ENHANCING AQUATIC CONNECTIVITY RESILIENCY AND FLOOD CAPACITY IN THE BLACK RIVER WATERSHED

BLADEN AND PENDER COUNTIES, NORTH CAROLINA

NOAA FY 2022 RESTORING FISH PASSAGE THROUGH BARRIER REMOVAL GRANT APPLICATION

PROJECT DESIGNS

SUBMITTED BY:

CAPE FEAR RESOURCE CONSERVATION & DEVELOPMENT

ASSESSING AQUATIC CONNECTIVITY IN THE BLACK RIVER WATERSHED REPORT

Assessing Aquatic Connectivity in the Black River Watershed

M&N Project #10292

Severe barrier on Big Branch in the Black River watershed.

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1. Introduction

The purpose of this report is to summarize the stream crossing assessments, preliminary engineering and conceptual design conducted by Moffatt & Nichol (M&N) for the topmost severe barriers identified for the "Assessing Aquatic Connectivity in the Black River Watershed" project (*M&N Project #10292*). Through the utilization of the Southeast Aquatic Resources Partnership (SARP) Barrier Prioritization Tool (BPT), ten of the most severe barriers were identified out of the 200 culverts and stream crossings surveyed to be evaluated through groundtruthing. These barriers were chosen based on the BPT Score, BPT analysis, and on feedback from state and federal resource agencies, including the NC Wildlife Resource Commission (NCWRC), US Fish and Wildlife Service and National Marine Fisheries Service due to the presence of priority focus streams and listed species in the project area. Five of the ten top severe barriers were then chosen after groundtruthing by M&N water resource engineers to move forward in preliminary engineering and design efforts based on feasibility and need for retrofitting to open stream habitat.

The Cape Fear River Partnership is a combination of many different federal, state, local, academic, and other entities in the region working together towards a comprehensive restoration of the Cape Fear River. Through this partnership came the development of the 5-Year Implementation Plan. A major issue identified are obstructions that block or impede fish passage. A goal of the 5-Year Implementation Plan is to restore access to historic migratory fish habitat. A target of that goal is to have at least five obstructions on tributaries be removed or modified within the five years. As a result, collaboration within the Cape Fear River Partnership and its Dam Removal Subgroup, this proposed pilot project of assessing aquatic connectivity in the Black River Watershed has been developed in coordination also with Cape Fear Resource, Conservation, and Development (CFRC&D), Southeast Aquatic Resources Partnership (SARP), and M&N. The target is to identify up to three to five of the most severe barriers for removal or modification.

This report summarizes the results of barrier identification for the "Assessing Aquatic Connectivity in the Black River Watershed" project. The project consists of three primary components, which include the award of grant funding, the project study area, and the methodology. CFRC&D desires to bring land, water, air, and community together through various initiatives. Their mission is to conserve natural resources while encouraging sound economic development and community development through project funding and implementation in southeastern North Carolina. Moffatt & Nichol saw a need for culvert prioritization in that region of the state and partnered with CFRC&D to obtain a grant to perform this work. The lower Black River Basin was then chosen as the study area because it is a high conservation priority and is an Outstanding Resource Water. The methodology was derived from the Stream Crossing Field Survey protocol developed by the SARP.

1.1 Background

Since 2017, the National Fish and Wildlife Foundation (NFWF) has released an annual grant opportunity through the Southeast Aquatics Program. This program focuses on freshwater ecosystems in various regions in the southeast. CFRC&D saw this as an opportunity to conduct studies in their region and applied in 2017. The focus that year was on water-related projects in the coastal watersheds of the Carolinas, specifically the Black River Watershed. CFRC&D was awarded $130,000 to assess aquatic connectivity in the lower Black River Basin. Assessing connectivity entailed surveying a total of 200 culverts to be scored and ranked as barriers to fish passage. After the assessments and rankings were complete, up to three culverts were then chosen for preliminary engineering and design to improve fish passage. All this work would fulfill the requirements of the grant award.

The lower Black River Basin was chosen as the project location for two primary reasons. The first is because it is designated as a high conservation priority for the North Carolina Wildlife Resources Commission (NCWRC) due to the rare aquatic species that inhabit this watershed. The second is because it is designated as an Outstanding Resource Water, which includes "unique and special waters having excellent water quality and being of exceptional state or national ecological or recreational significance." Specific rare aquatic species of interest for this area include:

- Atlantic and Shortnose Sturgeon (Federal and State Endangered)
- Thinlip Chub (State Special Concern)
- Broadtail Madtom (Federal Species of Concern).

The following Species of Greatest Conservation Need (SGCN) are also present:

- American Eel
- Ironcolor Shiner
- Blackbanded Sunfish
- Coastal Plain Crayfish.

2. Methodology

2.1 SARP Stream Crossing Protocol

The Southeast Aquatic Connectivity Program is one of many programs that the SARP coordinates. SARP is a state-driven partnership that includes a network of individuals from universities, conservation organizations, and federal agencies. The state and federal entities identified connectivity as a priority to be address in the southeast. The goal is to improve or maintain watershed connectivity. By restoring fish access to southeastern waters by effectively removing barriers to fish passage will help achieve this goal.

SARP linked with the existing efforts in the Northeast through the North Atlantic Aquatic Connectivity Collaborative (NAACC) and has transferred that knowledge down to the Southeast region with some changes to the protocol to fit the unique geography present. The NAACC developed common protocols for assessing road-stream crossings (culverts and bridges) and developed a regional database for these field data. SARP has since created a regional database to house the data collected as well as a web-based field collector form through the Survey123 app.

The initial development of the instruction guide was completed by the NAACC. With their permission and training support it has since been adapted to the Southeast region. The manual and three-day training workshop walks professionals through how to complete the Southeast Aquatic Connectivity Program's Stream Crossing Survey Data Form. The survey data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. On the first page, the top of the form contains general information about the crossing and the bottom half of that page is for data on the first specific structure at a crossing. Subsequent pages are used to capture additional culverts or bridge cells. It was essential to gather all the data required for each structure (culvert or bridge cell) for accurate assessment of the entire crossing in terms of aquatic passage. Stream crossing survey data can be collected digitally in the Southeast utilizing the Survey123 application or via paper datasheets that are then transferred digitally through the web-based entry form.

The stream crossing survey and barrier prioritization tool primarily focuses on assessing aquatic connectivity but other important factors that will be assessed include infrastructure conditions, stability, and vulnerability, debris from storm events (especially those following the hurricanes), identifying erosional hotspots and heavy sedimentation areas. All these factors play into the resiliency of our coast and the Cape Fear Basin. The importance of this method is the fact that it is a rapid assessment and since it is GIS-based, results of the tool will also be rapid and will allow us to identify specific sites.

2.2 GIS Data Analysis and Site Selection

To begin choosing the 200 sites to survey, SARP sent M&N an ArcGIS Map Package that contained GIS layers such as “NCwebviewersmallbarriers” and “HighRes_RoadStreamCrossings”. Other GIS layers retrieved from various sources included “NCDOT Structure Locations”, “Bladen_Pender_DOT_Non-National Bridge Inventory System (Non-NBIS)_BlackRiver”, “HUC12”, “2019_HUC12_Rare_Aquatic_EO”, “NCDOT_StateMaintainedRoads”, “National Hydrography Dataset (NHD)”, “National Flood Hazard Layer (NFHL)”, and “National Land Cover Dataset (NLCD)”. Over 700 stream crossings were compiled from these GIS layers. Crossings that were bridges or large culverts were eliminated from the list. Stream crossings were required to be on NHD streams, therefore crossings which did not cross NHD streams were eliminated also. Input from NCDOT about culverts already being replaced allowed those to be eliminated from the list of sites as well. Input from locals that attended the public information meetings (discussed below) was used to prioritize areas prone to flooding when selecting sites to survey. Just over 200 sites were compiled as potential sites to survey to account for the presence of a large amount of private land and agricultural land that the survey crew did not have access to and for culverts that were adequate in the field, not needing to be surveyed. The goal was to survey approximately 100 sites per county.

3. Public Involvement & Stakeholder Engagement

The Assessing Aquatic Connectivity in the Black River Watershed project was first presented at the CFRC&D Annual Meeting and Luncheon on October 29, 2018 to local officials and various other members of the organization. A project team meeting then followed held on January 2, 2019 with staff from M&N, the director of CFRC&D, staff from Bladen and Pender Counties, and staff from NCDOT Divisions 3 and 6. The presentation was given again and maps were displayed to help narrow down the approximately 700 stream crossing sites identified in the study area.

Two public information meetings were then held on February 12, 2019, with one in Bladen County and the other in Pender County, to inform the communities about the project as well. Public notices in the local newspapers were used to announce these meetings. Many comments were received from local attendees that helped to prioritize specific areas most in need of surveying due to high frequency of flooding. DOT staff, County staff, the director of CFRC&D, and M&N staff were all present at the public information meetings to present the project and help answer any questions.

4. SARP Barrier Ranking

Table 1: Prioritization scores of top five barriers

Site	Score	Barrier Type
152	0.46	Moderate
376	0.47240084237168367	Moderate
64	0.2243500279069767	Significant
236	0.1862355731225297	Severe
202	0.0790548707753479	Severe

5. Results

Field work began on June 13, 2019 and was finished on July 25, 2019. Less than twenty days were spent during that timeframe evaluating the 200 sites. The study area was comprised of fifteen 12-digit hydrologic unit codes (HUCs) (see Figure 1). The following HUCs contain rare species and were a priority to survey:

- Peters Creek – South River (49.78 sq. mi.)
- Smith Mill Pond Run – South River (53.97 sq. mi.)
- Lake Creek – South River (79.38 sq. mi.)
- Colvins Creek (30.99 sq. mi.)
- Upper Colly Creek (60.85 sq. mi.)
- Middle Colly Creek (59.42 sq. mi.)

- Lower Colly Creek (59.69 sq. mi.)
- Upper Moores Creek (31.01 sq. mi.)
- Middle Moores Creek (47.61 sq. mi.)
- Lower Moores Creek (28.17 sq. mi.)
- White Oak Branch (29.2 sq. mi.)

The remaining HUCs without rare species presence included:

- Cross Way Creek – Black River (21.11 sq. mi.)
- Rowan Creek – Black River (40.92 sq. mi.)
- Lyon Creek (42.91 sq. mi.)
- Cypress Creek (18.65 sq. mi.)

The study area totaled 653.66 square miles.

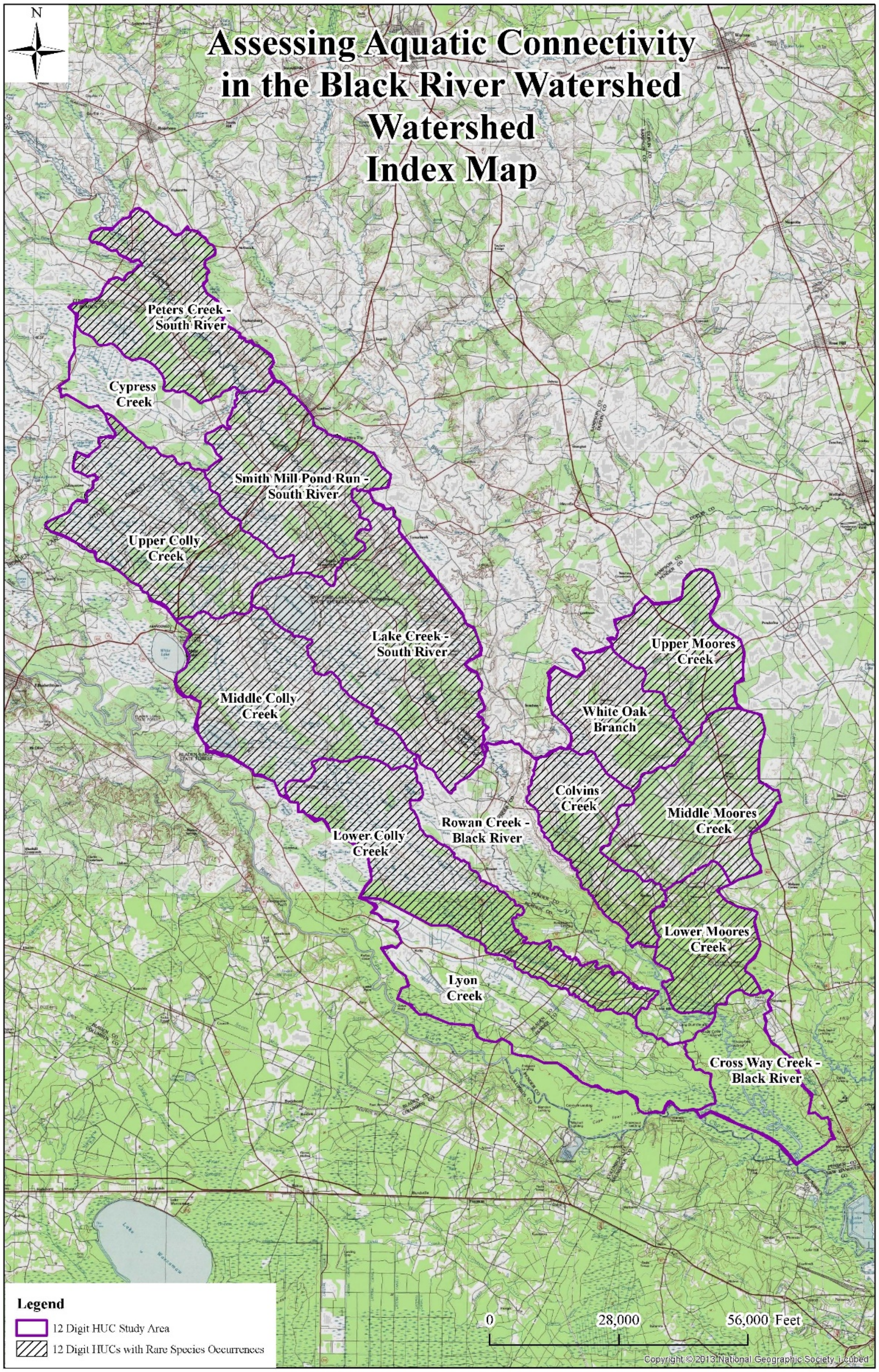


Figure 1: Watershed Index Map

Surveying of the sites was completed in a watershed manner, assessing approximately one watershed per field day. One site was surveyed in the Middle Colly Creek watershed (due to the presence of a large amount of private land). Five sites were surveyed in the Peter Creek and Cypress Creek watersheds. Six sites were surveyed in the Lower Colly Creek and Cross Way Creek watersheds. Eight sites were surveyed in the Upper Colly Creek and White Oak Branch watersheds. Thirteen sites were surveyed in the Middle Moores Creek watershed, fourteen sites in the Colvins Creek watershed, sixteen in the Smith Mill Pond Run watershed, seventeen in the Lake Creek watershed, and eighteen in the Upper Moores Creek watershed. A total of twenty sites were surveyed in the Rowan Creek watershed, twenty-four in the Lower Moores Creek watershed, and thirty-nine in the Lyon Creek watershed.

Sites were categorized as one of six types of barriers based on how severe the barrier was. The types of barrier severity are as follows:

- None:
- Insignificant:
- Minor:
- Moderate:
- Significant:
- Severe:

Thirty-six sites surveyed were identified as no barrier. Forty-nine sites surveyed were identified as insignificant barriers. Eighty-three sites surveyed were identified as minor barriers. Fifteen sites surveyed were identified as moderate barriers. Seven sites surveyed were identified as significant barriers. Ten sites surveyed were identified as severe barriers. See Table Two below for the specific survey results by watershed and barrier type severity. Figures 2 through 5 illustrate the results on aerial mapping. A total of 93 culverts were surveyed in Bladen County and 107 were surveyed in Pender County. The results are summarized below by barrier type severity and county (Table 3).

Table 2: Survey Results by Watershed and Barrier Type Severity

Watershed	No Barrier	Insignificant Barrier	Minor Barrier	Moderate Barrier	Significant Barrier	Severe Barrier
Peters Creek - South River	1	3	1	0	0	0
Smith Mill Pond Run - South River	7	5	4	0	0	0
Lake Creek - South River	2	3	9	1	2	0
Cypress Creek	1	1	3	0	0	0
Upper Colly Creek	2	2	2	1	1	0
Middle Colly Creek	0	0	1	0	0	0
Lower Colly Creek	0	2	3	0	1	0
Lyon Creek	5	12	20	2	0	0
Cross Way Creek - Black River	2	1	2	1	0	0
Rowan Creek - Black River	2	3	10	2	1	2
Colvins Creek	6	0	4	2	0	2
White Oak Branch	0	1	3	3	0	1
Upper Moores Creek	2	9	6	0	0	1
Middle Moores Creek	1	2	7	0	1	2
Lower Moores Creek	5	5	8	3	1	2
TOTAL	**36**	**49**	**83**	**15**	**7**	**10**
PERCENT OF TOTAL SITES	**18%**	**24.5%**	**41.5%**	**7.5%**	**3.5%**	**5%**

Table 3: Summarized Results by Barrier Type Severity and County

Type of Barrier	**Number in Bladen County**	**Number in Pender County**
None	18	18
Insignificant	28	21
Minor	38	45
Moderate	4	11
Significant	3	4
Severe	2	8
TOTAL	**93**	**107**

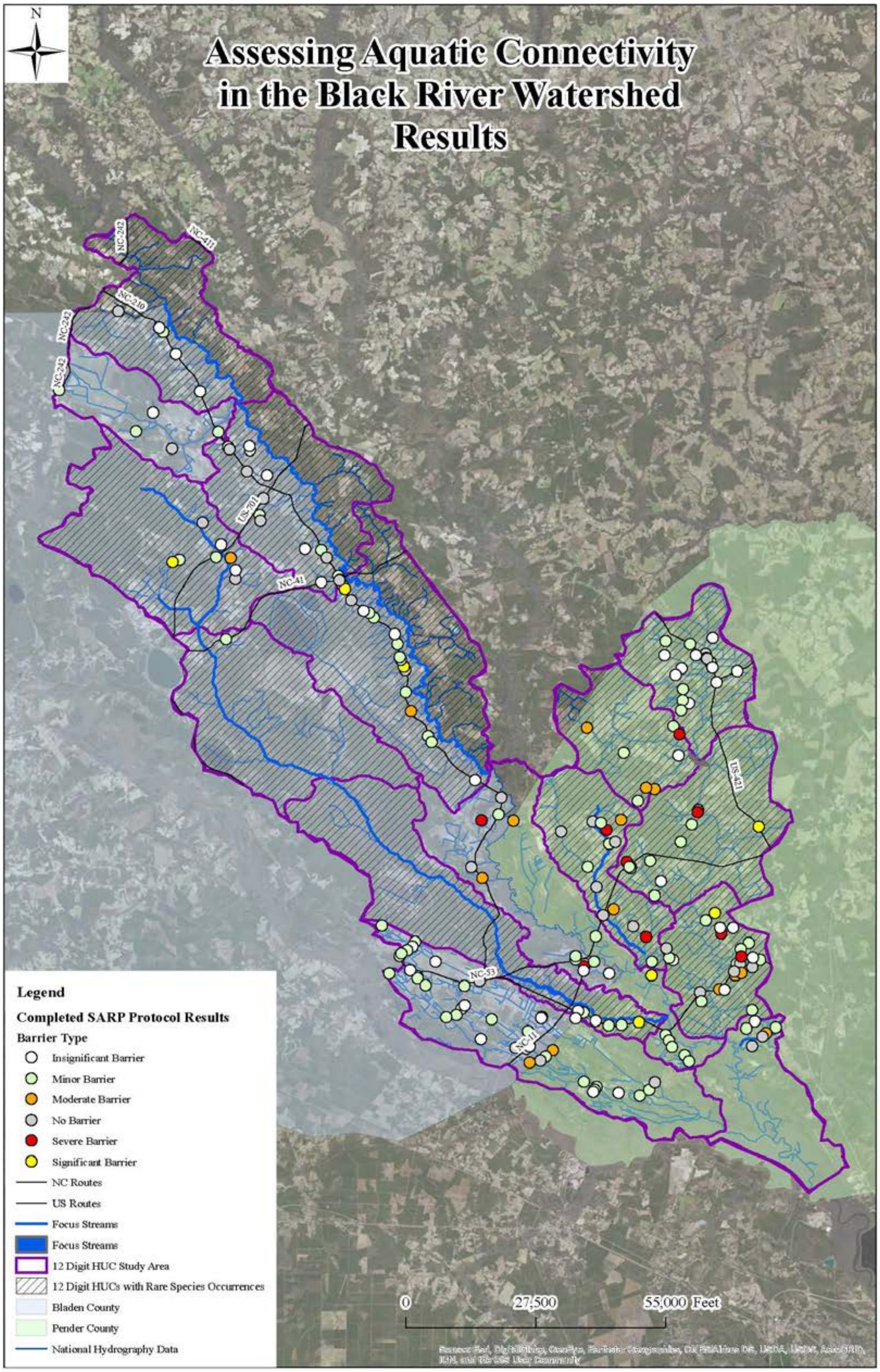


Figure 2 – SARP Protocol Results

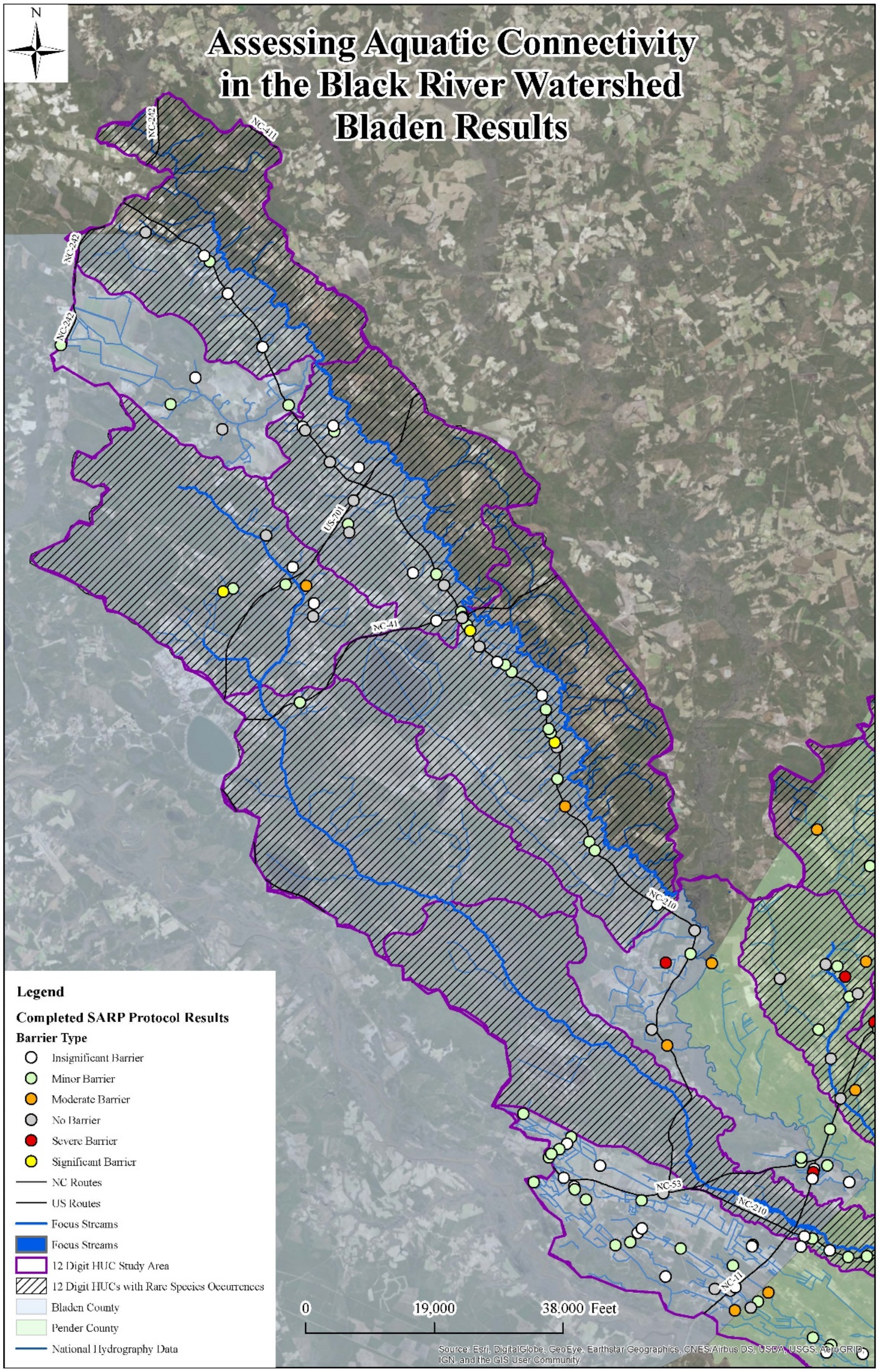


Figure 3 – SARP Protocol Results in Bladen County

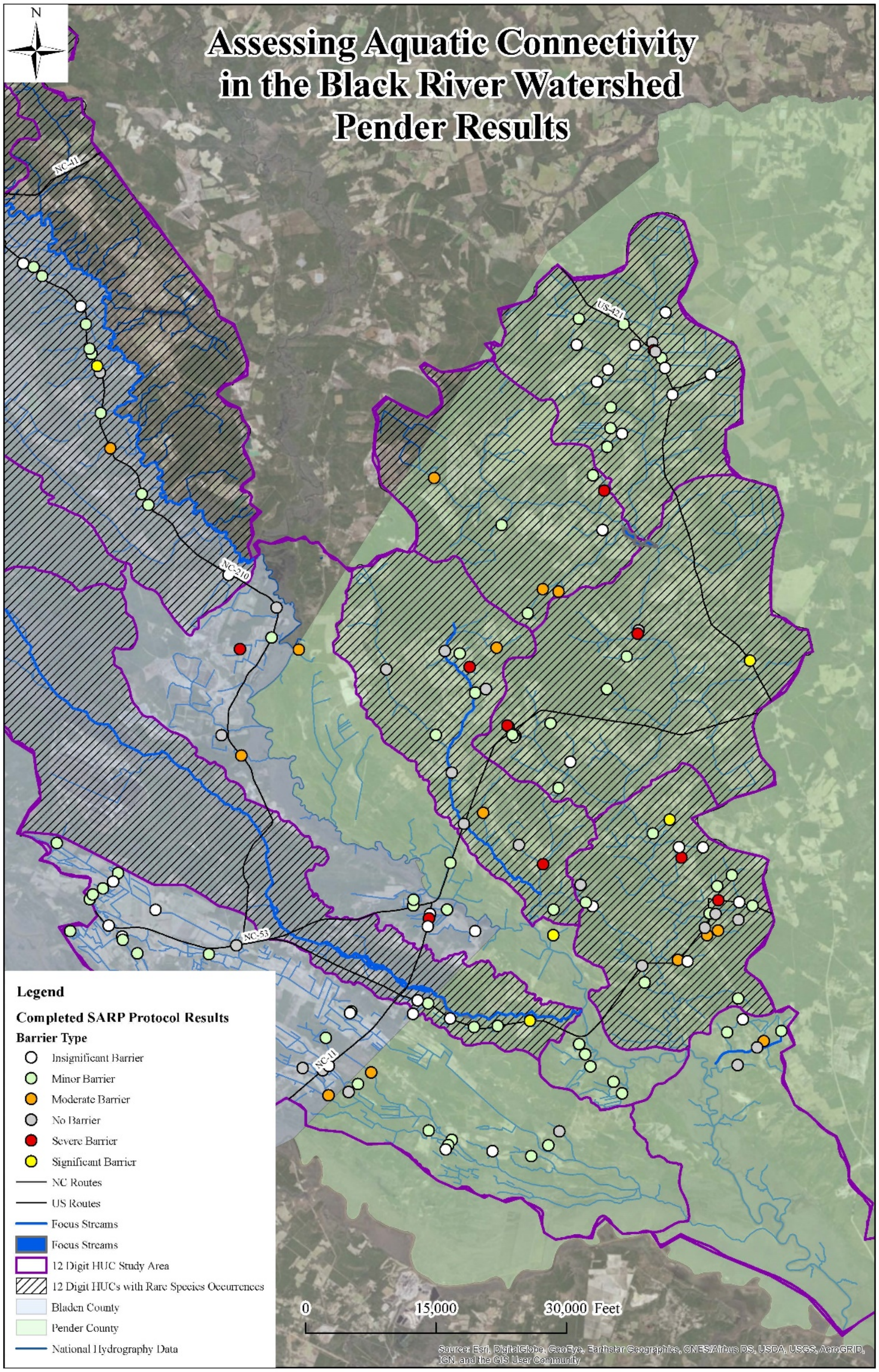


Figure 4 – SARP Protocol Results in Pender County

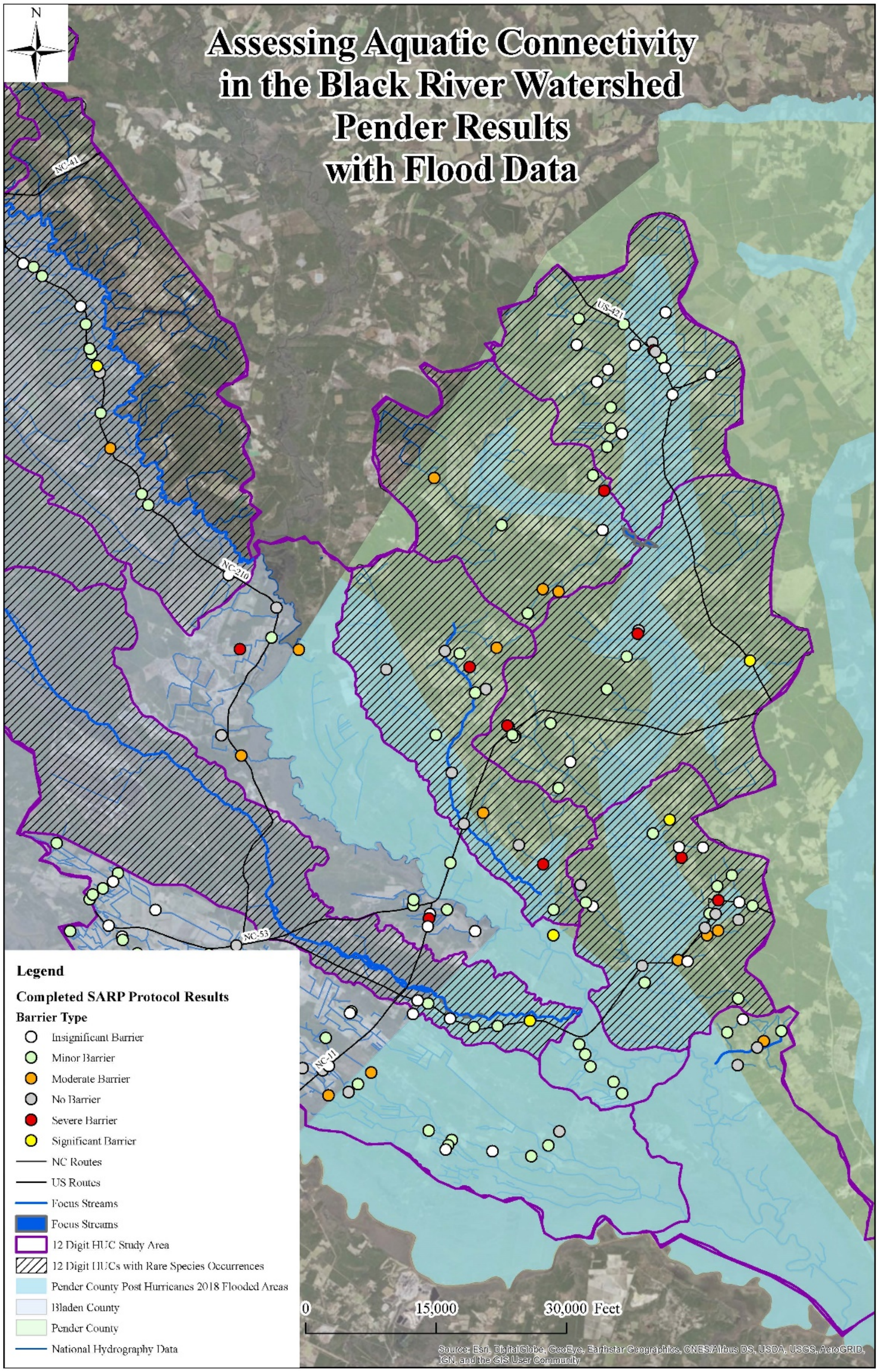


Figure 5 – Includes Flood Data from Drone Aerial Photography of Pender County Post Hurricane Florence and Hurricane Michael

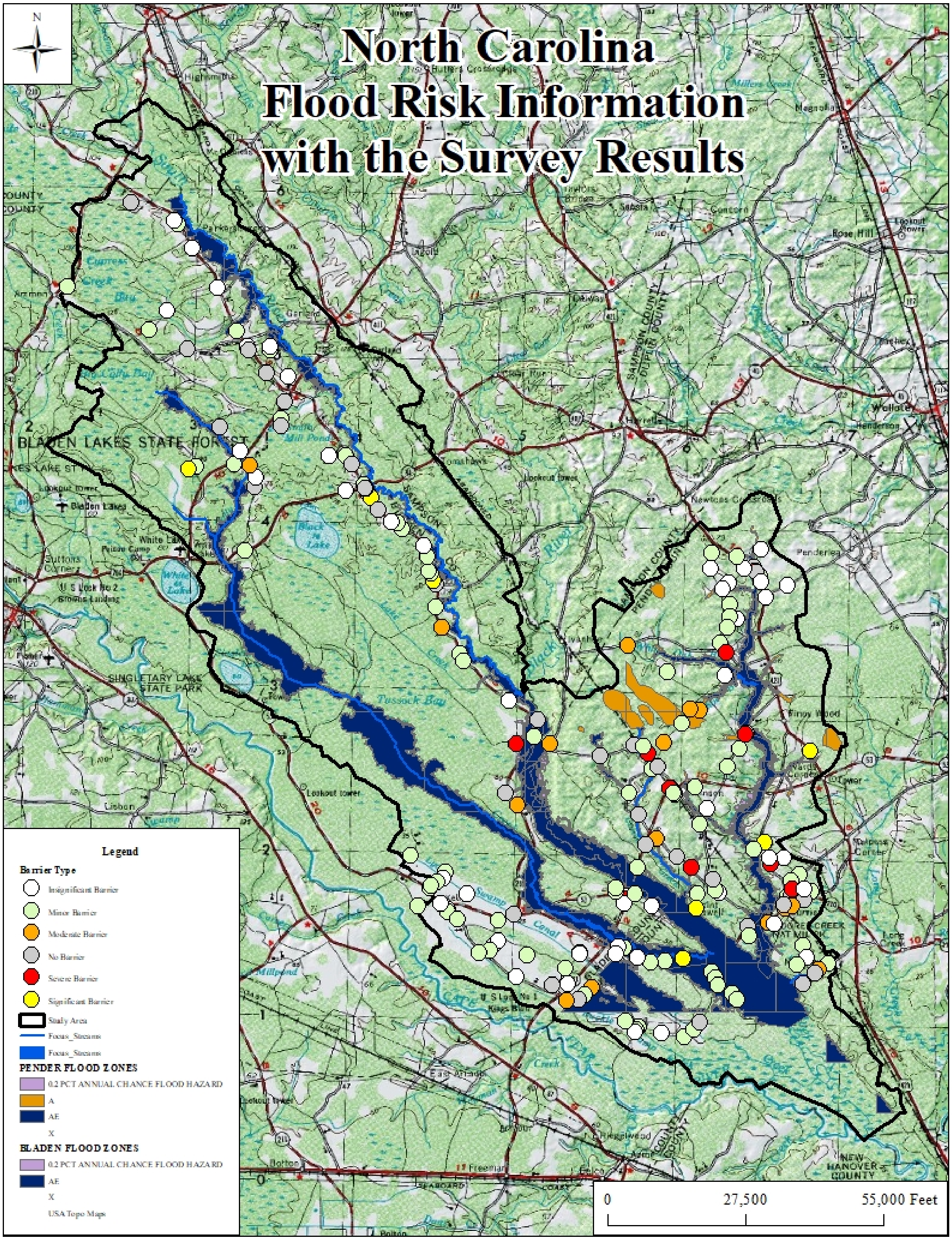


Figure 6 – Flood Risk Combined with Survey Results

- Ones selected as most severe

6. Groundtruth & Preliminary Engineering

The existing crossings were assessed and assigned a SARP score by using the Barrier Prioritization Tool (BPT). This scoring and subsequent field visit established a level of severity for the identified barriers. Field data from the entire set of crossings were reviewed. SARP scores were analyzed and 10 locations were identified based on status as moderate, significant, or severe barriers in locations that had significant sections of stream upstream. Five of these culverts were selected for more detailed analysis and conceptual design (Appendix C). USGS Streamstats (USGS Streamstats, 2019) was used to calculate the catchment area at the existing crossings. However, to account for future development, 5% of the total catchment area was assumed to be impervious. The hydrology for this area was determined by the USGS Regression equations which were fitted to the Hydrologic Region 4 according to USGS SIR 2014:5030 (USGS, 2014). 'HY-8' is a program from the Federal Highways Administration used for culvert design and analysis. Existing and proposed scenarios were modeled in HY-8 to satisfy the NCDOT criteria as well as to facilitate adequate passage for various biological and aquatic organisms known to be present in the watershed.

Topographic information (QL2 LiDAR) was downloaded from the North Carolina's Spatial Data Download website (DPS, 2018) and processed in ArcMap using Spatial Analysis tools. The processed topography was used to identify the elevation for the roadway centerline and roadway crown and to evaluate the channels just upstream and downstream from the culvert. A proposed replacement culvert was conservatively sized using future flow conditions. The NCDOT sizing criteria states that the culverts are to be designed based on the level of service the road crossing is located at and FEMA states the proposed headwater from a 100-year storm shall not be higher than the existing 100-year headwater. The preliminary engineering results and proposed culvert designs are provided in Appendix C.

7. Conclusion & Next Steps

Studying connectivity by assessing culverts will have mutual benefits for community resiliency as well. Streams are an important part of the ecosystem and landscape but are particularly vulnerable to fragmentation due to several human activities that can disrupt the continuity of stream ecosystems. The most familiar human-caused disruption are barriers such as dams. However, there is growing concern about the role of road crossings – especially culverts – in altering habitats and disrupting river and stream continuity.

When culverts are built, the primary purpose is for a road to be able to cross a stream and little to no consideration is given to the science behind stream dynamics. Undersized culverts can have extreme effects on hydrology, sediment transport, and the movement of fish and animals through a system. By restoring high priority culverts identified by this study, hopefully aquatic connectivity, hydrology and sediment transport of the streams will all be improved which will play an important role in community resiliency moving forward.

CFRC&D will continue to seek additional funds for project implementation of sites identified to be the most severe barriers for aquatic connectivity after preliminary engineering and design is accomplished. The future phase would include the design, permitting, and construction of two culverts to improve fish passage and system water quality. The proposed culvert replacements will also reduce the frequency of overtopping by being able to safely pass a 100-year flow event without overtopping. If this project is successful, we will aim to expand it into other watersheds that were heavily impacted by Hurricane Florence to assist with triage, assessment, and recovery efforts.

A variety of partners helped make this pilot project possible. SARP developed the protocol and Barrier Prioritization Tool. CFRC&D was the project lead. Bladen and Pender Counties were integral in developing community relationships and building support. NFWF supplied the funding through the awarding of the grant. M&N provided the field assessment and preliminary engineering and design technical effort. United States Fish and Wildlife Service (USFWS) was a technical support. NOAA assisted in identifying rare species historical observations. NCDOT contributed to the review of the protocol. NC WRC helped prioritize culverts. Cape Fear River Partnership facilitated resources. M&N desires to continue to support CFRC&D, as well as other partners. NFWF awarded an additional $500,000 for the design, permitting, and construction of one culvert. The anticipated schedule can be found below.

Tasks/Milestones	Milestone Date	Responsible Party
Stakeholder and Public Engagement Meetings	June 2021; Sepetmber 2021 and August 2022	CFRC&D/M&N
Stream and Wetland Delineation	July 1, 2021	M&N
Surveying Services	July 1, 2021	Sub-Contractor
Field Reconnaissance	July 1, 2021	M&N
Geo-technical Services	August 1, 2021	Sub-Contractor
Hydraulic Design	August 1, 2021	M&N
60% Design	September 1, 2021	M&N
90% Design	January 1, 2022	M&N
Final Design	May 1, 2022	M&N
Section 104 Water Quality Certification	September 1, 2021	M&N
FEMA CLOMR	December 1, 2021	M&N
Utility Coordination Services	January 1, 2022	M&N
Right of Way Acquisition	May 1, 2022	CFRC&D/County
Bidding/Negotiating	June 1, 2022	M&N
Construction Phase	September 1, 2022	M&N
Post-Construction Stream Crossing Assessment and FEMA LOMR	October 1, 2022	M&N/SARP

Figure 7: Anticipated schedule of milestones for culvert replacement

A long-term goal of the CFRC&D is to assess aquatic connectivity across the Cape Fear River Basin. "Assessing Aquatic Connectivity in the Black River Watershed" is a pilot project, i.e. it is the first time the adapted protocol has been used in a comprehensive project in North Carolina. With the completion of this pilot project, the goal and focus can shift to expanding the protocol into other watersheds.

8. References

(2019). Retrieved from USGS Streamstats: https://streamstats.usgs.gov/ss/

DPS, N. (2018). North Carolina Spatial Data Download. Retrieved from https://sdd.nc.gov/

USGS. (2014). Methods for Estimating the Magnitude and Frequency of Floods for Urban and Small Rural Streams in Georgia, South Carolina and North Carolina. Reston: USGS.

Appendix A
SARP Stream Crossing Instructions Manual and Survey Form

Appendix B
Resolution Agreement

Appendix C
Preliminary Engineering Report

SARP STREAM CROSSING FORMS AND INSTRUCTIONS

SOUTHEAST AQUATIC RESOURCES PARTNERSHIP
SARP

AQUATIC CONNECTIVITY
Stream Crossing Survey
DATA FORM

DATABASE ENTRY BY ____ ENTRY DATE ____

DATA ENTRY REVIEWED BY ____ REVIEW DATE ____

CROSSING DATA

Crossing Code____ **Local ID** (Optional)____

Date Observed (00/00/0000)____ **Lead Observer**____

Town/County____ **Stream**____

Road____ **Type** ☐ MULTILANE ☐ PAVED ☐ UNPAVED ☐ DRIVEWAY ☐ TRAIL ☐ RAILROAD

GPS Coordinates (Decimal degrees) ☐☐.☐☐☐☐☐ °N Latitude — ☐☐.☐☐☐☐☐ °W Longitude

Location Description

Crossing Type ☐ BRIDGE ☐ CULVERT ☐ MULTIPLE CULVERT ☐ FORD ☐ NO CROSSING ☐ REMOVED CROSSING ☐ BURIED STREAM ☐ INACCESSIBLE ☐ PARTIALLY INACCESSIBLE ☐ NO UPSTREAM CHANNEL ☐ BRIDGE ADEQUATE

Number of Culverts/ Bridge Cells ____

Photo IDs INLET____OUTLET____UPSTREAM____DOWNSTREAM____OTHER____

Flow Condition ☐ NO FLOW ☐ TYPICAL-LOW ☐ MODERATE ☐ HIGH

Crossing Condition ☐ OK ☐ POOR ☐ NEW ☐ UNKNOWN ☐ FAILING

Tidal Site ☐ YES ☐ NO ☐ UNKNOWN

Alignment ☐ FLOW-ALIGNED ☐ SKEWED (>45°)

Road Fill Height (Top of culvert to road surface; bridge = 0)____

(Select One) **Stream Measurement** ☐ Active Channel ☐ Wetted Channel ☐ Bankfull Width ____

Confidence ☐ HIGH ☐ LOW/ESTIMATED

Constriction ☐ SEVERE ☐ MODERATE ☐ SPANS ONLY BANKFULL/ ACTIVE CHANNEL ☐ SPANS FULL CHANNEL & BANKS

Tailwater Scour Pool
☐ NONE ☐ SMALL ☐ LARGE

Riparian Vegetation
Overstory ☐ High ☐ Low
Understory ☐ High ☐ Low
Ground level ☐ High ☐ Low

Inlet Scour Pool
☐ NONE ☐ SMALL ☐ LARGE

Riparian Vegetation
Overstory ☐ High ☐ Low
Understory ☐ High ☐ Low
Ground level ☐ High ☐ Low

Crossing Comments

BATS PRESENT? ☐ Y

STRUCTURE 1

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Outlet Armoring ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions **A. Width**____.____ **B. Height**____.____ **C. Substrate/Water Width**____.____ **D. Water Depth**____.____

Outlet Drop to Water Surface____.____ **Outlet Drop to Stream Bottom**____.____ **E. Abutment Height** (Type 7 bridges only)____.____

L. Structure Length (Top of structure)____.____ **L. Structure Length** (Bottom of structure) ____.____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED

Inlet Armoring ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Undermining ☐ Y ☐ N

Inlet Dimensions **A. Width** ____.____ **B. Height**____.____ **C. Substrate/Water Width** ____.____ **D. Water Depth** ____.____ **E. Inlet Drop to Stream Bottom** ____.____

ADDITIONAL CONDITIONS

Slope % (Optional)____ **Slope Confidence** ☐ HIGH ☐ LOW

Internal Structures ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER____

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____

Comments

02/17/2017

STRUCTURE 2

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface___________.____ **Outlet Drop to Stream Bottom**___________.____ **E. Abutment Height** (Type 7 bridges only)_______________.____

L. Structure Length (Top of structure)______________.____ **L. Structure Length** (Bottom of structure) ___________.____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width _____.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** _____.____ **E. Inlet Drop to Stream Bottom** _____.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER_________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____________

Comments

STRUCTURE 3

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface___________.____ **Outlet Drop to Stream Bottom**___________.____ **E. Abutment Height** (Type 7 bridges only)_______________.____

L. Structure Length (top of structure)______________.____ **L. Structure Length** (Bottom of structure) ___________.____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width _____.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** _____.____ **E. Inlet Drop to Stream Bottom** _____.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER_________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____________

Comments

STRUCTURE 4

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width______.____ **B. Height**______.____ **C. Substrate/Water Width**______.____ **D. Water Depth**______.____

Outlet Drop to Water Surface______.____ **Outlet Drop to Stream Bottom**______.____ **E. Abutment Height** (Type 7 bridges only)______.____

L. Structure Length (top of structure) ______.____ **L. Structure Length** (Bottom of structure) ______.____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width ______.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** ______.____ **E. Inlet Drop to Stream Bottom** ______.____

ADDITIONAL CONDITIONS

Slope % (Optional)______ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER______

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**______

Comments

STRUCTURE 5

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width______.____ **B. Height**______.____ **C. Substrate/Water Width**______.____ **D. Water Depth**______.____

Outlet Drop to Water Surface______.____ **Outlet Drop to Stream Bottom**______.____ **E. Abutment Height** (Type 7 bridges only)______.____

L. Structure Length (top of structure) ______.____ **L. Structure Length** (Bottom of structure) ______.____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width ______.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** ______.____ **E. Inlet Drop to Stream Bottom** ______.____

ADDITIONAL CONDITIONS

Slope % (Optional)______ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER______

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**______

Comments

STRUCTURE 6

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface__________.____ **Outlet Drop to Stream Bottom**__________.____ **E. Abutment Height** (Type 7 bridges only)________________.____

L. Structure Length (top of structure) ______________._____ **L. Structure Length** (Bottom of structure) __________._____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width _____.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** _____.____ **E. Inlet Drop to Stream Bottom** _____.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER__________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____________

Comments

STRUCTURE 7

Structure Material ☐ METAL ☐ CONCRETE ☐ PLASTIC ☐ WOOD ☐ ROCK/STONE ☐ FIBERGLASS ☐ COMBINATION

OUTLET

Outlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Outlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Outlet Grade (Pick one) ☐ AT STREAM GRADE ☐ FREE FALL ☐ CASCADE ☐ FREE FALL ONTO CASCADE ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN

Outlet Dimensions A. Width_________.____ **B. Height**_________.____ **C. Substrate/Water Width**_________.____ **D. Water Depth**_________.____

Outlet Drop to Water Surface__________.____ **Outlet Drop to Stream Bottom**__________.____ **E. Abutment Height** (Type 7 bridges only)________________.____

L. Structure Length (top of structure) ______________._____ **L. Structure Length** (Bottom of structure) __________._____ **Evidence of undermining** ☐ Y ☐ N

INLET

Inlet Shape ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 7 ☐ FORD ☐ UNKNOWN ☐ REMOVED **Inlet Armoring** ☐ NONE ☐ NOT EXTENSIVE ☐ EXTENSIVE

Inlet Type ☐ PROJECTING ☐ HEADWALL ☐ WINGWALLS ☐ HEADWALL & WINGWALLS ☐ MITERED TO SLOPE ☐ OTHER ☐ NONE

Inlet Grade (Pick one) ☐ AT STREAM GRADE ☐ INLET DROP ☐ PERCHED ☐ CLOGGED/COLLAPSED/SUBMERGED ☐ UNKNOWN **Undermining** ☐ Y ☐ N

Inlet Dimensions A. Width _____.____ **B. Height**______.____ **C. Substrate/Water Width** ______.____ **D. Water Depth** _____.____ **E. Inlet Drop to Stream Bottom** _____.____

ADDITIONAL CONDITIONS

Slope % (Optional)__________ **Slope Confidence** ☐ HIGH ☐ LOW **Internal Structures** ☐ NONE ☐ BAFFLES/WEIRS ☐ SUPPORTS ☐ OTHER__________

Structure Substrate Matches Stream ☐ NONE ☐ COMPARABLE ☐ CONTRASTING ☐ NOT APPROPRIATE ☐ UNKNOWN

Structure Substrate Type (Pick one) ☐ NONE ☐ SILT ☐ SAND ☐ GRAVEL ☐ COBBLE ☐ BOULDER ☐ BEDROCK ☐ ORGANIC MTRL ☐ UNKNOWN

Structure Substrate Coverage ☐ NONE ☐ 25% ☐ 50% ☐ 75% ☐ 100% ☐ UNKNOWN

Physical Barriers (Pick all that apply) ☐ NONE ☐ DEBRIS/SEDIMENT/ROCK ☐ DEFORMATION ☐ FREE FALL ☐ FENCING ☐ DRY ☐ OTHER

Severity (Choose carefully based on barrier type(s) above) ☐ NONE ☐ MINOR ☐ MODERATE ☐ SEVERE

Water Depth Matches Stream ☐ YES ☐ NO-SHALLOWER ☐ NO-DEEPER ☐ UNKNOWN ☐ DRY

Water Velocity Matches Stream ☐ YES ☐ NO-FASTER ☐ NO-SLOWER ☐ UNKNOWN ☐ DRY

Dry Passage through Structure? ☐ YES ☐ NO ☐ UNKNOWN **Height above Dry Passage**____________

Comments

Structure Shape & Dimensions

1) Select the Structure Shape number from the diagrams below and record it on the form for Inlet and Outlet Shape.

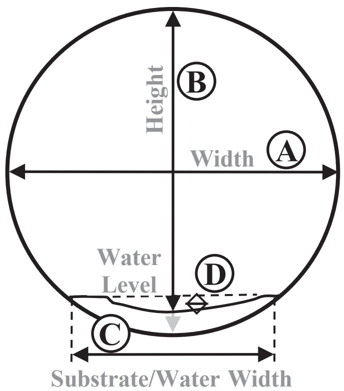
2) Record on the form in the approriate blanks dimensions **A**, **B**, **C** and **D** as shown in the diagrams;
C captures the width of water or substrate, whichever is wider; for dry culverts without substrate, C = 0.
D is the depth of water -- be sure to measure inside the structure; for dry culverts, D = 0.

3) Record Structure Length (**L**). (Record abutment height (**E**) only for Type 7 Structures.)

4) For multiple culverts, also record the Inlet and Outlet shape and dimensions for each additional culvert.

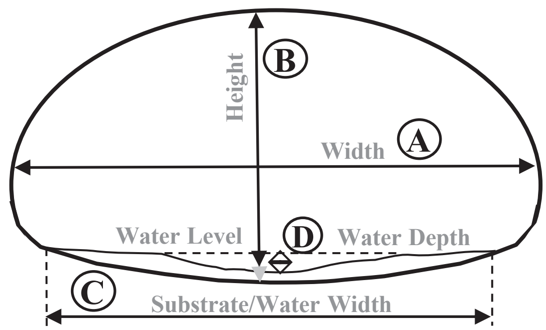
NOTE: Culverts 1, 2 & 4 may or may not have substrate in them, so height measurements (B) are taken from the level of the "stream bed", whether that bed is composed of substrate or just the inside bottom surface of a culvert (grey arrows below show measuring to bottom, black arrows show measuring to substrate).

1



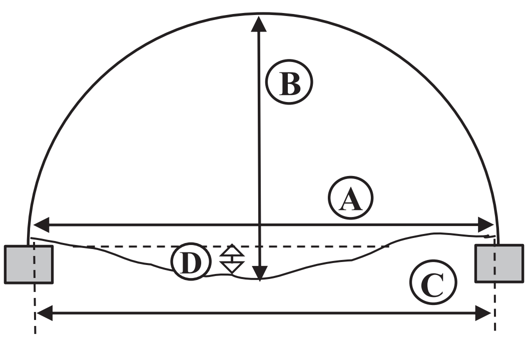
Round Culvert

2



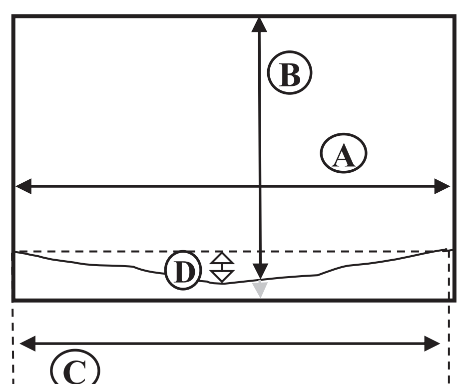
Pipe Arch/Elliptical Culvert

3



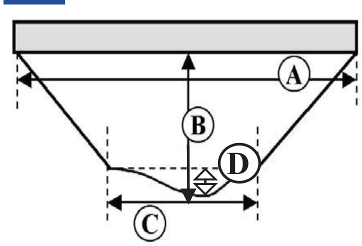
Open Bottom Arch Bridge/Culvert

4



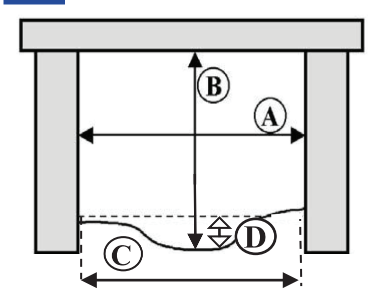
Box Culvert

5



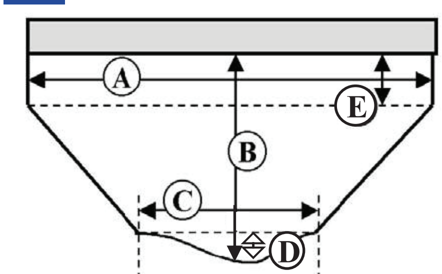
Bridge with Side Slopes

6



Box/Bridge with Abutments

7



Bridge with Abutments and Side Slopes

SARP Stream Crossing Survey Data Form
Instruction Guide

Original developed by
Alex Abbott and Scott Jackson as part of the
North Atlantic Aquatic Connectivity Collaborative

Adapted for the Southeast by the
Southeast Aquatic Resources Partnership

Version SE2.1 – September 2017

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Conservation Commission (State Wildlife Grants)

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The initial development of this instruction guide was completed by the NAACC and with permission and training support it has been adapted to the Southeast region. This adaption could not have been completed without the involvement of the NAACC, in particular Scott Jackson of UMASS as well as regional experts from USFWS, USFS, FWC, MDWFP and TNC. The adaption of the NAACC to the Southeast was largely funded by a State Wildlife Grant (SWG) awarded by the Florida Fish and Wildlife Conservation Commission, another SWG from Texas Parks and Wildlife Department, as well as funding from USFWS.

Jessica Graham

The following acknowledgments remain from the original instruction development by the NAACC.

The development of this instruction guide and the survey protocol it explains would not have been possible without the effort of many people involved with the NAACC. First and foremost, we would like to thank our colleagues from the NAACC Core Group who worked so diligently to develop and refine the concepts reflected here, and the documents resulting from their many days and hours of effort. The core group includes Rich Kirn of the Vermont Department of Fish and Wildlife, Jessie Levine, Erik Martin, and Michelle Brown of The Nature Conservancy, Jed Wright of the U.S. Fish and Wildlife Service Gulf of Maine Coastal Program, Melissa Ocana and Bob English of the University of Massachusetts Amherst, and Keith Nislow of the U.S. Forest Service. We are particularly thankful to Jessie Levine for her many hours of thorough editing.

In addition, the NAACC relies on a Working Group composed of dozens of professionals working across the region in state and federal agencies and nongovernmental organizations dedicated to improving stream connectivity for the health and resilience of our aquatic and terrestrial ecosystems, as well as safeguarding our infrastructure in the face of a changing climate and increasingly intense, and sometimes devastating storms. Thanks to all those who have lent their time and expertise to making our collaborative successful.

And, finally, thanks to the U.S. Fish and Wildlife Service North Atlantic Landscape Conservation Cooperative for funding this important work.

Alex Abbott & Scott Jackson

TABLE OF CONTENTS

OVERVIEW

This document provides guidance for completing the Southeast Aquatic Connectivity Program's Stream Crossing Survey Data Form.

The Southeast Aquatic Connectivity Program is one of many programs that the Southeast Aquatic Resources Partnership coordinates. SARP is a state-driven partnership that includes a network of individuals from universities, conservation organizations, and federal agencies. The state and federal agencies targeted connectivity as a priority objective needing to be address in the region. SARP connected with the existing efforts in the Northeast through the NAACC and has transferred that knowledge down to the Southeast region with some changed to the protocol to fit our unique geography. The NAACC developed common protocols for assessing road-stream crossings (culverts and bridges) and developed a regional database for these field data. SARP has created a regional database to house the data collected as well as a web-based field collector form through Survey123.

The survey data form is to be used for an entire road-stream crossing, which may include single or multiple culverts or multiple cell bridges. On the first page, the top of the form contains general information about the crossing, and the bottom half of that page is for data on the first (or only) structure at the crossing. Subsequent pages are used to add data where there are additional culverts or bridge cells. It can be difficult to determine how best to evaluate multiple culvert/cell crossings. Please remember that it is essential to gather all of the data required for each structure (pipe or bridge cell) for accurate assessment of the entire crossing in terms of aquatic organism passage. However, if the data sheet is incomplete for a variety of reasons, the data can still be entered into the database but may not be scored for passability.

Stream crossing survey data can be collected digitally in the Southeast using Survey123 or via paper datasheets and uploaded through the web-based entry form. Further instructions for data entry by each of these methods can be provided by Kat Hoenke.

Please be sure to complete every possible element of the field data form.

SURVEY PLANNING

General Planning

Any effort to survey stream crossings should be based on a plan that includes answers to the following key questions:

1. ***Who is primarily responsible for managing the surveys?***
   Currently, SARP staff can help inform priority areas for surveys and how to manage the data once surveys are completed. However, each entity may have their own priorities based on organizational goals and work plans that should not preclude you from using this protocol or uploading your data. Feel free to contact Kat Hoenke or Jessica Graham if you have any questions.

2. ***How will surveyors be trained?***
   At this time, training should be arranged through SARP until additional trainers are established throughout the region. The training includes both classroom and field survey practice. The most important elements of training are becoming familiar with this instruction manual and gaining practice through survey of a variety of crossings with an experienced surveyor and standardizing your assessments.

3. ***When should surveys be done?***
   Ideally, surveys should be conducted during low-flow periods for your specific geography.

4. ***How should we decide where to survey?***
   SARP can provide information on current ongoing efforts and SARP Conservation Opportunity Areas as well as regional biodiversity hotspots. However, survey locations are generally decided upon by the individual entity and can always be included in the database if the SEACN protocol is used. If you desired a larger conversation to align your entity's priorities with others across teh region, SARP can assist in coordinating and facilitating such discussions. In an effort to help inform those who are looking to conduct surveys we maintain a basic map of current and past efforts surveying across the region using the SEACN protocol. This map can be found at

5. ***How will we keep track of the sites visited?***
   You should maintain records, possibly as notations on paper maps, or in a table listing each planned survey site, showing which sites have been surveyed and when. Organize your survey forms by date, and be sure each survey form is complete. Once data has been entered into the SARP database
   you will be able to see all surveyed sites through online maps to verify that you have completed all planned crossings.

6. ***How can we access crossings on major highways, railroads and private land?***
   Depending on the scope of your surveys, you should have easy access to stream crossings on most public roads, though it is important to be aware of the right-of-way to avoid inadvertently trespassing on private land. Access to interstate highways and railroads is generally much more limited. For cases with limited access to crossings, you are responsible for contacting the appropriate owner or manager of those crossings to request access to conduct surveys. Similarly, for crossings on private roads, you should make concerted efforts to notify private landowners to request permission to conduct surveys on their lands. It may help to work with a local land trust, town or county governments, or state resource agencies to gain access from these landowners, as they often have similar needs for conducting habitat surveys or other resource assessments. In some survey efforts, when allowed by specific laws in effect in those jurisdictions, it has been considered permissible to survey crossings on private roads, particularly if good faith efforts to notify landowners have been undertaken first, or so long as crossings are not on posted or gated roads.

8. How can we be sure our data will lead to crossing improvements?

For your data to be useful in setting stream restoration priorities, we encourage you to collect data as completely and accurately as possible and ensure that the data are entered properly into the database. Finally, be sure that all data, including survey forms and site photographs, whether collected digitally or on paper, are transmitted to SARP for archiving.

SAFETY

Streams can be hazardous places, so take care to sensibly evaluate risks before you begin a survey at each stream crossing. While these efforts to record data about crossings are important, they are not nearly as important as your safety and well-being. Working around roads can be dangerous, so be sure to wear highly visible clothing, preferably safety vests in bright colors with reflective material; some vests have the additional bonus of containing many pockets to hold gear. Take care when parking and exiting your vehicle, and when crossing busy roads.

These surveys are best undertaken by teams of two people. This will facilitate taking measurements, making decisions in challenging situations, and recording data.

Take measurements seriously and carefully, but make estimates if necessary for your safety. Avoid wading into streams – even small ones – at high flows and entering pools of unknown depths, and take care scaling steep and rocky embankments. There are usually ways to effectively estimate some dimensions without risk. For example, an accurate laser rangefinder is a safe way to measure longer distances when conditions are unsafe, such as measuring culvert lengths through them instead of across busy roads.

EQUIPMENT

To collect data on stream crossing structures, you will need several essential pieces of equipment for measuring and recording, and some other items to keep you healthy and safe:

- ✓ **Instruction Guide for the NAACC Stream Crossing Survey Data Form** (this document)
- ✓ **Measuring Implements** in feet and tenths (decimal feet rather than inches)
    - o **Reel Tape:** For measuring structure lengths and channel widths; 100 feet.
    - o **Pocket Tape:** Best in 6 foot “Pocket Rod” version with no spring to rust.
    - o **Stadia Rod:** Telescoping, 13 feet long to measure structure dimensions such as water depth.
- ✓ **Safety Vests:** Brightly colored, reflective vests, preferably with lots of pockets to hold equipment, but most importantly to be seen on the road.
- ✓ **Waders or Hip Boots:** To stay dry, insulate from cold water, minimize abrasions, and allow access to tailwater pools and deeper streams**.**
- ✓ **Flashlight:** To be able to see features inside long dark structures.
- ✓ **Rangefinder** (optional): To safely take measurements without crossing structures, busy roadways or streams; should be accurate to within one foot for adequate data accuracy.
- ✓ **Sun Protection:** Hat, sunglasses, and sunscreen as needed.

- ✓ **Insect Repellent:** To protect from annoying or dangerous bites.
- ✓ **First Aid Kit:** To deal with any minor injuries, cuts, scrapes, etc.
- ✓ **Cell Phone:** In case of emergency, to coordinate surveys, or to ask questions of coordinators.

For Paper Surveys

- ✓ **Stream Crossing Survey Forms**: Best printed on waterproof paper. Bring along more than you expect to use. Even digital surveys should include these in case a digital device becomes inoperable.
- ✓ **Clipboard**, **Pencils & Erasers**
- ✓ **Stream Crossing Maps**: For planning sites to survey, and for recording sites assessed, a *DeLorme Atlas and Gazeteer* or similarly accurate and updated set of maps with topography is helpful for navigation.
- ✓ **GPS Receiver**: Set GPS to collect data in WGS84 datum, with Latitude and Longitude in decimal degrees.
- ✓ **Digital Camera**: Best if waterproof and shockproof, with sufficient battery power for a full day of surveying, and capable of storing approximately 100 low to moderate resolution images (approximately 100 - 500 kilobyte stored size, generally less than 1 million pixels–1 megapixel). Include batteries or battery charger, and download cable. A backup memory chip can be very useful to have on hand.

For Digital Surveys:

- ✓ **Tablet Computer:** Should be waterproof, and preferably shockproof, to be able to survive wet and rugged field conditions. Various mapping applications can be run to allow navigation to planned survey sites, replacing paper maps. For more information on this method of survey, refer to the NAACC Digital Data Collection User's Guide available at https://www.streamcontinuity.org/resources/naacc_documents.htm
- ✓ **GPS Receiver:** If not integral to the tablet computer, an external GPS device will be needed either to connect to the tablet via Bluetooth or wire, or at the least, to be able to provide correct coordinates for entering to the tablet manually.
- ✓ **Stream Crossing Survey Forms**: As a backup in case digital devices fail.

Unmapped Sites and Nonexistent Crossings

Survey teams may encounter unmapped crossings, or it may be unclear whether a crossing they have found in the field is on their map because its location does not match the map. In most cases, the surveyed crossing should be within 100-200 feet of the planned crossing. Survey teams also may encounter unmapped crossings because either the road was not mapped, as in the case of a road built to serve a new housing development, or because of an error in the road or stream data.

If there is no planned crossing near the site you are assessing, you need to assign a temporary *Crossing Code* to that crossing. A *Crossing Code* is composed of the prefix "xy" followed by the latitude and longitude of the site, with decimal degree latitude and longitude values as seven-digit numbers. For instance, a crossing located at 42.32914 degrees north and -72.67522 degrees west, will have the resulting *xy code* = "xy42329147267522," followed by the notation: "NEW XY" to indicate that this crossing site must be added to the map.

Conversely, a crossing may exist on the map but not in the field. If you try to navigate to a site and are certain that there is no crossing in the vicinity, you should select the "No Crossing" option for *Crossing Type* on the field data form. Some crossings may not actually exist due to errors in generating the crossing points. Another possibility is that there may have been a road crossing there at one time, but the crossing has been removed, but may still need to be surveyed to note passage problems. For these sites, you will select the "Removed Crossing" option. Similarly, sometimes an entire stream reach has been moved, particularly underground, in which case you will select the "Buried Stream" *Crossing Type*.

In all cases where a survey crew either cannot locate a mapped crossing or intends to add a new unmapped crossing, it is essential to check the location carefully to minimize navigation and data collection errors.

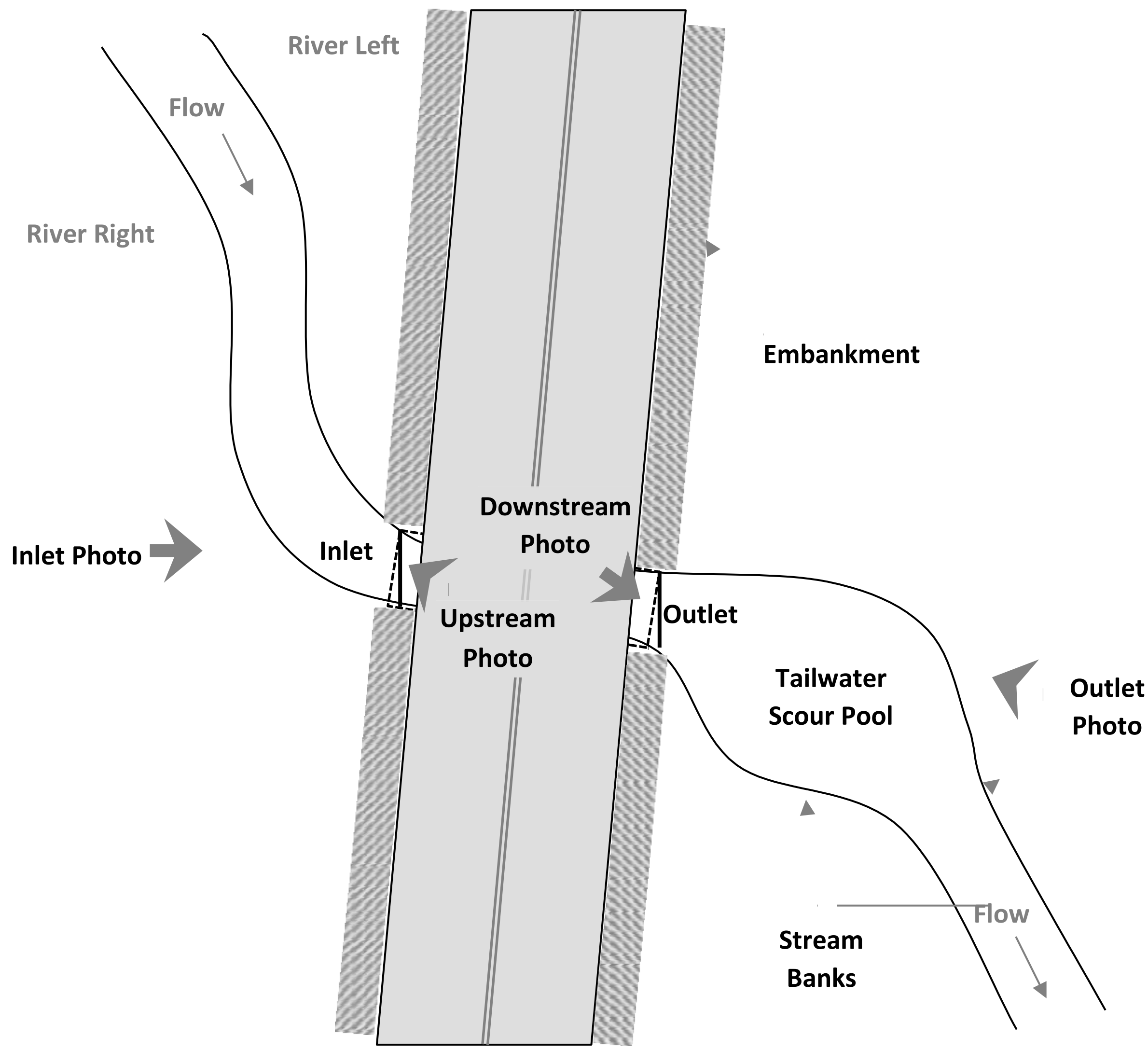
THE SURVEY DATA FORM

Shaded Boxes

The shading on the data form is intended to make the form easier to follow and complete. The different shading sets off elements related to certain groups of information from others.

Site Identification

While each crossing will be different from others in its details, many common features will be assessed, measured, or otherwise observed during all surveys. The diagram below contains the basic terminology for key stream crossing features in a simplified overhead view.



UNDISTURBED STREAM REFERENCE REACHES

When conducting crossing surveys, elements of this data form require you to understand key characteristics of an undisturbed, "natural" section of the stream (called a *reference reach*) near where the crossing is located. These characteristics include the stream's approximate width, depth, and velocity, and the type of substrate that predominates there. In general, you will need to go a distance upstream or downstream from the crossing that is between 10 and 20 times the width of the stream to get away from the influence of the crossing. This means for a 10-foot wide stream, you will need to go between 100 and 200 feet upstream or downstream from the crossing to find an undisturbed reach. The distance will be much larger for larger streams. Note that sometimes you will be unable to locate such a reference reach, either because upstream and downstream reaches are too disturbed or modified, or because access is limited, such as by *No Trespassing* signs. If the reference reach is restricted but you can access the crossing, do your best to assess it based on what you can see and make a note in the comments section that an adequate reference reach was unaccessible.

CROSSING DATA
(Top Section)

Complete this section for the entire crossing. Choose only one option for the fields with checkboxes in the crossing data section.

Crossing Code: This is the 18-character "xy code" assigned to each planned survey crossing on survey maps. Be very careful to record the correct numbers, as they represent the precise latitude and longitude of the planned crossing, which can be compared with the actual location you record as GPS Coordinates below.

Local ID: Optional field for a program's own coding systems. Does NOT replace the Crossing Code.

Date Observed: Date that the crossing was evaluated, following the form *M/D/Y*.

Lead Observer: The name of the survey team leader responsible for the quality of the data collected.

Town/County: The town or county in which the assessed crossing is located according to the map.

Stream: The name of the stream taken from the map, or if not named on the map, the name as known locally, or otherwise list as *Unnamed*.

Road: The name of the road taken from the map or from a road sign. Numbered roads should be listed as "Route #", where # is the route number, with multiple numbers separated by "/" when routes overlap at the crossing (e.g., "Route 1/95"). For driveways, trails, or railroads lacking known names, enter *Unnamed*.

Multilane: > 2 lanes, including divided highways (assumed paved)

Road Type: Choose only one option:

Paved: public or private roads

Unpaved: public or private roads

Driveway: serving only one or two houses or businesses (paved or unpaved)

Trail: primarily unpaved, or for all-terrain vehicles only, but includes paved recreational paths

Railroad: with tracks, whether or not currently used

GPS Coordinates: Latitude and Longitude in decimal degrees to 5 decimal places. Use of a GPS (Global Positioning System) receiver is required, but your smart phone or tablet computer may include this capability.

Map Datum: It is best to use *WGS84* datum.

Location Format: Use Latitude-Longitude decimal-degrees (often in GPS menu as "hddd.ddddd").

You should stand above the stream centerline, and ideally on the road centerline, when taking the GPS point, but use your judgment and beware of traffic.

Location Description: If there is any doubt about whether someone could find this crossing again, provide enough information about the exact location of the crossing so that others with your data sheet would be confident that they are at the same crossing that you evaluated. For example, the description might include "between houses at 162 and 164 Smith Road," "across from the Depot Restaurant," or "driveway north of Smith Road off Route 193." This information could also include additional location information, such as a site identification number used by road owners or managers.

CROSSING DATA
(Bottom Section)

Crossing Type: If a crossing is found at the planned location, choose the <u>one</u> most appropriate option.

> *Bridge*: A bridge has a deck supported by abutments (or stream banks). It may have more than one cell or section separated by one or more piers, in which case enter the number of cells to *Number of Culverts/Bridge* Cells. Enter data for any additional cells in *Structure 2 Data*, *Structure 3 Data*, etc.
>
> *Culvert*: A culvert consists of a structure buried under some amount of fill. If it is a single culvert, you need only complete the first page of the data form.
>
> *Multiple Culvert*: If there is more than one culvert, you must indicate that in *Number of Culverts/Bridge Cells* to the right. Data must be entered in sections for additional structures starting on the second page (*Structure 2 Data*, *Structure 3 Data*, etc.). Count ALL structures, regardless of their size.
>
> *Ford*: A ford is a shallow, open stream crossing, in which vehicles pass through the water. Fords may be armored to decrease erosion, and may include pipes to allow flow through the ford (*vented ford*).

If a planned crossing cannot be found or surveyed, the site will fit one of the following types:

> *No Crossing*: There is no crossing where anticipated, usually because of incorrect road or stream location on maps. No further data is required. <u>(Be sure you are in the correct location.)</u>
>
> *Removed Crossing*: A crossing apparently existed previously at the site but has been removed, so the stream now flows through the site with no provision for vehicles to cross over it. Continue to complete the survey form to the extent possible. Include information in Crossing Comments to explain your observations. For instance, indicate if an old culvert pipe is seen at the site, or if removal of the previous crossing structure left the stream with problems for aquatic organism passage.
>
> *Buried Stream*: The planned crossing site does not include an inlet and/or outlet, likely because a stream previously in this location has been rerouted, probably underground. In this case, survey is not possible, and no further data is required.
>
> *Inaccessible:* Survey is not possible because roads or trails to the crossing are not accessible. This may be due to private property posting, gates, poor condition, or other factors. Record in Crossing Comments why the site is inaccessible. No further data is required.
>
> *Partially Inaccessible:* Use this option when you can access a crossing well enough to collect some but not all required data. This is most likely to occur when you cannot access either the inlet or outlet side of a crossing and cannot reasonably estimate the dimensions or assess things like inlet grade, outlet grade, scour pool or tailwater armoring.
>
> *No Upstream Channel:* This option is for places where water crosses a road through a culvert but no road-stream crossing occurs because there is no channel up-gradient of the road. This can occur at the very headwaters of a stream or where a road crosses a wetland that lacks a stream channel (at least on the up-gradient side).
>
> *Bridge Adequate:* Coordinators have the option of using this classification for large bridges for which it is obvious that they present no barrier to aquatic organism passage. Observers may collect and enter data for these crossings but these data are not required.

Number of Culverts/Bridge Cells: For all Bridges with multiple sections or cells, and for all multiple culverts, you must enter the number of those cells or culvert structures here.

Photo IDs: All surveys should include a minimum of four digital photos of the following: crossing inlet, crossing outlet, stream channel upstream of crossing, and stream channel downstream of crossing. These photos are immensely useful in setting priorities for restoration. Note that photos of buried streams are optional but recommended.

It is essential that all photos be associated with the correct crossing. If you take photos with a digital camera (and sometimes when using a smart phone or tablet computer), you should record the photo numbers assigned by the camera on the survey form in the space for each photo perspective. To record the correct photo numbers from any camera, each person taking photos must be familiar with the numbering system of the camera used. Record the ID number of each photo in the blanks on the data form.

While you may take multiple photos at a site in order to choose the best ones later, you must record on the data form the ID numbers of all photos taken at the site. It can be very helpful to have one or more additional photos, especially when important characteristics are not captured on the four required photos. For instance, if there is extreme erosion at the site, or if other aspects of the crossing make it a likely barrier to connectivity, it is useful to capture these with one or two additional photos.

A simple way to know which photos were taken at a particular site is to use a black marker on a white dry-erase board to record the date and Crossing Code, and to have the first photo at the crossing show this white board displaying the date and Crossing Code. The white board should be strategically placed in the photo so that it is legible and does not block key features of the crossings. This will make the photo readily identifiable with the appropriate crossing. Some people have noted that white dry-erase boards and white paper reflect so much light that they are often “washed out” in the photos, making the codes written on the board impossible to read; use of a small blackboard and chalk may be preferable depending on light conditions.

Here are several additional tips for taking useful photos:

- Always include more than just the structure or stream area you are photographing; it is better to capture more context. Remember that with digital photos, we can zoom in to see detail.
- Including a stadia rod in photos of the inlet and outlet can be valuable to verify some measurements, and as a general reference for scale.
- When available, use a date/time stamp to code each photo.
- Set your camera to record in low to medium resolution so that the photos do not take up too much space on the memory card and when downloaded for storage. To minimize storage space but still allow a reasonable quality image, each photo should be between 100 and 500 kilobytes in size when downloaded. This often equates to a camera resolution setting of “1 Megapixel.”
- Review photos at the site to discard bad photos and to be sure all perspectives are well represented.
- If you haven’t used the camera before, practice to be sure you know how to take photos in dark or mixed light situations, as these often exist when surveying stream crossings.

The following are some examples of useful photos:

	Site 1	**Site2**	**Site 3**
Inlet			
Outlet			



Upstream



Downstream

Flow Condition: Check the appropriate box to indicate how much water is flowing in the stream. Normally, the value selected for the first perennial crossing of the day will hold for all perennial sites in the area during that day, unless a rainfall event changes the situation. Choose only one option.

No Flow: No water is flowing in the natural stream channel; this option is typical of extreme droughts for perennial streams, or frequent conditions for intermittent or ephemeral streams.

Typical-Low: This is the most commonly used and expected value for surveys conducted during summer low flows, particularly on perennial streams. Water level in the stream will typically be below the level of non-aquatic vegetation, exposing portions of stream banks and bottom.

Moderate: This value is selected when recent rains have raised water levels at or above the level of herbaceous (non-woody) stream bank vegetation.

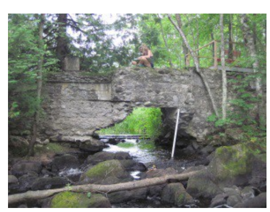
High: This value is selected only rarely, when flows are very high relative to stream banks, making crossing surveys very difficult or impossible, normally due to very recent, or ongoing major rain events. Avoid surveying crossings under high flows as data will not reflect more frequent flow conditions.

Crossing Condition: Check one box that best summarizes the condition of the crossing, based on your observations of the overall state or quality of the crossing, including all structures, particularly the largest or those carrying most of the flow. We are primarily trying to identify crossings in immediate danger of failing or in imminent need of replacement, as well as those that have been very recently installed. Focus primarily on the condition of structure materials.

OK: This is the value given to the vast majority of crossings. Many crossings have deficiencies such as surface rust, dents, dings, or cracks which do not indicate risk of failure.

Poor: This value is intended for structures where the material appears to be failing, such as metal culverts with rot (not just surface rust), or concrete, stone or wooden structures that are already collapsing, or in danger of immediate failure (see images below as examples).



New: This value is assigned only to a crossing that has been installed very recently. Look for unblemished structures with new riprap and/or vegetative bank stabilization.

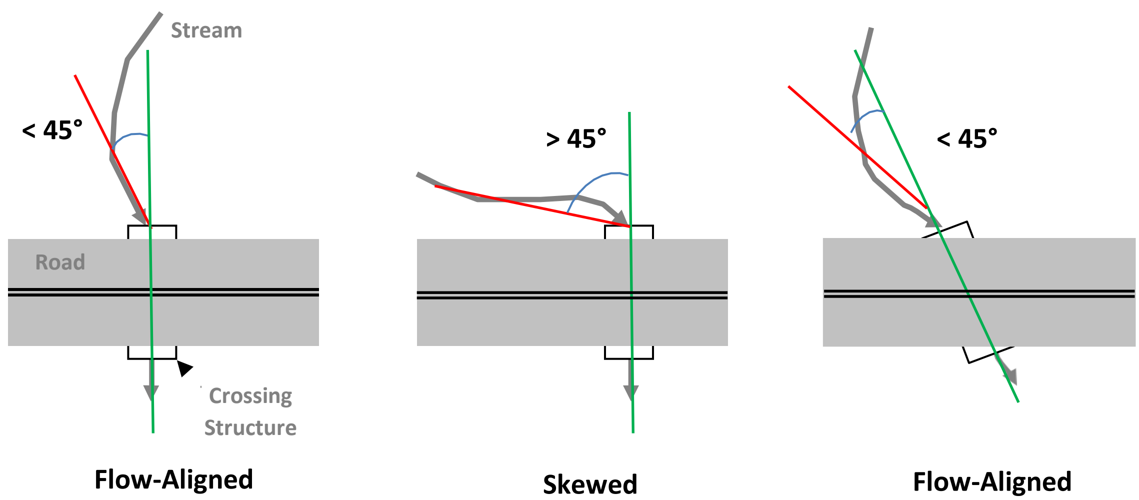
Unknown: This value applies to all sites where the condition of the crossing cannot be assessed, such as when submerged.

Tidal Site: Sites in tidal areas will often require additional survey to fully assess aquatic organism passage. This element is primarily meant to identify sites in a tidal zone. Choose only one option. Survey of tidal crossings is best done within one hour of low tide to improve access and provide the most useful data. Freshwater streams influenced by tides, often at great distances from the ocean, are more difficult to identify. Determining areas that may be influenced by the tide should be conducted prior to field collection. If surveys will be conducted in a potential area that is tidally influenced, we suggest bringing a salinity meter with the field gear to verify each site.

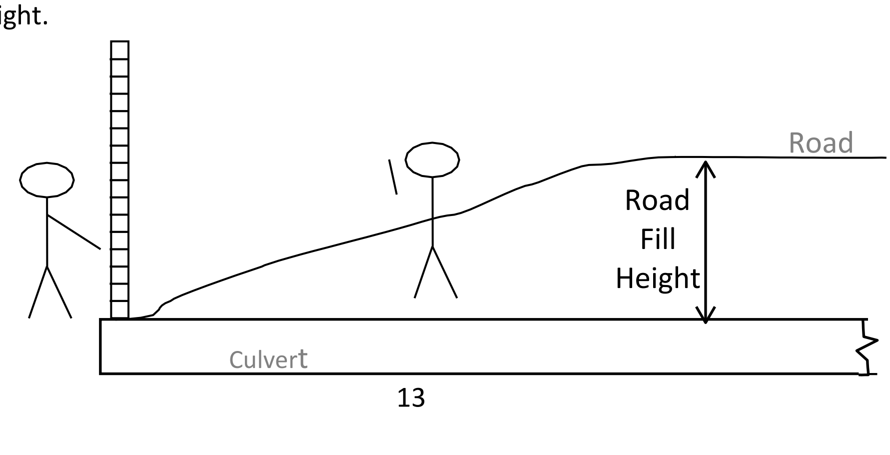
> *Yes:* Evidence shows that tidal waters regularly reach the crossing site. Evidence includes a clear wrack line (line of debris) marking the limit of recent tides. Other indications include observation of salt marsh plants (*spartina spp.*, not upland vegetation or freshwater wetland plants like cattails and common reed (*phragmites*), though both of these wetland plants *can* exist on the fringes of salt marshes) in the vicinity.
>
> *No*: Sites are not tidal if downstream banks obviously contain plants that could not survive salt water inundation, such as alders, maples, ferns, etc., normally seen on stream banks in upland areas.
>
> *Unknown*: Select when unsure of whether a crossing is in a tidal zone.

Alignment: Indicates the alignment of the crossing structure(s) relative to the stream at the inlet(s). Compare the crossing centerline (green lines below) to a centerline of the stream where it enters the crossing (red lines below).

> *Flow-Aligned*: The stream approaches the crossing at less than a 45 degree angle from the centerline.
>
> *Skewed*: The stream approaches the crossing structure(s) at an angle greater than 45 degrees from the centerline. Note that for some crossings the centerline is not perpendicular to the road.

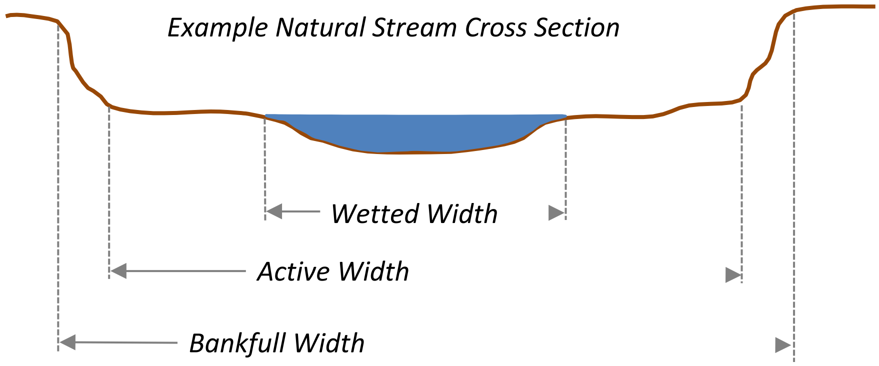


Road Fill Height: Within 1 foot, measure the height of fill material between the top of the crossing structure(s) and the road surface. This is best measured with two people when the road surface or fill height is above a surveyor's height, with one person holding a stadia rod, and the other sighting the elevation of the road surface from the side (see diagram below). For multiple culverts with differing amounts of fill over them, provide an average fill height.



Stream Measurement

Refer to the general illustrations below, and check the appropriate description from the list below to assess how constricted the flow of the stream is by the crossing compared to either the *bankfull*, *active*, or *wetted* channel. Choose only one option.



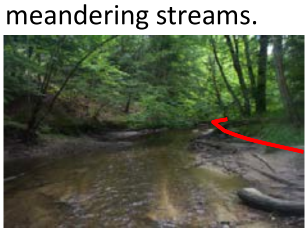
Active Channel: This is the area of the stream that is very frequently affected by flowing water. The width of the *active channel* can often be very close to the b*ankfull width* when stream banks are very steep.

Wetted Channel: This is simply the area of the stream that contains water at the time of survey, which may be significantly less than the *active channel*, depending on flow.

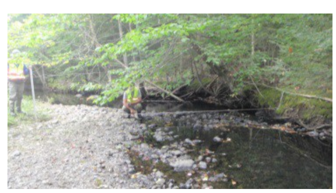
Bankfull Width (optional measurement)**:** This is a measure of the active stream channel width at bankfull flow, the point at which water completely fills the stream channel and where additional water would overflow into the floodplain. Estimates of the frequency of bankfull flows vary, but they may happen as often as monthly in part of the southeast, or only once every one or two years. This measurement takes practice and training to get correct and at times is difficult to determine. When done with high confidence (see next metric), bankfull width can be an extremely useful measurement, but it can be difficult and time consuming, and it will not be possible for all surveyors and sites (even with experienced surveyors). The first step is to identify bankfull flow indicators in an undisturbed reach, and the second step is to measure the width from bank to bank at those locations.

Indicators of bankfull flow (shown in the photographs below as the red line) include[1]:

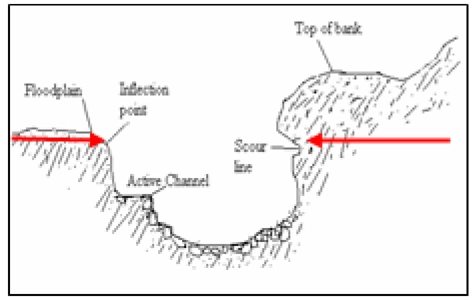
Abrupt transition from bank to floodplain: The point of change from a vertical bank to a more horizontal surface is the best identifier of bankfull stage, especially in low-gradient meandering streams.



Top of point bars: The point bar consists of channel material deposited on the inside of meander bends. Set the top elevation of point bars as the lowest possible bankfull.

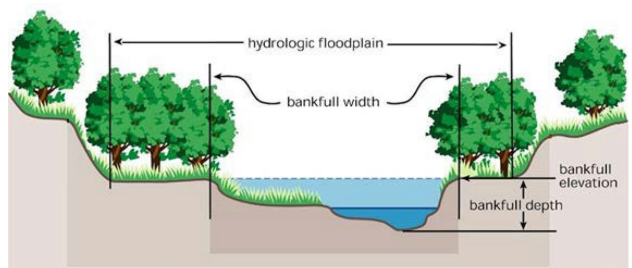


Bank undercuts: Maximum heights of bank undercuts are useful indicators of bankfull flow in steep channels lacking floodplains.



Changes in bank material: Changes in the particle size of sediment (rocks, soil, etc.) may indicate the upper limits of bankfull flows, with larger sediments exposed to more frequent channel-forming flows. Deposition of finer sediments on top of banks can also be used as an indication of previous flow heights.

Change in vegetation: Look for the low limit of woody vegetation, especially trees, on the bank, or a sharp break in the density or type of vegetation.



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[1] Adapted from Georgia Adopt-A-Stream "Visual Stream Survey" manual. Georgia Department of Natural Resources, 2002.

Bankfull Width Confidence: This qualifies your assessment of Bankfull Width based on your experience with its measurement and whether sufficient criteria were met in your measurements. Choose only one option.

High: Select this option only when you are highly confident that your assessment of Bankfull Width meets the following criteria:

- Clear indicators are present to define the limits of Bankfull Width.
- The recorded value is an average of at least three measurements in different locations.
- All measurements of Bankfull Width were taken in undisturbed locations well upstream or downstream of the crossing.
- No tributaries enter between the crossing and your area(s) of measurements.
- No measures taken at stream bends, pools, braided channels, or close to stream obstructions.

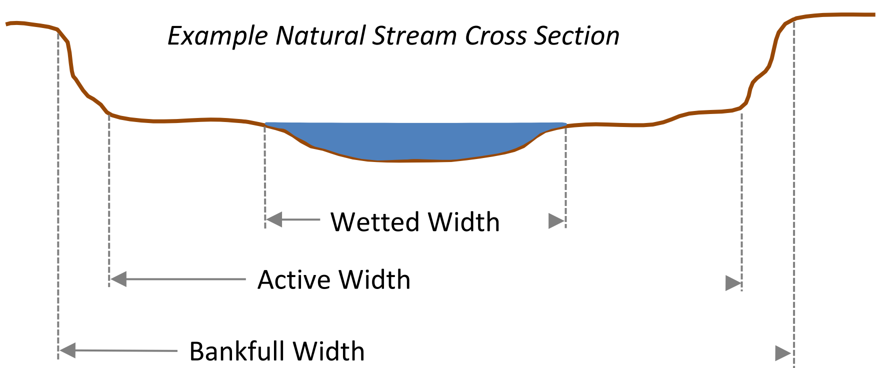
Low/Estimated: Select this when **any** of the above criteria cannot be met.

Constriction: Regardless of whether you measured Bankfull Width above, this element assesses how the width of the crossing (including all of its structures) compares to the width of the natural stream channel. Refer to the above section on determining Bankfull Width for reference. Two other ways of assessing the width of the natural stream channel consider the *active channel* and the *wetted channel*.

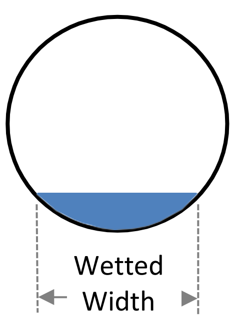
The ***active channel*** is the area of the stream that is very frequently affected by flowing water. The width of the *active channel* can often be very close to the Bankfull Width when stream banks are very steep. The ***wetted channel*** is simply the area of the stream that contains water at the time of survey, which may be significantly less than the *active channel*, depending on flow.

Refer to the general illustrations below, and check the appropriate description from the list below to assess how constricted the flow of the stream is by the crossing compared to either the *bankfull*, *active*, or *wetted* channel. Choose only one option.

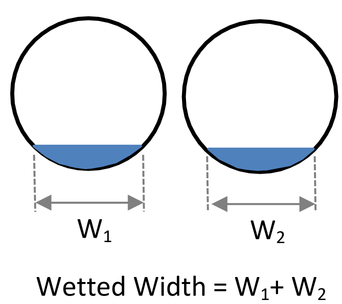
Example Natural Stream Cross Section



Example Culvert Cross Section



Example Multiple Culvert Cross Section



Severe: The total width of the crossing (sum of widths of all crossing structures) is less than 50% of the bankfull or active width of the natural stream, or the total *wetted width* of the crossing is less than 50% of the wetted width of the stream.

Moderate: The crossing is *greater than* 50% of the bankfull or active width of the natural stream, but less than the full bankfull or active channel width.

Spans Only Bankfull/Active Channel: The crossing encompasses the approximate width of the bankfull or active channel.

Spans Full Channel & Banks: The crossing completely spans beyond the *Bankfull Width* of the natural stream, as often evidenced by banks within the crossing structure.

Tailwater Scour Pool: This is a pool created downstream of a crossing as a result of high flows exiting the crossing. Use as a reference natural pools in a portion of the stream that is outside the influence of the crossing structure. A scour pool is considered to exist when its size (a combination of length, width, and depth) is larger than pools found in the natural stream.

None: There is no difference between the length, width, or depth of the tailwater pool compared with reference pools, or no tailwater pool exists at the site.

Small: The tailwater pool is between one and two times the length, width, or depth of reference pools.

Large: The tailwater pool is more than twice the length, width or depth of reference pools.

Inlet Scour Pool: This is a pool created upstream of a crossing as a result of a multitude of factors including constriction, large flood plains, and high flows entering the crossings structure. In the Southeast this is not episodic and often occurs during any large summer rain event. Use as a reference natural pools in a portion of the stream that is outside the influence of the crossing structure. A scour pool is considered to exist when its size (a combination of length, width, and depth) is larger than pools found in the natural stream. Check Large if the length, width or depth of the pool is two or more times larger than of pools in the natural stream channel. Otherwise, check Small if the pool is between one and two times the length, width, or depth of pools in the natural channel (see above).

None: There is no difference between the length, width, or depth of the upstream pool compared with reference pools, or no upstream pool exists at the site.

Small: The upstream pool is between one and two times the length, width, or depth of reference pools.

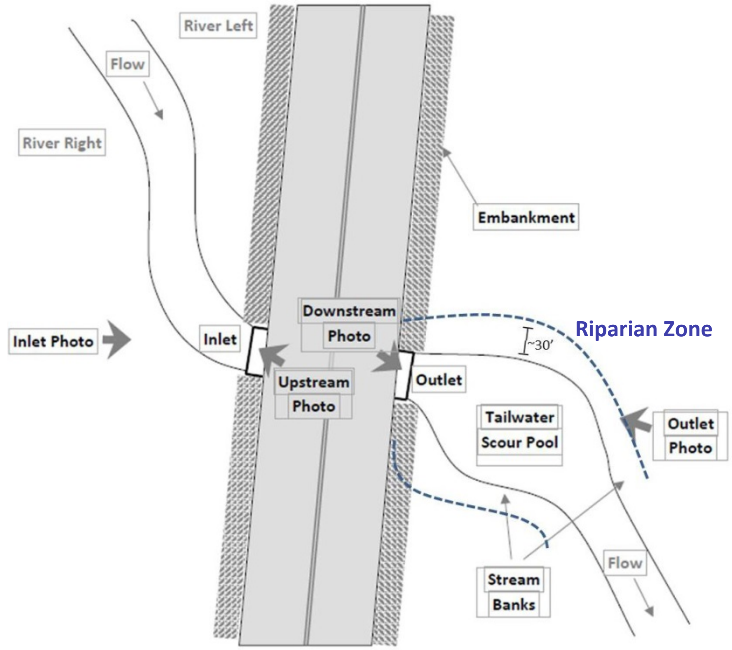
Large: The upstream pool is more than twice the length, width or depth of reference pools.

Riparian Vegetation (Tailwater & Inlet sides)-Optional: This metric was added in an effort to capture the risk of habitat degradation surrounding the culvert and scour pools. Lower levels of vegetation indicate a higher risk of erosion, scouring, structure undermining, as well as impacts to instream habitats. This metric is considering the immediate 30' buffer zone surrounding the scour pools (see image below for example area around tailwater scour pool). If the vegetation type (overstory, understory, and ground level) is greater than 50% then it is high, if less than 50% then it is low.

Overstory: Defined as the upper layer or zone formed by mature tree crowns

Understory: For this protocol, the understory is defined as the layer below the overstory and above the ground level. It includes layers commonly referred to as midstory, woody understory, herbaceous, and shrub layers.

Ground level: This refers to the immediate ground cover that is below the herbaceous/shrub layer. This refers primarily to rooted vegetation and not leaf litter. However, if there are significant leave litter (complete coverage) it should be noted in the notes section.



Crossing Comments: Use this area for brief comments about any aspect of the overall crossing survey that warrants additional information. Do <u>not</u> use this box for comments about particular structures; comment boxes for each structure are provided elsewhere on the form.

STRUCTURE DATA
Outlet

*<u>Choose only one option</u> for structure data fields **except** when identifying Internal Structures and Physical Barriers.*

*When there are multiple culverts and/or bridge cells, <u>**number them from left to right, while looking downstream toward the culvert inlet.**</u>*

The left-most structure is Structure 1, and structure numbers increase to the right. See examples below.

For each structure, you will complete all of the following information.

Structure Material: Record here the primary material of which the structure is made, i.e., the material that makes up the majority of the structure. When in doubt, focus on the material that is most in contact with the stream. If a structure is made of two materials, such as a bridge with concrete abutments and a steel deck structure, a metal culvert that has been lined along its entire bottom with concrete, or a crossing with different types of structures at inlet and outlet, select *Combination*. <u>Choose only one option</u>.

Outlet Shape:

Refer to the diagrams on the last page of the field data form

Record the structure number that best matches the shape of the structure opening observed at the inlet of the culvert. This is usually simple, but when a shape seems unusual, you should carefully choose the most reasonable option from among the eight available. We collect this information to be able to find the "open area" inside the structure above any water or substrate, so the shape is vital to accurately calculate area. <u>Choose only one option</u>.

1 - Round Culvert: This is a circular pipe. It may or may not have substrate inside, even though the diagram on the field form shows a layer of substrate. It may be compressed slightly in one dimension, and should be considered round unless it is truly squashed so that it reflects a type 2 shape below.




2 - Pipe Arch/Elliptical Culvert: This is essentially a squashed round culvert, where the lower portion is flatter, and the upper portion is a semicircular arch, or as on the right below, more of a pure ellipse. It may or may not have substrate inside (the diagram on the field form shows a layer of substrate).



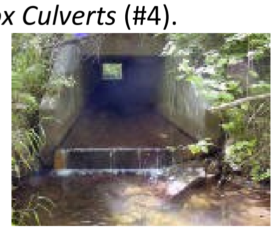

3 - Open Bottom Arch Bridge/Culvert: This structure will often look like a round culvert on the top half, but it will not have a bottom. There will be some sort of footings to stabilize it, either buried metal or concrete footings, or concrete footings that rise some height above the channel bottom. There will be natural substrate throughout the structure. To distinguish between an embedded Pipe Arch Culvert and an Open Bottom Arch, note that the sides of the Pipe Arch curve inward in their lower section, while the sides of the Open Bottom Arch will run straight downward into the streambed substrate or to a vertical footing. Beware of confusion between an Open Bottom Arch and an embedded Round Culvert; Open Bottom Arches tend to be larger than most Round Culverts. This shape could also be selected for certain bridges that have a similar arched shape and are not well represented by other bridge types (Types 5, 6, 7, below).




4 - Box Culvert: These structures are usually made of concrete or stone, but sometimes of corrugated metal with a slightly arched top. Typically, they have a top, two sides, and a bottom.

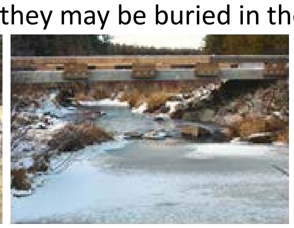
A box culvert <u>without</u> a bottom, called a bottomless box culvert, should be classified as a *Box/Bridge with Abutments* (#6, below). If you cannot tell if the structure has a bottom, classify it as a *Box/Bridge with Abutments* (#6). The images below show *Box Culverts* (#4).



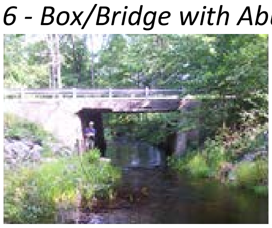


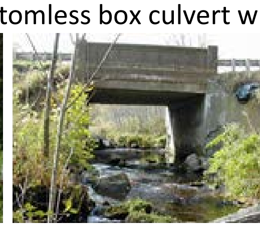

5 - Bridge with Side Slopes: This is a bridge with angled banks up to the bottom of the road deck. This type will have no obvious abutments, though they may be buried in the road fill.






6 - Box/Bridge with Abutments: This is a bridge or bottomless box culvert with vertical sides.

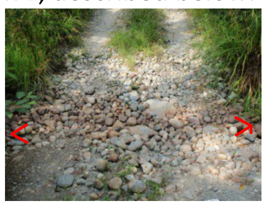





7 - Bridge with Side Slopes and Abutments: This is a bridge with sloping banks and vertical abutments (typically short) that support the bridge deck. (Arrows below show the abutments.)

Ford: A ford is a shallow, open stream crossing that may have aminimal structure to stabilize where vehicles drive across the stream bottom. The arrows below indicate the length of a ford, to be measured as Dimension *L*, described below.

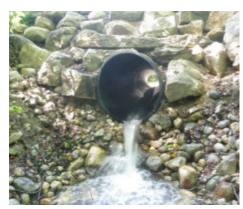
Unknown: Select when a structure's shape is unidentifiable for any reason. Typically, the inlet shape may be unidentifiable because it is submerged or completely blocked with debris.

Removed: Select when the structure is no longer present.

Outlet Armoring: Select from the options to indicate the presence and extent of material placed below the outlet for the purpose of diffusing flow and minimizing scour. The most common form of outlet armoring is a layer of riprap (angular rock) placed below the outlet. A few pieces of rock that may have fallen into the stream near the structure's outlet **do not** constitute outlet armoring. Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom at the outlet. <u>Choose only one option</u>.

Refer to the photos below for examples of each option.

None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize outlet scour.

Not Extensive: There is of a layer of material covering an area *less than 50% of the stream width* placed purposefully below the outlet specifically to minimize the effects of scour.

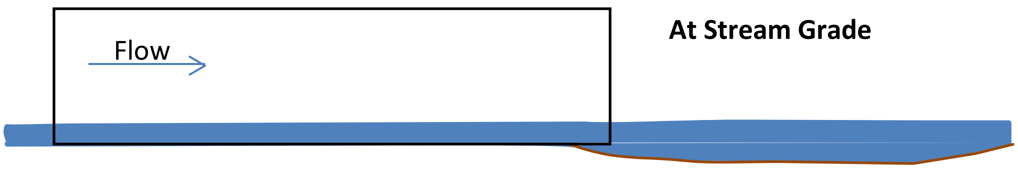
    

Extensive: Select this option only if you observe an extensive layer of material covering an area more than 50% of the stream width, which was put in place specifically to minimize scour at the outlet.

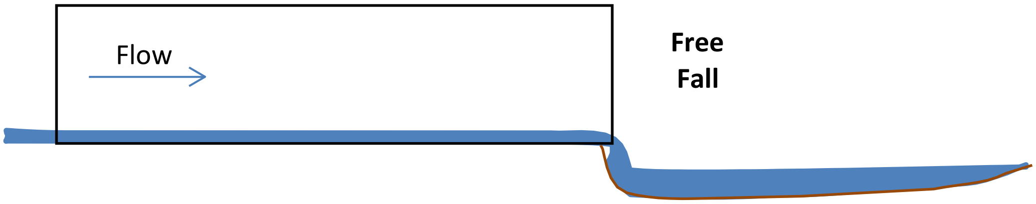
Outlet Grade: Outlet grade is an observation of the relative elevation of the structure to the streambed and how water flows as it exits the structure. This is not an assessment of stream slope (gradient).
<u>Choose only one option</u>.

At Stream Grade: The bottom of the outlet of the structure is at approximately the same elevation as the stream bottom (there may be a small drop from the inside surface of the structure down to the stream bottom), such that <u>**water does not drop downward at all**</u> when flowing out of the structure. Such outlets can normally be considered to be “backwatered” by the downstream stream bed.

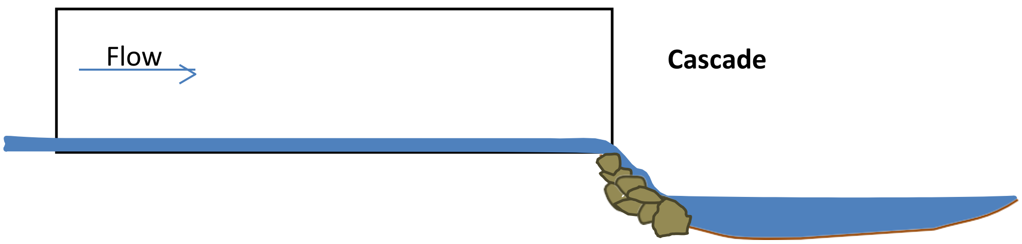


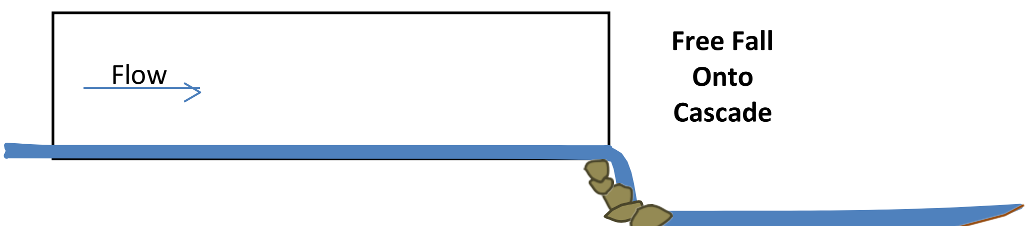
Free Fall: The outlet of the structure is above the stream bottom such that <u>**water drops vertically**</u> when flowing out of the structure.



Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **<u>water flows very steeply downward across rock or other hard material</u>** when flowing from the structure. Think of this as series of small waterfalls at the outlet.



Free Fall Onto Cascade: The outlet of the structure is raised above the stream bottom at the outlet such that **<u>water drops vertically onto a steep area of rock or other hard material, then flows very steeply downward</u>** until it reaches the stream.



Outlet Dimensions: <u>Four</u> measurements should be taken at the outlet and <u>inside</u> all structures, and an additional **<u>two</u>** should be taken for all structures with an Outlet Grade marked as *Free Fall, Cascade* or Free *Fall*

Onto Cascade. The four measurements are shown on the diagrams on the last page of the field data form, and the others are illustrated below.

Dimension A, ***Structure Width***: To the nearest tenth of a foot, measure the full width of the structure outlet according to the location of the horizontal arrows labeled ***A*** in the diagrams. Take this measurement **inside** the structure.

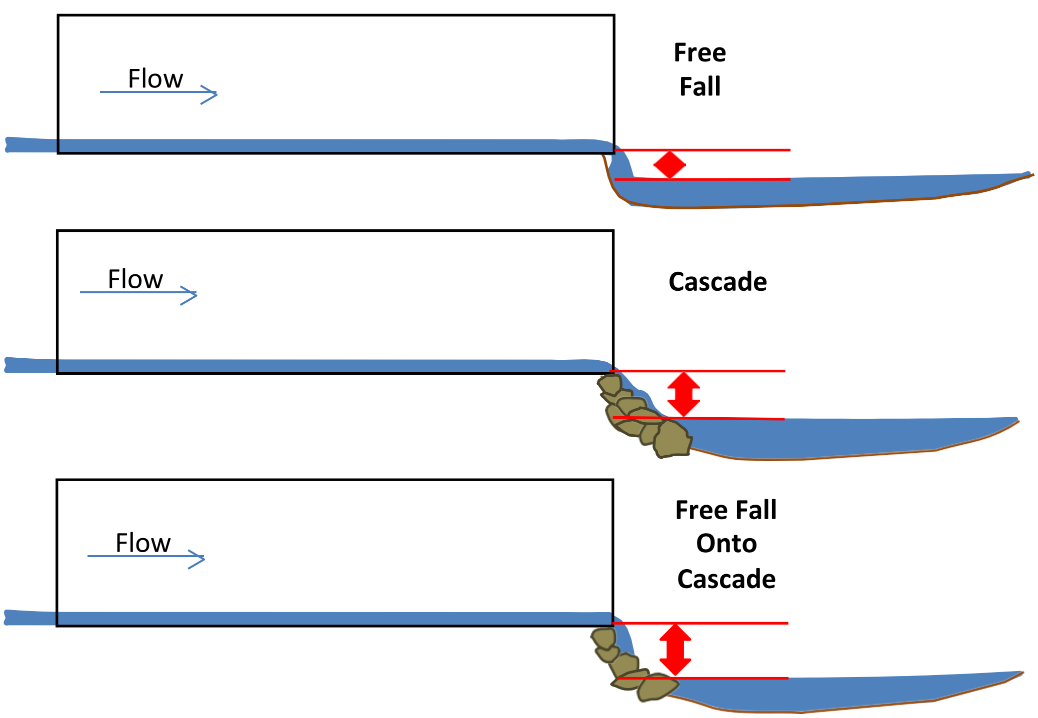
Dimension B, ***Structure Height***: To the nearest tenth of a foot, measure the height of the structure outlet according to the location of the vertical arrows labeled ***B*** in the diagrams. Take this measurement **inside** the structure. If there is no substrate inside, this will be the full height of a structure from bottom to top. If there is substrate inside, this will be the height from the top of the stream bottom substrate up to the inside top of the structure.

Dimension C, ***Substrate/Water Width***: To the nearest tenth of a foot, measure the width of **either** the substrate layer in the bottom of the structure, or of the water surface, whichever is **wider** according to the general location indicated by the arrows labeled ***C*** in the diagrams. This measurement must be taken **inside** the structure near the outlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure only the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

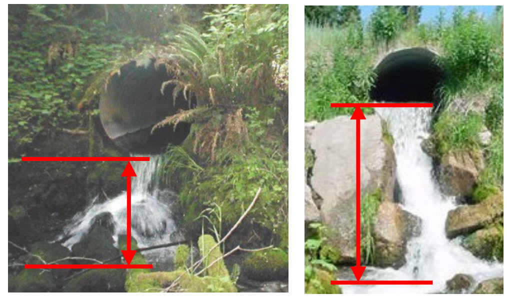
Dimension D, ***Water Depth***: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest hundredth of a foot), measure the average depth of water in the structure at the outlet according to the location of the vertical arrows labeled ***D*** in the diagrams. This measurement must be taken **inside** the structure. When there are lots of different depths due to a very uneven bottom, take several measurements and record the average. For fords, measure the water depth at the downstream limit of the ford.

Outlet Drop to Water Surface: This measurement is only applicable to *Free Fall, Cascade* and Free *Fall Onto Cascade* outlets. To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the water surface outside the structure. For *Cascade* and *Free Fall Onto Cascade* structures, measure to the surface of the water at the bottom of the cascade. Refer to the diagrams and photos below for guidance; the red arrows indicate where to make this measurement. When assessing *At Stream* Grade structures or dry structures in streams without flow or water in an outlet pool, this measurement must be *zero*.



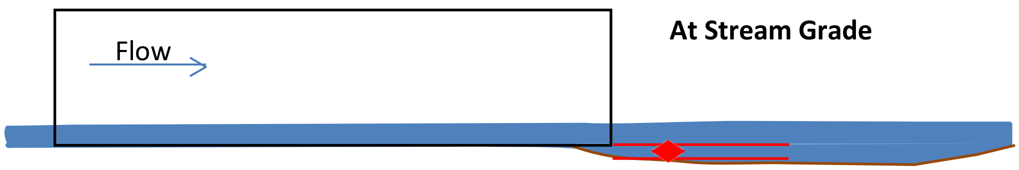
Free Fall

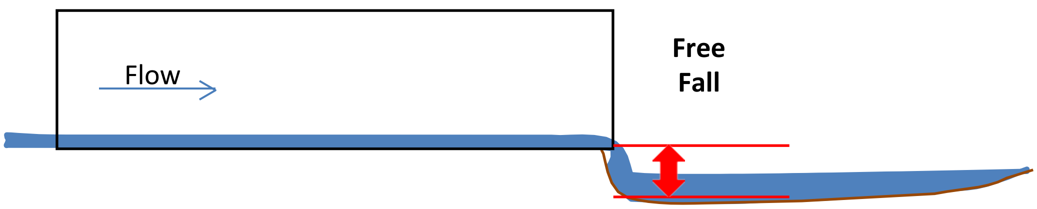
Free Fall

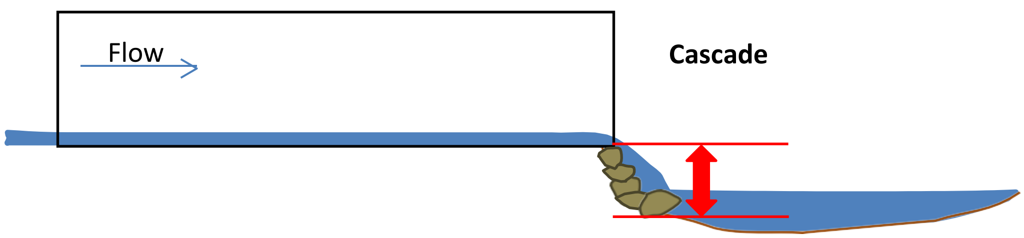


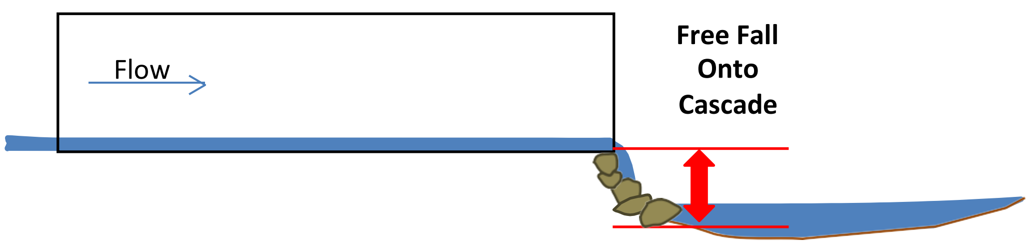
Free Fall Onto Cascade

Outlet Drop to Stream Bottom: To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the stream bottom at the place where the water falls from the outlet. For *At Stream* Grade structures, this may be hard to measure, and may be a very small drop. For *Cascade* and *Free Fall Onto Cascade* structures, measure the full vertical drop to the stream bottom at the end of the cascade. Refer to the diagrams below for guidance.





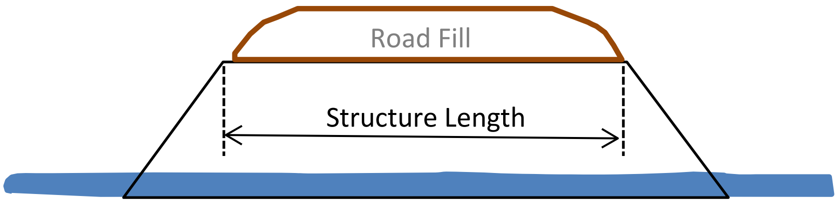




Abutment Height, *Dimension E*: This measurement is taken only when surveying a *Bridge with Side Slopes and Abutments* (#7 structure**)**. To the nearest foot, measure the height of the vertical abutments from the top of the side slopes up to the bottom of the bridge deck structure.



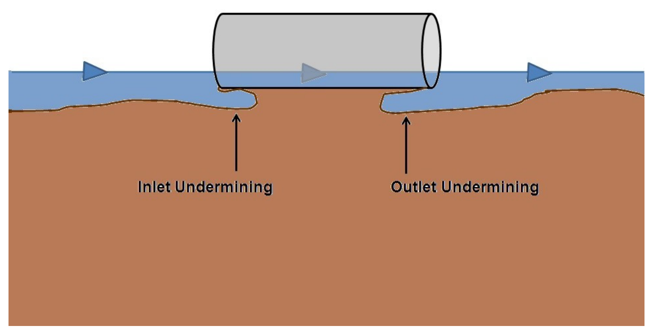

Structure Length, *Dimension L*: To the nearest foot, measure the length of the structure at its top.



Undermining (Outlet and Inlet): Undermining occurs when water velocity causes a scouring underneath the structure. If there is evidence of undermining it indicates a greater likelihood of structure failure. In the Southeast this can occur on both the inlet and outlet sides. Undermining is present if there is space greater than 6" under the structure. If so, then select **Yes**, if less than 6" or none, select **No**.

Yes: Defined as a space greater than 6" underneath the structure itself. (Not to be mistaken with the scour pool).
No: Defined as a space less than 6" or none present at all.

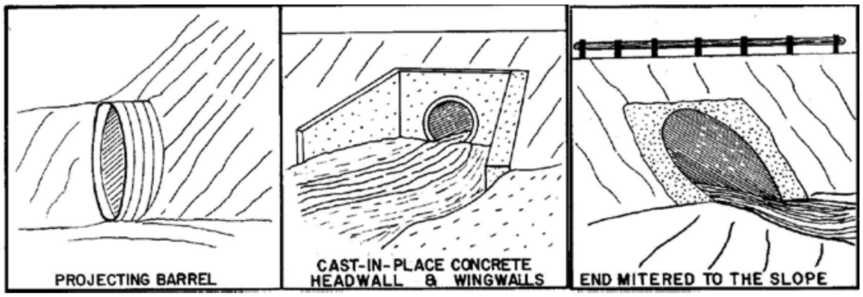




STRUCTURE DATA
Inlet

Inlet Shape: Refer to the diagrams on the last page of the field data form, and record here the number that best matches the shape of the structure at its outlet. Refer to the instructions for **Outlet Shape** for examples and photos.

Inlet Type: Choose only one option for the style of a culvert inlet, which affects how water flows into the crossing, particularly at higher flows. The drawings here are meant as general guides, but refer to the photos below for more specific images of each type.



Projecting: The inlet of the culvert projects out from (is not flush with) the road embankment.

Headwall: The inlet is set flush in a vertical wall, often composed of concrete or stone.

Wingwalls: The inlet is set within angled walls meant to funnel water flow. These walls can be composed of the same material as the culvert, or different material. It is relatively rare to see wingwalls without a headwall.

Headwall & Wingwalls: The inlet is set flush in a vertical wall, and has angled walls to funnel flow.

Mitered to Slope: The inlet is angled to fit **flush with the slope of the road embankment**. Note that many mitered culverts project out from the embankment, and should be recorded as *Projecting*.




Other: There may be some other inlet characteristics that do not match any of the above types and which may limit flow into the culvert (but are not *Physical Barriers*), in which case select *Other*, and explain in *Structure Comments*.

None: The inlet does not have any of the above features or characteristics.




Inlet Armoring: The same measurement as for the outlet. Select from the options to indicate the presence and extent of material placed below the inlet for the purpose of diffusing flow and minimizing scour. This is a common occurrence in parts of the Southeast where they will install armoring on both sides of the structure to diffuse flow during high rain events. The most common form of armoring is a layer of riprap (angular rock) placed below the inlet. A few pieces of rock that may have fallen into the stream near the structure's inlet **do not** constitute armoring. **Armoring of the road embankment and stream banks should not be confused with armoring of the stream bottom at the inlet.** Choose only one option. (Pictures on page 19)

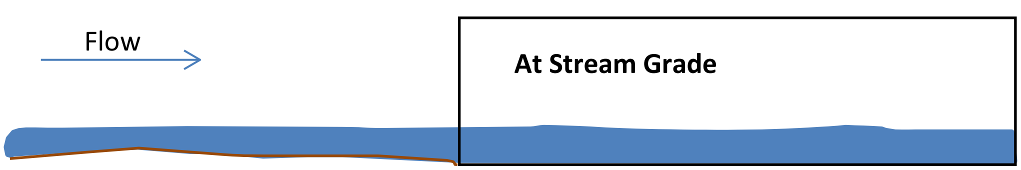
None: This situation represents the majority of crossing structures. You may observe rocks that have fallen from the embankment or that are natural to the stream. Most cascades do not constitute armoring unless specifically put in place to minimize outlet scour.

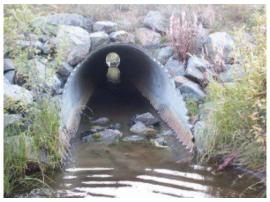
Not Extensive: There is of a layer of material covering an area *less than 50% of the stream width* placed purposefully below the outlet specifically to minimize the effects of scour.

Extensive: Select this option only if you observe an extensive layer of material covering an area more than 50% of the stream width, which was put in place specifically to minimize scour at the outlet.

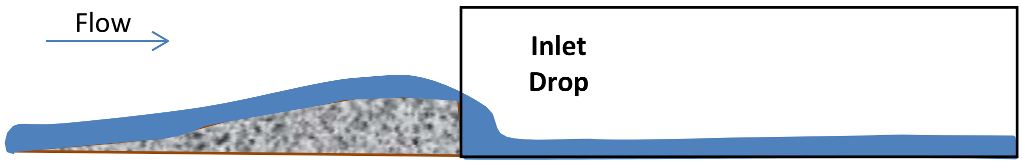
Inlet Grade: An observation of the relative elevation of the stream bottom as it enters the structure. This is not an assessment of stream slope (gradient). Choose only one option.

At Stream Grade: The inlet of the structure is at approximately the same elevation as the stream bottom upstream of the structure.



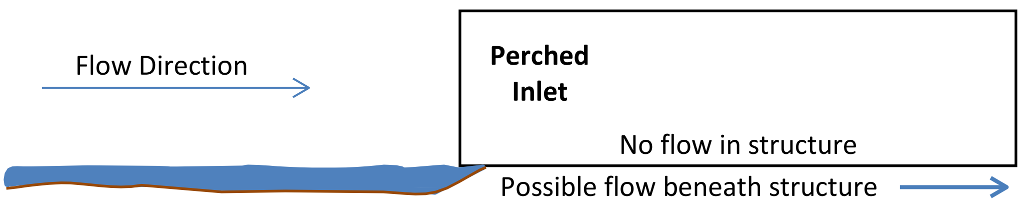
   

Inlet Drop: Water in the stream has a near-vertical drop from the stream channel down into the inlet of the structure. This usually occurs because sediment has accumulated above the inlet. The drop should be very obvious and not typical of natural drops in that stream. If there is a debris blockage or dam at the inlet, use **Physical** Barriers to record those features, and mark *At Stream Grade* here.



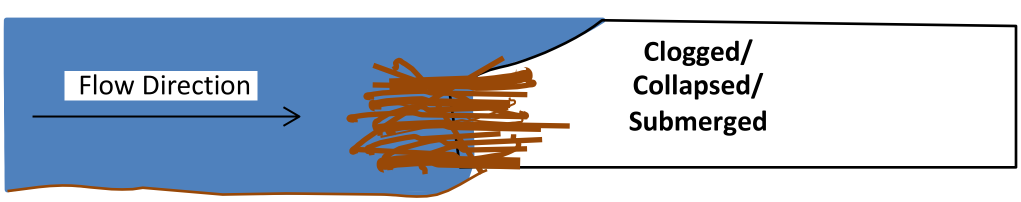
   

Perched: The inlet of the structure is set too high for the stream, and little water passes through the structure during normal low summer flows, though the stream has water upstream and downstream of the crossing. The structure inlet is above the surface of water in the stream. Water can enter the structure only at higher flows. This is a relatively rare condition, found mostly on very small streams. At such sites, there is generally water backed up above the inlet. In some cases water may be "piping" underneath the structure.



Clogged/Collapsed/Submerged: The structure inlet is either full of debris, collapsed, or completely underwater (not usually all three), making inlet measurements impossible. This may be found in places where beavers or debris have plugged a structure inlet so completely that water has backed up and covered the inlet, or where a crossing has collapsed to the point that it cannot be measured at its inlet.



Unknown: The inlet cannot be located or observed, or for some other reason you cannot determine the *Inlet Grade*, or take any inlet measurements.

Inlet Dimensions: There are four basic measurements to take at the inlet and outlet of each structure; these four measurements are to be made inside the structure. These are shown on the diagrams on the **last page of the field data form.**

Dimension A, ***Structure Width:*** To the nearest tenth of a foot, measure the full width of the structure inlet according to the location of the horizontal arrows labeled ***A*** in the diagrams. Take this measurement **inside** the structure.

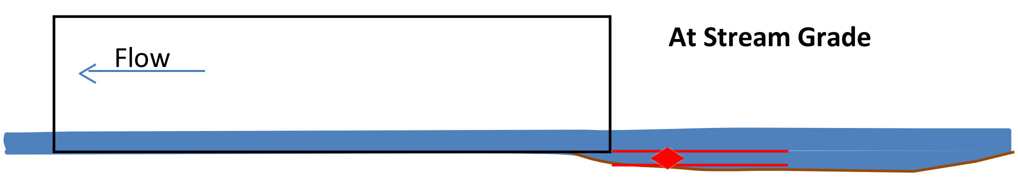
Dimension B, ***Structure Height***: To the nearest tenth of a foot, measure the height of the structure inlet according to the location of the vertical arrows labeled ***B*** in the diagrams. Take this measurement **inside** the structure. This may be the full height of a culvert pipe if there is no substrate inside, or if there is substrate, it will be the height from the top surface of the substrate up to the inside top of the structure.

Dimension C, ***Substrate/Water Width***: To the nearest tenth of a foot, measure the width of **either** the substrate layer in the bottom of the structure, or the water surface, whichever is wider, according to the general location indicated by the arrows labeled ***C*** in the diagrams. Take this measurement **inside** the structure at the inlet. Some rules of thumb for Dimension C are below:

- When there is no substrate in a structure, measure the width of the water surface.
- When there is no water in a structure, but there is substrate, measure the width of substrate.
- When there is no substrate or water in a structure, C = 0.

*Dimension D, **Water Depth***: To the nearest tenth of a foot (except when < 0.1 foot, to the nearest *hundredth* of a foot), measure the average depth of water in the structure at the inlet according to the location of the vertical arrows labeled ***D*** in the diagrams. This measurement must be taken **inside** the structure. When there are many different water depths due to a very uneven structure bottom, take several measurements and record the average. For fords, measure the water depth at the upstream limit of the ford.

Inlet Drop to Stream Bottom: To the nearest tenth of a foot, measure from the inside bottom surface of the structure (**not** the top of the water) down to the stream bottom at the place where the water enters the inlet. For *At Stream* Grade structures, this may be hard to measure, and may be a very small drop. For *Cascade* and *Free Fall Onto Cascade* structures, measure the full vertical drop to the stream bottom at the end of the cascade. Refer to the diagrams below for guidance.



At Stream Grade

ADDITIONAL CONDITIONS

Slope %*:* (Optional) Calculate or estimate the percent slope of the crossing from inlet to outlet by using one of several optional methods described below. Note that this measurement or estimate can be important to calculating the hydraulic capacity of the crossing, and is difficult to measure accurately without the proper tools. In general, the ease and accuracy of these different methods relates directly to the cost of the tools needed, with the most easy-to-use and accurate measurement tools costing more.

1) The simplest accurate method for measuring slope is to use an accurate laser rangefinder/hypsometer with a slope function, and to measure from inlet to outlet at the same height in relation to each invert. For instance, a person with a known eye height of 5.0 feet sights from one end of a culvert by standing on top of the inlet to the 5.0 foot mark on a stadia rod on top of the outlet. You must take at least three measurements and average them, and be sure the instrument is set to read in percent, not degrees.
2) Another method for measuring slope is to use an auto level or other accurate survey instrument to measure the vertical difference between inlet and outlet invert elevations, then dividing this number by the length of the structure, and multiplying by 100.
3) The next best approach is to use a clinometer that measures slope to the nearest half percent, measuring from a fixed point above one invert (inlet or outlet) to the same height above the opposite invert such as described above under method 1. Many clinometers include both percent and degree scales; be sure to use the percent scale.
4) Another less accurate approach is to sight from a fixed elevation above the inlet invert with a hand level to a stadia rod at the outlet invert, to take the difference in height between the two points, divide by the structure length, and multiply by 100.

Slope Confidence: Rate the confidence you have in your slope measurement or estimate according to the criteria below:

High: Used method 1 above, taking multiple measurements and averaging them, or used method 2 above.

Low: Used methods 3 or 4 above, taking multiple measurements and averaging them.

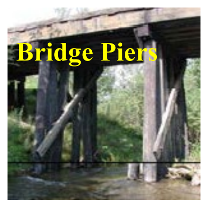
Internal Structures: Indicate the presence of structures inside the crossing structure. These may include baffles or weirs used to slow flow velocities and help to pass fish, as well as trusses, rods, piers or other structures intended to support a crossing structure, but which may interfere with flow and aquatic organism passage. See photos below for examples of internal structures. Choose any option(s) that apply.

None: There are no apparent structures inside the crossing structure.

Baffles/Weirs: Baffles (partial width) or weirs (full width, notched or not) are incorporated into the structure, either inside or at its outlet, to help aquatic organisms move through the structure.

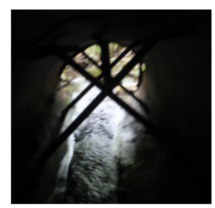
Supports: Some type of structural supports, such as bridge piers, vertical or horizontal beams, or rods apparently meant to support the structure, are observed inside the crossing structure.

Other: Structure(s) other than the categories above are present inside the crossing structure. Provide a very brief description of those structures here, or more fully describe them under **Structure Comments**. <u>**Do not**</u> include here items such as bedrock, material blockages, structural deformation, or inlet fencing to exclude beavers, which will be recorded below as **Physical Barriers**.









Structure Substrate Matches Stream*:* <u>Choose only one option</u> based on a comparison of the substrate (e.g., rock, gravel, sand) inside the structure and the substrate in the natural, undisturbed stream channel.

None: Select this option when there is very little (e.g., a thin layer of silt or a few pieces of rock) or no substrate inside the structure.

Comparable: The substrate inside the structure is similar in size to the substrate in the natural stream channel.

Contrasting: The substrate inside the structure is different in size from the substrate in the natural channel.

Not Appropriate: The substrate inside the structure is very different in size (usually much larger) than the substrate in the natural stream channel. Imagine turtles that typically move along a sandy stream trying to traverse an area of large cobbles, angular riprap or boulders (rarely observed).

Unknown: There is no way to observe if there is substrate inside the structure or what type it is. Select this option when deep, fast, or dark water or other factors do not allow direct observation.

Structure Substrate Type: Choose only one option from the table below to indicate the most common or dominant substrate type inside the structure. If you are certain that the structure contains substrate, but cannot assess the type, select *Unknown*. If there is no substrate in the structure, select *None*.

Substrate Type	Feet	Approximate Relative Size
Silt	< 0.002	Finer than salt
Sand	0.002 – 0.01	Salt to peppercorn
Gravel	0.01 – 0.2	Peppercorn to tennis ball
Cobble	0.2 – 0.8	Tennis ball to basketball
Boulder	> 0.8	Bigger than a basketball
Bedrock	Unmeasurable	Unknown - buried
Organic Mtrl.	Unmeasurable	Most commonly leaf litter or grass/algae

Structure Substrate Coverage: Choose one option, based on the extent of the substrate inside the crossing structure as a ***continuous*** layer across the entire bottom of the structure from bank to bank (side to side).

None: Substrate covers less than 25% of the length of the structure, or there is no substrate inside the structure at all.

25%: Substrate covers *at least* 25% of the length of the structure.

50%: Substrate covers *at least* 50% of the length of the structure.

75%: Substrate covers *at least* 75% of the length of the structure.

100%: Substrate forms a ***continuous*** layer throughout the ***entire*** structure.

Unknown: It is not possible to directly observe whether substrate forms a continuous layer on the structure bottom.

Physical Barriers: Select any of these barrier types in or associated with the structure you are surveying, but do not include here information already captured in **Outlet Grade**. Note here additional barriers, including those associated with Inlet Grade or blockages, or Internal Structures. If a barrier feature affects more than one structure at a crossing (e.g., a beaver dam), include it for all affected structures. Refer to the photos below for examples of physical barriers.

Note that some structures have a combination of physical barriers. Check all that apply.

None: There are no physical barriers associated with this structure aside from any already noted in **Outlet Grade**.

Debris/Sediment/Rock: Woody debris or synthetic material, rock, or sediment blocks the flow of water into or through the structure. This can consist of wood or other vegetation, trash, sand, gravel, or rock. Do not check this option if you observe only very small amounts of debris that are likely to be washed away during the next rain event. Also, do not confuse sediment inside a structure that constitutes an appropriate stream bed with an accumulation that limits flow or passage of organisms.





Deformation: The structure is deformed in such a way that it significantly limits flow or inhibits the passage of aquatic organisms. This does not include minor dents and slightly misshapen structures.



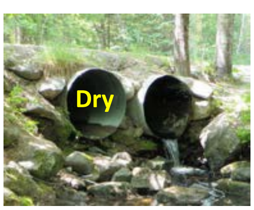

*Free Fall***:** In addition to its **Outlet Grade**, which may include a *Free Fall*, the structure has one or more **additional** vertical drops associated with it. These may include a dam at the inlet, a vertical drop over bedrock inside the structure, or some other feature likely to inhibit passage of aquatic organisms. Note that a *Free Fall* inside a structure is often more limiting than similar size drops found in an undisturbed natural reach of the same stream which occur where there may be multiple paths for organisms to follow. A *Free Fall* can exist because of a debris blockage, so both physical barriers would be recorded.




Fencing: The structure has some sort of fencing, often at the inlet to deter beavers. Depending on the mesh size of that fencing, it may directly block the movement of aquatic and terrestrial organisms, and it may become clogged with debris. If also blocked with debris, be sure to check *Debris/Sediment/Rock* as a **Physical Barrier** type as well.




Dry: There is no water in this structure, though water is flowing in the stream. Note that if you recorded *No Flow* for crossing Flow Condition, you should not select *Dry* here, as we expect a dry structure at a dry crossing; it is not in itself a physical barrier. This barrier type helps to identify passage problems associated with overflow or secondary crossing structures.



Other: There may be different situations that do not fit clearly into one of the above categories, but may still represent significant physical barriers to aquatic organism passage. Use this option to capture such situations, and add information in Structure Comments. Below are examples of some unusual physical barriers which may not fit under Physical Barrier categories listed above.

These are examples of structures with a combination of physical barriers. Multiple relevant barrier types should be selected.





Severity: <u>Choose only one option for each surveyed structure</u>, and rank the severity based on an assessment of *the cumulative effect of all physical barriers affecting that structure* according to the table that follows. <u>Do not</u> consider information already captured in **Outlet Grade**. Decide on an overall severity for each structure by considering all the different Physical Barriers present. If any barrier affects more than one structure at a crossing, it should be included in the severity rating for each structure affected. Refer to the table below for guidance in choosing the **Severity** rating.

Physical Barrier	Severity	Severity Definition
None	*None*	No physical barriers exist - **apart from** Outlet Grade
Debris/Sediment/Rock *Logs, branches, leaves, silt, sand, gravel, rock*	*None*	None beyond few leaves or twigs as may occur in stream
	Minor	< 10% of the open area of the structure is blocked
	Moderate	10% - 50% of open area blocked
	Severe	> 50% of open area of structure blocked
Deformation *Significant dents, crushed metal, collapsing structures*	*None*	Small dents and cracks – insignificant effect on flow
	Minor	Flow is limited < 10%
	Moderate	Flow is limited between 10% - 50%
	Severe	Flow is limited > 50%
Free Fall *Vertical or near-vertical drop*	*None*	No vertical drop exists - **apart from** Outlet Grade
	Minor	0.1 - 0.3 foot vertical drop - **apart from** Outlet Grade
	Moderate	0.3 - 0.5 foot vertical drop - **apart from** Outlet Grade
	Severe	> 0.5 foot vertical drop - **apart from** Outlet Grade
Fencing *Wire, metal grating, wood*	*None*	No fencing exists in any part of the structure
	Minor	Widely spaced wires or grating with > 0.5 foot (6 inch) gaps
	Moderate	Wires or grating with 0.2 - 0.5 foot (~ 2-6 inches)spacing
	Severe	Wires or grating with < 0.2 foot (~ 2 inch) spacing
Dry	*Minor*	May be passable at somewhat higher flows
	Moderate	Not likely passable at higher flows
	Severe	Impassable at higher flows
Other	*Minor*	Use best judgment based on above standards
	Moderate	Use best judgment based on above standards
	Severe	Use best judgment based on above standards

Water Depth Matches Stream: Compare the water depth inside the structure with the water depth in the natural stream channel away from the influence of the crossing. Choose only one option.

Yes: The depth in the crossing falls within the range of depths naturally occurring in that reach of the stream and **for comparable distances** along the length of the stream. For example, if a structure has a water depth of 0.2 feet through the entire structure's length of 60 feet, and there comparable sections of the stream with a 0.2 foot water depth for approximately 60 feet of the channel, select *Yes*.

No-Shallower: This means that the water depth in the crossing is less than depths that occur naturally in a similar length of the undisturbed stream, or the shallower depth through the structure covers a greater length than occurs in the natural stream.

No-Deeper: This means that the water depth in the crossing is greater than depths that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure depth to natural stream depth is not possible.

Water Velocity Matches Stream*:* Compare the water velocity inside the structure with the velocity in the natural stream channel away from the influence of the crossing. Choose only one option.

Yes: The water velocity in the crossing falls within the range of velocities naturally occurring in that reach of the stream **for comparable distances**. If velocities in the crossing are observed in the natural stream channel, and those velocities persist over the same distance as the structure length, select *Yes.*

No-Faster: This means that the water velocity in the structure is greater than velocities that occur naturally in a similar length of the undisturbed stream, or the velocity through the structure persists over a longer distance than occurs in the natural stream.

No-Slower: This means that the velocity in the crossing is less than velocities that occur naturally in a similar length of the undisturbed stream. This is rarely observed.

Unknown: A comparison of structure velocity to natural stream velocity is not possible.

Dry Passage Through Structure? Consider this question two different ways, depending on whether water is flowing through the structure. Choose only one option.

If there is water flowing in the structure: Is there a continuous dry stream bank through at least one side of the structure that allows the safe movement of terrestrial or semi-aquatic animals, and does this dry pathway connect to the stream banks upstream and downstream of the structure?

If there is no water flowing in the structure: then there is continuous dry passage through the structure.

Yes: A continuous bank connects upstream, through the structure, and downstream, or there is otherwise continuous dry passage through the structure.

No: There is no dry passage, the dry passage is not continuous, or the dry passage through the structure does not connect with stream banks upstream or downstream.

Unknown: It is not possible to determine if continuous dry passage exists through this structure.

Height Above Dry Passage: If there is dry passage through the structure, measure the average height from the dry stream bank to the top of the structure directly above (i.e., the clearance) to the nearest tenth of a foot. If both stream banks are dry and connected, record the higher measurement. If the structure has no water flow, measure the average height above the bottom of the structure or dry stream bed to the top of the structure.

Comments: Use this area to briefly comment on any aspects of the structure needing more information. Enter comments about the overall crossing in the **Crossing Comments** box.

ALPHABETIZED INDEX FOR REFERENCE **PAGE #**

PRELIMINARY ENGINEERING REPORT

Appendix C
Conceptual Design of 5 High Priority Culverts

Introduction

The proposed culvert replacements will support the Black River Aquatic Connectivity Assessment. The retrofit or replacement of these structures will improve biological and aquatic connection between the upstream and downstream of the existing stream crossings where this connection has been broken due to various reasons like extensive scour at the downstream end causing the culvert to be perched well above the normal water surface which inhibits the free passage of aquatic organisms under normal flow conditions or the structures being possibly built at improper outlet invert elevations. The existing crossings were assessed and assigned a SARP (Southeast Aquatic Resources Partnership) score by using a Barrier Prioritization Tool (BPT). This scoring and field visit established a level of severity for the identified barriers. Field data from the entire set of crossings were reviewed. SARP scores were analyzed and 10 locations were identified based on status as moderate, significant, or severe barriers in locations that had significant sections of stream upstream. Five of these culverts were selected for more detailed analysis and conceptual design. These five locations, along with their SARP scores, are shown in Table I.

Site	*SARP Score*	*Barrier Type*	*Latitude*	*Longitude*
152	0.46	Moderate	34.63770	-78.13776
376	0.47	Moderate	34.42688	-78.07896
64	0.22	Significant	34.68921	-78.37003
236	0.19	Severe	34.48575	-78.16040
202	0.08	Severe	34.47356	-78.09328

Table I: Culvert Ratings of Five Culverts Identified for Conceptual Design

USGS Streamstats (USGS Streamstats, 2019) was used to calculate the catchment area at the existing crossings. However, to account for future development, 5% of the total catchment area was assumed to be impervious. The hydrology for this area was determined by the USGS Regression equations which were fitted to the Hydrologic Region 4 according to USGS SIR 2014:5030 (USGS, 2014). Table II includes the catchment area as well as the computed flows and stream length upstream of the crossing. 'HY-8' is a program from the Federal Highways Administration used for culvert design and analysis. Existing and proposed scenarios were modeled in HY-8 to satisfy the NCDOT criteria as well as to facilitate adequate passage for various biological and aquatic organisms known to be present in the watershed. These results are displayed as a comparison in Table III, followed by, Table IV, which exhibits a preliminary cost estimate for each of these culvert replacements.

Topographic information (QL2 LiDAR) was downloaded from the North Carolina's Spatial Data Download website (DPS, 2018) and processed in ArcMap using Spatial Analysis tools. The processed topography was used to identify the elevation for the roadway centerline and roadway crown and to evaluate the channels just upstream and downstream from the culvert. A proposed replacement culvert was conservatively sized using future flow conditions. Table III shows the existing and proposed culvert sizes along with the respective headwater elevations. The NCDOT sizing criteria states that the culverts are to be designed based on the level of service the road crossing is located at and FEMA states the proposed headwater from a 100-year storm shall not be higher than the existing 100-year headwater.

Site	*Catchment Area (Sq. Miles)*	*Existing Impervious Area (%)*	*Proposed Impervious Area (%)*	*Q10 (cfs)*	*Q25 (cfs)*	*Q100 (cfs)*	*Miles of re-established Stream Connection*
152	2.67	0.03	5.0	394	561	857	1.99
376	0.69	0.76	5.0	192	272	411	2.33
64	0.18	0.00	5.0	79	107	152	0.60
236	1.78	0.22	5.0	349	482	708	3.16
202	0.39	0.30	5.0	145	242	289	1.05

Table II: Hydrologic Parameter, Estimated Flow Rates and Stream Lengths for Culverts Selected for Conceptual Design.

Site	*Existing Culvert Size & Material*	*# of Barrels*	*Proposed Culvert Replacement Size & Material*	*# of Barrels*	*Existing 100-YR Headwater Elevation (ft.)*	*Proposed 100-YR Headwater Elevation (ft.)*
152	48" CSP	2	72" RCP	2	62.5	61.5
376	60" CSP	2	72" RCP	2	28.6	25.8
64	48" CSP	1	60" RCP	1	61.1	58.4
236	54" RCP	4	72" RCP	4	19.3	23.2
202	48" RCP	1	60" RCP	2	31.0	26.8

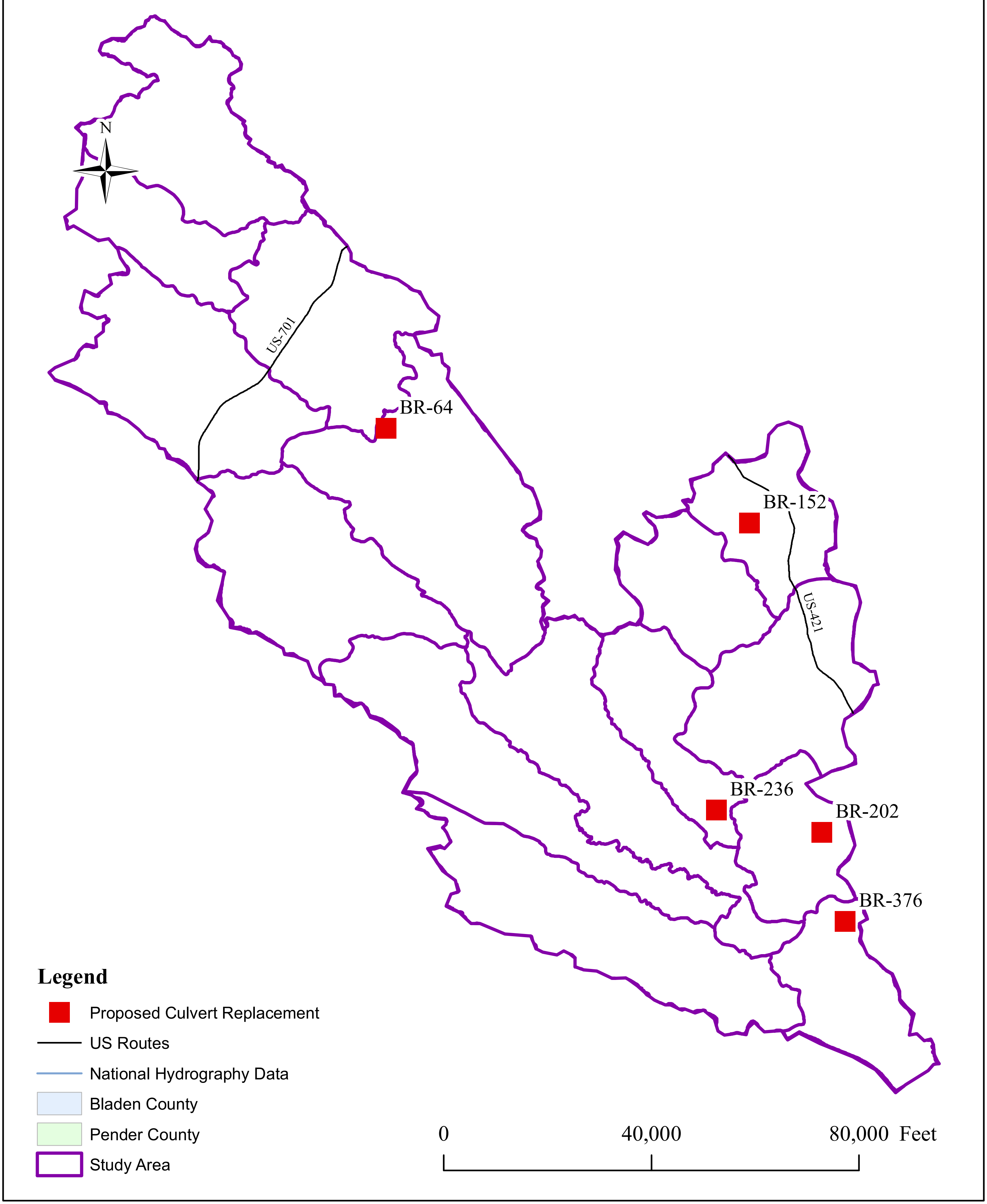
Table III: Existing and Proposed Replacement Culvert Comparison

*CSP = Corrugated Steel Pipe
RCP = Reinforced Concrete Pipe

Site	*Construction Cost*	*Engineering Cost*	*Contingency*	*Supplemental Cost*	*Total*
152	$264,465.00	$26,446.50	$58,182.30	$3,500.00	$352,593.80
376	$299,480.00	$29,948.00	$65,885.60	$3,500.00	$398,813.60
64	$221,905.00	$22,190.50	$48,819.10	$3,500.00	$296,414.60
236	$328,570.00	$32,857.00	$72,285.40	$3,500.00	$437,212.40
202	$257,405.00	$25,740.50	$56,629.10	$3,500.00	$343,274.60

Table IV: Cost Estimates for Culvert Replacements

Vicinity Map



Culvert Replacements

BR-152

BR-152 is proposed as a culvert replacement to support the Black River Aquatic Connectivity Assessment. The existing crossing assessment resulted in a SARP score of 0.46. Field measurements indicate that the culvert is perched about 1.8’ above the normal water surface elevation which inhibits the free passage of aquatic organisms under normal flow conditions. This scoring and field visit established that the crossing was to be classified as a moderate barrier.

Looking sideways at the culvert outlet.

Picture Credit: Jeff Crump, M&N, November 11, 2019

The existing structure is a double-barreled 48” Corrugated Steel Pipes which are about 51’ in length providing crossing for Bulltail Creek under Indian Hill Road.

Upstream Culvert Inlet. Beaver activity was observed upstream of this culvert.

Picture Credit: Jeff Crump, M&N, November 11, 2019

Looking upstream

Picture Credit: Jeff Crump, M&N, November 11, 2019

Looking downstream

Picture Credits: Jeff Crump, M&N, November 11, 2019

USGS Streamstats (USGS Streamstats, 2019) indicates a drainage area of 2.67 Square miles at the existing crossing with 0.03 % impervious area. However, to account for future development, 5% of the total catchment area was assumed to be impervious. Then, a proposed replacement culvert was conservatively sized using future flow conditions. The proposed culvert is a double-barreled 72" Reinforced Concrete Pipe.

The proposed culvert was evaluated in HY-8 with respect to the NCDOT sizing criteria. Since Indian Hill Road is considered a Minor Arterial road, the criteria states that the crossing is to be designed for a 25-year storm (Chang, 2016) and that the proposed headwater from a 100-year storm is not higher than the existing 100-year headwater (Chang, 2016, pp. 9-5). The proposed culvert satisfies both of those requirements.

The 10-year flow overtops the roadway in the existing condition. The proposed culvert replacements will reduce the frequency of overtopping by being able to safely pass a 25-year flow without overtopping.

Existing culvert

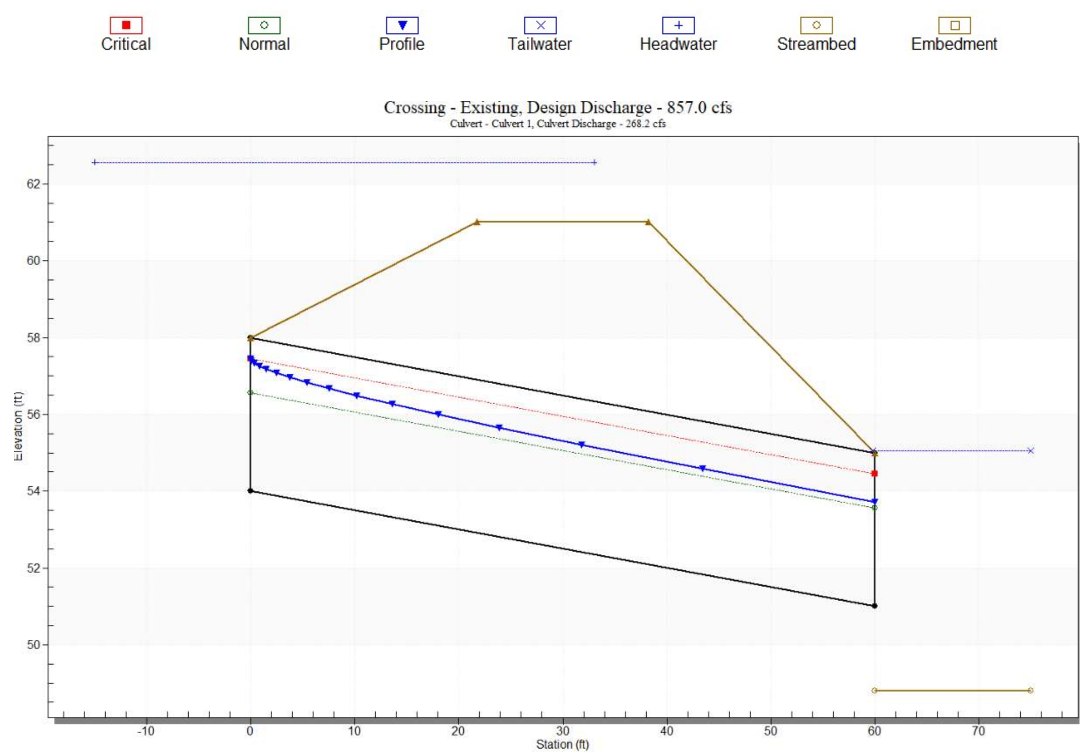
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	143.00	143.00	58.27	**4.27**	1.01	5-S2n	1.74	2.55	1.83	2.45	12.35	2.06
10 YR	394.00	246.84	61.62	**7.62**	5.02	5-S2n	2.42	3.34	2.56	4.22	14.09	2.78
25 YR	561.00	255.91	62.00	**8.00**	5.37	5-S2n	2.48	3.39	2.63	5.06	14.21	3.07
100 YR	857.00	268.23	62.56	**8.56**	6.19	5-S2n	2.56	3.45	2.71	6.26	14.38	3.44

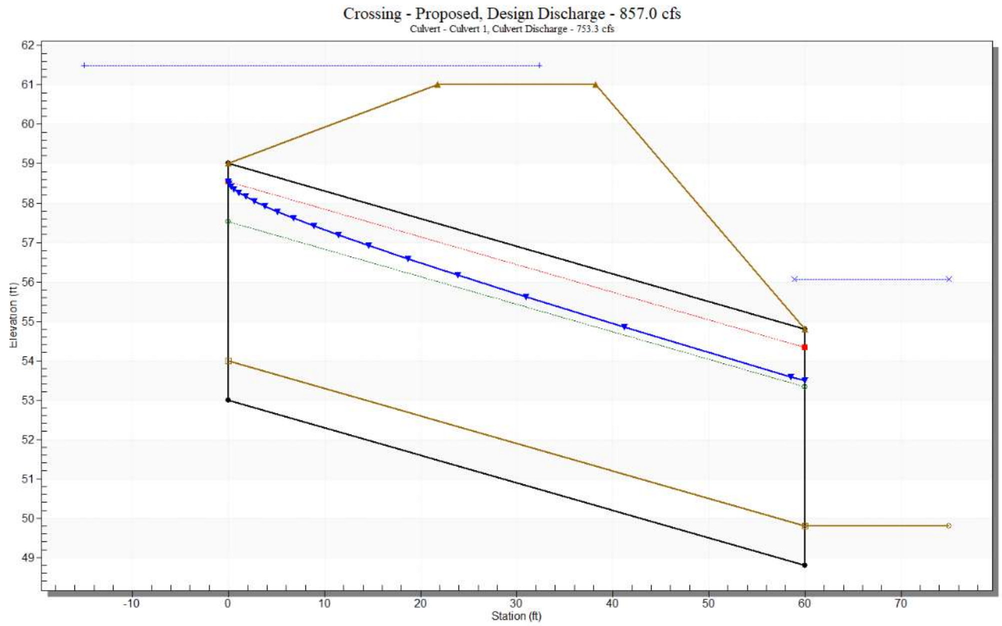
Proposed Culvert

Results from HY8 for existing and proposed culverts at BR-152

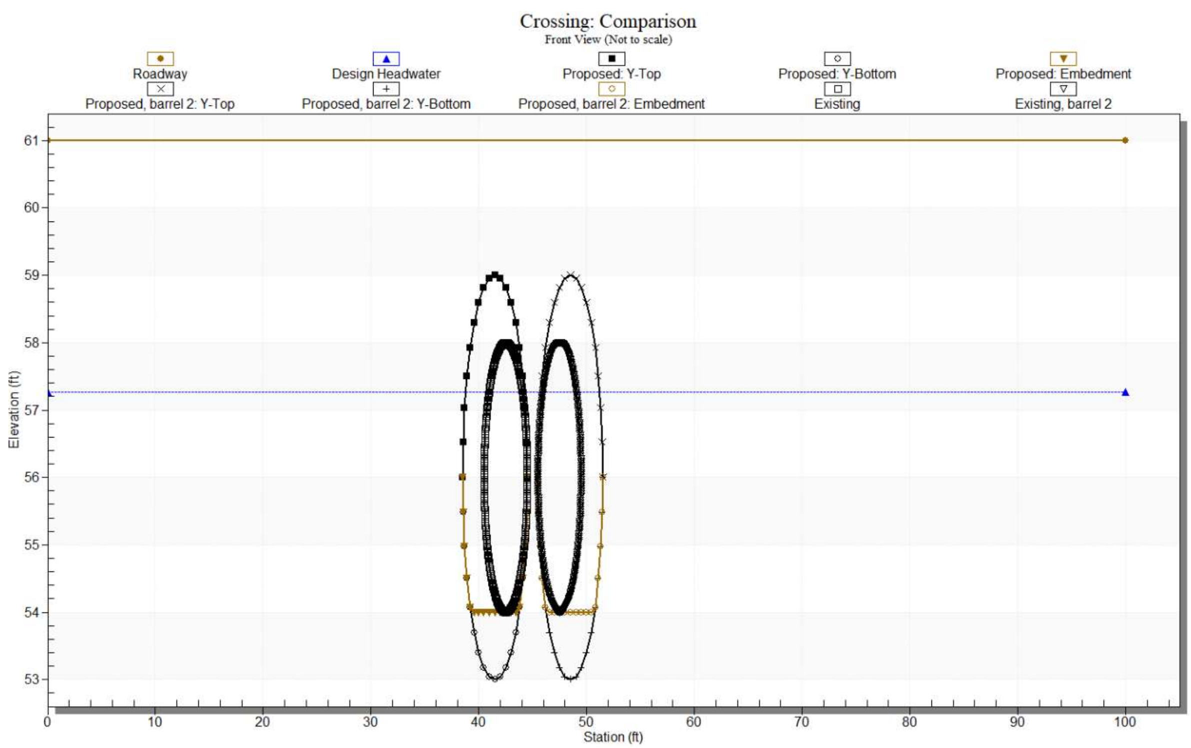
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	143.00	143.00	56.09	**2.09**	-1.41	1-S2n	1.25	1.81	1.25	2.45	10.63	2.06
10 YR	394.00	394.00	58.06	**4.06**	2.59	1-S2n	2.34	3.32	2.42	4.22	14.21	2.78
25 YR	561.00	561.00	59.40	**5.40**	0.86	5-S2n	2.90	4.02	3.02	5.06	16.11	3.07
100 YR	857.00	753.30	61.49	**7.49**	2.06	5-S2n	3.53	4.54	3.69	6.26	17.94	3.44

100-year Water Surface Elevations for Existing and Proposed Crossings

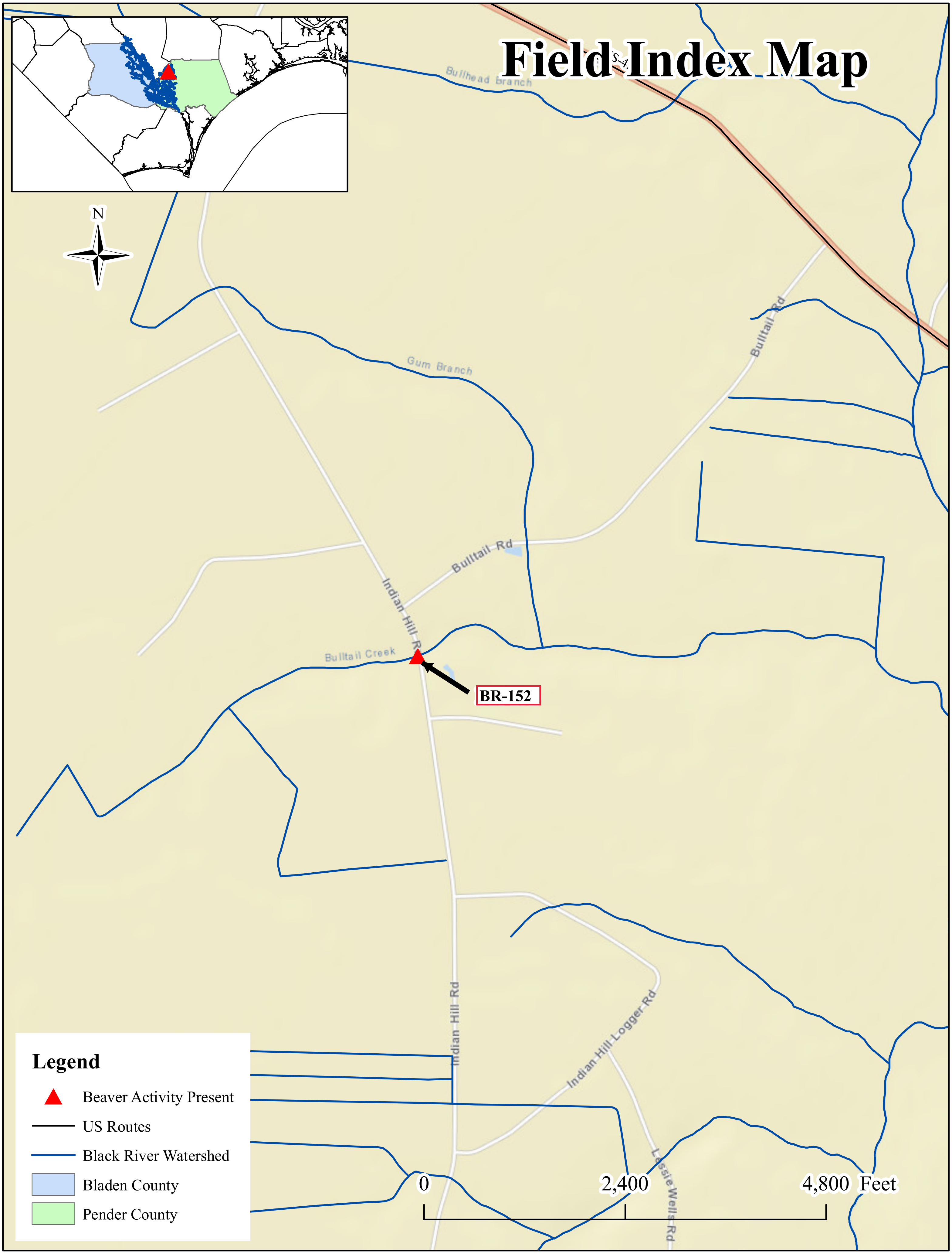




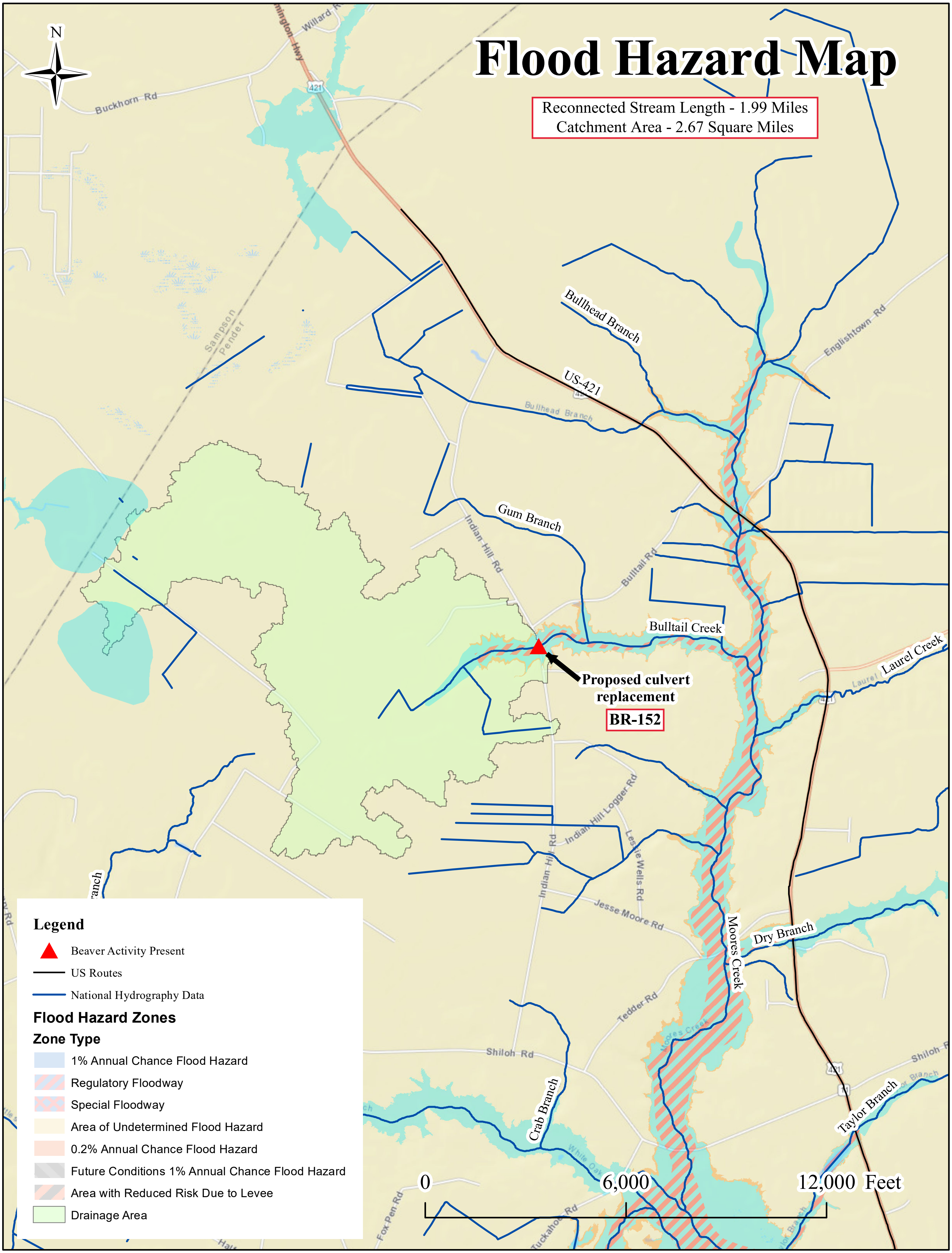
Crossing Comparison: Existing vs Proposed Upstream Face of BR-152



BR-152 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, BRIDGE, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE, PERMITS	1	LS	$35,000.00	$35,000.00
2	CLEARING AND GRUBBING	1	AC	$5,000.00	$5,000.00
3	REMOVE EXISTING PAVEMENT	230	SY	$10.00	$2,300.00
4	PAVEMENT MATERIAL AND MARKINGS	1	LS	$135,000.00	$135,000.00
5	EROSION AND SEDIMENT CONTROL	1	LS	$7,000.00	$7,000.00
6	TEMPORARY SILT FENCE	445	LF	$3.00	$1,335.00
7	EROSION CONTROL MATTING	200	SY	$3.00	$600.00
8	CONCRETE WASHOUT STRUCTURE	1	EA	$1,000.00	$1,000.00
9	MILLING BITUMINOUS PAVEMENT	230	SY	$15.00	$3,450.00
10	72" RCP	120	LF	$500.00	$60,000.00
11	PIPE OUTLET	2	EA	$1,000.00	$2,000.00
12	SEEDING	0.20	AC	$6,000.00	$1,200.00
13	TRAFFIC CONTROL	1	LS	$3,000.00	$3,000.00
14	SOIL MATERIALS	300	CY	$20.00	$6,000.00
15	TOPSOIL	50	CY	$30.00	$1,500.00
16	FILTER FABRIC	8	SY	$10.00	$80.00
SECTION A: ROADWAY, BRIDGE, DRAINAGE SUBTOTAL					**$264,465.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (10%)	1	LS	$26,446.50	$26,446.50
18	CONTINGENCY (20%)	1	LS	$58,182.30	$58,182.30
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$3,500.00	$3,500.00
SECTION B: GENERAL PROJECT SUBTOTAL					$88,128.80
(Sum of Section A Roadway, Bridge, Drainage plus Section B General Project Subtotal) PROJECT TOTAL					**$ 352,593.80**



Field Index Map
N
Bullhead Branch
Gum Branch
Bulltail Rd
Indian Hill Rd
Bulltail Creek
BR-152
Indian Hill Logger Rd
Lessie Wells Rd
Legend
Beaver Activity Present
US Routes
Black River Watershed
Bladen County
Pender County
0
2,400
4,800 Feet


Flood Hazard Map
Reconnected Stream Length - 1.99 Miles
Catchment Area - 2.67 Square Miles
N
Buckhorn Rd
Willard Rd
Bullhead Branch
US-421
Englishtown Rd
Gum Branch
Indian Hill Rd
Bulltail Rd
Bulltail Creek
Proposed culvert replacement
BR-152
Laurel Creek
Indian Hill Logger Rd
Leslie Wells Rd
Jesse Moore Rd
Moores Creek
Dry Branch
Tedder Rd
Shiloh Rd
Crab Branch
Taylor Branch
Tuckahoe Rd
Fox Pen Rd
Sampson
Pender
0
6,000
12,000 Feet
Legend
Beaver Activity Present
US Routes
National Hydrography Data
Flood Hazard Zones
Zone Type
1% Annual Chance Flood Hazard
Regulatory Floodway
Special Floodway
Area of Undetermined Flood Hazard
0.2% Annual Chance Flood Hazard
Future Conditions 1% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee
Drainage Area

BR-376

BR-376 is proposed as a culvert replacement to support the Black River Aquatic Connectivity Assessment. There is significant buckling towards the center of culvert which could lead to upstream flooding. The existing crossing assessment resulted in a SARP score of 0.47. Field measurements indicate that the culvert is perched about 1.2’ above the stream bed invert which inhibits the free passage of aquatic organisms under normal flow conditions. This scoring classified the crossing as a moderate barrier.

Upstream inlet barrel #1 shows significant collapse.

Picture Credit: Jeff Crump, M&N, November 11, 2019

Upstream inlet barrel #2 shows the severity of deterioration on the barrel.
Picture Credit: Jeff Crump, M&N, November 11, 2019

Debris at the upstream inlet of the culvert
Picture Credit: Jeff Crump, M&N, November 11, 2019

The existing structure is a double-barreled 60” Corrugated Steel pipes about 83’ in length providing crossing for Bear Branch under Blueberry Road.

Looking downstream
Picture Credit: Jeff Crump, M&N, November 11, 2019

USGS Streamstats (USGS Streamstats, 2019) indicates a drainage area of 0.69 square miles at the existing crossing with 0.76 % impervious area. However, to account for future development, 5% of the total catchment area was assumed to be impervious. Then, a proposed culvert replacement was conservatively sized using future flow conditions in HY-8. The proposed culvert is a double-barreled 72” Reinforced Concrete Pipe.

The Proposed culvert was evaluated in HY-8 with respect to the NCDOT sizing criteria. Since Blueberry Road is considered a Minor Arterial road, the criteria states that the crossing is to be designed for a 25-year storm **(Chang, 2016)** and that the proposed headwater from a 100-year storm is not supposed to be higher than the existing 100-year headwater **(Chang, 2016, pp. 9-5)**. The proposed culvert satisfies both of those requirements.

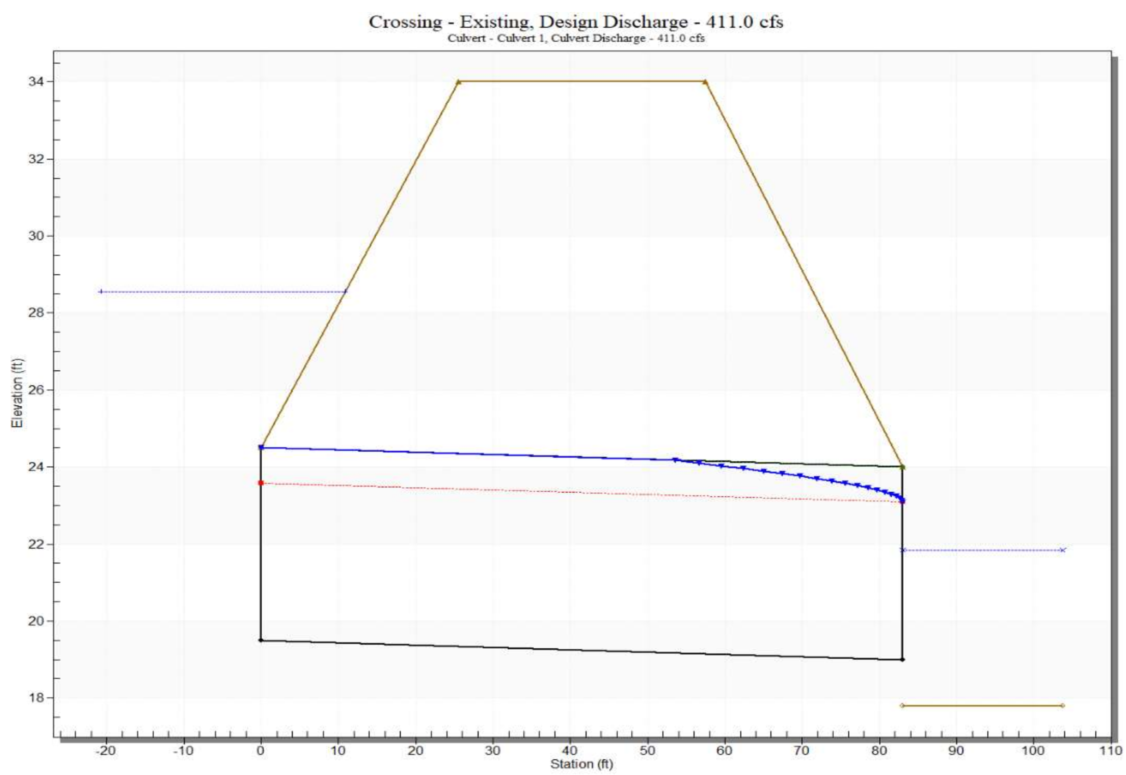
Existing culvert

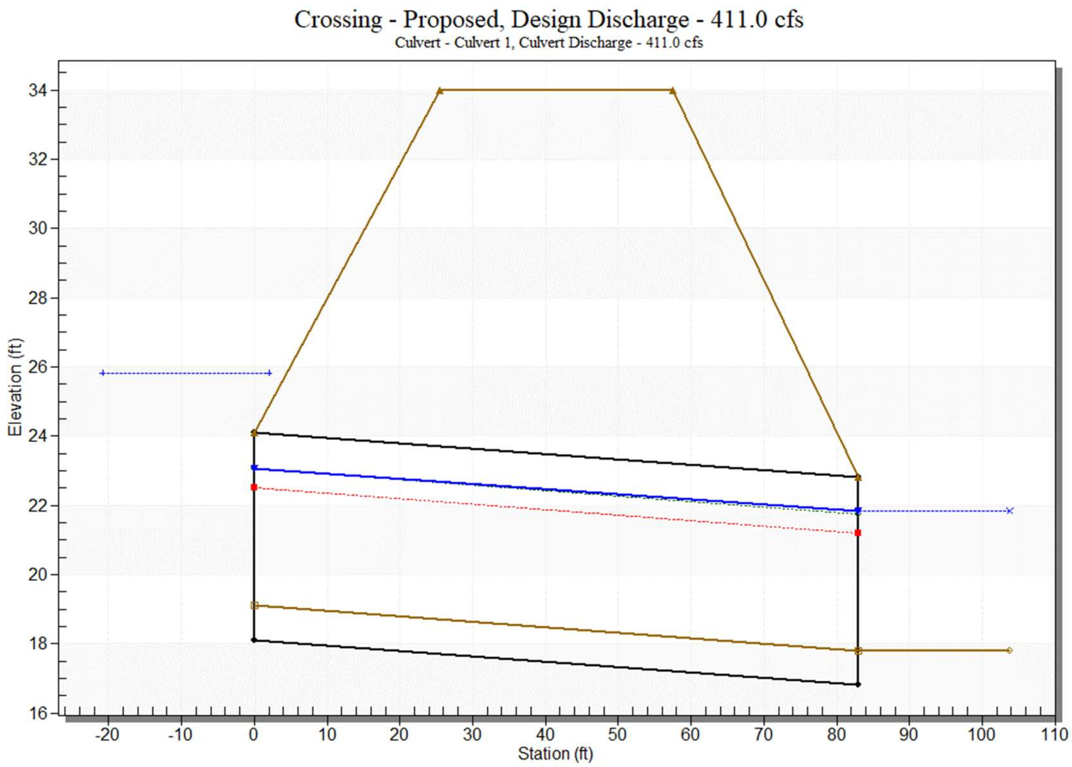
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	70.00	70.00	22.17	2.44	**2.67**	2-M2c	1.89	1.64	1.64	1.53	6.24	3.31
10 YR	192.00	192.00	24.25	4.48	**4.75**	2-M2c	3.53	2.78	2.78	2.64	8.55	4.36
25 YR	272.00	272.00	25.47	5.85	**5.97**	7-M2c	5.00	3.34	3.34	3.15	9.77	4.74
100 YR	411.00	411.00	28.55	**9.05~**	9.04	7-M2c	5.00	4.09	4.09	4.04	11.97	4.58

Proposed culvert

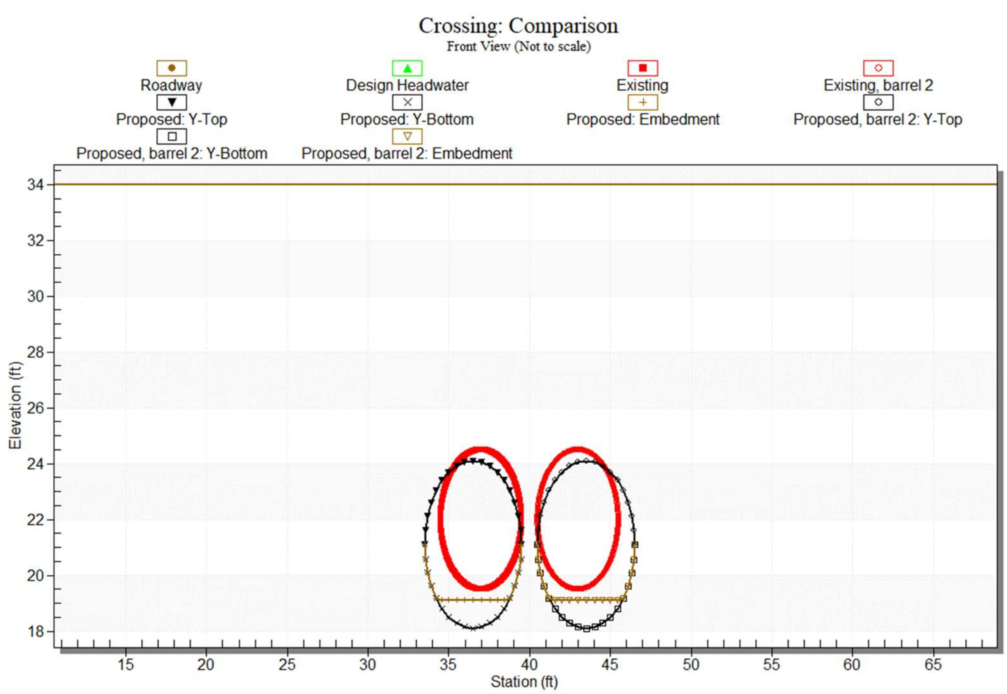
Results from HY8 for existing and proposed culverts at BR-376

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	70.00	70.00	21.21	1.36	**2.11**	3-M1t	1.28	1.15	1.53	1.53	4.28	3.31
10 YR	192.00	192.00	23.08	2.69	**3.98**	3-M1t	2.38	2.17	2.64	2.64	6.49	4.36
25 YR	272.00	272.00	24.11	3.33	**5.01**	7-M1t	2.95	2.66	3.15	3.15	7.68	4.74
100 YR	411.00	411.00	25.82	4.32	**6.72**	7-M1t	3.95	3.40	4.04	4.04	9.27	4.58





100-year Water Surface Elevations for Existing and Proposed Crossings



Crossing Comparison: Existing vs Proposed Upstream Face of BR-376

BR-376 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, BRIDGE, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE, PERMITS	1	LS	$40,000.00	$40,000.00
2	CLEARING AND GRUBBING	1	AC	$5,000.00	$5,000.00
3	REMOVE EXISTING PAVEMENT	230	SY	$10.00	$2,300.00
4	PAVEMENT MATERIAL AND MARKINGS	1	LS	$136,000.00	$136,000.00
5	EROSION AND SEDIMENT CONTROL	1	LS	$7,000.00	$7,000.00
6	TEMPORARY SILT FENCE	450	LF	$3.00	$1,350.00
7	EROSION CONTROL MATTING	200	SY	$3.00	$600.00
8	CONCRETE WASHOUT STRUCTURE	1	EA	$1,000.00	$1,000.00
9	MILLING BITUMINOUS PAVEMENT	230	SY	$15.00	$3,450.00
10	72" RCP	166	LF	$500.00	$83,000.00
11	PIPE OUTLET	2	EA	$1,000.00	$2,000.00
12	SEEDING	0.20	AC	$6,000.00	$1,200.00
13	TRAFFIC CONTROL	1	LS	$3,000.00	$3,000.00
14	SOIL MATERIALS	600	CY	$20.00	$12,000.00
15	TOPSOIL	50	CY	$30.00	$1,500.00
16	FILTER FABRIC	8	SY	$10.00	$80.00
SECTION A: ROADWAY, BRIDGE, DRAINAGE SUBTOTAL					**$299,480.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (10%)	1	LS	$29,948.00	$29,948.00
18	CONTINGENCY (20%)	1	LS	$65,885.60	$65,885.60
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$3,500.00	$3,500.00
SECTION B: GENERAL PROJECT SUBTOTAL					$99,333.60
(Sum of Section A Roadway, Bridge, Drainage plus Section B Genral Project) PROJECT TOTAL					**$ 398,813.60**


Field Index Map
N
Blueberry Rd
Borough Rd
Montague Rd
Bear Branch
BR-376
E Bear Branch Dr
Bear Branch Dr
Riverland Dr
Legend
Proposed Culvert Replacement
US Routes
NC Routes
National Hydrography Data
Bladen County
Pender County
0
1,600
3,200
Feet

Flood Hazard Map
Reconnected Stream Length - 2.33 Miles
Catchment Area - 0.69 Square Miles
N
Proposed culvert replacement
BR-376
Blueberry Rd
Borough Rd
Saddle Ridge Rd
Stirrup Dr
Montague Rd
Bear Branch
E Bear Branch Dr
Bear Branch Dr
Oak Ave
Riverland Dr
Smoot Ave
Legend
Proposed culvert replacement
US Routes
National Hydrography Data
Flood Hazard Zones
Zone Type
1% Annual Chance Flood Hazard
Regulatory Floodway
Special Floodway
Area of Undetermined Flood Hazard
0.2% Annual Chance Flood Hazard
Future Conditions 1% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee
Drainage Area
0
1,600
3,200 Feet

BR-64

BR-64 is proposed as a culvert replacement to support the Black River Aquatic Connectivity Assessment. The existing crossing assessment resulted in a SARP score of 0.22. Field measurements indicate that the culvert is perched about 0.9' above the normal water surface elevation which inhibits the free passage of aquatic organisms under normal flow conditions. This scoring and field visit established that the crossing was to be classified as a significant barrier.

Culvert upstream inlet

Picture Credit: Jeff Crump, M&N, November 11, 2019

The existing structure is a 48" Corrugated Steel pipe about 53' in length providing crossing for an upper tributary to South River under NC 210.

USGS Streamstats (USGS Streamstats, 2019) indicates a drainage area of 0.18 square miles at the existing crossing with 0.0 % impervious area. However, to account for future development, 5% of the total catchment area was assumed to be impervious. Then, a proposed replacement culvert was conservatively sized using future flow conditions. The proposed culvert is a single 60” Reinforced Concrete Pipe.

The Proposed culvert was evaluated in HY-8 with respect to the NCDOT sizing criteria. Since NC 210 is considered a Major Arterial road, the criteria states that the crossing is to be designed for a 50-year storm **(Chang, 2016)** and that the proposed headwater from a 100-year storm is not supposed to be higher than the existing 100-year headwater **(Chang, 2016, pp. 9-5)**. The proposed culvert satisfies both of those requirements.

The 100-year flow overtops the roadway in the existing condition. The proposed culvert replacements will reduce the frequency of overtopping by being able to safely pass a 100-year flow without overtopping.

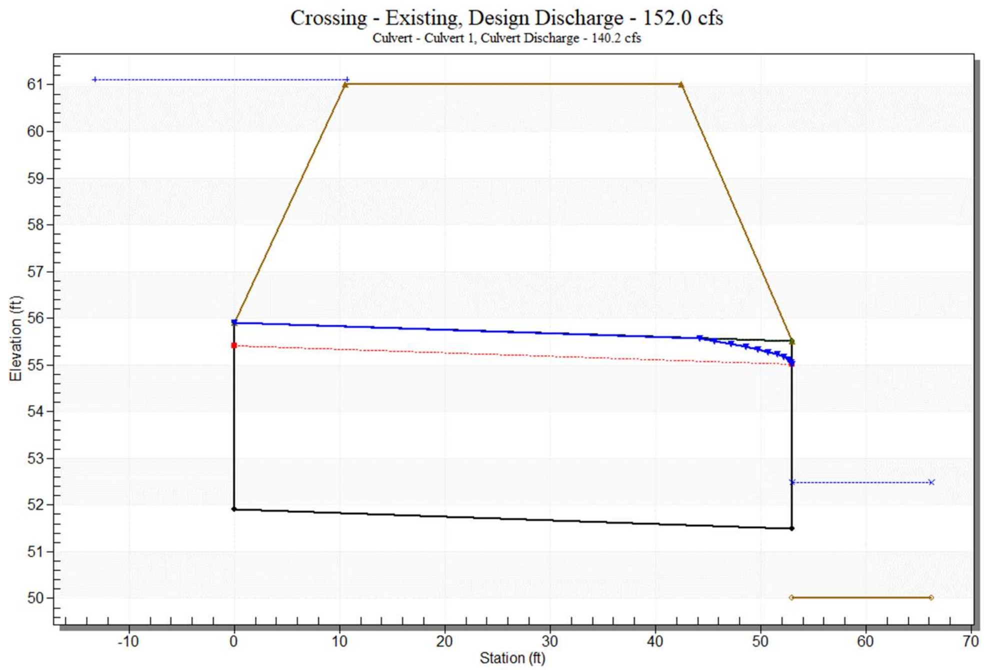
Existing culvert

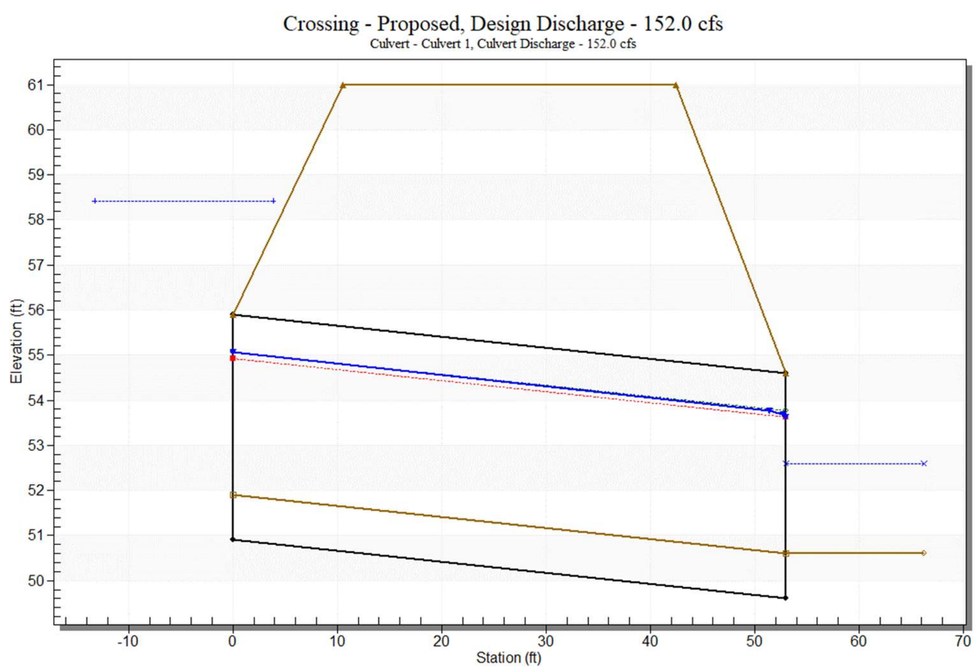
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	33.00	33.00	54.72	2.59	**2.82**	2-M2c	1.92	1.70	1.70	1.34	6.47	3.72
10 YR	79.00	79.00	56.70	4.74	**4.80**	7-M2c	4.00	2.69	2.69	1.88	8.79	4.69
50 YR	129.00	129.00	60.08	**8.18~**	7.88	7-M2c	4.00	3.40	3.40	2.38	11.33	3.92
100 YR	152.00	140.19	61.12	**9.22~**	8.77	7-M2c	4.00	3.51	3.51	2.48	11.99	4.05

Proposed culvert

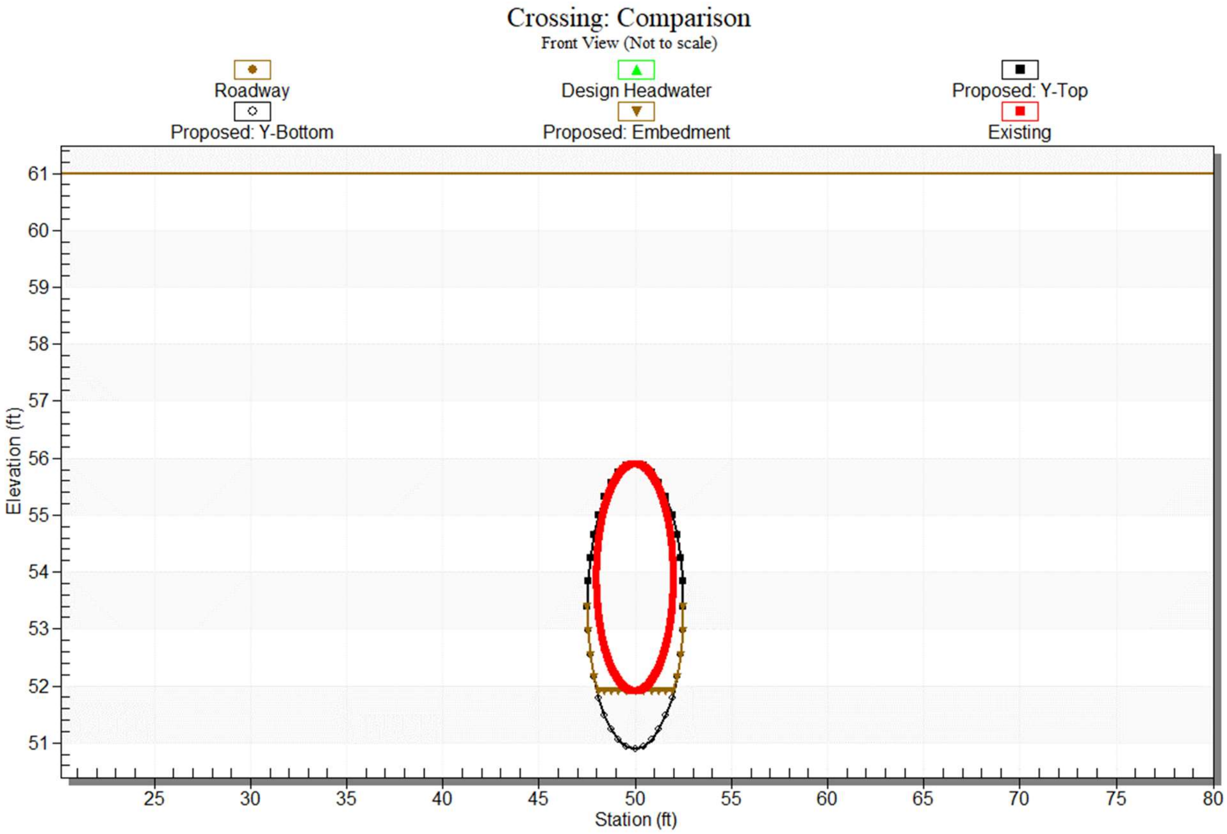
Results from HY8 for existing and proposed culverts at BR-64

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	33.00	33.00	53.38	**1.48**	-0.25	1-S2n	1.18	1.21	1.18	1.05	5.95	3.52
10 YR	79.00	79.00	54.50	**2.60**	1.73	1-S2n	2.02	2.06	2.02	1.64	8.05	3.41
50 YR	129.00	129.00	57.70	3.57	**5.80**	7-M2c	2.79	2.77	2.77	1.89	9.90	3.79
100 YR	152.00	152.00	58.42	4.05	**6.52**	7-M2c	3.17	3.03	3.03	1.98	10.77	3.93





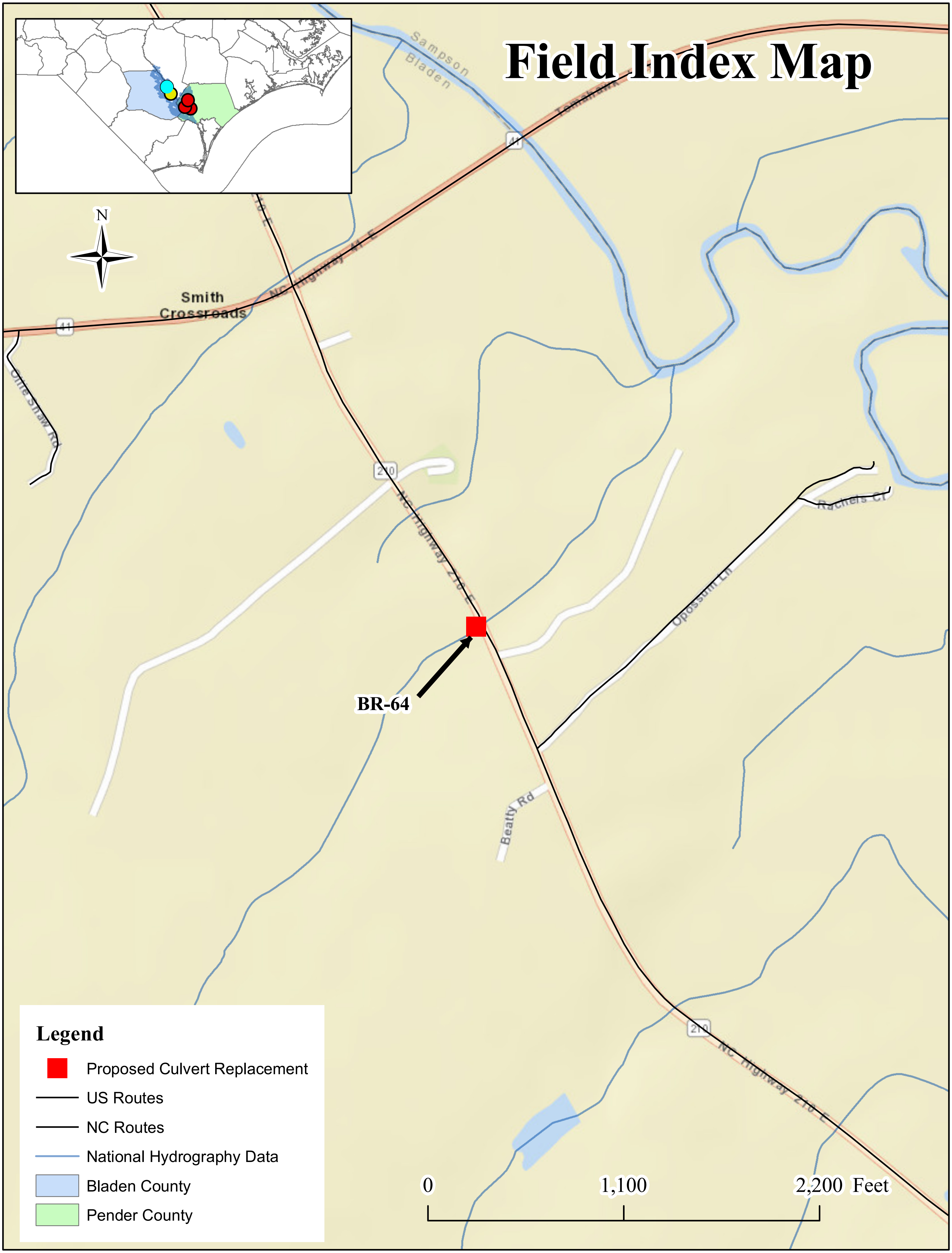
100-year Water Surface Elevations for Existing and Proposed Crossings

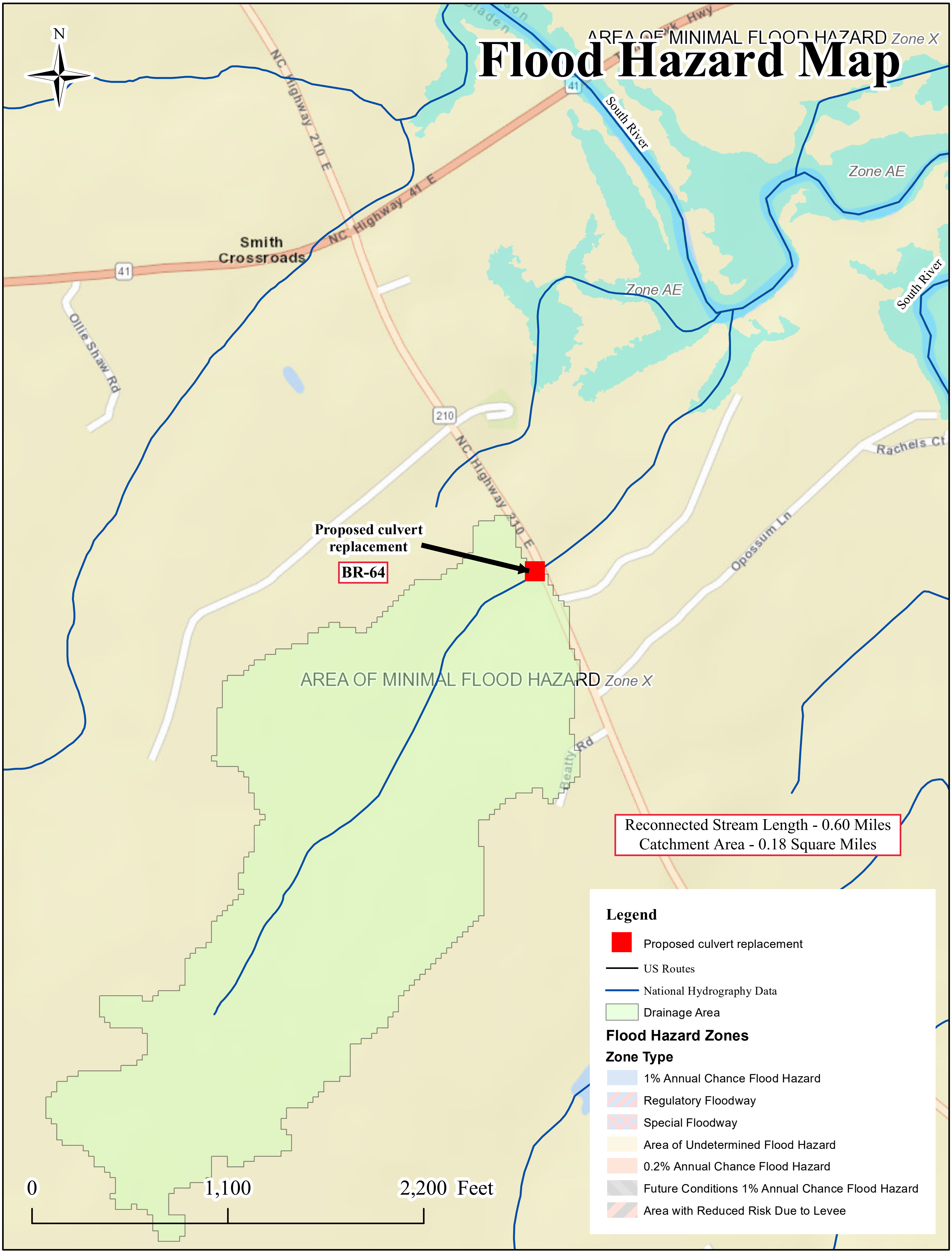


Crossing Comparison: Existing vs Proposed Upstream Face of BR-236

BR-64 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, BRIDGE, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE, PERMITS	1	LS	$30,000.00	$30,000.00
2	CLEARING AND GRUBBING	1	AC	$5,000.00	$5,000.00
3	REMOVE EXISTING PAVEMENT	230	SY	$10.00	$2,300.00
4	PAVEMENT MATERIAL AND MARKINGS	1	LS	$134,500.00	$134,500.00
5	EROSION AND SEDIMENT CONTROL	1	LS	$7,000.00	$7,000.00
6	TEMPORARY SILT FENCE	435	LF	$3.00	$1,305.00
7	EROSION CONTROL MATTING	200	SY	$3.00	$600.00
8	CONCRETE WASHOUT STRUCTURE	1	EA	$1,000.00	$1,000.00
9	MILLING BITUMINOUS PAVEMENT	230	SY	$15.00	$3,450.00
10	60” RCP	53	LF	$490.00	$25,970.00
11	PIPE OUTLET	1	EA	$1,000.00	$1,000.00
12	SEEDING	0.20	AC	$6,000.00	$1,200.00
13	TRAFFIC CONTROL	1	LS	$3,000.00	$3,000.00
14	SOIL MATERIALS	200	CY	$20.00	$4,000.00
15	TOPSOIL	50	CY	$30.00	$1,500.00
16	FILTER FABRIC	8	SY	$10.00	$80.00
SECTION A: ROADWAY, BRIDGE, DRAINAGE TOTAL					**$221,905.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (10%)	1	LS	$22,190.50	$22,190.50
18	CONTINGENCY (20%)	1	LS	$48,819.10	$48,819.10
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$3,500.00	$3,500.00
SECTION B: GENERAL PROJECT SUBTOTAL					$74,509.60
(Sum of Section A Roadway, Bridge, Drainage plus Section B General Project) PROJECT TOTAL					**$ 296,414.60**

Field Index Map





Flood Hazard Map
N
AREA OF MINIMAL FLOOD HAZARD Zone X
South River
Zone AE
Zone AE
South River
Smith Crossroads
NC Highway 41 E
NC Highway 210 E
Ollie Shaw Rd
Rachels Ct
Opossum Ln
Beatty Rd
Proposed culvert replacement
BR-64
AREA OF MINIMAL FLOOD HAZARD Zone X
Reconnected Stream Length - 0.60 Miles
Catchment Area - 0.18 Square Miles
Legend
Proposed culvert replacement
US Routes
National Hydrography Data
Drainage Area
Flood Hazard Zones
Zone Type
1% Annual Chance Flood Hazard
Regulatory Floodway
Special Floodway
Area of Undetermined Flood Hazard
0.2% Annual Chance Flood Hazard
Future Conditions 1% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee
0
1,100
2,200 Feet

BR-236

BR-236 is proposed as a culvert replacement to support the Black River Aquatic Connectivity Assessment. The existing crossing assessment resulted in a SARP score of 0.19. Field measurements indicate that the culvert is perched about 1.2’ above the normal water surface elevation which inhibits the free passage of aquatic organisms under normal flow conditions. Also, there is some undermining of the downstream-most culvert segment along with some joint separation. This scoring and field visit established that the crossing was to be classified as a severe barrier.

Culvert upstream inlet.

Picture Credit: Jeff Crump, M&N, November 11, 2019

The existing structure is a four-barreled 54” reinforced concrete pipe culvert about 53’ in length providing crossing for Big Branch under Slocum Trail.

Culvert outlet shows that the culvert is perched

Picture Credit: Jeff Crump, M&N, November 11, 2019

Looking upstream from the culvert

Picture Credit: Jeff Crump, M&N, November 11, 2019

USGS Streamstats (USGS Streamstats, 2019) indicates a drainage area of 1.78 square miles at the existing crossing with 0.22 % impervious area. However, to account for future development, 5% of the total catchment area was assumed to be impervious. Then, a proposed replacement culvert was conservatively sized using future flow conditions. The proposed culvert is a four-barreled 72" Reinforced Concrete Pipe.

The Proposed culvert was evaluated in HY-8 with respect to the NCDOT sizing criteria. Since Slocum Trail is considered a Minor Arterial road, the criteria states that the crossing is to be designed for a 25-year storm (Chang, 2016) and that the proposed headwater from a 100-year storm is not supposed to be higher than the existing 100-year headwater (Chang, 2016, pp. 9-5). The proposed culvert satisfies both of those requirements.

The 100-year overtops the roadway in the existing condition. The proposed culvert replacements will reduce the frequency of overtopping by being able to safely pass a 100-year flow without overtopping.

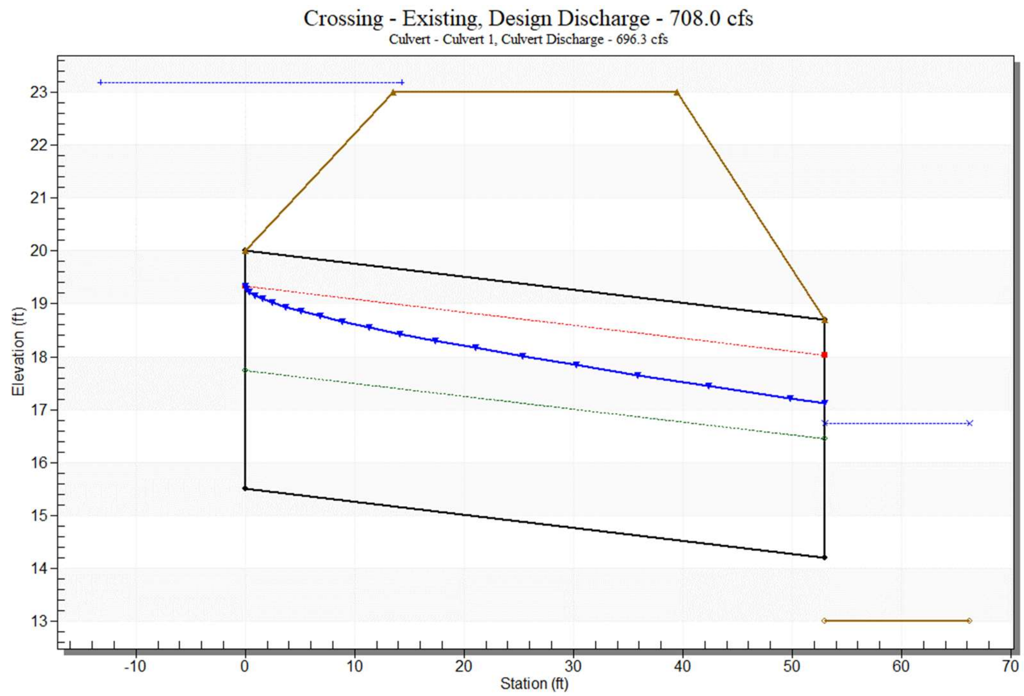
Existing culvert

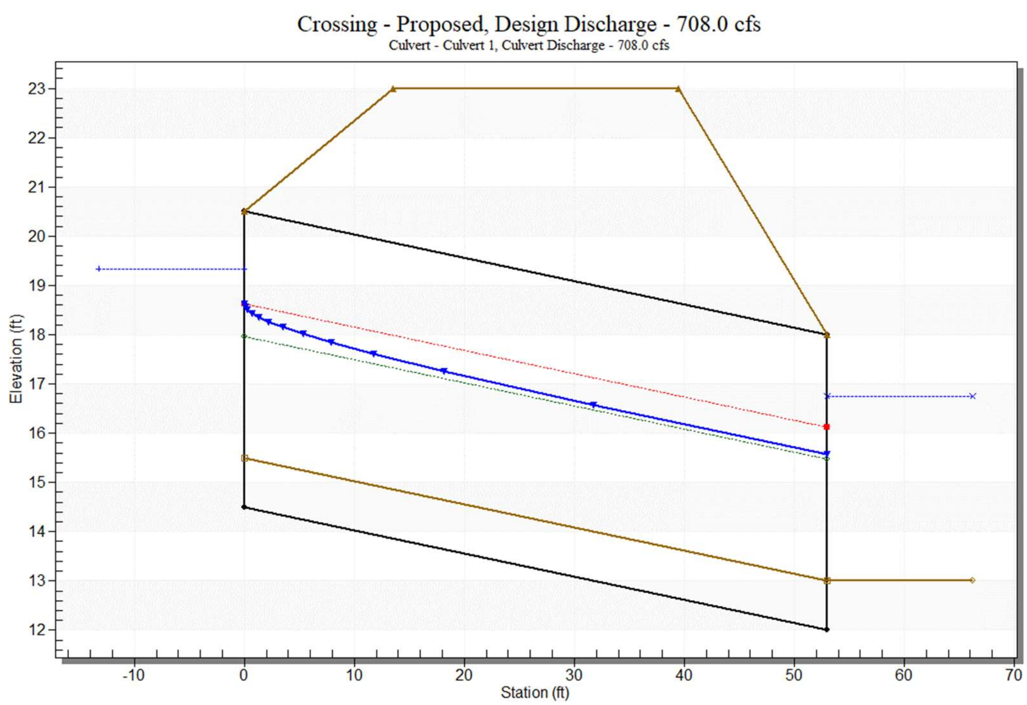
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	138.00	138.00	16.77	**1.27**	-0.81	1-S2n	0.90	1.14	0.90	1.61	7.36	5.02
10 YR	349.00	349.00	17.95	**2.45**	0.62	1-S2n	1.60	2.04	1.60	2.63	9.84	6.56
25 YR	482.00	482.00	18.51	**3.01**	1.53	1-S2n	1.97	2.49	1.97	3.10	10.83	7.17
100 YR	708.00	708.00	19.33	**3.83**	3.27	1-S2n	2.47	3.12	2.56	3.75	12.02	7.96

Proposed culvert

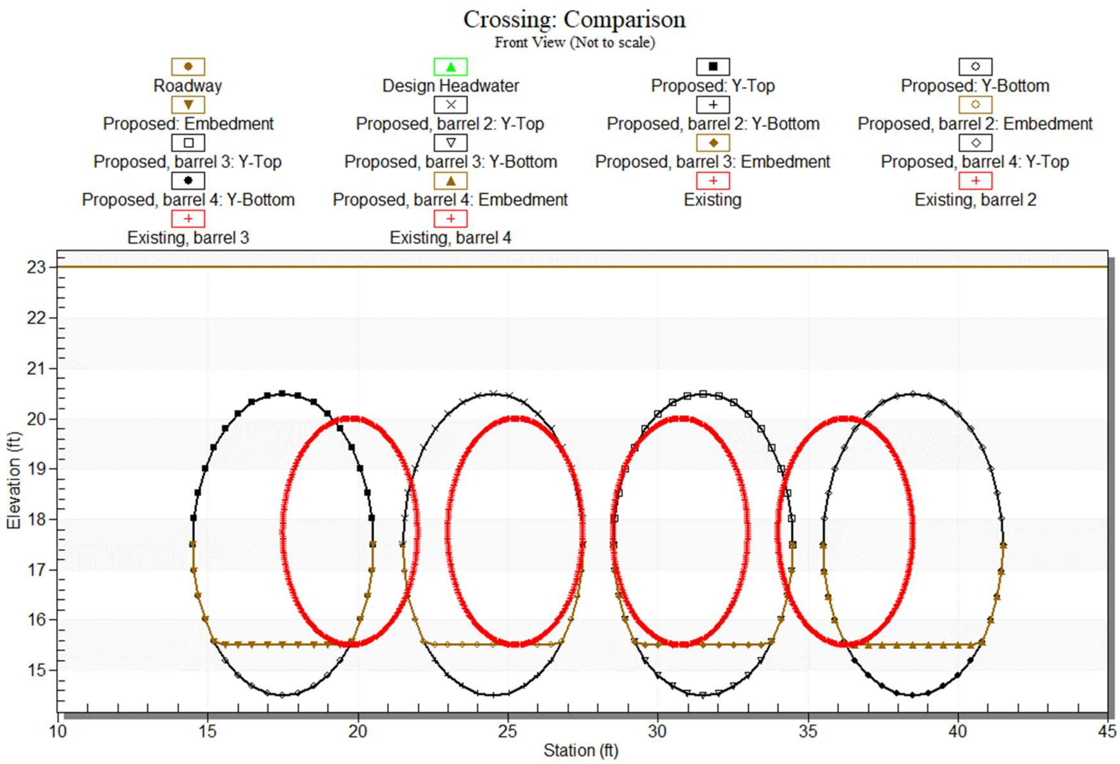
Results from HY8 for existing and proposed culverts at BR-236

Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	138.00	138.00	17.80	**2.30**	0.51	1-S2n	0.95	1.68	1.12	1.61	10.80	5.02
10 YR	349.00	349.00	19.64	**4.14**	2.22	1-S2n	1.53	2.73	1.92	2.63	13.01	6.56
25 YR	482.00	482.00	20.77	**5.27**	3.43	5-S2n	1.82	3.23	2.33	3.10	14.00	7.17
100 YR	708.00	696.29	23.18	**7.68**	6.01	5-S2n	2.25	3.83	2.91	3.75	15.51	7.96



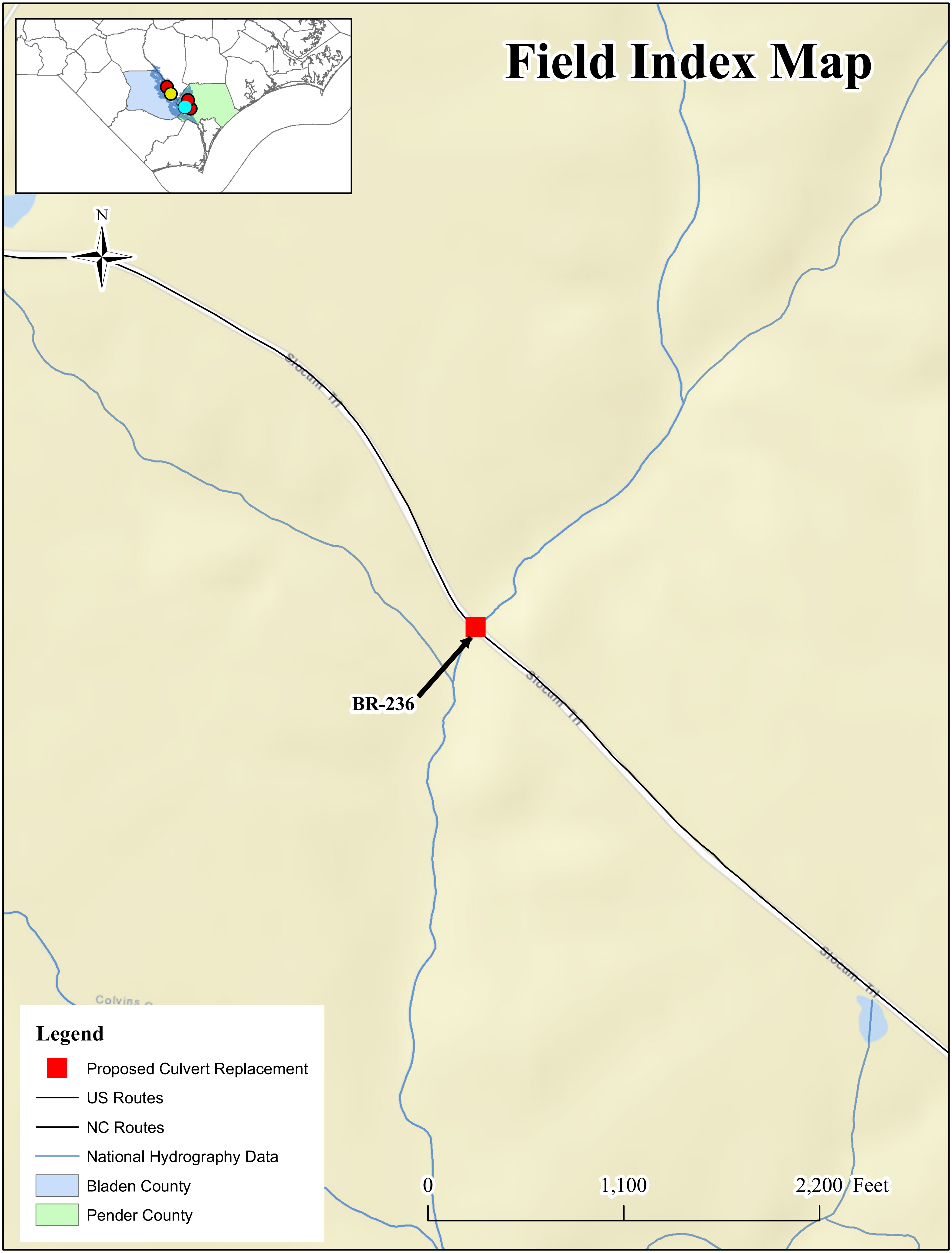


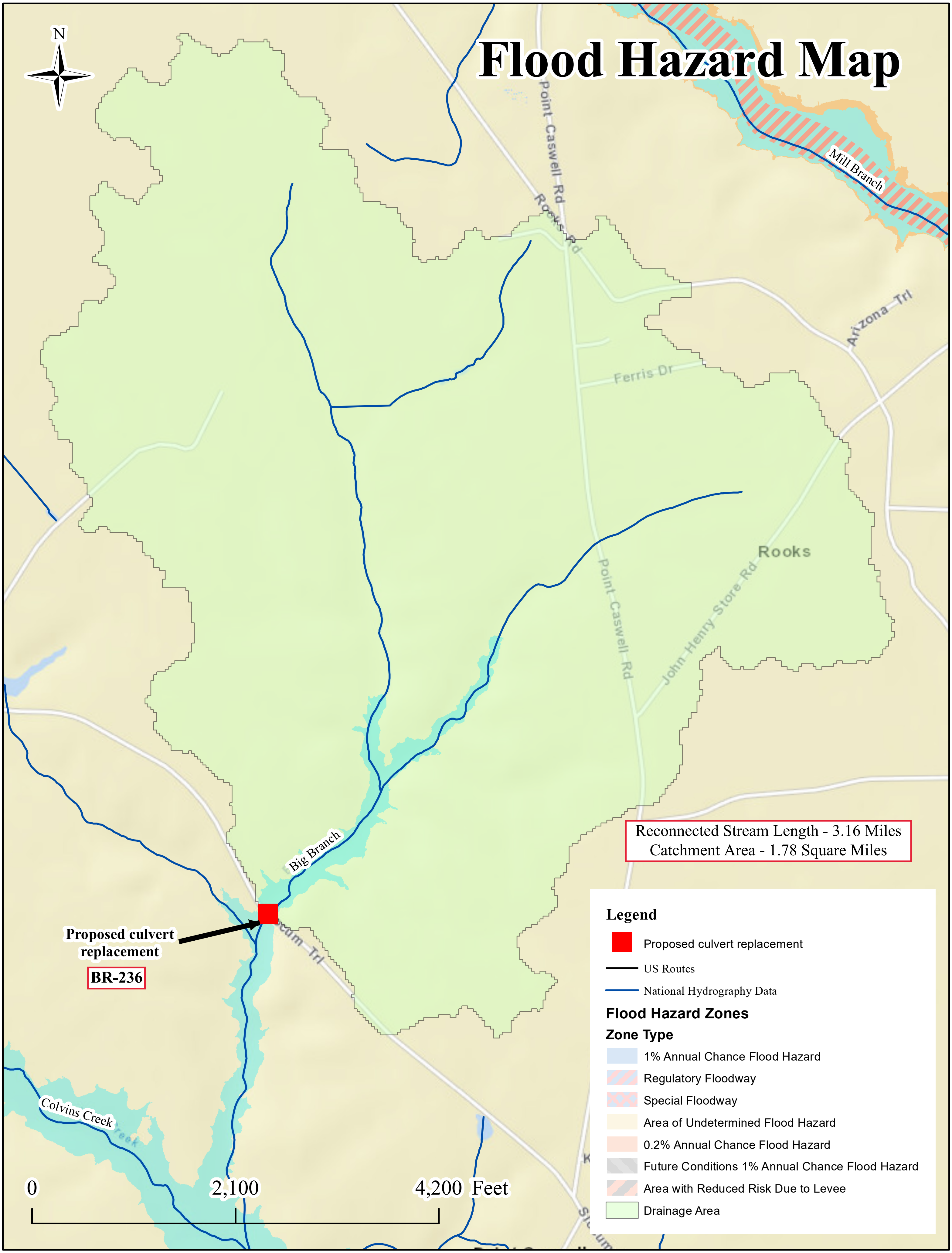
100-year Water Surface Elevations for Existing and Proposed Crossings



Crossing Comparison: Existing vs Proposed Upstream Face of BR-236

BR-236 CULVERT REPLACMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, BRIDGE, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE, PERMITS	1	LS	$44,000.00	$44,000.00
2	CLEARING AND GRUBBING	1	AC	$5,000.00	$5,000.00
3	REMOVE EXISTING PAVEMENT	230	SY	$10.00	$2,300.00
4	PAVEMENT MATERIAL AND MARKINGS	1	LS	$136,000.00	$136,000.00
5	EROSION AND SEDIMENT CONTROL	1	LS	$7,000.00	$7,000.00
6	TEMPORARY SILT FENCE	480	LF	$3.00	$1,440.00
7	EROSION CONTROL MATTING	200	SY	$3.00	$600.00
8	CONCRETE WASHOUT STRUCTURE	1	EA	$1,000.00	$1,000.00
9	MILLING BITUMINOUS PAVEMENT	230	SY	$15.00	$3,450.00
10	72” RCP	212	LF	$500.00	$106,000.00
11	PIPE OUTLET	4	EA	$1,000.00	$4,000.00
12	SEEDING	0.20	AC	$6,000.00	$1,200.00
13	TRAFFIC CONTROL	1	LS	$3,000.00	$3,000.00
14	SOIL MATERIALS	600	CY	$20.00	$12,000.00
15	TOPSOIL	50	CY	$30.00	$1,500.00
16	FILTER FABRIC	8	SY	$10.00	$80.00
SECTION A: ROADWAY, BRIDGE, DRAINAGE SUBTOTAL					**$328,570.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (10%)	1	LS	$32,857.00	$32,857.00
18	CONTINGENCY (20%)	1	LS	$72,285.40	$72,285.40
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$3,500.00	$3,500.00
SECTION B: GENRAL PROJECT SUBTOTAL					$108,642.40
(Sum of Section A Roadway, Bridge, Drainage plus Section B General Project) PROJECT TOTAL					**$ 437,212.40**


Field Index Map
N
Slocum Trl
BR-236
Slocum Trl
Slocum Trl
Legend
Proposed Culvert Replacement
US Routes
NC Routes
National Hydrography Data
Bladen County
Pender County
0
1,100
2,200 Feet



Flood Hazard Map
N
Point Caswell Rd
Rooks Rd
Mill Branch
Arizona Trl
Ferris Dr
Rooks
John Henry Store Rd
Big Branch
Proposed culvert replacement
BR-236
Colvins Creek
Reconnected Stream Length - 3.16 Miles
Catchment Area - 1.78 Square Miles
Legend
Proposed culvert replacement
US Routes
National Hydrography Data
Flood Hazard Zones
Zone Type
1% Annual Chance Flood Hazard
Regulatory Floodway
Special Floodway
Area of Undetermined Flood Hazard
0.2% Annual Chance Flood Hazard
Future Conditions 1% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee
Drainage Area
0
2,100
4,200 Feet

BR-202

BR-202 is proposed as a culvert replacement to support the Black River Aquatic Connectivity Assessment. The existing crossing assessment resulted in a SARP score of 0.08. Field measurements indicate that the culvert is perched about 1.5’ above the normal water surface elevation which inhibits the free passage of aquatic organisms under normal flow conditions. Hence, the scoring and field visit established that this crossing was to be classified as a severe barrier.

Culvert outlet shows that the culvert is perched

Picture Credit: Jeff Crump, M&N, November 11, 2019

The existing structure is a 48” Reinforced Concrete pipe about 53’ in length providing crossing for an Upper tributary to Deer Valley Branch under NC 210.

Looking upstream from the culvert.

Picture Credit: Jeff Crump, M&N, November 11, 2019

Looking downstream from the culvert.

Picture Credit: Jeff Crump, M&N, November 11, 2019

USGS Streamstats (USGS Streamstats, 2019) indicates a drainage area of 0.39 square miles at the existing crossing with 0.30 % impervious area. However, to account for future development, 5% of the total catchment area was assumed to be impervious. Then, a proposed replacement culvert was conservatively sized using future flow conditions. The proposed culvert is a double-barreled 60” Reinforced Concrete Pipe.

The Proposed culvert was evaluated in HY-8 with respect to the NCDOT sizing criteria. Since NC 210 is considered a Major Arterial, the criteria states that the crossing is to be designed for a 50-year storm (Chang, 2016) and that the proposed headwater from a 100-year storm is not supposed to be higher than the existing 100-year headwater (Chang, 2016, pp. 9-5). The proposed culvert satisfies both of those requirements.

The 10-year flow overtops the roadway in the existing condition. The proposed culvert replacements will reduce the frequency of overtopping by being able to safely pass a 100-year flow without overtopping.

Existing culvert

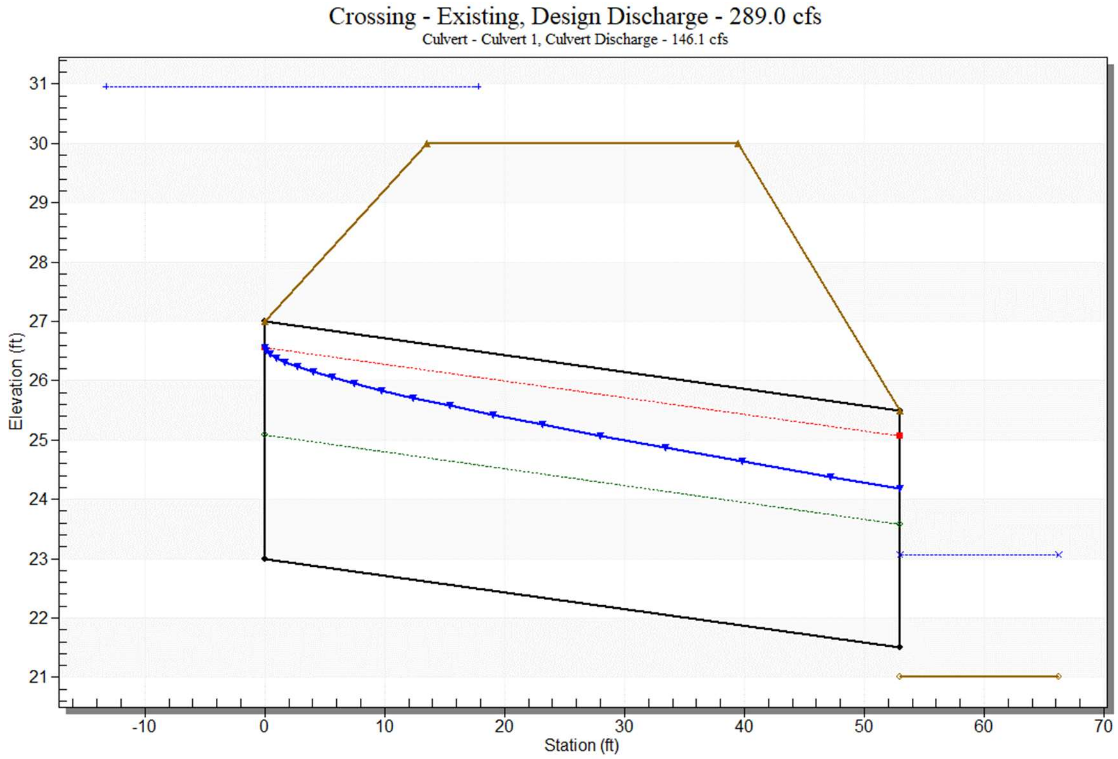
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	58.00	58.00	26.41	**3.41**	1.36	1-S2n	1.24	2.29	1.53	0.93	12.65	2.32
10 YR	145.00	134.90	30.17	**7.17**	5.31	5-S2n	1.98	3.46	2.55	1.47	15.45	3.06
50 YR	242.00	143.26	30.75	**7.75**	5.74	5-S2n	2.05	3.54	2.65	1.89	15.76	3.56
100 YR	289.00	146.14	30.96	**7.96**	5.90	5-S2n	2.08	3.56	2.68	2.06	15.86	3.74

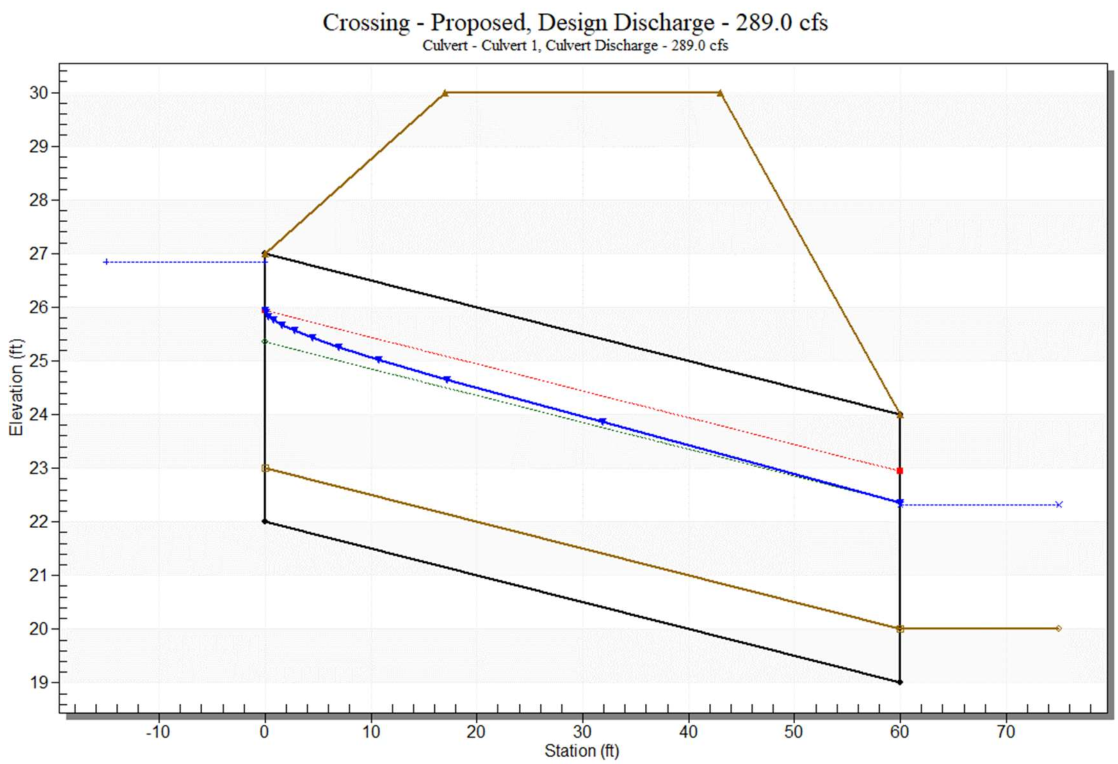
Proposed culvert

Results from HY8 for existing and proposed culverts at BR-202

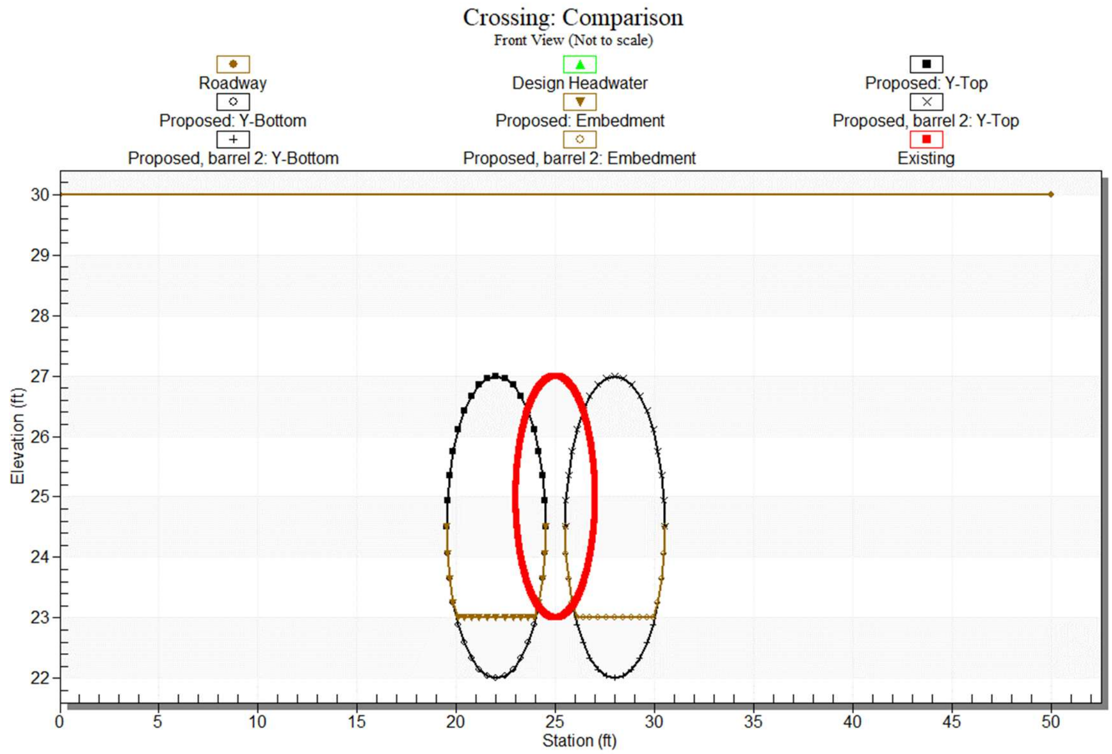
Discharge Names	Total Discharge (cfs)	Culvert Discharge (cfs)	Headwater Elevation (ft)	Inlet Control Depth(ft)	Outlet Control Depth(ft)	Flow Type	Normal Depth (ft)	Critical Depth (ft)	Outlet Depth (ft)	Tailwater Depth (ft)	Outlet Velocity (ft/s)	Tailwater Velocity (ft/s)
2 YR	58.00	58.00	24.30	**1.30**	-1.75	1-S2n	0.87	1.11	0.87	0.99	7.31	2.55
10 YR	145.00	145.00	25.42	**2.42**	-0.19	1-S2n	1.55	1.97	1.55	1.62	9.74	3.35
50 YR	242.00	242.00	26.36	**3.36**	2.01	1-S2n	2.11	2.67	2.11	2.12	11.80	3.86
100 YR	289.00	289.00	26.84	**3.84**	3.29	1-S2n	2.36	2.95	2.36	2.32	12.59	4.03

100-year Water Surface Elevations for Existing and Proposed Crossings

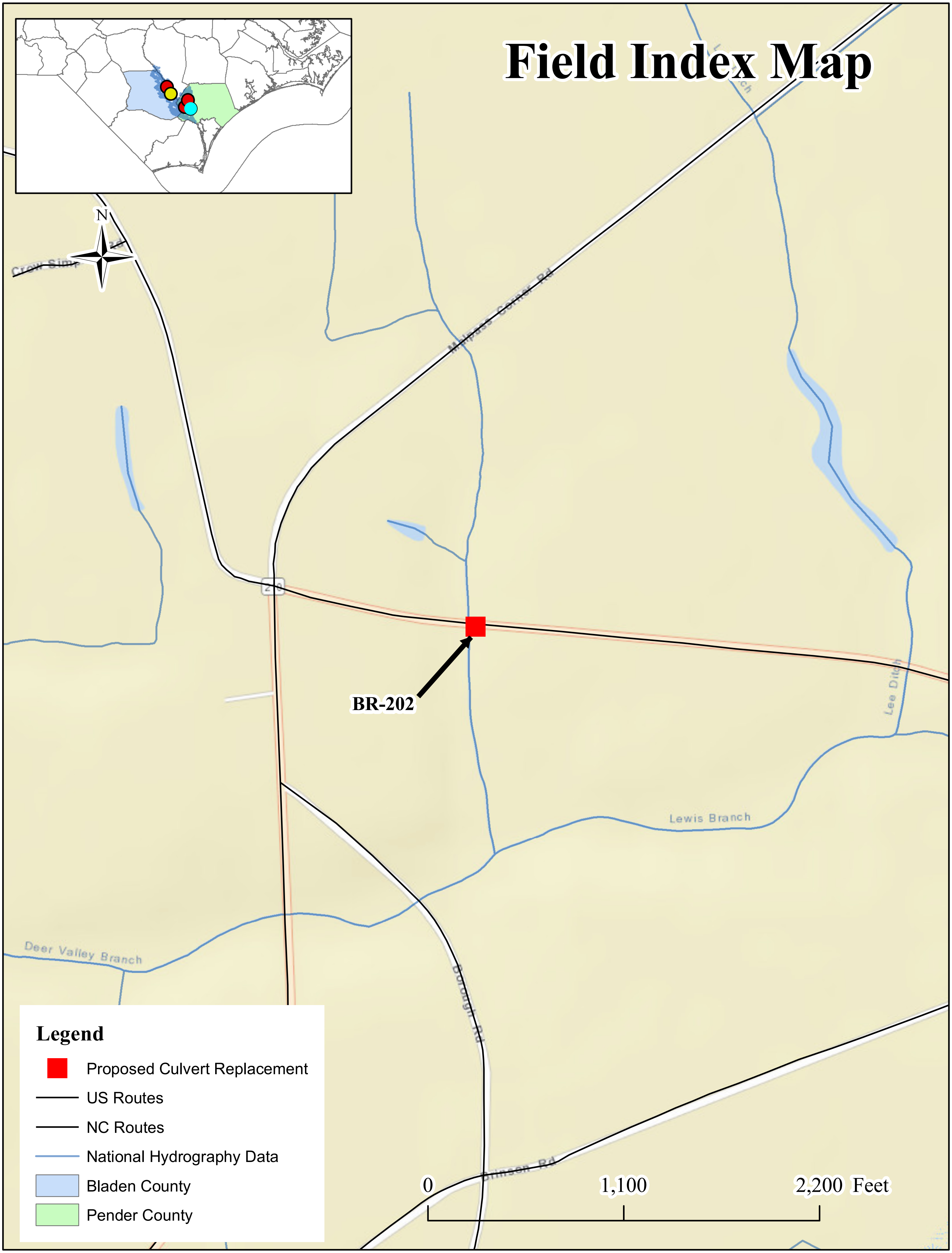


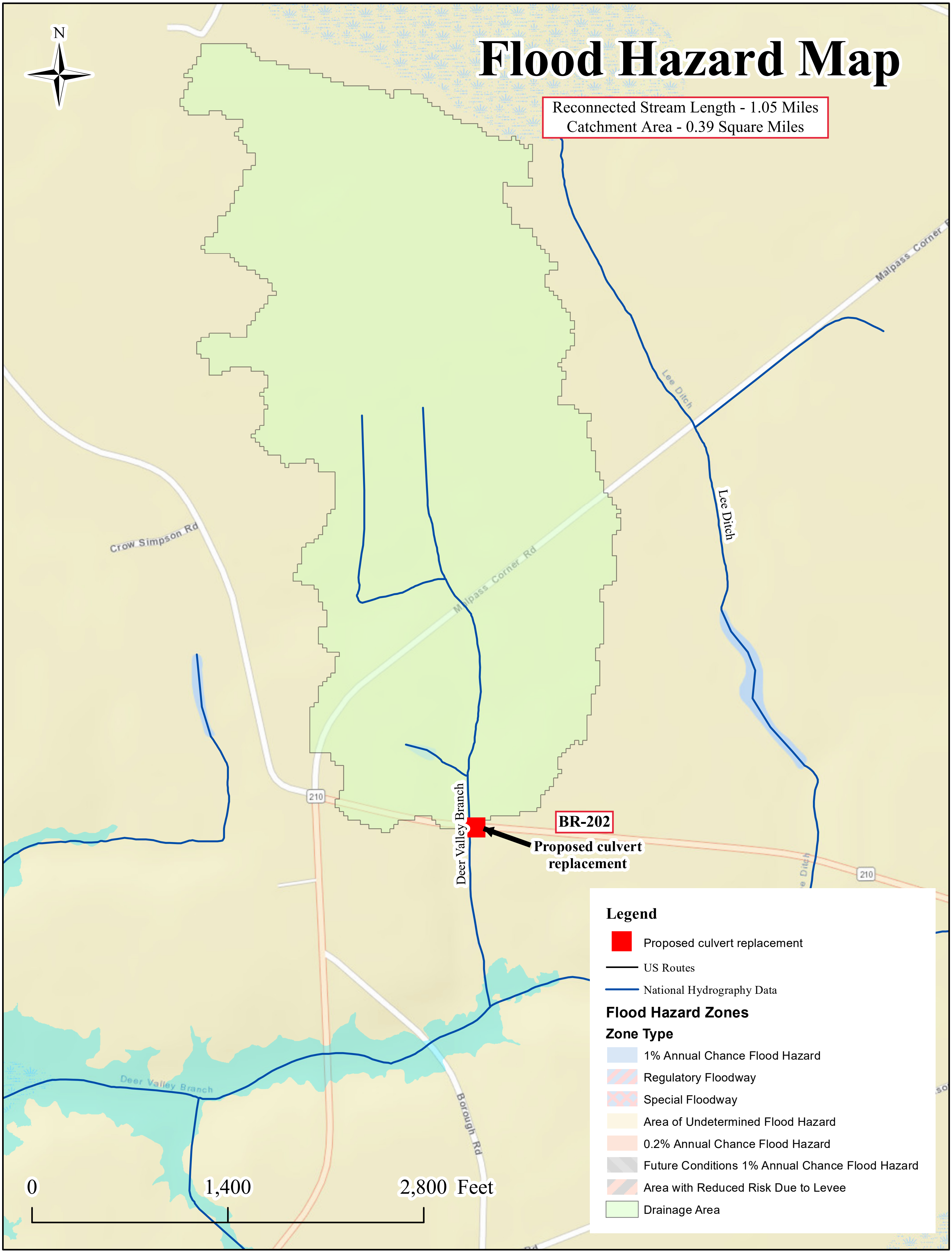


Crossing Comparison: Existing vs Proposed Upstream Face of BR-202



BR-202 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, BRIDGE, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE, PERMITS	1	LS	$35,000.00	$35,000.00
2	CLEARING AND GRUBBING	1	AC	$5,000.00	$5,000.00
3	REMOVE EXISTING PAVEMENT	230	SY	$10.00	$2,300.00
4	PAVEMENT MATERIAL AND MARKINGS	1	LS	$136,000.00	$136,000.00
5	EROSION AND SEDIMENT CONTROL	1	LS	$7,000.00	$7,000.00
6	TEMPORARY SILT FENCE	445	LF	$3.00	$1,335.00
7	EROSION CONTROL MATTING	200	SY	$3.00	$600.00
8	CONCRETE WASHOUT STRUCTURE	1	EA	$1,000.00	$1,000.00
9	MILLING BITUMINOUS PAVEMENT	230	SY	$15.00	$3,450.00
10	60” RCP	106	LF	$490.00	$51,940.00
11	PIPE OUTLET	2	EA	$1,000.00	$2,000.00
12	SEEDING	0.20	AC	$6,000.00	$1,200.00
13	TRAFFIC CONTROL	1	LS	$3,000.00	$3,000.00
14	SOIL MATERIALS	300	CY	$20.00	$6,000.00
15	TOPSOIL	50	CY	$30.00	$1,500.00
16	FILTER FABRIC	8	SY	$10.00	$80.00
SECTION A: ROADWAY, BRIDGE, DRAINAGE SUBTOTAL					**$257,405.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (10%)	1	LS	$25,740.50	$25,740.50
18	CONTINGENCY (20%)	1	LS	$56,629.10	$56,629.10
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$3,500.00	$3,500.00
SECTION B: GENERAL PROJECT SUBTOTAL					$85,869.60
(Sum of Section A Roadway, Bridge, Drainage plus Section B General Project) PROJECT TOTAL					**$ 343,274.60**


Field Index Map
N
Malpass Corner Rd
BR-202
Lee Ditch
Lewis Branch
Deer Valley Branch
Borough Rd
Stinson Rd
Legend
Proposed Culvert Replacement
US Routes
NC Routes
National Hydrography Data
Bladen County
Pender County
0
1,100
2,200 Feet



Flood Hazard Map
Reconnected Stream Length - 1.05 Miles
Catchment Area - 0.39 Square Miles
N
Malpass Corner Rd
Lee Ditch
Crow Simpson Rd
Deer Valley Branch
210
BR-202
Proposed culvert replacement
Borough Rd
0
1,400
2,800 Feet
Legend
Proposed culvert replacement
US Routes
National Hydrography Data
Flood Hazard Zones
Zone Type
1% Annual Chance Flood Hazard
Regulatory Floodway
Special Floodway
Area of Undetermined Flood Hazard
0.2% Annual Chance Flood Hazard
Future Conditions 1% Annual Chance Flood Hazard
Area with Reduced Risk Due to Levee
Drainage Area

References

(2019). Retrieved from USGS Streamstats: https://streamstats.usgs.gov/ss/

Chang, D. S. (2016). Guidelines for Drainage Studies and Hydraulic Design. Raleigh: NCDOT.

DPS, N. (2018). *North Carolina Spatial Data Download*. Retrieved from https://sdd.nc.gov/

USGS. (2014). *Methods for Estimating the Magnitude and Frequency of Floods for Urban and Small Rural Streams in Georgia, South Carolina and North Carolina.* Reston: USGS.

PROJECT COST ESTIMATES

Engineering (Design) and Construction costs have been updated from the 2019 Preliminary Engineering Report to better align with current year costs. Costs have been impacted due to COVID, supply chain struggles as well as recent inflation hikes. M&N has updated these costs based on the latest information from both local and national resources. In addition, M&N has provided sufficient cost based on projected permitting, possible utility relocations and proposed right of way / easement purchases to construct these projects.

Multi-site Budget Summary				
Project Element	**Total Budget**	**NOAA Request**	**Matching Funds**	**Leveraged Funds**
Site BR-152				
Replace existing 2 @ 48" corrugated steel pipes with 2 @ 72" Reinforced Concrete Pipes under Indian Hill Road crossing Bulltail Creek in Pender County, NC				
Personnel	$ 24,000	$ 24,000	$ -	$ -
Fringe	$ -	$ -	$ -	$ -
Travel	$ 500	$ 500	$ -	$ -
Contractual	$ 600,000	$ 600,000	$ -	$ -
Supplies	$ -	$ -	$ -	$ -
Phase Total	**$ 624,500**	**$ 624,500**	**$ -**	**$ -**
Site BR-376				
Replace existing 2 @ 60" corrugated steel pipes with 2 @ 72" Reinforced Concrete Pipes under Blueberry Road crossing Bear Branch in Pender County, NC				
Personnel	$ 24,000	$ 24,000	$ -	$ -
Fringe	$ -	$ -	$ -	$ -
Travel	$ 500	$ 500	$ -	$ -
Contractual	$ 700,000	$ 700,000	$ -	$ -
Phase Total	**$ 724,500**	**$ 724,500**	**$ -**	**$ -**
Site BR-64				
Replace existing 1 @ 48" corrugated steel pipe with 1 @ 60" Reinforced Concrete Pipe under NC 210 crossing an upper tributary to South River in Bladen County, NC				
Personnel	$ 24,000	$ 24,000	$ -	$ -
Fringe	$ -	$ -	$ -	$ -
Travel	$ 500	$ 500	$ -	$ -
Contractual	$ 450,000	$ 450,000	$ -	$ -
Supplies	$ -	$ -	$ -	$ -
Other	$ -	$ -	$ -	$ -
Phase Total	**$ 474,500**	**$ 474,500**	**$ -**	**$ -**
Site BR-236				
Replace existing 4 @ 54" reinforced concrete pipes with 4 @ 72" Reinforced Concrete Pipes under Slocum Trail crossing Big Branch in Pender County, NC				
Personnel	$ 24,000	$ 24,000	$ -	$ -
Fringe	$ -	$ -	$ -	$ -
Travel	$ 500	$ 500	$ -	$ -
Contractual	$ 130,000	$ 130,000	$ -	$ -
Supplies	$ -	$ -	$ -	$ -
Other	$ -	$ -	$ -	$ -
Phase Total	**$ 154,500**	**$ 154,500**	**$ -**	**$ -**

Multi-site Budget Summary				
Project Element	**Total Budget**	**NOAA Request**	**Matching Funds**	**Leveraged Funds**
Site BR-202				
Replace existing 1 @ 48" reinforced concrete pipe with 1 @ 60" Reinforced Concrete Pipe under NC 210 crossing an upper tributary to Deer Valley Branch in Pender County, NC				
Personnel	$ 24,000	$ 24,000	$ -	$ -
Fringe	$ -	$ -	$ -	$ -
Travel	$ 500	$ 500	$ -	$ -
Contractual	$ 520,000	$ 520,000	$ -	$ -
Supplies	$ -	$ -	$ -	$ -
Other	$ -	$ -	$ -	$ -
Phase Total	**$ 544,500**	**$ 544,500**	**$ -**	**$ -**
Project Total	**$ 2,522,500**	**$ 2,522,500**	**$ -**	**$ -**

BR-64 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE	1	LS	$ 50,000.00	$ 50,000.00
2	CLEARING AND GRUBBING	1	AC	$ 30,000.00	$ 30,000.00
3	REMOVAL OF EXISTING ASHPALT PAVEMENT	300	SY	$ 30.00	$ 9,000.00
4	MILLING OF EXISTING PAVEMENT	100	SY	$ 20.00	$ 2,000.00
5	EARTHWORK	800	CY	$ 50.00	$ 40,000.00
6	DRAINAGE (60" RCP / HEADWALLS)	60	LF	$ 1,000.00	$ 60,000.00
7	EROSION CONTROL	0.50	AC	$ 50,000.00	$ 25,000.00
8	STEEL BEAM GUARDRAIL / ANCHOR UNITS	200	LF	$ 115.00	$ 23,000.00
9	TRAFFIC CONTROL	1	LS	$ 15,000.00	$ 15,000.00
10	PAVEMENT MARKINGS	1	LS	$ 12,000.00	$ 12,000.00
				SECTION A: ROADWAY, DRAINAGE TOTAL	**$ 266,000.00**
SECTION B: GENERAL PROJECT					
11	ENGINEERING (~15%)	1	LS	$ 42,000.00	$ 42,000.00
12	CONTINGENCY (~35%)-ROW, UTIL, Permitting	1	LS	$ 112,000.00	$ 112,000.00
13	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$ 30,000.00	$ 30,000.00
				SECTION B: GENERAL PROJECT SUBTOTAL	$ 184,000.00
				(Sum of Section A Roadway, Drainage plus Section B General Project) PROJECT TOTAL	**$ 450,000.00**

BR-152 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE	1	LS	$ 50,000.00	$ 50,000.00
2	CLEARING AND GRUBBING	1	AC	$ 30,000.00	$ 30,000.00
3	REMOVAL OF EXISTING ASHPALT PAVEMENT	300	SY	$ 30.00	$ 9,000.00
4	MILLING OF EXISTING PAVEMENT	100	SY	$ 20.00	$ 2,000.00
5	EARTHWORK	1100	CY	$ 50.00	$ 55,000.00
6	DRAINAGE (72" RCP / HEADWALLS)	120	LF	$ 1,200.00	$ 144,000.00
7	EROSION CONTROL	0.50	AC	$ 50,000.00	$ 25,000.00
8	STEEL BEAM GUARDRAIL / ANCHOR UNITS	200	LF	$ 115.00	$ 23,000.00
9	TRAFFIC CONTROL	1	LS	$ 15,000.00	$ 15,000.00
10	PAVEMENT MARKINGS	1	LS	$ 12,000.00	$ 12,000.00
SECTION A: ROADWAY, DRAINAGE SUBTOTAL					**$ 365,000.00**
SECTION B: GENERAL PROJECT					
17	ENGINEERING (~15%)	1	LS	$ 55,000.00	$ 55,000.00
18	CONTINGENCY (~35%)-ROW, UTIL, Permitting	1	LS	$ 150,000.00	$ 150,000.00
19	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$ 30,000.00	$ 30,000.00
SECTION B: GENERAL PROJECT SUBTOTAL					$ 235,000.00
(Sum of Section A Roadway, Drainage plus Section B General Project Subtotal) PROJECT TOTAL					**$ 600,000.00**

BR-202 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE	1	LS	$ 50,000.00	$ 50,000.00
2	CLEARING AND GRUBBING	1	AC	$ 30,000.00	$ 30,000.00
3	REMOVAL OF EXISTING ASHPALT PAVEMENT	300	SY	$ 30.00	$ 9,000.00
4	MILLING OF EXISTING PAVEMENT	100	SY	$ 20.00	$ 2,000.00
5	EARTHWORK	800	CY	$ 50.00	$ 40,000.00
6	DRAINAGE (60" RCP / HEADWALLS)	106	LF	$ 1,000.00	$ 106,000.00
7	EROSION CONTROL	0.50	AC	$ 50,000.00	$ 25,000.00
8	STEEL BEAM GUARDRAIL / ANCHOR UNITS	200	LF	$ 115.00	$ 23,000.00
9	TRAFFIC CONTROL	1	LS	$ 15,000.00	$ 15,000.00
10	PAVEMENT MARKINGS	1	LS	$ 12,000.00	$ 12,000.00
				SECTION A: ROADWAY, DRAINAGE SUBTOTAL	**$ 312,000.00**
SECTION B: GENERAL PROJECT					
11	ENGINEERING (~15%)	1	LS	$ 48,000.00	$ 48,000.00
12	CONTINGENCY (~35%)-ROW, UTIL, Permitting	1	LS	$ 130,000.00	$ 130,000.00
13	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$ 30,000.00	$ 30,000.00
				SECTION B: GENERAL PROJECT SUBTOTAL	$ 208,000.00
				(Sum of Section A Roadway, Drainage plus Section B General Project) PROJECT TOTAL	**$ 520,000.00**

BR-236 CULVERT REPLACMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE	0	LS	$ 50,000.00	$ -
2	CLEARING AND GRUBBING	0	AC	$ 30,000.00	$ -
3	REMOVAL OF EXISTING ASHPALT PAVEMENT	0	SY	$ 30.00	$ -
4	MILLING OF EXISTING PAVEMENT	100	SY	$ 20.00	$ 2,000.00
5	EARTHWORK	1100	CY	$ 50.00	$ 55,000.00
6	DRAINAGE (72" RCP / HEADWALLS)	0	LF	$ 1,200.00	$ -
7	EROSION CONTROL	1	AC	$ 50,000.00	$ 25,000.00
8	STEEL BEAM GUARDRAIL / ANCHOR UNITS	200	LF	$ 115.00	$ 23,000.00
9	TRAFFIC CONTROL	0	LS	$ 15,000.00	$ -
10	PAVEMENT MARKINGS	0	LS	$ 12,000.00	$ -
SECTION A: ROADWAY, DRAINAGE SUBTOTAL					**$ 105,000.00**
SECTION B: GENERAL PROJECT					
11	ENGINEERING (0%)	1	LS	$ -	$ -
12	CONTINGENCY (0%)	1	LS	$ -	$ -
13	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$ 25,000.00	$ 25,000.00
SECTION B: GENRAL PROJECT SUBTOTAL					$ 25,000.00
(Sum of Section A Roadway, Drainage plus Section B General Project) PROJECT TOTAL					**$ 130,000.00**

BR-376 CULVERT REPLACEMENT					
ITEM #	**ITEM DESCRIPTION**	**EST. QTY**	**UNIT**	**UNIT COST**	**TOTAL**
SECTION A: ROADWAY, DRAINAGE					
1	MOBILIZATION, BONDS, INSURANCE	1	LS	$ 50,000.00	$ 50,000.00
2	CLEARING AND GRUBBING	1	AC	$ 30,000.00	$ 30,000.00
3	REMOVAL OF EXISTING ASHPALT PAVEMENT	300	SY	$ 30.00	$ 9,000.00
4	MILLING OF EXISTING PAVEMENT	100	SY	$ 20.00	$ 2,000.00
5	EARTHWORK	1200	CY	$ 50.00	$ 60,000.00
6	DRAINAGE (72" RCP / HEADWALLS)	170	LF	$ 1,200.00	$ 204,000.00
7	EROSION CONTROL	0.50	AC	$ 50,000.00	$ 25,000.00
8	STEEL BEAM GUARDRAIL / ANCHOR UNITS	200	LF	$ 115.00	$ 23,000.00
9	TRAFFIC CONTROL	1	LS	$ 15,000.00	$ 15,000.00
10	PAVEMENT MARKINGS	1	LS	$ 12,000.00	$ 12,000.00
				SECTION A: ROADWAY, DRAINAGE SUBTOTAL	**$ 430,000.00**
SECTION B: GENERAL PROJECT					
11	ENGINEERING (~15%)	1	LS	$ 65,000.00	$ 65,000.00
12	CONTINGENCY (~35%)-ROW, UTIL, Permitting	1	LS	$ 175,000.00	$ 175,000.00
13	CONSTRUCTION STAKES, LINES AND GRADE (To include Construction Surveying, Supplemental Field Surveying and Supplemental Surveying Office Calculations)	1	LS	$ 30,000.00	$ 30,000.00
				SECTION B: GENERAL PROJECT SUBTOTAL	$ 270,000.00
				(Sum of Section A Roadway, Drainage plus Section B Genral Project) PROJECT TOTAL	**$ 700,000.00**

DESIGN PLANS: BR-236

PROJECT: BR-236

CAPE FEAR RESOURCE CONSERVATION AND DEVELOPMENT

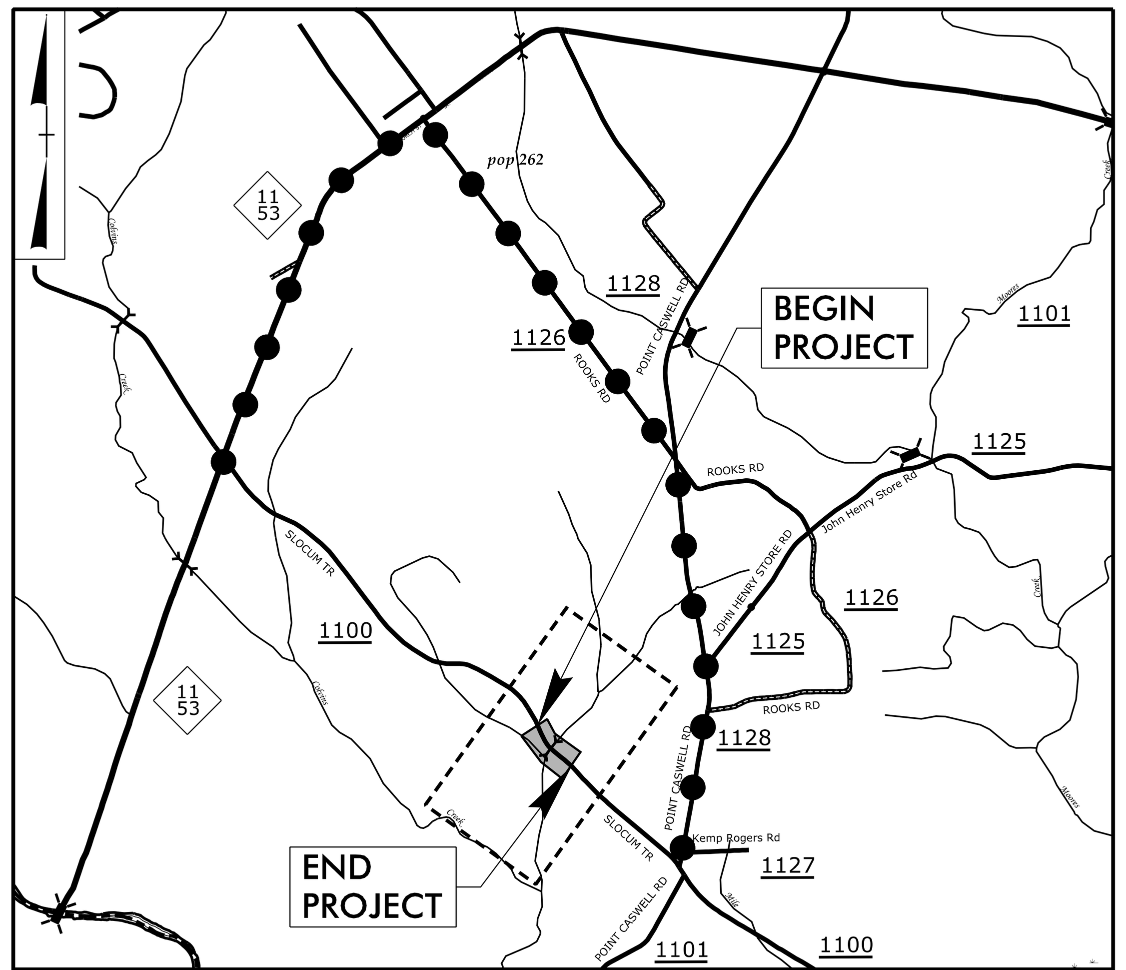
PENDER COUNTY

PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
BR-236	1	

LOCATION: SR 1100 (SLOCUM TRAIL) CULVERT REPLACEMENT AT BIG BRANCH

TYPE OF WORK: PAVING, GRADING, DRAINAGE, CULVERT

See Sheet 1B For Conventional Symbols

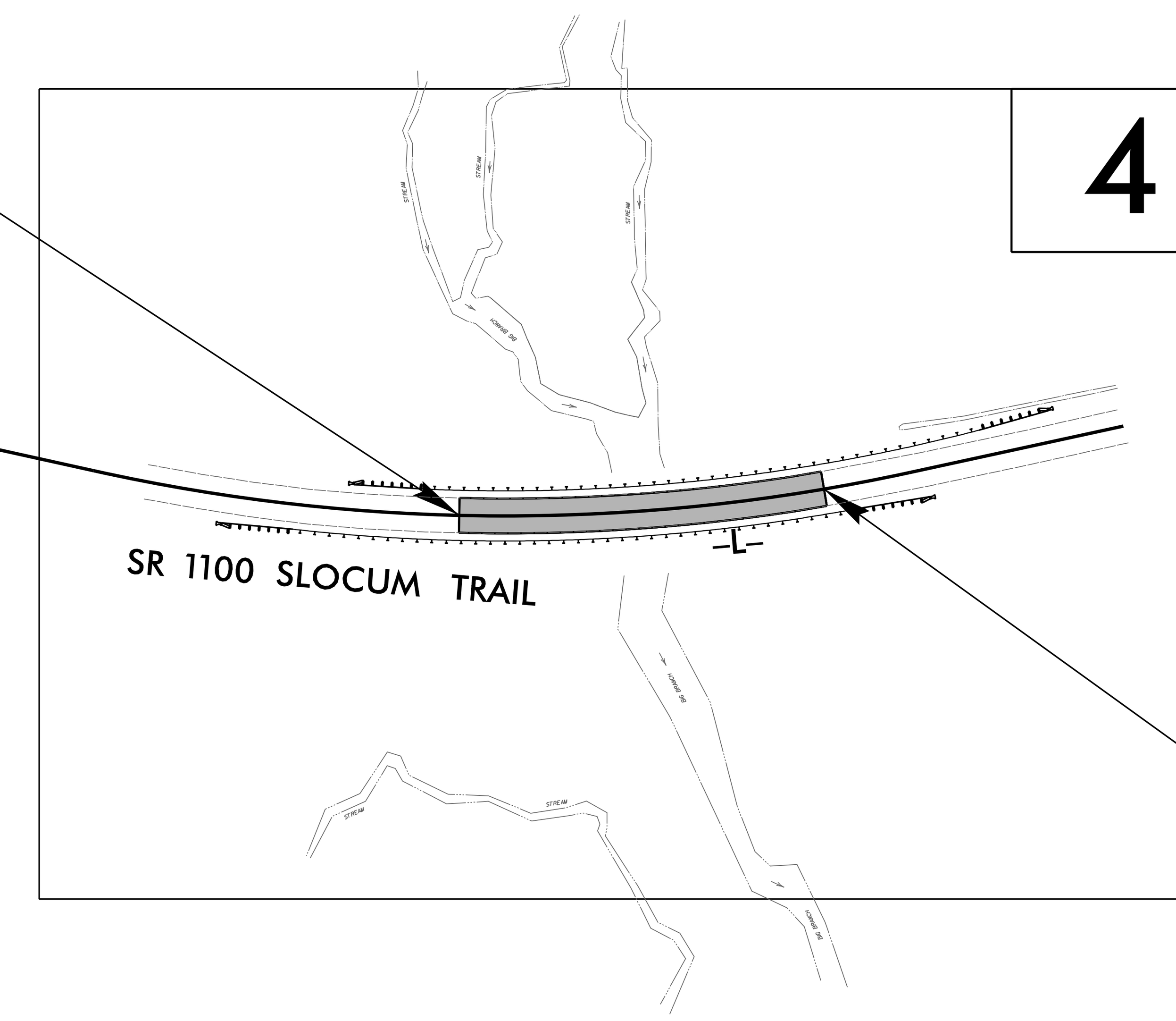


VICINITY MAP
(NOT TO SCALE)

● ● ● ● OFFSITE DETOUR

BEGIN PROJECT BR-236
-L- STA 12+80.00

TO NC 53



TO NC 210

END PROJECT BR-236
-L- STA 14+70.00

NAD 83/NA 2011

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

THERE IS NO CONTROL OF ACCESS ON THIS PROJECT.
CLEARING ON THIS PROJECT SHALL BE PERFORMED TO THE LIMITS ESTABLISHED BY METHOD ____

GRAPHIC SCALES

20 10 0 20 40
PLANS

20 10 0 20 40
PROFILE (HORIZONTAL)

4 2 0 4 8
PROFILE (VERTICAL)

DESIGN DATA

ADT 2022 = 150
ADT DESIGN YEAR = NA
K = NA
D = NA
T = NA
V = 55 MPH
FUNC CLASS = LOCAL-SUB REGIONAL

PROJECT LENGTH

LENGTH ROADWAY PROJECT BR-236	=	0.036
LENGTH STRUCTURE PROJECT BR-236	=	0.000
TOTAL LENGTH PROJECT BR-236	=	0.036

Prepared In the Office of:
moffatt & nichol
4700 FALLS OF NEUSE ROAD, SUITE 300
RALEIGH, NORTH CAROLINA 27609
(919) 781-4626 VOICE (919) 781-4869 FAX
NC License NO.: F-0105

RIGHT OF WAY DATE:
TBD

LETTING DATE:
TBD

TRENT HUFFMAN, P.E.
PROJECT ENGINEER

GRAY MODLIN, P.E.
PROJECT DESIGN ENGINEER

CAPE FEAR RESOURCE CONSERVATION AND DEVELOPMENT CONTACT

HYDRAULICS ENGINEER
moffatt & nichol
SIGNATURE: P.E.

ROADWAY DESIGN ENGINEER
moffatt & nichol
SIGNATURE: P.E.

09/08/99

6/28/2022
Q:\RA\0292-01\20 CADD\BR236\Roadway\Proj\BR236_rdy_tsh.dgn
zliu

PROJECT REFERENCE NO.	SHEET NO.
BR-236	2A-1
ROADWAY DESIGN ENGINEER	PAVEMENT DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

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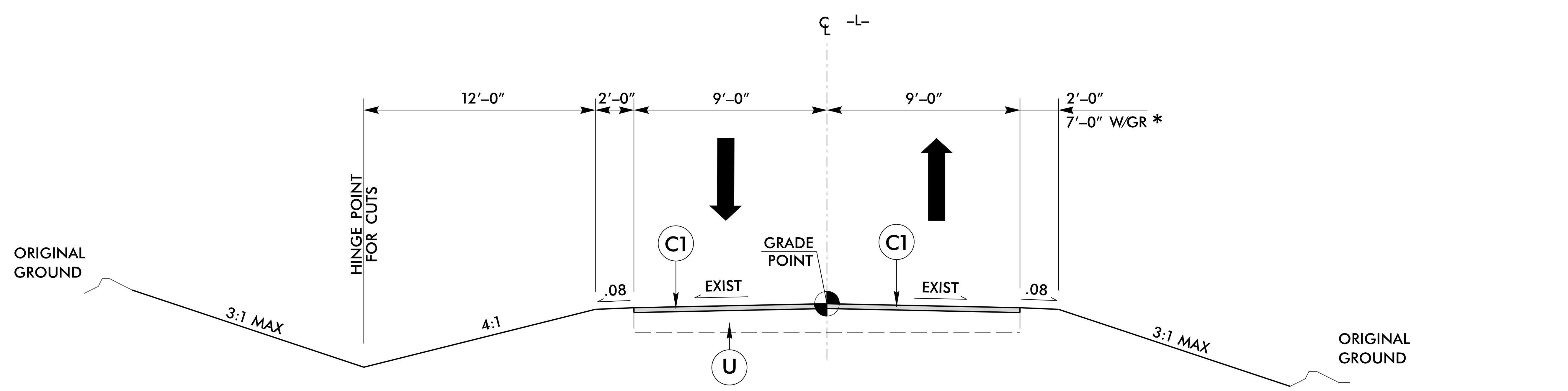
NC License NO.: F-0105

PRELIMINARY PAVEMENT SCHEDULE

(PRELIMINARY PAVEMENT DESIGN PER NCDOT DIVISION 3 DATED 04/25/22)

C1	PROP. APPROX. 1½" ASPHALT CONCRETE SURFACE COURSE, TYPE S9.5C, AT AN AVERAGE RATE OF 168.0 LBS. PER SQ. YD.	T	EARTH MATERIAL
E1	PROP. APPROX. 5.5" ASPHALT CONCRETE BASE COURSE, TYPE B25.0C, AT AN AVERAGE RATE OF 627 LBS. PER SQ. YD.	U	EXISTING PAVEMENT

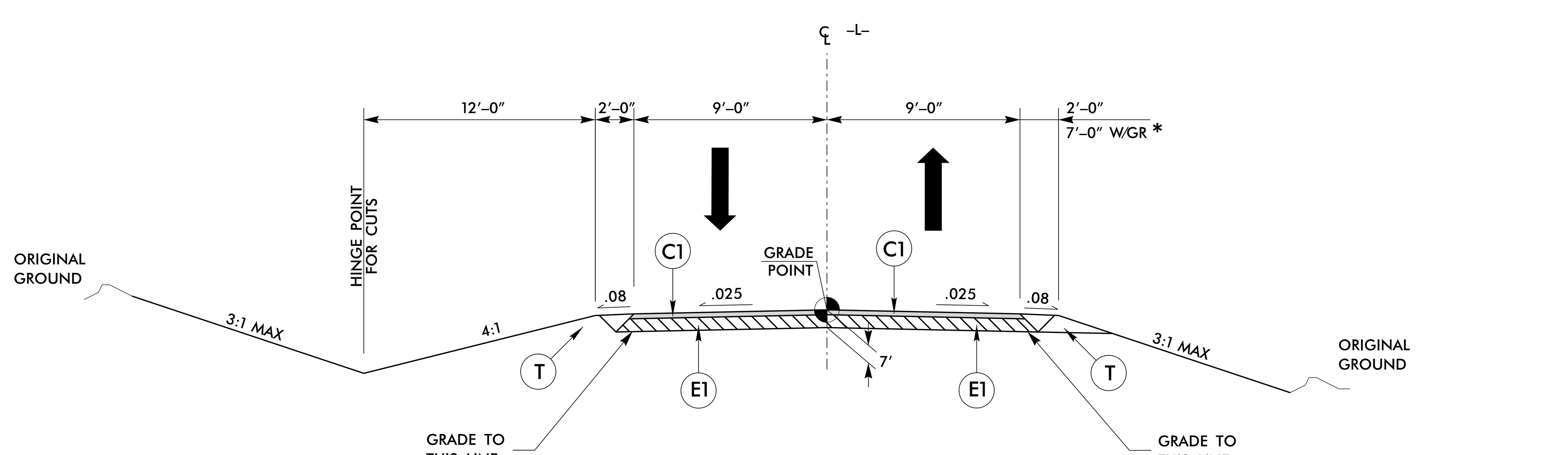
NOTE: PAVEMENT EDGE SLOPES ARE 1:1 UNLESS SHOWN OTHERWISE.



* NOTE: PLACE GUARDRAIL 4'-0" FROM EDGE OF TRAVEL

TYPICAL SECTION NO. 1

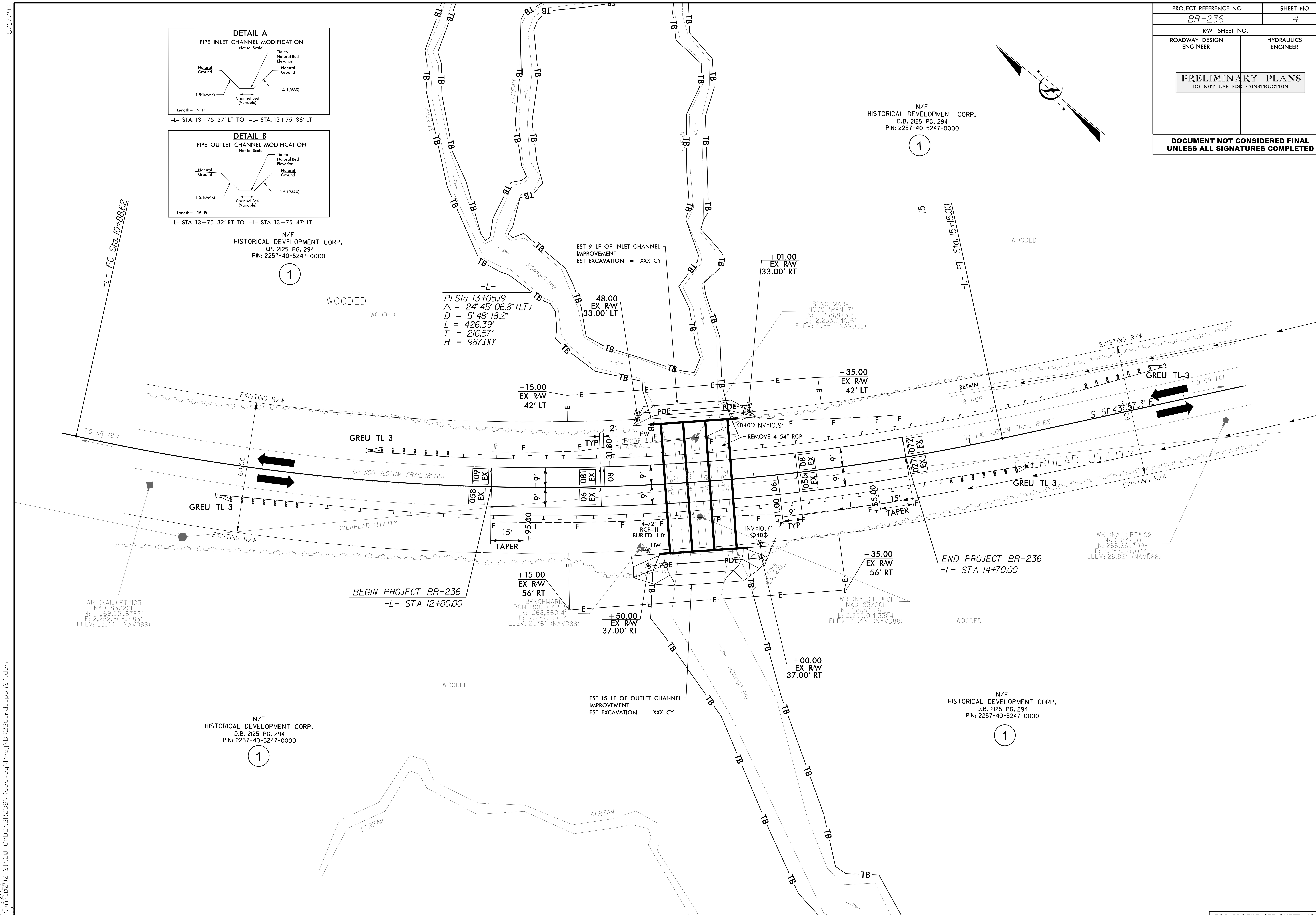
–L– STA. 12+80.00 TO –L– STA. 13+30.00
–L– STA. 14+20.00 TO –L– STA. 14+70.00



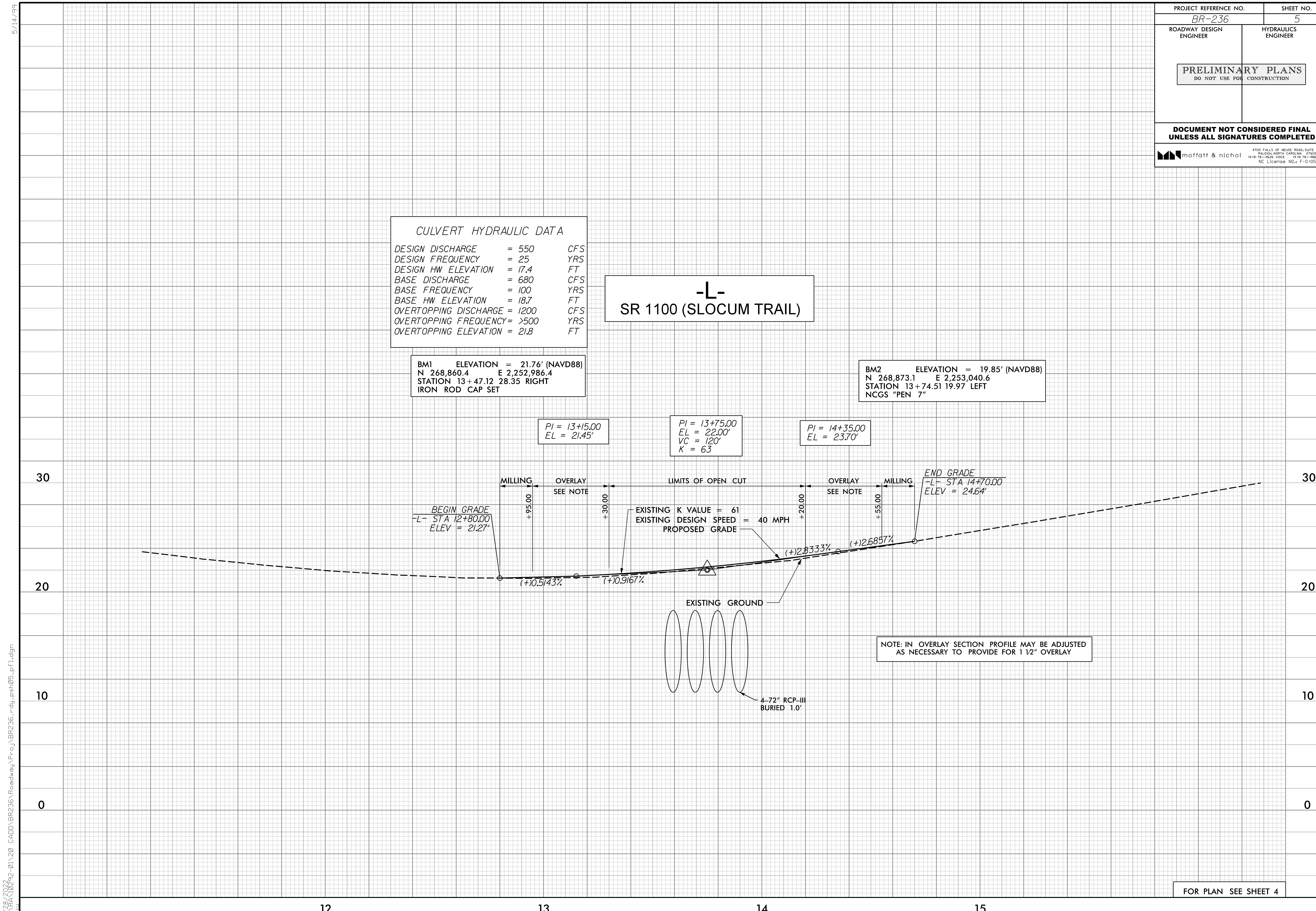
TYPICAL SECTION NO. 2

–L– STA. 13+30.00 TO –L– STA. 14+20.00

* NOTE: PLACE GUARDRAIL 4'-0" FROM EDGE OF TRAVEL



PROJECT REFERENCE NO.
BR-236
SHEET NO.
4
R/W SHEET NO.
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED
DETAIL A
PIPE INLET CHANNEL MODIFICATION
(Not to Scale)
Natural Ground
Tie to Natural Bed Elevation
Natural Ground
1.5:1(MAX)
Channel Bed (Variable)
1.5:1(MAX)
Length = 9 Ft.
-L- STA. 13+75 27' LT TO -L- STA. 13+75 36' LT
DETAIL B
PIPE OUTLET CHANNEL MODIFICATION
(Not to Scale)
Length = 15 Ft.
-L- STA. 13+75 32' RT TO -L- STA. 13+75 47' LT
N/F
HISTORICAL DEVELOPMENT CORP.
D.B. 2125 PG. 294
PIN: 2257-40-5247-0000
-L- PC Sta. 10+88.62
-L- PT Sta. 15+15.00
-L-
PI Sta 13+05.19
△ = 24° 45' 06.8" (LT)
D = 5° 48' 18.2"
L = 426.39'
T = 216.57'
R = 987.00'
WOODED
EST 9 LF OF INLET CHANNEL IMPROVEMENT
EST EXCAVATION = XXX CY
EST 15 LF OF OUTLET CHANNEL IMPROVEMENT
EST EXCAVATION = XXX CY
+48.00 EX R/W 33.00' LT
+01.00 EX R/W 33.00' RT
+15.00 EX R/W 42' LT
+35.00 EX R/W 42' LT
+15.00 EX R/W 56' RT
+35.00 EX R/W 56' RT
+50.00 EX R/W 37.00' RT
+00.00 EX R/W 37.00' RT
BENCHMARK NCGS "PEN 7" N: 268,873.1' E: 2,253,040.6' ELEV: 19.85' (NAVD88)
BENCHMARK IRON ROD CAP SET N: 268,860.4' E: 2,252,986.4' ELEV: 21.76' (NAVD88)
WR (NAIL) PT#103 NAD 83/2011 N: 269,051.6785' E: 2,252,865.7183' ELEV: 23.44' (NAVD88)
WR (NAIL) PT#101 NAD 83/2011 N: 268,848.6122 E: 2,253,014.3364 ELEV: 22.43' (NAVD88)
WR (NAIL) PT#102 NAD 83/2011 N: 268,691.3098' E: 2,253,201.0442' ELEV: 28.86' (NAVD88)
EXISTING R/W
GREU TL-3
SR 1100 SLOCUM TRAIL 18' BST
TO SR 1201
TO SR 1101
OVERHEAD UTILITY
S 51° 43' 57.3" E
REMOVE 4-54" RCP
INV=10.9'
INV=10.7'
4-72" RCP-III BURIED 1.0'
PDE
HW
CONCRETE HEADWALL
RETAIN 18" RCP
TAPER
TYP
BEGIN PROJECT BR-236
-L- STA 12+80.00
END PROJECT BR-236
-L- STA 14+70.00
BIG BRANCH
STREAM
FOR PROFILE, SEE SHEET NO. 5


PROJECT REFERENCE NO. BR-236
SHEET NO. 5
ROADWAY DESIGN ENGINEER
HYDRAULICS ENGINEER
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION
DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED
moffatt & nichol
4700 FALLS OF NEUSE ROAD, SUITE 300 RALEIGH, NORTH CAROLINA 27609
(919) 781-4626 VOICE (919) 781-4869 FAX
NC License NO.: F-0105
CULVERT HYDRAULIC DATA
DESIGN DISCHARGE = 550 CFS
DESIGN FREQUENCY = 25 YRS
DESIGN HW ELEVATION = 17.4 FT
BASE DISCHARGE = 680 CFS
BASE FREQUENCY = 100 YRS
BASE HW ELEVATION = 18.7 FT
OVERTOPPING DISCHARGE = 1200 CFS
OVERTOPPING FREQUENCY = >500 YRS
OVERTOPPING ELEVATION = 21.8 FT
-L-
SR 1100 (SLOCUM TRAIL)
BM1 ELEVATION = 21.76' (NAVD88)
N 268,860.4 E 2,252,986.4
STATION 13+47.12 28.35 RIGHT
IRON ROD CAP SET
BM2 ELEVATION = 19.85' (NAVD88)
N 268,873.1 E 2,253,040.6
STATION 13+74.51 19.97 LEFT
NCGS "PEN 7"
PI = 13+15.00
EL = 21.45'
PI = 13+75.00
EL = 22.00'
VC = 120'
K = 63
PI = 14+35.00
EL = 23.70'
MILLING
OVERLAY
SEE NOTE
LIMITS OF OPEN CUT
OVERLAY
SEE NOTE
MILLING
END GRADE
-L- STA 14+70.00
ELEV = 24.64'
BEGIN GRADE
-L- STA 12+80.00
ELEV = 21.27'
+95.00
+30.00
+20.00
+55.00
EXISTING K VALUE = 61
EXISTING DESIGN SPEED = 40 MPH
PROPOSED GRADE
(+)2.8333%
(+)2.6857%
(+)0.5143%
(+)0.9167%
EXISTING GROUND
4-72" RCP-III
BURIED 1.0'
NOTE: IN OVERLAY SECTION PROFILE MAY BE ADJUSTED AS NECESSARY TO PROVIDE FOR 1 1/2" OVERLAY
30
20
10
0
12
13
14
15
FOR PLAN SEE SHEET 4
5/14/99
6/28/2022
Q:\FTA\10292-01\20 CADD\BR236\Roadway\Proj\BR236_rdy_psh05_pfl.dgn

6/23/16

0 2.5 5	PROJ. REFERENCE NO.	SHEET NO.
	BR-236	X-1

Note: Approximate quantities only. Unclassified Excavation, Borrow Excavation, Fine Grading, Clearing and Grubbing, Breaking of Existing Pavement, and Removal of Existing Pavement will be paid for at the contract lump sum price for "Grading."

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

6/28/2022
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zliu

PROJ. REFERENCE NO.	SHEET NO.
BR-236	X-2

6/23/16

6/28/2022
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zliu

0 2.5 5	PROJ. REFERENCE NO.	SHEET NO.
	BR-236	X-3