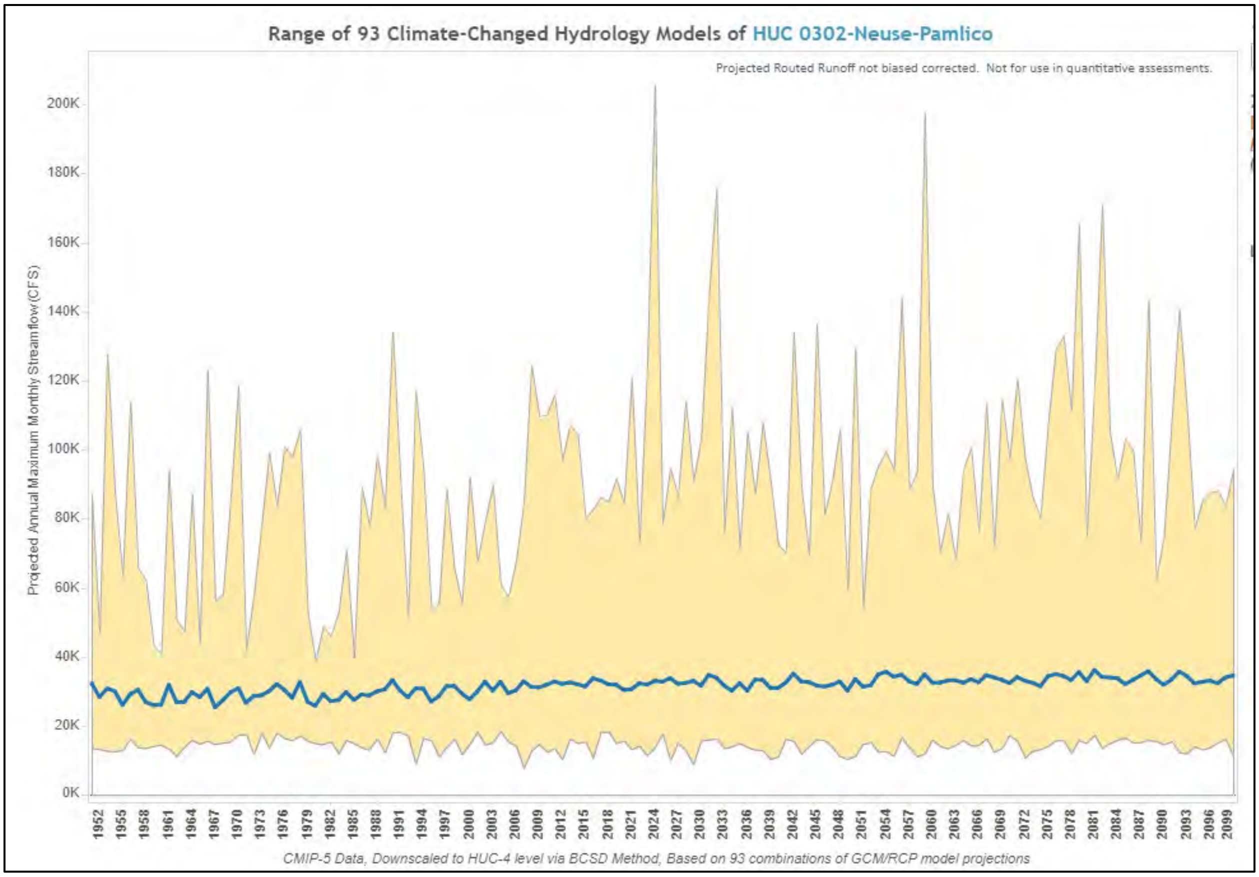

Figure 57. Range of GCM/RCP Projections for the HUC-0302 Neuse-Pamlico

Figure 58 displays only the mean result of the range of the 93 projections of future, climate changed hydrology which are shown in Figure 57. A linear regression line was fit to this mean and displays an increasing trend with a slope of approximately 28.5 cfs/yr. It should be noted that the p-value associated with this trend is less than 0.0001, indicating that the trend should be considered as statistically significant.

These outputs from the CHAT qualitatively suggest that annual maximum monthly flows, and therefore annual peak flows, are expected to increase in the future relative to the current time.

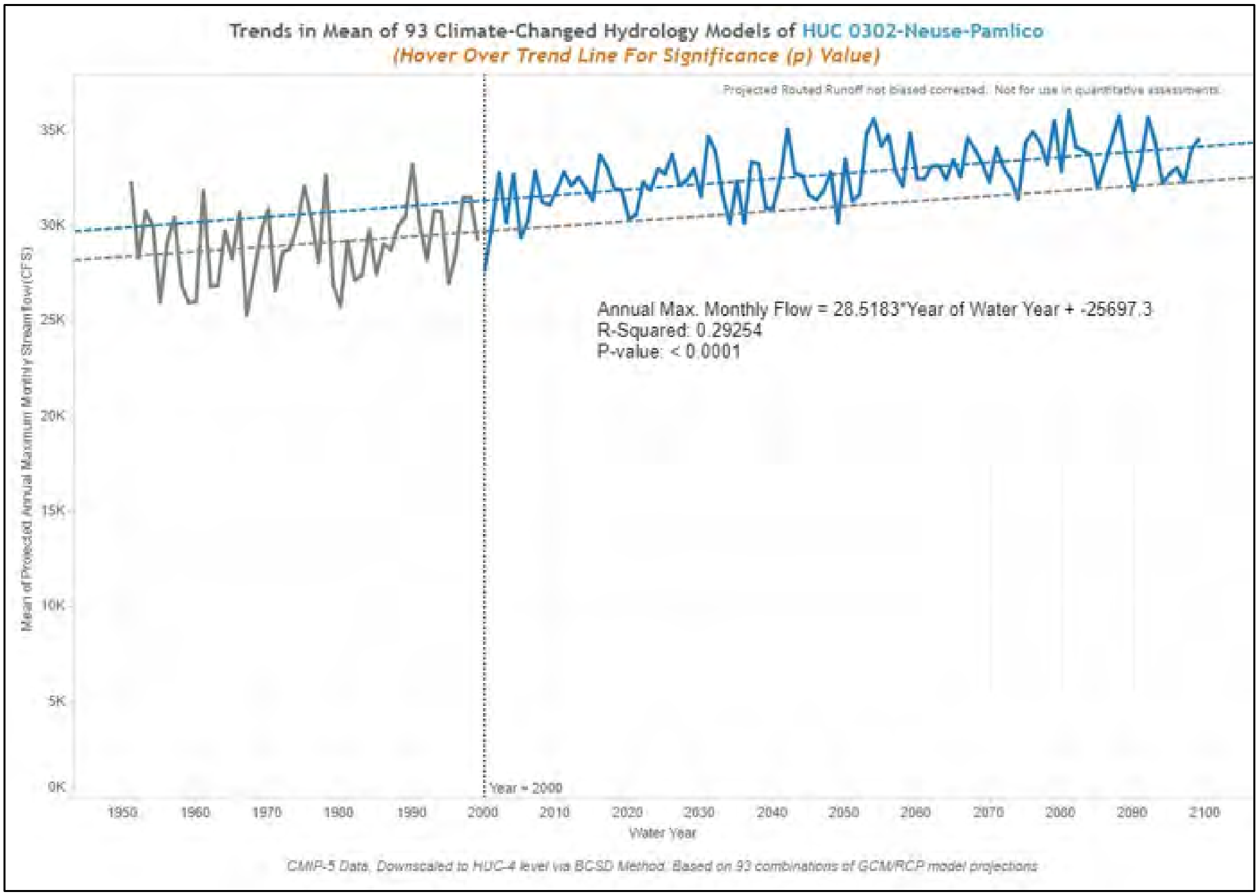

Figure 58. Mean of GCM/RCP Projections for the HUC-0302 Neuse-Pamlico

7.5.2 Vulnerability Assessment

The USACE Watershed Climate Vulnerability Assessment Tool (VA Tool) facilitates a screening level, comparative assessment of how vulnerable a given HUC-4 watershed is to the impacts of climate change relative to the other 201 HUC-4 watersheds within the continental United States (CONUS) using the same 93 projections in the CHAT. The tool can be used to assess the vulnerability of a specific USACE business line such as “Flood Risk Reduction” or “Navigation” to projected climate change impacts. Assessments using this tool help to identify and characterize specific climate threats and particular sensitivities or vulnerabilities, at least in a relative sense, across regions and business lines. The tool uses the Weighted Ordered Weighted Average (WOWA) method to represent a composite index of how vulnerable a given HUC-4 watershed (Vulnerability Score) is to climate change specific to a given business line. The HUC-4 watersheds with the top 20% of WOWA scores are flagged as being vulnerable.

Flood risk reduction is the most relevant business line for the GUC CAP, Section 14 Feasibility Study and is the primary business line analyzed with the USACE Climate Vulnerability Assessment Tool. Other business lines included in the VA Tool are ecosystem restoration, emergency management, hydropower, navigation, recreation, regulatory, and water supply. While the flood risk reduction is the main business line discussed in detail, all other business lines were analyzed as well.

When assessing future risk projected by climate change, the USACE Climate Vulnerability Assessment Tool makes an assessment for two 30-year epochs of analysis centered at 2050 and 2085. These two periods were selected to be consistent with many of the other national and international analyses. The Vulnerability tool assesses how vulnerable a given HUC-4 watershed is to the impacts of climate change for a given business line using climate hydrology based on a combination of projected climate outputs from the GCMs and representative concentration pathway (RCPs) resulting in 100 traces per watershed per time period. The top 50% of the traces is called “wet” and the bottom 50% of the traces is called “dry.” Meteorological data projected by the GCMs is translated into runoff using the Variable Infiltration Capacity (VIC) macro-scale hydrologic model. For this assessment, the default National Standards Settings are used to carry out the vulnerability assessment.

For the Flood Risk Management business line, the HUC 0302 Neuse-Pamlico Basin is not within the top 20% of vulnerable watersheds within the CONUS for any of the four scenarios, which is not to say that vulnerability to future climate change does not exist within the basin. Table 10 displays the overall vulnerability scores for the business line relevant to this study under both wet and dry scenarios and under both time epochs. The indicators driving the residual vulnerability for the flood risk management business line are shown in Figure 59. Table 10 and Table 11 display the indicators contributing to vulnerability within the Neuse-Pamlico Basin for the flood risk reduction business line; the tables are generally sorted from largest to smallest average indicator contribution to vulnerability. Additionally, the tables display the indicator code, name, and a brief description of the indicator’s meaning.

Regarding the Flood Risk Reduction business line, the primary indicators driving vulnerability within the watershed are the flood magnification factor (indicator 568C), and acres of urban area within the 500-year floodplain (indicator 590). The flood magnification factor represents how the monthly flow exceeded 10% of the time is predicted to change in the future; a value greater than 1 indicates flood flow is predicted to increase, which is true for the Neuse-Pamlico Basin. The acres of urban area withing the 500-year flood plain indicator measures the acres of urban area within the 500-year flood plain, which impacts the land-use/landcover in the area.

Note that some of the indicators contain a suffix of “L” (local) or “C” (cumulative). Indicators with an “L” suffix reflect flow generated within only one HUC-4 watershed, whereas indicators with a “C” suffix reflect flow generated within a HUC-4 watershed and any upstream watersheds.

It is important to note the variability displayed in the VA tool’s results (Table 10, Table 11) highlights some of the uncertainty associated with the projected climate change data used as an input to the VA tool. Because the wet and dry scenarios represent the upper and lower 50% of the GCM outputs, the variability between the wet and dry scenarios underestimates the larger variability between all the underlying projected climate changed hydrology estimates. This variability can also be seen between the 2050 and 2085 epochs, as well as various other analysis within this report, such as output from the CHAT.

Table 10. Overall Vulnerability Score for Epochs and Selected Scenarios

Business Line	**Flood Risk Reduction**	
Epoch	**2050**	**2085**
Dry	45.13	47.59
Wet	48.16	51.99

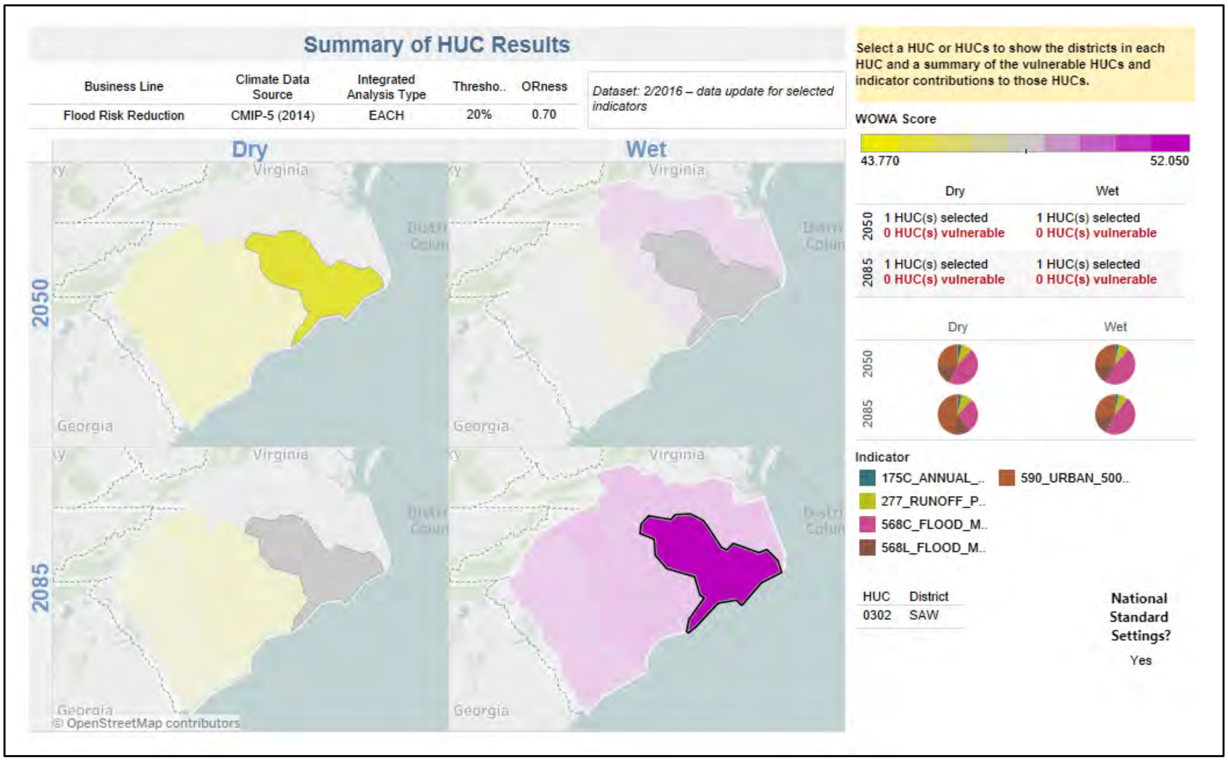

Figure 59. VA Tool Summary of HUC Results for Flood Risk Reduction Business Line

Table 11. Vulnerability Indicators for Flood Risk Reduction Business Line

Indicator Code	Indicator Name	Description (Flood Risk Reduction)	2050 Dry	2050 Wet	2085 Dry	2085 Wet
568C	Cumulative Flood Magnification Factor	Change in flood runoff: ratio of indicator 571C (monthly runoff exceeded 10% of the time, including upstream freshwater inputs) to 571C in base period.	45.15%	46.92%	28.07%	47.18%
277	Percent Change in Runoff Divided by the Percent Change in Precipitation	Median of: deviation of runoff from monthly mean times average monthly runoff divided by deviation of precipitation from monthly mean times average monthly precipitation.	8.84%	8.45%	8.94%	7.66%
568L	Local Food Magnification Factor	Change in flood runoff: Ratio of indicator 571L (monthly runoff exceeded 10% of the time, excluding upstream freshwater inputs) to 571L in base period.	14.82%	15.40%	14.18%	15.49%
175C	Cumulative Annual Covariance of Unregulated Runoff	Long-term variability in hydrology: ratio of the standard deviation of annual runoff to the annual runoff mean. Includes upstream freshwater inputs (cumulative).	3.18%	2.97%	3.28%	2.72%
590	Acres of Urban Area Within 500-Year Floodplain	Acres of urban area within the 500-year floodplain.	28.01%	26.25%	45.54%	26.96%

7.6 Summary and Conclusion

7.6.1 Observed Summary and Conclusion

Based on the observed literature review, there is a consistent consensus that points toward mild increases in annual temperature in the South Atlantic-Gulf Region over the past century, particularly over the past 40 years. Annual precipitation totals have become more variable in recent years compared to earlier in the 20th century. Evidence has also been presented, but with limited consensus, of mildly increasing trends in the magnitude of annual and seasonal precipitation for parts of the study area. These results are seemingly contradicted by several studies that have shown decreasing trends in streamflow throughout the area, particularly since the 1970s. The study authors evaluated watersheds that experienced minimal water withdrawals and/or transfers. Results presented here also suggest that increasing temperatures may also play a role in decreasing streamflows, despite the lack of corresponding precipitation decline.

Every gage that was analyzed via Climate Hydrology Assessment Tool did not have a statistically significant linear trend. A few of the gages were not within the CHAT and the

Tar River at Greenville, NC gage did not have the 30-year period of record needed to perform the analysis, so it was not analyzed either. There were no statistically significant trends detected in either gage that would indicate significant changes in observed streamflow due to climate change, long-term natural climate trends, or land use/land cover changes.

Using the Nonstationarity Detection Tool only one stream gage produced a nonstationarity and it is the 020817747 Tar R at US 401 at Louisburg, NC gage. The NSD calculated that a consensus of distribution occurred in 1971 by the CVM and KS methods, but the calculations presented no robustness. All other gages either did not have enough data to perform an analysis or the data that was found on USGS was not recent enough to be feasible for the analysis.

7.6.2 Projected Trends Summary and Conclusion

Based on the projected literature review, there is strong consensus in the literature that air temperatures will increase in the study area, and throughout the country, over the next century. The studies reviewed here generally agree on an increase in mean annual air temperature of approximately 2 to 4 ºC 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 here are roughly evenly split with respect to projected increases vs. decreases in future annual precipitation. Projections generated by coupling GCMs with macro-scale hydrologic models in some cases indicate a reduction in future streamflows but in other cases indicate a potential increase in streamflows in the study region. Of the limited number of studies reviewed here, results are approximately evenly split between the two.

Upon examination of the range of model results from the Climate Hydrology Assessment Tool, there is a clear increasing trend in the higher projections, whereas the lower projections appear to be relatively stable and unchanging through time. The spread of the model results also increases with time, which is to be expected as uncertainty in future projection increases as time moves away from the model initiation point. Sources of variation and the significant uncertainty associated with these models include the boundary conditions applied to the GCMs, as well as variation between GCMs and selection of RCPs applied. Climate model downscaling and a limited temporal resolution further contribute to the uncertainty associated with CHAT results. There is also uncertainty associated with the hydrologic models. The large spread of results shown in Figure 57 highlights current climatic and hydrologic modeling limitations and associated uncertainty. Figure 58 displays only the mean result of the range of the 93 projections of future, climate changed hydrology which are shown in Figure 57. A linear regression line was fit to this mean and displays an increasing trend with a slope of approximately 28.5 cfs/yr. It should be noted that the p-value associated with this trend is less than 0.0001, indicating that the trend should be considered as statistically significant.

Results from the USACE Vulnerability Assessment tool were analyzed for the project area and found no outstanding vulnerabilities compared with other HUCs across the continental United States. While the project area is not within the top 20% of vulnerable HUCs nationally, that does not imply that vulnerability to climate change does not exist. The VA tool indicates that the change in flood runoff (cumulative), combined with the acres of urban area within 500-year floodplain, are driving flood risk reduction vulnerability.

8 References

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APPENDIX C
Cost Estimation Supporting Documentation

Cost Engineering - General Discussion

1. Cost Estimates were prepared under guidance given in the Corps of Engineers Regulation ER 1110-2-1302 and EP 1110-1-8 Vol 3, Cost Book Dated 2018.

2. Cost Estimates were produced using MCACES with the 2022 MII Cost Book and quantities provided by Wilmington District Design Section. Labor rates were adjusted to current local North Carolina Davis Bacon rates. Cost Book material rates were adjusted to Q3 2022 RSMeans values or taken from a field quote in the same time period. The assumed construction start is Q2 FY24 with a completion by Q4 FY24. Midpoint of construction is assumed Q3 FY24. Construction estimate is escalated to the midpoint of construction using Total Project Cost Summary escalation percentages.

3. Cost Estimate Issues and Assumptions.

- Site Access will be available through the water treatment plant and their access road to the pump house.
- Disposal of excess spoil can be used on site of the water treatment facility as discussed with the stakeholders
- Project will be mostly completed by a subcontractor.

4. Markups.

Sales Tax – 7%
Market/Covid Labor Markups – 5%
Market/Covid Labor Markups – 10%
Acquisition Strategy – Project does not have a defined acquisition strategy, but in the past such efforts have been completed with small business contractors. Applied a 10% markup to cover unknown strategy.

Contractor Markups
JOOH – Calculated
HOOH – 10%
Profit – 10%
Bond – Class B

5. Project Construction Schedule. The assumed construction start is Q2 FY24 with a completion by Q4 FY24.

6. Risk Analysis. Abbreviated Risk Analysis was performed to determine the contingencies in accordance with ER 1110-2-1302. See attached Risk Register and Input & Results forms for details. Construction cost contingency was determined to be 31%. Design & Implementation (i.e. PED) contingency was determined to be 20%. S&A contingency was determined at 22%.

7. References.

a. EC 11-2-225, Corps of Engineers Civil Works Direct Program: Program Development Guidance Fiscal Year 2024, 31 March 2022.

b. ER 1105-2-100, Planning Guidance Notebook, 22 April 2000.

c. ER 1110-1-1300, Cost Engineering Policy and General Requirements, 26 March 1993.

d. ER 1110-2-1150, Engineering and Design for Civil Works Projects, 31 August 1999.

e. ER 1110-2-1302, Civil Works Cost Engineering, 30 June 2016.

f. EP 1110-1-8 Volume 2, Construction Equipment Ownership and Operating Expense Schedule – Region III, 12 August 2021.

Total Project Cost Summary

**** TOTAL PROJECT COST SUMMARY ****

PROJECT: **Greenville Utilities Bank Stabilization**
PROJECT NO: **P2 495966**
LOCATION: **Greenville,NC**

DISTRICT: **Wilmington District** PREPARED: **9/28/2022**
POC: **CHIEF, COST ENGINEERING, Stephen Roman**

This Estimate reflects the scope and schedule in report; Feasibility_EA_Integrated_Rpt_DRAFT_ATR_ 093022

Civil Works Work Breakdown Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**						**TOTAL PROJECT COST (FULLY FUNDED)**			
						Program Year (Budget EC): 2023 Effective Price Level Date: 1-Oct- 22									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	REMAINING COST ($K)	Spent Thru: 1-Oct-15 ($K)	TOTAL FIRST COST ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
16	BANK STABILIZATION	$1,008	$312	31%	$1,320		$1,008	$312	$1,320		$1,320	4.2%	$1,050	$326	$1,376
				-		-						-			
				-		-						-			
				-		-						-			
	CONSTRUCTION ESTIMATE TOTALS:	$1,008	$312		$1,320		$1,008	$312	$1,320		$1,320	4.2%	$1,050	$326	$1,376
01	LANDS AND DAMAGES	$2	$1	25%	$3		$2	$1	$3		$3	4.2%	$2	$1	$3
30	PLANNING, ENGINEERING & DESIGN	$226	$45	20%	$271		$226	$45	$271		$271	2.8%	$232	$46	$279
31	CONSTRUCTION MANAGEMENT	$146	$32	22%	$178		$146	$32	$178		$178	2.8%	$150	$33	$183
	PROJECT COST TOTALS:	$1,382	$390	28%	$1,772		$1,382	$390	$1,772		**$1,772**	3.9%	$1,435	$406	$1,841

______________________ CHIEF, COST ENGINEERING, Stephen Roman

______________________ PROJECT MANAGER, Jason Glazener

______________________ CHIEF, REAL ESTATE, XXX

______________________ CHIEF, PLANNING, XXX

______________________ CHIEF, ENGINEERING, XXX

______________________ CHIEF, OPERATIONS, XXX

______________________ CHIEF, CONSTRUCTION, XXX

______________________ CHIEF, CONTRACTING, XXX

______________________ CHIEF, PM-PB, xxxx

______________________ CHIEF, DPM, XXX

ESTIMATED TOTAL PROJECT COST:		**$1,841**
ESTIMATED FEDERAL COST:	**65%**	$1,196
ESTIMATED NON-FEDERAL COST:	**35%**	$644
22 - FEASIBILITY STUDY (CAP studies):		**$150**
ESTIMATED FEDERAL COST:	83%	$125
ESTIMATED NON-FEDERAL COST:	17%	$25
ESTIMATED FEDERAL COST OF PROJECT		**$1,321**

**** TOTAL PROJECT COST SUMMARY ****

**** CONTRACT COST SUMMARY ****

PROJECT: Greenville Utilities Bank Stabilization
LOCATION: Greenville,NC
This Estimate reflects the scope and schedule in report; Feasibility_EA_Integrated_Rpt_DRAFT_ATR_ 093022

DISTRICT: Wilmington District
POC: CHIEF, COST ENGINEERING, Stephen Roman
PREPARED: 9/28/2022

WBS Structure		**ESTIMATED COST**				**PROJECT FIRST COST (Constant Dollar Basis)**				**TOTAL PROJECT COST (FULLY FUNDED)**				
		Estimate Prepared:			**27-Jun-22**	Program Year (Budget EC):			2023					
		Estimate Price Level:			1-Oct-22	Effective Price Level Date:			1 -Oct-22					
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	***B***	***C***	***D***	***E***	***F***	***G***	***H***	***I***	***J***	***P***	***L***	***M***	***N***	***O***
	PHASE 1 or CONTRACT 1													
16	BANK STABILIZATION	$1,008	$312	31.0%	$1,320		$1,008	$312	$1,320	2024Q3	4.2%	$1,050	$326	$1,376
	CONSTRUCTION ESTIMATE TOTALS:	$1,008	$312	31.0%	$1,320		$1,008	$312	$1,320			$1,050	$326	$1,376
01	LANDS AND DAMAGES	$2	$1	25.0%	$3		$2	$1	$3	2024Q3	4.2%	$2	$1	$3
30	PLANNING, ENGINEERING & DESIGN													
2.5%	Project Management	$25	$5	20.0%	$30		$25	$5	$30	2024Q1	2.8%	$26	$5	$31
1.0%	Planning & Environmental Compliance	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
10.0%	Engineering & Design	$101	$20	20.0%	$121		$101	$20	$121	2024Q1	2.8%	$104	$21	$125
1.0%	Reviews, ATRs, IEPRs, VE	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
1.0%	Life Cycle Updates (cost, schedule, risks)	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
1.0%	Contracting & Reprographics	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
2.0%	Engineering During Construction	$20	$4	20.0%	$24		$20	$4	$24	2024Q1	2.8%	$21	$4	$25
2.0%	Planning During Construction	$20	$4	20.0%	$24		$20	$4	$24	2024Q1	2.8%	$21	$4	$25
1.0%	Adaptive Management & Monitoring	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
1.0%	Project Operations	$10	$2	20.0%	$12		$10	$2	$12	2024Q1	2.8%	$10	$2	$12
31	CONSTRUCTION MANAGEMENT													
10.0%	Construction Management	$101	$22	22.0%	$123		$101	$22	$123	2024Q1	2.8%	$104	$23	$127
2.0%	Project Operation:	$20	$4	22.0%	$24		$20	$4	$24	2024Q1	2.8%	$21	$5	$25
2.5%	Project Management	$25	$6	22.0%	$31		$25	$6	$31	2024Q1	2.8%	$26	$6	$31
	CONTRACT COST TOTALS:	$1,382	$390		$1,772		$1,382	$390	**$1,772**			$1,435	$406	**$1,841**

Filename: GUC Section 14 ATR Updated TPCS October 2022 rev 04.xlsx
TPCS

Risk Register

Abbreviated Risk Analysis

Greenville Utilities Section 14
Feasibility (Recommended Plan)

Meeting Date: 19-Jul-22

PDT Members
Note: PDT involvement is commensurate with project size and involvement.

Represents	Name
Project Management:	Jason Glazener
Planner:	Jason Glazener
Study Manager:	NAME
Contracting:	NAME
Real Estate:	Samantha Kelly
Relocations:	NAME
OTHER:	NAME
Engineering & Design:	Steven Stello
Technical Lead:	Wes Brown
Geotech:	Name
H&H	Wes Brown
Civil:	NAME
Structural:	NAME
Mechanical:	NAME
Electrical:	NAME
Cost Engineering:	Matthew Shropshire
Construction:	NAME
Operations:	NAME
Environmental:	Justin Bashaw
VE	NAME
Sponsor:	Anthony Whitehead
DOT & PF Sponsor	NAME
OTHER:	NAME
OTHER:	NAME
OTHER:	NAME
	NAME

Greenville Utilities Section 14 Recommended Plan

Feasibility (Recommended Plan)

Abbreviated Risk Analysis

Meeting Date: 19-Jul-22

Risk Level

	Negligible	Marginal	Moderate	Significant	Critical
Very Likely	2	3	4	5	5
Likely	1	2	3	4	5
Possible	0	1	2	3	4
Unlikely	0	0	1	2	3

Risk Register

Use/ View	Risk Element	Feature of Work	Concerns	PDT Discussions & Conclusions (Include logic & justification for choice of Likelihood & Impact)	Impact	Likelihood	Risk Level
	Project Management & Scope Growth					Maximum Project Growth	40%
Yes	PS-1	Mobilization and Demobilization	• Potential for scope growth, added features and quantities? • Investigations sufficient to support design assumptions?	Possible scope growth due to changing site conditions, would have marginal impact to the type of equipment used for this project.	Marginal	Possible	1
Yes	PS-2	Site Supervision	• Potential for scope growth, added features and quantities? • Investigations sufficient to support design assumptions?	Possible Scope growth. Scope growth here would typically occur due to changing site conditions, which could have an effect on the site supervision.	Marginal	Possible	1
Yes	PS-3	Earthwork	• Potential for scope growth, added features and quantities? • Investigations sufficient to support design assumptions? • Design confidence?	Possible Scope growth. Scope growth here would typically occur due to changing site conditions.	Marginal	Possible	1
Yes	PS-13	Planning, Engineering, & Design	• Potential for scope growth, added features and quantities?	Possible that some design effort may need to be re-touched prior to construction increasing and/or prolonged construction duration due to weather/river condition affecting construction.	Marginal	Likely	2
Yes	PS-14	Construction Management	• Potential for scope growth, added features and quantities?	Possible that some design effort may need to be re-touched after contract award based on new information provided in survey, increasing need for engineering during construction.	Marginal	Likely	2

	Acquisition Strategy				**Maximum Project Growth**		**30%**
Yes	AS-1	Mobilization and Demobilization	• Limited bid competition anticipated? • Veteran owned or small business likely?	Potential for small business contracting or lack of bids could lead to increased costs.	Marginal	Likely	2
Yes	AS-2	Site Supervision	• Limited bid competition anticipated? • Veteran owned or small business likely?	Potential for small business contracting or lack of bids could lead to increased costs.	Marginal	Likely	2
Yes	AS-3	Earthwork	• Limited bid competition anticipated? • Veteran owned or small business likely?	Potential for small business contracting, leading to increased costs.	Marginal	Likely	2
Yes	AS-13	Planning, Engineering, & Design	N/A	Anticipate no impact to the cost of the project.	Negligible	Unlikely	0
Yes	AS-14	Construction Management	N/A	Anticipate no impact to the cost of the project.	Negligible	Unlikely	0

	Construction Elements				**Maximum Project Growth**		**15%**
Yes	CON-1	Mobilization and Demobilization	• Accelerated schedule or harsh weather schedule?	Multiple times for equipment removal due to high water at the site.	Marginal	Possible	1
Yes	CE-2	Site Supervision	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims? • High risk or complex construction elements, site access, in-water?	Construction time frame is from Oct 1 to Feb 1 for this location. High water is not assumed, but does happen during this time period. This could have an effect on total project duration and	Moderate	Possible	2
Yes	CE-3	Earthwork	• Accelerated schedule or harsh weather schedule? • Potential for construction modification and claims? • High risk or complex construction elements, site access, in-water?	Construction time frame is from Oct 1 to Feb 1 for this location. High water is not assumed, but does happen during this time period. This could have an effect on total project duration and	Moderate	Likely	3
Yes	CE-13	Planning, Engineering, & Design		N/A	Negligible	Unlikely	0
Yes	CE-14	Construction Management		Slowed working conditions could push schedule and cause delays, increasing CM costs.	Marginal	Possible	1

	Specialty Construction or Fabrication				**Maximum Project Growth**		**50%**
Yes	SC-1	Mobilization and Demobilization	N/A	N/A	Negligible	Unlikely	0
Yes	SC-2	Site Supervision	N/A	N/A	Negligible	Unlikely	0
Yes	SC-3	Earthwork	N/A	N/A	Negligible	Unlikely	0
Yes	SC-13	Planning, Engineering, & Design	N/A	N/A	Negligible	Unlikely	0
Yes	SC-14	Construction Management	N/A	N/A	Negligible	Unlikely	0
	Technical Design & Quantities				**Maximum Project Growth**		**20%**
Yes	T-1	Mobilization and Demobilization	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	Quantities well defined per current site conditions. However, design and quantities largely based on site investigation. Actual site condition could vary from this lesser resolution of detail regarding existing slope conditions.	Negligible	Possible	0
Yes	T-2	Site Supervision	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	Quantities well defined per current site conditions. However, design and quantities largely based on site investigation. Actual site condition could vary from this lesser resolution of detail regarding existing slope conditions.	Marginal	Likely	2
Yes	T-3	Earthwork	• Level of confidence based on design and assumptions? • Sufficient investigations to develop quantities?	Quantities well defined per current site conditions. However, design and quantities largely based on site investigation. Actual site condition could vary from this lesser resolution of detail regarding existing slope conditions.	Marginal	Likely	2
Yes	T-13	Planning, Engineering, & Design			Negligible	Unlikely	0
Yes	T-14	Construction Management			Marginal	Unlikely	0

	Cost Estimate Assumptions				Maximum Project Growth		**25%**
Yes	EST-1	Mobilization and Demobilization	• Site accessibility, transport delays, congestion?	Due to the site conditions and traffic flow from land to the placement embankment there could be delays and congestion during construction.	Marginal	Possible	**1**
Yes	EST-2	Site Supervision	• Reliability and number of key quotes? • Assumptions regarding crew, productivity, overtime?	Currently assumes three person supervision, but could be two people dual hatted for a cost savings. However if strong floods occur during the construction time frame it could lead to need to work overtime to hit the finish date.	Marginal	Possible	**1**
Yes	EST-3	Earthwork	• Assumptions regarding crew, productivity, overtime? • Reliability and number of key quotes?	Reliable quotes have been obtained from suppliers. Productivity rates and construction methods have been discussed with the PDT and used to establish cost estimate, but actual methods and productivity may vary from what was assumed. Cost concerns due to inflation, material and labor costs, fuel costs, and post covid concerns.	Marginal	Likely	**2**
Yes	EST-13	Planning, Engineering, & Design	• Lack confidence on critical cost items?	E&D amounts estimated as a % of Construction Contract amounts per PDT input. Actual costs and % are unlikely to vary marginally.	Marginal	Likely	**2**
Yes	EST-14	Construction Management	• Lack confidence on critical cost items?	S&A amounts estimated as a % of Construction Contract amounts per PDT input. Actual costs and % are unlikely to vary marginally.	Marginal	Likely	**2**
	External Project Risks				Maximum Project Growth		**20%**
Yes	EX-1	Mobilization and Demobilization	• Political influences, lack of support, obstacles? • Unanticipated inflations in fuel, key materials?	In a time of varying inflation and fuel prices, could impact mobilization and demobilization.	Marginal	Possible	**1**
Yes	EX-2	Site Supervision	• Political influences, lack of support, obstacles?	Inability of non-federal sponsor to obtain funds could result in delays and/or added costs to project. Depending on when the study and design would be completed could impact the award and construction start. Given the construction window, it could impact the project.	Moderate	Possible	**2**
Yes	EX-3	Earthwork	• Political influences, lack of support, obstacles?	Inability of non-federal sponsor to obtain funds could result in delays and/or added costs to project. Depending on when the study and design would be completed could impact the award and construction start. Given the construction window, it could impact the project.	Moderate	Possible	**2**
Yes	EX-13	Planning, Engineering, & Design	• Political influences, lack of support, obstacles?	Inability of non-federal sponsor to obtain funds could result in delays and/or added costs to project.	Marginal	Possible	**1**
Yes	EX-14	Construction Management	• Political influences, lack of support, obstacles?	Inability of non-federal sponsor to obtain funds could result in delays and/or added costs to project.	Marginal	Possible	**1**

Abbreviated Risk Analysis

Project (less than $40M): **Greenville Utilities Section 14**
Project Development Stage/Alternative: **Feasibility (Recommended Plan)**
Risk Category: **Low Risk: Typical Construction, Simple**

Alternative: **Recommended Plan**
Meeting Date: **7/19/2022**

Total Estimated Construction Contract Cost = $ 1,007,952

	CWWBS	Feature of Work	Estimated Cost		% Contingency	$ Contingency	Total
	01 LANDS AND DAMAGES	Real Estate	$ -		25%	$ -	$ -
1	16 BANK STABILIZATION	Mobilization and Demobilization	$ 69,983		23%	$ 16,381	$ 86,364
2	16 BANK STABILIZATION	Site Supervision	$ 342,134		29%	$ 100,760	$ 442,894
3	16 BANK STABILIZATION	Earthwork	$ 595,835		33%	$ 198,378	$ 794,213
4			$ -		0%	$ -	$ -
5			$ -		0%	$ -	$ -
6			$ -		0%	$ -	$ -
7			$ -		0%	$ -	$ -
8			$ -		0%	$ -	$ -
9			$ -		0%	$ -	$ -
10			$ -		0%	$ -	$ -
11			$ -		0%	$ -	$ -
12	All Other	**Remaining Construction Items**	$ -	*0.0%*	0%	$ -	$ -
13	30 PLANNING, ENGINEERING, AND DESIGN	**Planning, Engineering, & Design**	$ 227,000		20%	$ 44,987	$ 271,987
14	31 CONSTRUCTION MANAGEMENT	**Construction Management**	$ 146,000		22%	$ 31,444	$ 177,444
XX	FIXED DOLLAR RISK ADD (EQUALLY DISPERSED TO ALL, MUST INCLUDE JUSTIFICATION SEE BELOW)					$ -	

Totals				
Real Estate	$ -	0%	$ -	$ -
Total Construction Estimate	$ 1,007,952	31%	$ 315,518	$ 1,323,470
Total Planning, Engineering & Design	$ 227,000	20%	$ 44,987	$ 271,987
Total Construction Management	$ 146,000	22%	$ 31,444	$ 177,444
Total Excluding Real Estate	**$ 1,380,952**	**28%**	**$ 391,948**	**$ 1,772,900**

	Base	**50%**	**80%**
Confidence Level Range Estimate ($000's)	$1,381k	$1,616k	$1,773k

* 50% based on base is at 5% CL.

Fixed Dollar Risk Add: (Allows for additional risk to be added to the risk analsyis. Must include justification. Does not allocate to Real Estate.	

MII Cost Summary

GUC Section 14 Selected Alternative Estimate 27 Sept 2022 ATR Review
Project: Greenville Utilities Commission Section 14
Project Description: This estimate includes the selected ROM for proposed solution to the erosion issues at the Greenville Utilities Commission water treatment plant. Overall scope is to fix slipping and stop erosion over approximately 280 LF of riverbank.

Location: Greenville, NC

Assumptions:

Sales Tax – 7%
Market/Covid Labor Markups – 5%
Market/Covid Labor Markups – 10%
Escalation – Assume project will start within one year of estimate, 3% escalation applied
Contingency – Assumes 15% contingency on oversite and mobilization/demobilization and 50% contingency for earthwork and construction due to the lack of detail and early design.
Acquisition Strategy – Project does not have a defined acquisition strategy, but in the past such efforts have been completed with small business contractors. Applied a 25% markup to cover unknown strategy.
Project Duration – Duration Varies between each alternative, ranges from 3 to 6 months.

Contractor Markups:
JOOH – Calculated, varies between alternatives ranges from 6% - 10%.
HOOH – 10%
Profit – 10%
Bond – Class B

Estimated by Matthew Shropshire
Designed by Steve Stello
Prepared by Matthew Shropshire

Preparation Date 10/7/2022
Effective Date of Pricing 10/7/2022
Estimated Construction Time Days

Description	Page

Description	UOM	Quantity	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	ContractCost	ProjectCost
Detail View			**249,243.64**	**113,823.79**	**170,080.33**	**40,000.00**	**916,319.90**	**1,007,951.89**
Alternative 2 - Rip Rap	**LS**	**1.0000**	**249,243.64**	**113,823.79**	**170,080.33**	**40,000.00**	**916,319.90**	**1,007,951.89**
			0.0000	*0.0000*	*0.0000*	*40,000.0000*	*63,621.1813*	*69,983.2994*
Mob/Demob	**EA**	**1.0000**	**0.00**	**0.00**	**0.00**	**40,000.00**	**63,621.18**	**69,983.30**
Prime Mob/Demob	LS	1.0000	0.00	0.00	0.00	10,000.00	13,533.63	14,887.00
(Note: Assume 5% of prime cost ~$10k.)								
Sub Mob/Demob	LS	1.0000	0.00	0.00	0.00	30,000.00	50,087.55	55,096.30
(Note: Assume 5% of sub cost ~$30k.)								
			66,515.7281	*3,055.9460*	*0.0000*	*0.0000*	*103,676.8965*	*114,044.5861*
Site Supervision	**MO**	**3.0000**	**199,547.18**	**9,167.84**	**0.00**	**0.00**	**311,030.69**	**342,133.76**
			37,629.0053	*1,833.5676*	*0.0000*	*0.0000*	*53,407.1934*	*58,747.9127*
Prime Oversite Crew	MO	3.0000	112,887.02	5,500.70	0.00	0.00	160,221.58	176,243.74
(Note: Assume 3 months duration)								
			28,886.7228	*1,222.3784*	*0.0000*	*0.0000*	*50,269.7031*	*55,296.6734*
Sub Oversite Crew	MO	3.0000	86,660.17	3,667.14	0.00	0.00	150,809.11	165,890.02
			49,696.4606	*104,655.9537*	*170,080.3253*	*0.0000*	*541,668.0293*	*595,834.8322*
Earthwork	**EA**	**1.0000**	**49,696.46**	**104,655.95**	**170,080.33**	**0.00**	**541,668.03**	**595,834.83**
			4,318.5976	*14,089.5352*	*311.9050*	*0.0000*	*31,254.6940*	*34,380.1634*
Excavation	**BCY**	**1.0000**	**4,318.60**	**14,089.54**	**311.91**	**0.00**	**31,254.69**	**34,380.16**
			2.2403	*3.1061*	*0.0000*	*0.0000*	*8.9263*	*9.8189*
Excavate and load, bank measure, wet material, 2 C.Y. bucket, hydraulic excavator	BCY	750.0000	1,680.23	2,329.57	0.00	0.00	6,694.70	7,364.17
(Note: From PDT notes Assume 750 CY.)								
			0.7071	*2.9566*	*0.0000*	*0.0000*	*6.1168*	*6.7284*
Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 C.Y. truck, cycle 1 mile, 15 MPH, excludes loading equipment	LCY	862.5000	609.86	2,550.03	0.00	0.00	5,275.70	5,803.27
(Note: Material Assumed to be hauled on site to a suitable dump location. A 15% swell factor applied to convert from BCY.)								
			0.6395	*0.0187*	*0.6238*	*0.0000*	*2.1404*	*2.3544*
Synthetic erosion control, silt fence, install and maintain, remove, 3' high	LF	500.0000	319.74	9.34	311.91	0.00	1,070.18	1,177.20
(Note: Assume 500 LF needed.)								
			1.0697	*8.6326*	*0.0000*	*0.0000*	*16.1988*	*17.8187*
Rough grading, open site, large area, 300 H.P., dozer	BCY	750.0000	802.26	6,474.45	0.00	0.00	12,149.09	13,364.00

Description	UOM	Quantity	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	ContractCost	ProjectCost
(Note: Crew out put lowered to be adjusted to the overall duration of the excavated material.)								
			1,813.0241	*5,452.2816*	*0.0000*	*0.0000*	*12,130.0453*	*13,343.0498*
Clearing & grubbing, dense brush, including stumps, clear and grub	ACR	0.5000	906.51	2,726.14	0.00	0.00	6,065.02	6,671.52
(Note: Assume 0.5 Acres of brush grubbing over 305 LF by aprox 55 ft..)								
			15.5422	*35.9727*	*71.6456*	*0.0000*	*205.6269*	*226.1896*
Stone Placement	**CY**	**2,260.0000**	**35,125.46**	**81,298.24**	**161,919.01**	**0.00**	**464,716.80**	**511,188.48**
			1.5713	*6.5701*	*0.0000*	*0.0000*	*13.5928*	*14.9521*
Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 30 min load/wait/unload, 20 C.Y. truck, cycle 20 miles, 50 MPH, excludes loading equipment	LCY	3,390.0000	5,326.69	22,272.70	0.00	0.00	46,079.53	50,687.48
(Note: Hauling needed to deliever stone to site and store. Qty needed is 2260 CY * 1.5 = 3390 LCY.)								
			4.0080	*4.7897*	*44.7260*	*0.0000*	*89.3624*	*98.2987*
Rip Rap Placement	TON	3,250.0000	13,026.03	15,566.60	145,359.50	0.00	290,427.87	319,470.66
(Note: Price Obatained from Matin Marietta on 1 April 2022 at $38/ton (not delivered) for Class 2 Rip Rap. Producivity Assumes 20 tons/hour. Assume 1.25 tons of rip rap for 1 CY. Qty needed is 2260 CY * 1.25 = 2250 + 15% for w/l = 3250 tons. Quantity assumed from "Quantities Updated 22 June 2022.pdf",)								
			0.2357	*0.0000*	*5.9674*	*0.0000*	*10.3566*	*11.3922*
Geosynthetic soil stabilization, geotextile fabric, woven, heavy duty, 600 lb. tensile strength	SY	2,775.0000	654.05	0.00	16,559.51	0.00	28,739.50	31,613.45
(Note: Given 19,200 SF based on given qtys from "Quantity assumed from "Quantities Updated 22 June 2022.pdf", converted to 2,134 SY assume 30% more for overlap and waste loss gives 2,134 * 1.3 = 2775 SY)								
			1.7677	*7.3914*	*0.0000*	*0.0000*	*15.2919*	*16.8211*
Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 C.Y. truck, cycle 1 mile, 15 MPH, excludes loading equipment	LCY	3,390.0000	5,992.52	25,056.79	0.00	0.00	51,839.47	57,023.41
(Note: Hauling for site stockpile to final placement location. Crew out put adjust to reflect placment duration.)								
			4.4806	*8.1425*	*0.0000*	*0.0000*	*21.0754*	*23.1830*
Excavate and load, bank measure, blasted rock, 2 C.Y. bucket, hydraulic excavator	BCY	2,260.0000	10,126.17	18,402.13	0.00	0.00	47,630.44	52,393.48
(Note: Crew to place rock from stockpile and load to transport truck to placement. Out put adjusted to be similar to total placement time duration.)								
Final Grade and Seed	**LS**	**1.0000**	**8,940.17**	**6,280.42**	**1,677.23**	**0.00**	**28,212.33**	**31,033.56**
			1.6949	*0.4146*	*0.4473*	*0.0000*	*4.2687*	*4.6956*
Seeding, mechanical seeding, fine grading and seeding, with equipment, includes lime, fertilizer & seed	SY	3,750.0000	6,355.78	1,554.87	1,677.23	0.00	16,007.77	17,608.55
(Note: Assume 3000 SY + 25% for w/l.)								

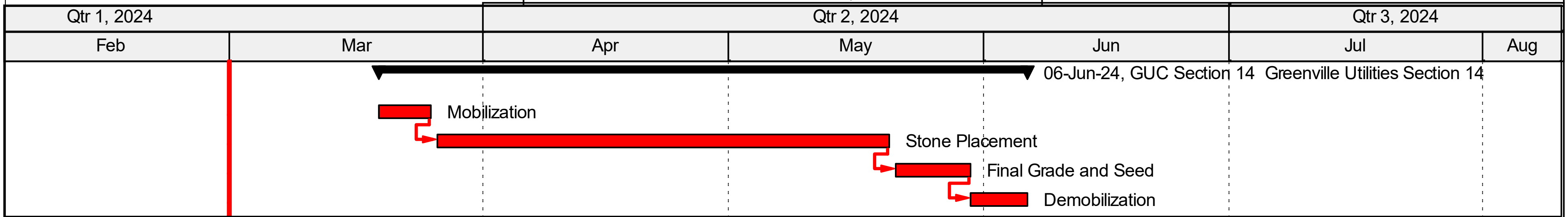
Description	UOM	Quantity	DirectLabor	DirectEQ	DirectMatl	DirectSubBid	ContractCost	ProjectCost
			0.8615	*1.5752*	*0.0000*	*0.0000*	*4.0682*	*4.4750*
Fine grading, fine grade for small irregular areas, to 15,000 S.Y.	SY	3,000.0000	2,584.38	4,725.55	0.00	0.00	12,204.55	13,425.01
(Note: Assume 3000 SY)								
			16.4029	*37.3471*	*77.1524*	*0.0000*	*218.5526*	*240.4078*
Temporary Bench	**CY**	**80.0000**	**1,312.23**	**2,987.77**	**6,172.19**	**0.00**	**17,484.21**	**19,232.63**
(Note: Assume stone placement for a excavtor, that extends past the base placement for benching. Fills in 6' h x 11' L triangle over a width of 14'. Area = (0.5*6*11) * 14 = 462 CF = 17.2 CY. Assume an extra 15% for Waste/loss = 20 CY for each bench. Assuming possibly 4 locations needed. for a total of 80 CY.)								
			1.5713	*6.5701*	*0.0000*	*0.0000*	*13.5928*	*14.9521*
Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 30 min load/wait/unload, 20 C.Y. truck, cycle 20 miles, 50 MPH, excludes loading equipment	LCY	120.0000	188.56	788.41	0.00	0.00	1,631.13	1,794.25
(Note: Hauling needed to deliever stone to site and store. Qty needed is 80 CY * 1.5 = 120 LCY.)								
			4.0080	*4.7897*	*44.7260*	*0.0000*	*89.3624*	*98.2987*
Rip Rap Placement	TON	138.0000	553.11	660.98	6,172.19	0.00	12,332.01	13,565.22
(Note: Price Obatained from Matin Marietta on 1 April 2022 at $38/ton (not delivered) for Class 2 Rip Rap. Producivity Assumes 20 tons/hour. Assume 1.25 tons of rip rap for 1 CY. Qty needed is 80 CY * 1.25 = 120 + 15% for w/l = 138 tons.)								
			1.7677	*7.3914*	*0.0000*	*0.0000*	*15.2919*	*16.8211*
Cycle hauling(wait, load, travel, unload or dump & return) time per cycle, excavated or borrow, loose cubic yards, 20 min load/wait/unload, 20 C.Y. truck, cycle 1 mile, 15 MPH, excludes loading equipment	LCY	120.0000	212.12	886.97	0.00	0.00	1,835.03	2,018.53
(Note: Hauling for site stockpile to final placement location. Crew out put adjust to reflect placment duration.)								
			4.4806	*8.1425*	*0.0000*	*0.0000*	*21.0754*	*23.1830*
Excavate and load, bank measure, blasted rock, 2 C.Y. bucket, hydraulic excavator	BCY	80.0000	358.45	651.40	0.00	0.00	1,686.03	1,854.64
(Note: Crew to place rock from stockpile and load to transport truck to placement. Out put adjusted to be similar to total placement time duration.)								

Construction Schedule

Activity ID	Activity Name	Original Duration	Remaining Duration	Schedule % Complete	Start	Finish	Total Float	Qtr 1, 2024 Jan
GUC Section 14	**Greenville Utilities Section 14**	58	58	0%	19-Mar-24	06-Jun-24	0	
A1000	Mobilization	5	5	0%	19-Mar-24*	25-Mar-24	0	
A1010	Stone Placement	40	40	0%	26-Mar-24	20-May-24	0	
A1020	Final Grade and Seed	8	8	0%	21-May-24	30-May-24	0	
A1030	Demobilization	5	5	0%	30-May-24	06-Jun-24	0	

Actual Level of Effort
Remaining Work
Actual Work
Critical Remainin...

TASK filter: All Activities



Actual Level of Effort
Remaining Work
Actual Work
Critical Remainin...

TASK filter: All Activities

Cost Certification

WALLA WALLA COST ENGINEERING MANDATORY CENTER OF EXPERTISE

COST AGENCY TECHNICAL REVIEW CERTIFICATION STATEMENT

For Project No. 495966

SAW – Greenville Utilities Commission Section 14
Emergency Streambank and Shoreline Erosion

The Greenville Utilities Commission Section 14 – Emergency Streambank and Shoreline Erosion as presented by Wilmington District, has undergone a successful Cost Agency Technical Review (Cost ATR), performed by the Walla Walla District Cost Engineering Mandatory Center of Expertise (Cost MCX) team. The Cost ATR included study of the project scope, report, cost estimates, schedules, escalation, and risk-based contingencies. This certification signifies the products meet the quality standards as prescribed in ER 1110-2-1150 Engineering and Design for Civil Works Projects and ER 1110-2-1302 Civil Works Cost Engineering.

As of October 20, 2022, the Cost MCX certifies the estimated total project cost:

FY23 Project First Cost:	$1,772,000
Fully Funded Total Project Cost:	$1,841,000
Federal Cost of Project:	$1,321,000

It remains the responsibility of the District to correctly reflect these cost values within the Final Report and to implement effective project management controls and implementation procedures including risk management through the period of Federal participation.

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Michael P. Jacobs, PE, CCE
Chief, Cost Engineering MCX
Walla Walla District

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Raleigh Ecological Services Field Office
Post Office Box 33726
Raleigh, NC 27636-3726
Phone: (919) 856-4520 Fax: (919) 856-4556

In Reply Refer To: September 08, 2022
Project Code: 2022-0083530
Project Name: GREENVILLE UTILITIES COMMISSION, EMERGENCY STREAMBANK AND SHORELINE EROSION PROTECTION PROJECT

Subject: List of threatened and endangered species that may occur in your proposed project location or may be affected by your proposed project

To Whom It May Concern:

The enclosed species list identifies threatened, endangered, proposed and candidate species, as well as proposed and final designated critical habitat, that may occur within the boundary of your proposed project and/or may be affected by your proposed project. The species list fulfills the requirements of the U.S. Fish and Wildlife Service (Service) under section 7(c) of the Endangered Species Act (Act) of 1973, as amended (16 U.S.C. 1531 *et seq.*). If your project area contains suitable habitat for any of the federally-listed species on this species list, the proposed action has the potential to adversely affect those species. If suitable habitat is present, surveys should be conducted to determine the species' presence or absence within the project area. The use of this species list and/or North Carolina Natural Heritage program data should not be substituted for actual field surveys.

New information based on updated surveys, changes in the abundance and distribution of species, changed habitat conditions, or other factors could change this list. Please feel free to contact us if you need more current information or assistance regarding the potential impacts to federally proposed, listed, and candidate species and federally designated and proposed critical habitat. Please note that under 50 CFR 402.12(e) of the regulations implementing section 7 of the Act, the accuracy of this species list should be verified after 90 days. This verification can be completed formally or informally as desired. The Service recommends that verification be completed by visiting the ECOS-IPaC website at regular intervals during project planning and implementation for updates to species lists and information. An updated list may be requested through the ECOS-IPaC system by completing the same process used to receive the enclosed list.

The purpose of the Act is to provide a means whereby threatened and endangered species and the ecosystems upon which they depend may be conserved. Under sections 7(a)(1) and 7(a)(2) of the Act and its implementing regulations (50 CFR 402 *et seq.*), Federal agencies are required to utilize their authorities to carry out programs for the conservation of threatened and endangered species and to determine whether projects may affect threatened and endangered species and/or designated critical habitat.

A Biological Assessment is required for construction projects (or other undertakings having similar physical impacts) that are major Federal actions significantly affecting the quality of the human environment as defined in the National Environmental Policy Act (42 U.S.C. 4332(2)(c)). For projects other than major construction activities, the Service suggests that a biological evaluation similar to a Biological Assessment be prepared to determine whether the project may affect listed or proposed species and/or designated or proposed critical habitat. Recommended contents of a Biological Assessment are described at 50 CFR 402.12.

If a Federal agency determines, based on the Biological Assessment or biological evaluation, that listed species and/or designated critical habitat may be affected by the proposed project, the agency is required to consult with the Service pursuant to 50 CFR 402. In addition, the Service recommends that candidate species, proposed species and proposed critical habitat be addressed within the consultation. More information on the regulations and procedures for section 7 consultation, including the role of permit or license applicants, can be found in the "Endangered Species Consultation Handbook" at:

http://www.fws.gov/endangered/esa-library/pdf/TOC-GLOS.PDF

Migratory Birds: In addition to responsibilities to protect threatened and endangered species under the Endangered Species Act (ESA), there are additional responsibilities under the Migratory Bird Treaty Act (MBTA) and the Bald and Golden Eagle Protection Act (BGEPA) to protect native birds from project-related impacts. Any activity, intentional or unintentional, resulting in take of migratory birds, including eagles, is prohibited unless otherwise permitted by the U.S. Fish and Wildlife Service (50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)). For more information regarding these Acts see https://www.fws.gov/birds/policies-and-regulations.php.

The MBTA has no provision for allowing take of migratory birds that may be unintentionally killed or injured by otherwise lawful activities. It is the responsibility of the project proponent to comply with these Acts by identifying potential impacts to migratory birds and eagles within applicable NEPA documents (when there is a federal nexus) or a Bird/Eagle Conservation Plan (when there is no federal nexus). Proponents should implement conservation measures to avoid or minimize the production of project-related stressors or minimize the exposure of birds and their resources to the project-related stressors. For more information on avian stressors and recommended conservation measures see https://www.fws.gov/birds/bird-enthusiasts/threats-to-birds.php.

In addition to MBTA and BGEPA, Executive Order 13186: *Responsibilities of Federal Agencies to Protect Migratory Birds*, obligates all Federal agencies that engage in or authorize activities that might affect migratory birds, to minimize those effects and encourage conservation measures that will improve bird populations. Executive Order 13186 provides for the protection of both migratory birds and migratory bird habitat. For information regarding the implementation of Executive Order 13186, please visit https://www.fws.gov/birds/policies-and-regulations/executive-orders/e0-13186.php.

We appreciate your concern for threatened and endangered species. The Service encourages Federal agencies to include conservation of threatened and endangered species into their project planning to further the purposes of the Act. Please include the Consultation Code in the header of this letter with any request for consultation or correspondence about your project that you submit to our office.

Attachment(s):

- Official Species List
- Migratory Birds
- Marine Mammals

Official Species List

This list is provided pursuant to Section 7 of the Endangered Species Act, and fulfills the requirement for Federal agencies to "request of the Secretary of the Interior information whether any species which is listed or proposed to be listed may be present in the area of a proposed action".

This species list is provided by:

Raleigh Ecological Services Field Office
Post Office Box 33726
Raleigh, NC 27636-3726
(919) 856-4520

Project Summary

Project Code:	2022-0083530
Project Name:	GREENVILLE UTILITIES COMMISSION, EMERGENCY STREAMBANK AND SHORELINE EROSION PROTECTION PROJECT
Project Type:	Water Supply Pipeline - Maintenance/Modification - Above Ground
Project Description:	Repair and stabilization of the riverbank at the water intakes on the Tar River is needed to prevent potential collapse of the riverbank and damage to the water intake pipes and intake structure and prevent loss of water supply. The current condition the riverbank is too unstable to allow safe access to maintenance equipment to clear debris and sediment from the water intakes.

Project Location:

Approximate location of the project can be viewed in Google Maps: https://www.google.com/maps/@35.6388479,-77.39973705631249,14z

Counties: Pitt County, North Carolina

Endangered Species Act Species

There is a total of 6 threatened, endangered, or candidate species on this species list.

Species on this list should be considered in an effects analysis for your project and could include species that exist in another geographic area. For example, certain fish may appear on the species list because a project could affect downstream species.

IPaC does not display listed species or critical habitats under the sole jurisdiction of NOAA Fisheries[1], as USFWS does not have the authority to speak on behalf of NOAA and the Department of Commerce.

See the "Critical habitats" section below for those critical habitats that lie wholly or partially within your project area under this office's jurisdiction. Please contact the designated FWS office if you have questions.

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1. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

Mammals

NAME	STATUS
West Indian Manatee *Trichechus manatus* There is **final** critical habitat for this species. The location of the critical habitat is not available. ***This species is also protected by the Marine Mammal Protection Act, and may have additional consultation requirements.*** Species profile: https://ecos.fws.gov/ecp/species/4469	Threatened

Reptiles

NAME	STATUS
American Alligator *Alligator mississippiensis* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/776	Similarity of Appearance (Threatened)

Amphibians

NAME	STATUS
Neuse River Waterdog *Necturus lewisi* There is **final** critical habitat for this species. Your location overlaps the critical habitat. Species profile: https://ecos.fws.gov/ecp/species/6772	Threatened

Clams

NAME	STATUS
Atlantic Pigtoe *Fusconaia masoni* There is **final** critical habitat for this species. The location of the critical habitat is not available. Species profile: https://ecos.fws.gov/ecp/species/5164	Threatened
Tar River Spinymussel *Parvaspina steinstansana* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/1392	Endangered

Insects

NAME	STATUS
Monarch Butterfly *Danaus plexippus* No critical habitat has been designated for this species. Species profile: https://ecos.fws.gov/ecp/species/9743	Candidate

Critical habitats

There is 1 critical habitat wholly or partially within your project area under this office's jurisdiction.

NAME	STATUS
Neuse River Waterdog *Necturus lewisi* https://ecos.fws.gov/ecp/species/6772#crithab	Final

Migratory Birds

Certain birds are protected under the Migratory Bird Treaty Act[1] and the Bald and Golden Eagle Protection Act[2].

Any person or organization who plans or conducts activities that may result in impacts to migratory birds, eagles, and their habitats should follow appropriate regulations and consider implementing appropriate conservation measures, as described below.

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1. The Migratory Birds Treaty Act of 1918.
2. The Bald and Golden Eagle Protection Act of 1940.
3. 50 C.F.R. Sec. 10.12 and 16 U.S.C. Sec. 668(a)

The birds listed below are birds of particular concern either because they occur on the USFWS Birds of Conservation Concern (BCC) list or warrant special attention in your project location. To learn more about the levels of concern for birds on your list and how this list is generated, see the FAQ below. This is not a list of every bird you may find in this location, nor a guarantee that every bird on this list will be found in your project area. To see exact locations of where birders and the general public have sighted birds in and around your project area, visit the E-bird data mapping tool (Tip: enter your location, desired date range and a species on your list). For projects that occur off the Atlantic Coast, additional maps and models detailing the relative occurrence and abundance of bird species on your list are available. Links to additional information about Atlantic Coast birds, and other important information about your migratory bird list, including how to properly interpret and use your migratory bird report, can be found below.

For guidance on when to schedule activities or implement avoidance and minimization measures to reduce impacts to migratory birds on your list, click on the PROBABILITY OF PRESENCE SUMMARY at the top of your list to see when these birds are most likely to be present and breeding in your project area.

NAME	BREEDING SEASON
American Kestrel *Falco sparverius paulus* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA https://ecos.fws.gov/ecp/species/9587	Breeds Apr 1 to Aug 31
Bald Eagle *Haliaeetus leucocephalus* This is not a Bird of Conservation Concern (BCC) in this area, but warrants attention because of the Eagle Act or for potential susceptibilities in offshore areas from certain types of development or activities. https://ecos.fws.gov/ecp/species/1626	Breeds Sep 1 to Jul 31

NAME	BREEDING SEASON
Brown-headed Nuthatch *Sitta pusilla* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds Mar 1 to Jul 15
Cerulean Warbler *Dendroica cerulea* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/2974	Breeds Apr 26 to Jul 20
Chimney Swift *Chaetura pelagica* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Mar 15 to Aug 25
Lesser Yellowlegs *Tringa flavipes* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9679	Breeds elsewhere
Prairie Warbler *Dendroica discolor* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 1 to Jul 31
Prothonotary Warbler *Protonotaria citrea* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds Apr 1 to Jul 31
Red-headed Woodpecker *Melanerpes erythrocephalus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Sep 10
Rusty Blackbird *Euphagus carolinus* This is a Bird of Conservation Concern (BCC) only in particular Bird Conservation Regions (BCRs) in the continental USA	Breeds elsewhere
Short-billed Dowitcher *Limnodromus griseus* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska. https://ecos.fws.gov/ecp/species/9480	Breeds elsewhere
Wood Thrush *Hylocichla mustelina* This is a Bird of Conservation Concern (BCC) throughout its range in the continental USA and Alaska.	Breeds May 10 to Aug 31

Probability Of Presence Summary

The graphs below provide our best understanding of when birds of concern are most likely to be present in your project area. This information can be used to tailor and schedule your project activities to avoid or minimize impacts to birds. Please make sure you read and understand the FAQ "Proper Interpretation and Use of Your Migratory Bird Report" before using or attempting to interpret this report.

Probability of Presence (■)

Each green bar represents the bird's relative probability of presence in the 10km grid cell(s) your project overlaps during a particular week of the year. (A year is represented as 12 4-week months.) A taller bar indicates a higher probability of species presence. The survey effort (see below) can be used to establish a level of confidence in the presence score. One can have higher confidence in the presence score if the corresponding survey effort is also high.

How is the probability of presence score calculated? The calculation is done in three steps:

1. The probability of presence for each week is calculated as the number of survey events in the week where the species was detected divided by the total number of survey events for that week. For example, if in week 12 there were 20 survey events and the Spotted Towhee was found in 5 of them, the probability of presence of the Spotted Towhee in week 12 is 0.25.
2. To properly present the pattern of presence across the year, the relative probability of presence is calculated. This is the probability of presence divided by the maximum probability of presence across all weeks. For example, imagine the probability of presence in week 20 for the Spotted Towhee is 0.05, and that the probability of presence at week 12 (0.25) is the maximum of any week of the year. The relative probability of presence on week 12 is 0.25/0.25 = 1; at week 20 it is 0.05/0.25 = 0.2.
3. The relative probability of presence calculated in the previous step undergoes a statistical conversion so that all possible values fall between 0 and 10, inclusive. This is the probability of presence score.

Breeding Season (■)
Yellow bars denote a very liberal estimate of the time-frame inside which the bird breeds across its entire range. If there are no yellow bars shown for a bird, it does not breed in your project area.

Survey Effort (|)
Vertical black lines superimposed on probability of presence bars indicate the number of surveys performed for that species in the 10km grid cell(s) your project area overlaps. The number of surveys is expressed as a range, for example, 33 to 64 surveys.

No Data (–)
A week is marked as having no data if there were no survey events for that week.

Survey Timeframe
Surveys from only the last 10 years are used in order to ensure delivery of currently relevant information. The exception to this is areas off the Atlantic coast, where bird returns are based on all years of available data, since data in these areas is currently much more sparse.

■ probability of presence ■ breeding season | survey effort – no data

Additional information can be found using the following links:

- Birds of Conservation Concern https://www.fws.gov/program/migratory-birds/species
- Measures for avoiding and minimizing impacts to birds https://www.fws.gov/library/collections/avoiding-and-minimizing-incidental-take-migratory-birds
- Nationwide conservation measures for birds https://www.fws.gov/sites/default/files/documents/nationwide-standard-conservation-measures.pdf

Migratory Birds FAQ

Tell me more about conservation measures I can implement to avoid or minimize impacts to migratory birds.

Nationwide Conservation Measures describes measures that can help avoid and minimize impacts to all birds at any location year round. Implementation of these measures is particularly important when birds are most likely to occur in the project area. When birds may be breeding in the area, identifying the locations of any active nests and avoiding their destruction is a very helpful impact minimization measure. To see when birds are most likely to occur and be breeding in your project area, view the Probability of Presence Summary. Additional measures or permits may be advisable depending on the type of activity you are conducting and the type of infrastructure or bird species present on your project site.

What does IPaC use to generate the list of migratory birds that potentially occur in my specified location?

The Migratory Bird Resource List is comprised of USFWS Birds of Conservation Concern (BCC) and other species that may warrant special attention in your project location.

The migratory bird list generated for your project is derived from data provided by the Avian Knowledge Network (AKN). The AKN data is based on a growing collection of survey, banding, and citizen science datasets and is queried and filtered to return a list of those birds reported as occurring in the 10km grid cell(s) which your project intersects, and that have been identified as warranting special attention because they are a BCC species in that area, an eagle (Eagle Act requirements may apply), or a species that has a particular vulnerability to offshore activities or development.

Again, the Migratory Bird Resource list includes only a subset of birds that may occur in your project area. It is not representative of all birds that may occur in your project area. To get a list of all birds potentially present in your project area, please visit the Rapid Avian Information Locator (RAIL) Tool.

What does IPaC use to generate the probability of presence graphs for the migratory birds potentially occurring in my specified location?

The probability of presence graphs associated with your migratory bird list are based on data provided by the Avian Knowledge Network (AKN). This data is derived from a growing collection of survey, banding, and citizen science datasets.

Probability of presence data is continuously being updated as new and better information becomes available. To learn more about how the probability of presence graphs are produced and how to interpret them, go the Probability of Presence Summary and then click on the "Tell me about these graphs" link.

How do I know if a bird is breeding, wintering or migrating in my area?

To see what part of a particular bird's range your project area falls within (i.e. breeding, wintering, migrating or year-round), you may query your location using the RAIL Tool and look at the range maps provided for birds in your area at the bottom of the profiles provided for each bird in your results. If a bird on your migratory bird species list has a breeding season associated with it, if that bird does occur in your project area, there may be nests present at some point within the timeframe specified. If "Breeds elsewhere" is indicated, then the bird likely does not breed in your project area.

What are the levels of concern for migratory birds?
Migratory birds delivered through IPaC fall into the following distinct categories of concern:

1. "BCC Rangewide" birds are Birds of Conservation Concern (BCC) that are of concern throughout their range anywhere within the USA (including Hawaii, the Pacific Islands, Puerto Rico, and the Virgin Islands);
2. "BCC - BCR" birds are BCCs that are of concern only in particular Bird Conservation Regions (BCRs) in the continental USA; and
3. "Non-BCC - Vulnerable" birds are not BCC species in your project area, but appear on your list either because of the Eagle Act requirements (for eagles) or (for non-eagles) potential susceptibilities in offshore areas from certain types of development or activities (e.g. offshore energy development or longline fishing).

Although it is important to try to avoid and minimize impacts to all birds, efforts should be made, in particular, to avoid and minimize impacts to the birds on this list, especially eagles and BCC species of rangewide concern. For more information on conservation measures you can implement to help avoid and minimize migratory bird impacts and requirements for eagles, please see the FAQs for these topics.

Details about birds that are potentially affected by offshore projects
For additional details about the relative occurrence and abundance of both individual bird species and groups of bird species within your project area off the Atlantic Coast, please visit the Northeast Ocean Data Portal. The Portal also offers data and information about other taxa besides birds that may be helpful to you in your project review. Alternately, you may download the bird model results files underlying the portal maps through the NOAA NCCOS Integrative Statistical Modeling and Predictive Mapping of Marine Bird Distributions and Abundance on the Atlantic Outer Continental Shelf project webpage.

Bird tracking data can also provide additional details about occurrence and habitat use throughout the year, including migration. Models relying on survey data may not include this information. For additional information on marine bird tracking data, see the Diving Bird Study and the nanotag studies or contact Caleb Spiegel or Pam Loring.

What if I have eagles on my list?
If your project has the potential to disturb or kill eagles, you may need to obtain a permit to avoid violating the Eagle Act should such impacts occur.

Proper Interpretation and Use of Your Migratory Bird Report
The migratory bird list generated is not a list of all birds in your project area, only a subset of birds of priority concern. To learn more about how your list is generated, and see options for identifying what other birds may be in your project area, please see the FAQ "What does IPaC use to generate the migratory birds potentially occurring in my specified location". Please be aware this report provides the "probability of presence" of birds within the 10 km grid cell(s) that overlap your project; not your exact project footprint. On the graphs provided, please also look carefully at the survey effort (indicated by the black vertical bar) and for the existence of the "no

data" indicator (a red horizontal bar). A high survey effort is the key component. If the survey effort is high, then the probability of presence score can be viewed as more dependable. In contrast, a low survey effort bar or no data bar means a lack of data and, therefore, a lack of certainty about presence of the species. This list is not perfect; it is simply a starting point for identifying what birds of concern have the potential to be in your project area, when they might be there, and if they might be breeding (which means nests might be present). The list helps you know what to look for to confirm presence, and helps guide you in knowing when to implement conservation measures to avoid or minimize potential impacts from your project activities, should presence be confirmed. To learn more about conservation measures, visit the FAQ "Tell me about conservation measures I can implement to avoid or minimize impacts to migratory birds" at the bottom of your migratory bird trust resources page.

Marine Mammals

Marine mammals are protected under the Marine Mammal Protection Act. Some are also protected under the Endangered Species Act[1] and the Convention on International Trade in Endangered Species of Wild Fauna and Flora[2].

The responsibilities for the protection, conservation, and management of marine mammals are shared by the U.S. Fish and Wildlife Service [responsible for otters, walruses, polar bears, manatees, and dugongs] and NOAA Fisheries[3] [responsible for seals, sea lions, whales, dolphins, and porpoises]. Marine mammals under the responsibility of NOAA Fisheries are **not** shown on this list; for additional information on those species please visit the Marine Mammals page of the NOAA Fisheries website.

The Marine Mammal Protection Act prohibits the take of marine mammals and further coordination may be necessary for project evaluation. Please contact the U.S. Fish and Wildlife Service Field Office shown.

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1. The Endangered Species Act (ESA) of 1973.
2. The Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) is a treaty to ensure that international trade in plants and animals does not threaten their survival in the wild.
3. NOAA Fisheries, also known as the National Marine Fisheries Service (NMFS), is an office of the National Oceanic and Atmospheric Administration within the Department of Commerce.

NAME

West Indian Manatee *Trichechus manatus*
Species profile: https://ecos.fws.gov/ecp/species/4469

IPaC User Contact Information

Agency: Army Corps of Engineers
Name: Justin Bashaw
Address: 69 Darlington Avenue
City: Wilmington
State: NC
Zip: 28403
Email justin.p.bashaw@usace.army.mil
Phone: 9102514581