FINAL
MONITORING REPORT
YEAR 6 (2023)
MUD LICK CREEK MITIGATION SITE
Chatham County, North Carolina
NCDMS Project No. 93482
Contract No. 7683
USACE Action ID No. SAW-2014-00736 & DWR Project No 2014-1127
SCO No. 1209857-01
Data Collection: April-September 2023
Submission: February 2024

PREPARED FOR:

N.C. DEPARTMENT OF ENVIRONMENTAL QUALITY
DIVISION OF MITIGATION SERVICES
1601 MAIL SERVICE CENTER
RALEIGH, NORTH CAROLINA 27699-1601

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PREPARED BY:

AXIOM ENVIRONMENTAL, INC.
218 SNOW AVENUE
RALEIGH, NORTH CAROLINA 27603

PROJECT SUMMARY

The North Carolina Division of Mitigation Services (NCDMS) has established the Mud Lick Creek Mitigation Site (Site) located within the Cape Fear River Basin Cataloging Unit (CU) 03030003 in the Upper Rocky River local watershed planning (LWP) area and 14-digit HUC 03030003070010. The Site was identified as a priority mitigation project in the *Detailed Assessment and Targeting of Management Report* (Tetra Tech 2005). The main stressors to aquatic resources identified during the watershed assessments described in the LWP documents include the following.

- Nutrient (nitrogen and phosphorous) loading from farming;
- Sediment loading from overland runoff, disturbed surfaces, and streambank erosion;
- Cattle access to streams increasing bank erosion and fecal coliform contamination; and
- Insufficient bank vegetation.

The project will contribute to meeting management recommendations to offset these stressors as described above for the LWP area by accomplishing the following primary goals.

- Control and reduce nutrient sources from the Site;
- Reduce sediment loads from disturbed areas on the Site and from eroding stream banks;
- Increased aeration of flows within the project extent promoting increases in dissolved oxygen concentrations;
- Reduce sources of fecal coliform pollution;
- Improve instream habitat;
- Reduce thermal loadings;
- Reconnect channels with floodplains and raise local water table; and
- Restore riparian habitat.

These goals will be accomplished through the following objectives:

- Restore riparian vegetation on the Site and thereby reduce sediment loads to streams from stream banks and existing pastures, increase on-Site retention of sediment and nutrients, create riparian habitat, and provide shade for streams to reduce thermal loadings;
- Stabilize eroding streambanks to reduce sediment inputs;
- Install fencing around the perimeter of the conservation easement to eliminate livestock access to streams, thereby reducing sediment, nutrient, and fecal coliform inputs;
- Plant restored and stabilized streambanks with native species to improve stability and habitat;
- Install instream structures to improve stability, create habitat, and help aerate stream flows;
- Raise streambeds to reconnect restored channels to floodplains and raise local water tables; and
- Restore streams and vegetation so the Site looks natural and aesthetically pleasing.

Stream Success Criteria: The stream restoration performance criteria for the Site will follow approved performance criteria presented in the 2015 *Mud Lick Creek Mitigation Site Final Mitigation Plan* as described below.

Stream Dimension: Riffle cross-sections on the restoration reaches and enhancement II reaches, where banks were re-graded (three reaches of Mud Lick Creek), should be stable and should show little change in bankfull area, maximum depth, and width-to-depth ratio. Bank-height-ratios shall not exceed 1.2 and entrenchment ratios shall be at least 2.2 for restored channels to be considered stable. All riffle cross-sections should fall within the parameters defined for channels of the appropriate stream type. If any changes do occur, these changes will be evaluated to assess whether the stream channel is showing signs of instability. Indicators of instability include a vertically incising thalweg or eroding channel banks. Changes in the channel that indicate a movement toward stability or enhanced habitat include a decrease in

the width-to-depth ratio in meandering channels or an increase in pool depth. Remedial action would not be taken if channel changes indicate a movement toward stability.

Stream Pattern and Profile: The as-built survey will include a longitudinal profile for the baseline monitoring report. Longitudinal profile surveys will not be conducted during the seven-year monitoring period unless other indicators during the annual monitoring indicate a trend toward vertical and lateral instability.

Substrate: Substrate materials in the restoration reaches should indicate a progression towards or the maintenance of coarser materials in the riffle features and smaller particles in the pool features.

Hydraulics: Two bankfull flow events, in separate monitoring years, must be documented on the restoration reaches and enhancement II reaches where banks were re-graded (three reaches of Mud Lick Creek) within the seven-year monitoring period.

Vegetation Success Criteria: The final vegetative success criteria will be the survival of 210 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of the required monitoring period (year seven). The interim measure of vegetative success for the Site will be the survival of at least 320 planted stems per acre at the end of the third monitoring year and at least 260 stems per acre at the end of the fifth year of monitoring. If this performance standard is met by year five and stem density is trending towards success (i.e., no less than 260 stems/acre), monitoring of vegetation on the Site may be terminated with written approval by the USACE in consultation with the NC Interagency Review Team. The extent of invasive species coverage will also be monitored and controlled as necessary throughout the required monitoring period (seven years).

Photo Documentation: Photographs should illustrate the Site's vegetation and morphological stability on an annual basis. Cross-section photos should demonstrate no excessive erosion or degradation of the banks. Longitudinal photos should indicate the absence of persistent bars within the channel or vertical incision. Grade control structures should remain stable. Deposition of sediment on the bank side of vane arms is preferable. Maintenance of scour pools on the channel side of vane arms is expected.

Visual Assessments: Visual assessments should support performance standards as described above.

As per Sections 7.2 and 12.4 of the Mitigation Plan, physio-chemical and biological parameters were included as part of specialized monitoring, depending on the data that could be obtained during the baseline period. Monitoring of these parameters was for investigative purposes only and not tied to mitigation success or credit. The sample size and variability of the pre-construction physio-chemical data was inadequate for the purposes of post-construction comparison and therefore, these will not be monitored moving forward. However, fish and macrobenthos will be monitored at the stations indicated in the asset and monitoring features map (Figure 2, Appendix B).

Site Background: The Site is located in northwestern Chatham County, north of Siler City and northwest of Silk Hope (Figure 1, Appendix B). The Site is located within United States Geological Survey (USGS) Hydrologic Unit and Targeted Local Watershed 03030003070010 (North Carolina Division of Water Resources Subbasin 03-06-12) of the Cape Fear River Basin. Prior to construction, the Site was used for agricultural livestock production. The proposed project will improve water quality as well as provide numerous ecological benefits within the Cape Fear River Basin. The project will help meet management recommendations of the *Upper Rocky River Local Watershed Plan* by restoring a vegetated riparian buffer zone, stabilizing eroding stream banks, and removing livestock from streams and riparian zones. These activities will result in reduced nutrient, sediment, and fecal coliform inputs; improved aquatic and riparian habitat, and other ecological benefits.

Mitigation Components: Project mitigation efforts will generate 2832 Stream Mitigation Units (SMUs) as the result of the following (Table 1, Appendix A & Figure 2, Appendix B).

- Restoration of 1215 linear feet of Site streams
- Enhancement (Level II) of 2426 linear feet of Site streams

Site design was completed in June 2015. Site construction occurred May 24–August 25, 2017 (final walkthrough) and the Site was planted in February 2018. Completed project activities, reporting history, completion dates, project contacts, and project attributes are summarized in Tables 1-4 (Appendix A). The assets and credits in the report, and shown in Table 1, are based upon approved as-built numbers as approved by the IRT on 11/1/2018.

TABLE OF CONTENTS

APPENDICES

1.0 METHODS

Monitoring of restoration efforts will be performed for seven years, or until success criteria are fulfilled. Monitoring is proposed for the stream channel and vegetation. In general, the restoration success criteria, and required remediation actions, are based on the *Stream Mitigation Guidelines* (USACE et al. 2003). Monitoring features are summarized in the following table and described below; monitoring features are depicted on Figure 2 (Appendix B).

Monitoring Summary

Parameter	Monitoring Feature	Quantity	Frequency
Streams			
Dimension	Cross-sections	7 riffles & 3 pools	annually
Substrate	Pebble counts	3 riffles	annually
Hydrology	Crest gauges	3	annually
Vegetation	Vegetation Plots	12	annually
	Warranty Plots	10	MY1
Visual assessments		Entire Site	biannually
Exotic & nuisance species		Entire Site	annually
Project boundary		Entire Site	annually
Reference photographs		22	annually
Supplemental Monitoring			
Biological	Macrobenthos	5 sites (Preconstruction only) 3 sites (MY3, MY5, & MY7)	
	Fish	3 sites (Preconstruction only) 2 sites (MY4 & MY7)	

Streams

The restored stream reaches are proposed to be monitored for geometric activity as follows.

- 7 permanent riffle cross-sections
- 3 permanent pool cross-sections
- 3 riffle pebble count samples for substrate analysis
- 3 stream crest gauges

The data will be presented in graphic and tabular format. Data to be presented will include 1) cross-sectional area, 2) bankfull width, 3) average depth, 4) maximum depth, and 5) width-to-depth ratio. Substrate analysis will be evaluated through pebble counts at three riffle cross-sections and data presented as a D50 for stream classification and tracking purposes. The stream will subsequently be classified according to stream geometry and substrate (Rosgen 1996). Significant changes in channel morphology including bank-height-ratios and entrenchment ratios will be tracked and reported by comparing data to asbuilt measurements in addition to each successive monitoring year. Annual photographs will include 22 fixed station photographs (12 vegetation plots and 10 cross-sections) (Appendix B). The Site contains three stream crest gauges to assist with documentation of bankfull events. One bankfull event was documented during monitoring year 6 (2023), making a total of seven bankfull events documented over the monitoring period to date (Table 13, Appendix E).

Year 6 cross-section data indicate little change from as-built conditions and that the streams are functioning as designed, overall, with the exception of cross-section 2, a riffle on Mud Lick Creek. Pool cross-sections,

such as cross-section 8, are typically not monitored for bank-height-ratio because they are naturally sediment storage and transport areas within a stream. This is apparent in review of the varying D_{max} and LBH values exhibited by cross-section 8 throughout the monitoring period. Bank erosion has not been noted within or adjacent to cross-section 8, and overall, the reach appears stable. Cross-section 1 has been characterized by increased bank height ratio for the past several monitoring years. It is located within an Enhancement (Level II) reach of stream that has scoured in previous years; however, the scour appears to have been minimized and the channel has reformed natural top-of-bank indicators within the dimensional parameters of the channel. Cross-section 1 has remained relatively consistent and stable for the past 3 monitoring years. Cross-section 2 has an increased bank-height ratio of 1.29 due to heavy scouring along the inner bend (right bank). This scour was first observed during year 2 (2019) but remained stable through year 5 (2022). It appears the scour was increased by beaver activity during year 6, and it is now considered an area of concern. All site cross-sections, except for cross-section 2, meet success criteria during year 6 (2023).

Three stream areas of concern were observed during monitoring year 6 (2023), two of which were documented during previous monitoring years. Stream Area of Concern #1 is located along Mud Lick Creek R2 where approximately 50 feet of the right bank and 20 feet of the left bank have eroded to the point of bank sloughing. This area has only slightly increased in size due to the erosive nature of the soils, lack of woody vegetation, and continued storm flows. Stream Area of Concern #2 consists of scouring and sloughing along an outer bend along Mud Lick Creek R3, immediately downstream from cross-section 1. This was initially attributed to significant storm events that occurred during 2018, however, subsequent high discharge events have continued to erode the outer bend. Stream area of Concern #3 consists of the aforementioned scour on the inner bend at cross-section 2; approximately 30 feet in total. All stream areas of concern are located within enhancement II reaches. No areas of erosion or instability were observed in restoration reaches of North and East Branch. All structures were stable and banks were well-vegetated with live stakes and herbaceous vegetation. All stream reaches generating restoration credit are functioning as designed and are stable throughout. Stream areas of concern are depicted on Figure 2 in Appendix B.

Vegetation

Restoration monitoring procedures for vegetation health will monitor plant survival and species diversity. After planting of the area was completed, 12 permanent vegetation plots were installed and monitored at the Site; annual results are in Appendix C. Annual measurements of vegetation will consist of the following.

- 10 plant warranty inspection plots (only MY1)
- 12 CVS vegetation plots

A photographic record of plant growth should be included in each annual monitoring report; vegetation plot photographs from year 6 (2023) are included in Appendix B. During the first year, vegetation will receive a cursory, visual evaluation on a periodic basis to ascertain the degree of overtopping of planted elements by nuisance species. Subsequently, quantitative sampling of vegetation will be performed as outlined in the *CVS-EEP Protocol for Recording Vegetation, Version 4.2* (Lee et al. 2008) in late fall/early winter of the first monitoring year and annually toward the end of the growing season for the remainder of the monitoring period until vegetation success criteria are achieved.

Year 6 (2023) stem count measurements for twelve permanent CVS plots indicate the planted stem density across the Site is 270 planted stems per acre, exceeding the Year 7 stem density success criteria of 210 stems per acre. Nine of the twelve individual CVS plots met success criteria based on planted stems alone; however, when including naturally recruited stems of American elm (*Ulmus americana*) and American

sycamore (*Platanus occidentalis*), the stem densities of plots 6 and 11 are above success criteria. Plot 1 was one stem shy of success. This plot experienced mortality of two stems between MY3 and MY4 and one more between MY4 and MY5. There are no natural recruits in the plot (Table 9, Appendix C). Plot 11 is dominated by dense herbaceous vegetation and high numbers of naturally recruited American sycamore (*Platanus occidentalis*), increasing competition with planted stems. Additionally, several small but dense populations of Chinese privet (*Ligustrum sinense*) and tree of heaven (*Ailanthus altissima*) were observed scattered throughout the Site. Although invasive treatments have been ongoing, these areas remain previous years. Invasive species populations are depicted on Figure 2 (Appendix B).

Due to decreasing Site stem density and continued observation of deer browse and competition with herbaceous species, DMS implemented an adaptive management that includes supplementally planting 1- and 3-gallon containerized trees across 2.04 acres of the Site. Supplemental planting areas are depicted on Figure 2 (Appendix B), the supplemental planting list is in Table 8 (Appendix C), and the adaptive management plan is detailed in Appendix F. As a part of the adaptive management plan, three temporary transects were requested by the DMS in areas that were replanted. All three transects met success criteria with an average of 418 stems per acre. Transect locations are depicted on Figure 2 (Appendix B), and results are in Table 10 (Appendix C).

Project Boundaries & Visual Assessments

Locations of any fence damage, vegetation damage, boundary encroachments, etc. will be documented and included in the mapping. No boundary encroachments were observed during Year 6 (2023) monitoring.

Visual assessments will be performed along all streams on a bi-annual basis during the seven-year monitoring period. Problem areas will be noted such as channel instability (i.e. lateral and/or vertical instability, in-stream structure failure/instability and/or piping, headcuts), vegetated buffer health (i.e. low stem density, vegetation mortality, invasive species or encroachment), beaver activity, or livestock access. Areas of concern will be mapped and photographed accompanied by a written description in the annual report. Problem areas will be re-evaluated during each subsequent visual assessment. Results of the year 6 (2023) visual assessment are summarized in Tables 5A-C and 6 (Appendix B).

During year 3 (2020) monitoring, onsite beaver activity was observed including a significant dam along North Branch R3, a dam along Mud Lick Creek R2, and several smaller dams throughout the Site. In response, on November 4, 2020, USDA trapped beavers and removed six dams. A small beaver dam was observed during year 5 (2022) along North Branch R2. The stream was dry at the time of assessment, therefore, it was unclear if there were active beaver populations still within the site. During year 6 (2023), a large beaver dam was located just downstream of XS-5 on North Branch R2. Most of the dam was removed, but there was a large beaver lodge in the vicinity of the dam. It was unclear if there is still an active beaver population on the site, and perhaps the dam was overlooked during beaver trapping efforts. APHIS was contracted in 2023 to visit the site quarterly and manage beaver as necessary through project closeout.

Supplementary Monitoring

Supplemental monitoring will include biological monitoring in the Spring as follows.

- 3 benthos sampling sites (MY3, MY5, & MY7)
- 2 fish sampling sites (MY4 & MY7)

Additional parameters are being monitored for analytical purposes and are not tied to mitigation success and associated credit releases. The primary criteria for indication of improvement for the benthos and fish will be an increase of at least one bio classification between the pre-con assessment and the post-con

monitoring. Richness and EPT metrics will be analyzed as well. Based on values tabulated on Habitat Assessment Field Data Sheets, benthic macroinvertebrate habitat appears to be improving at the Site. Overall values for the data sheets have improved by 10 to 54 points since preconstruction. In addition, each independent variable on the data sheets has shown improvement over the monitoring period, except for channel modification. Biotic index (tolerance of a stream benthic community) has not shown significant improvement with station MLC-2 shifting from a Fairly Poor to Very Poor designation, station MLC-3 shifting from Poor to Very Poor, and station NBR-5 remaining within the Poor range. A summary of benthic results including Habitat Field Data Assessment Sheet scores and Biotic Index values from laboratory analysis results (preconstruction to MY5) is presented below.

Site	**MLC-2**			**MLC-3**			**MLC-5**		
Habitat Assessment Field Data Sheet Data	**Precon (2015)**	**MY3 (2020)**	**MY 5 (2022)**	**Precon (2015)**	**MY3 (2020)**	**MY5 (2022)**	**Precon (2015)**	**MY3 (2020)**	**MY5 (2022)**
Channel Modification	5	3	4	5	3	3	4	5	5
Instream Habitat	11	14	11	11	11	11	9	18	15
Bottom Substrate	3	8	4	3	11	8	1	11	6
Pool Variety	4	10	6	6	10	6	0	10	6
Riffle Habitats	7	14	7	7	10	7	0	16	16
Bank Stability and Veg	8	4	10	13	6	11	10	14	12
Light Penetration	7	7	10	7	7	7	2	2	10
Riparian Veg Zone Width	2	10	10	1	10	10	12	10	10
Total Score	**47**	**70**	**62**	**53**	**68**	**63**	**26**	**86**	**81**
Biotic Index	6.01	8.05	8.25	6.64	6.68	7.70	6.90	5.90	7.70

2.0 REFERENCES

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2008. CVS-EEP Protocol for Recording Vegetation. Version 4.2. North Carolina Department of Environment and Natural Resources, Ecosystem Enhancement Program. Raleigh, North Carolina.

North Carolina Division of Mitigation Services (NCDMS) 2015. Mud Lick Creek Mitigation Site Final Mitigation Plan.

Rosgen D. 1996. Applied River Morphology. Wildland Hydrology. Pagosa Springs, Colorado.

Tetra Tech, 2005. Upper Rocky River Local Watershed Plan Preliminary Findings Report. Prepared for the North Carolina Ecosystem Enhancement Program.

United States Army Corps of Engineers (USACE), United States Environmental Protection Agency (USEPA), North Carolina Wildlife Resources Commission (NCWRC), Natural Resources Conservation Service (NRCS), and North Carolina Division of Water Quality (NCDWQ). 2003. Stream Mitigation Guidelines. State of North Carolina.

Appendix A.
Background Tables

Table 1. Project Mitigation Components
Table 2. Project Activity and Reporting History
Table 3. Project Contacts Table
Table 4. Project Attributes Table

Table 1. Mud Lick Creek (ID-93482) - Mitigation Assets and Components**

Project Component (reach ID, etc.)	Wetland Position and HydroType	Existing Footage	Stationing	Mitigation Plan Footage	As-Built Footage *	Restoration Level	Approach Priority Level	Mitigation Ratio (X:1)	Mitigation Credits	Notes/Comments
North Branch R1		318	100+10 - 103+28	327	318	EII	-	1.5	212.000	Planting, fencing
North Branch R2		522	103+28 - 108+66	520	538	R	PI	1	538.000	
North Branch R3		351	108+66 - 111+51	303	265	R	P2	1	265.000	20 LF of restoration was removed from North Branch Reach 2 in order to account for an easement break
East Branch R1		165	200+05 - 201+69	168	164	EII	-	1.5	109.333	Planting, fencing
East Branch R2		315	201+69 - 205+81	409	412	R	P2	1	412.000	
Mud Lick Creek R1		525	300+72 - 306+23	623	551	EII	-	1.5	367.333	Planting, fencing, bank repairs
Mud Lick Creek R2		718	306+23 - 313+14	693	660	EII	-	1.5	440.000	Planting, fencing, bank repairs; 31 LF of enhancement II was removed from Mud Lick Creek Reach 2 in order to account for an easement break
Mud Lick Creek R3		733	313+14 - 320+47	748	733	EII	-	1.5	488.667	Planting, fencing, bank repairs

*Reach start and end stationing may differ slightly from the mitigation plan due to removal of stream lengths that are outside the conservation easement. The upstream ends of Mud Lick Creek, North Branch, and East Branch experienced footage reductions of 72', 10', and 5' respectively, while the downstream end of Mud Lick Creek experienced a footage reduction of 17'.

**The assets and credits in the report and shown in Table 1 are based upon approved as-built numbers as approved by the IRT on 11/1/2018.

Length and Area Summations by Mitigation Category

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)
		Riverine	Non-Riverine	
Restoration	1215			
Enhancement				
Enhancement I				
Enhancement II	2426			
Creation				
Preservation				
High Quality Pres				

Overall Assets Summary

	Overall
Asset Category	**Credits**
Stream	**2,832.333**

Table 2. Project Activity and Reporting History
Mud Lick Creek (ID-93482)

Elapsed Time Since Grading Complete: 6 years 6 months
Elapsed Time Since Planting Complete: 6 years 0 months
Number of Reporting Years: 6

Activity or Deliverable	Data Collection Complete	Completion or Delivery
Project Institution	--	February 13, 2013
Mitigation Plan	--	December 2015
404 Permit Date	--	March 25, 2016
Final Design – Construction Plans	--	June 2015
Construction	--	August 25, 2017
Bare Root; Containerized; and B&B Plantings for the Entire Project Site	February 2018	February 2018
Baseline Monitoring Document (Year 0 Monitoring Baseline)	July 2018	September 2018
Monitoring Year 1 (2018) Document	December 2018	December 2018
Monitoring Year 2 (2019) Document	September 2019	January 2020
Monitoring Year 3 (2020) Document	September/October 2020	January 2021
Monitoring Year 4 (2021) Document	October 2021	December 2021
Monitoring Year 5 (2022) Document	September 2022	January 2023
Monitoring Year 6 (2023) Document	September 2023	February 2024

Table 3. Project Contact Table

Mud Lick Creek (ID-93482)

Designer	Wildlands Engineering, Inc. (License No. F-0831) 312 West Millbrook Rd, Suite 225 Raleigh, NC 27609 Angela N. Allen, PE (919) 851-9986
Construction Plans and Sediment and Erosion Control Plans	Wildlands Engineering, Inc. (License No. F-0831) 312 West Millbrook Rd, Suite 225 Raleigh, NC 27609 Angela N. Allen, PE (919) 851-9986
Construction Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101 Michael Anderson (336) 725-2010
Planting Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101 Stephen Joyce (336) 725-2010
As-built Surveyors	Allied Associates, PA 4720 Kester Mill Road Winston Salem, NC 27103 David Alley (336) 765-2377
Baseline Data Collection	Axiom Environmental, Inc. 218 Snow Avenue Raleigh, NC 27603 Grant Lewis (919) 215-1693

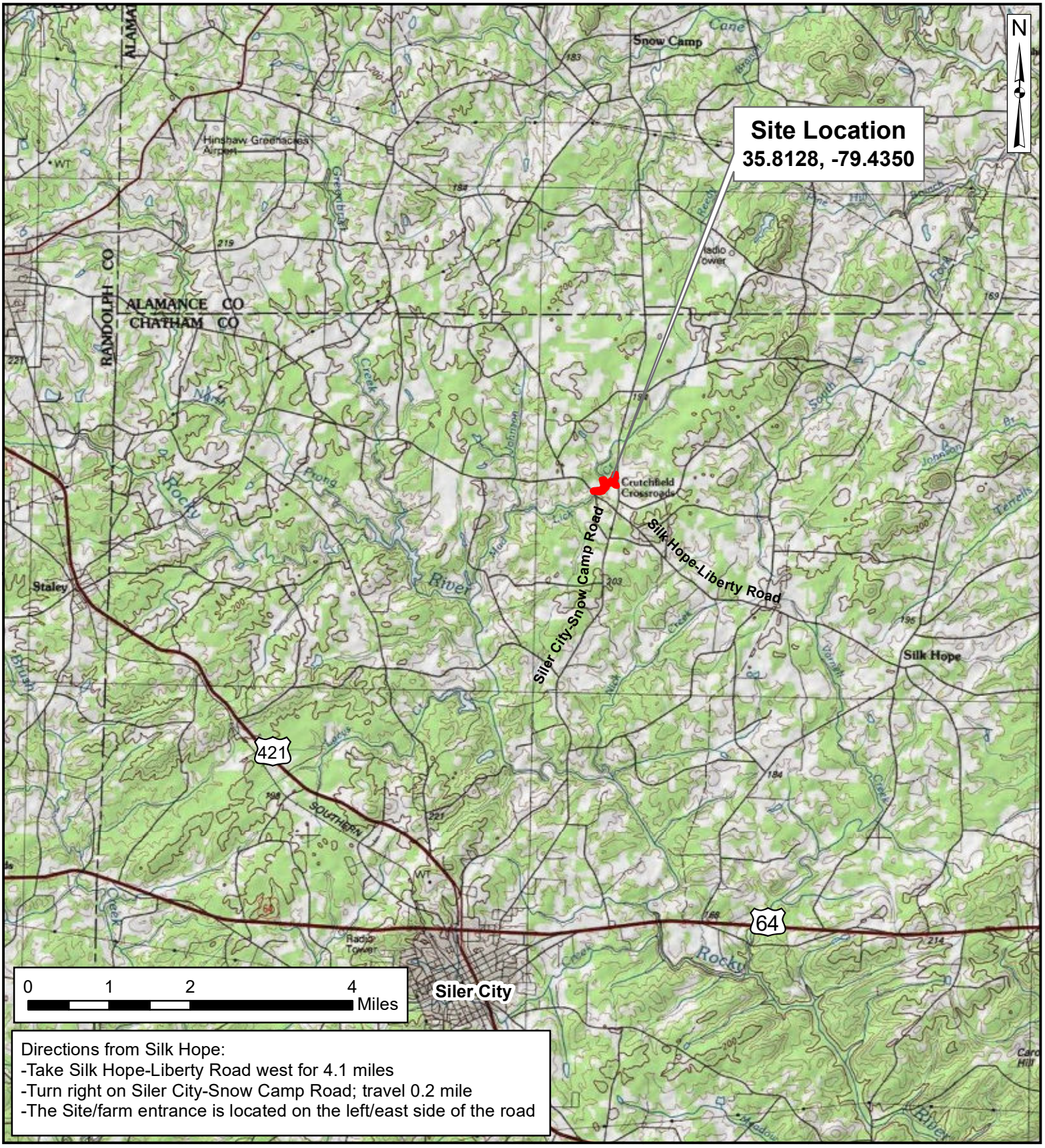
Table 4. Project Baseline Information and Attributes

Mud Lick Creek (ID-93482)

Project Information						
Project name	Mud Lick Creek Mitigation Site					
Project county	Chatham County, North Carolina					
Project area (Acres)	11.2					
Project coordinates (lat/long)	35.8128°N, 79.4350°W					
Planted Acres	9.6					
Project Watershed Summary Information						
Physiographic region	Carolina Slate Belt of the Piedmont Physiographic Province					
Project river basin	Cape Fear River Basin					
USGS hydrologic unit (8 digit/14-digit)	03030003/03030003070010					
NCDWR Sub-basin	03-06-12					
Project drainage area (mi^2)	3.64					
% Drainage area impervious	< 1%					
CGIA land use classification	Developed, Forested/Scrubland, Agriculture/Managed Herb., Open Water					
Reach Summary Information						
Parameters	**Mud Lick Creek – R1**	**Mud Lick Creek – R2**	**Mud Lick Creek – R3**	**North Branch – R1**	**North Branch – R2**	**East Branch**
Restored length (linear feet)	551	660	733	856	265	576
Valley confinement	Slightly confined - unconfined					
Drainage area (acres/mi^2)	1747/2.73	2170/3.39	2330/3.64	236.8/0.37	416/0.65	172.8/0.27
Perennial (P), Intermittent (I)	P	P	P	P	P	P
NCDWR water quality classification	WS-III, CA					
Stream Classification (existing)	E4	C4	E4	E4	B4c	B4c
Stream Classification (proposed)	E4	C4	E4	C4	C4	C4
Evolutionary trend (Simon & Hupp)	IV/V	IV/V	IV/V	IV	IV	IV
FEMA classification	AE	AE	AE	AE	AE	AE
Regulatory Considerations						
Regulation	**Applicable?**	**Resolved?**	**Supporting Documentation**			
Waters of the US – Section 404	Yes	Yes	SAW-2014-00736			
Waters of the US – Section 401	Yes	Yes	SAW-2014-00736			
Endangered Species Act	Yes	Yes	No Effect – CE Document			
Historic Preservation Act	No	NA	CE Document			
Coastal Zone Management Act (CZMA/CAMA)	No	NA	NA			
FEMA Floodplain Compliance	Yes	Yes	Chatham County Floodplain Development Permit #14-001			
Essential Fisheries Habitat	No	NA	NA			

Appendix B
Visual Assessment Data

Figure 1. Vicinity Map
Figure 2. Current Conditions Plan View
Tables 5A-5C. Visual Stream Morphology Stability Assessment
Table 6. Vegetation Condition Assessment
Vegetation Plot Photographs



Directions from Silk Hope:
-Take Silk Hope-Liberty Road west for 4.1 miles
-Turn right on Siler City-Snow Camp Road; travel 0.2 mile
-The Site/farm entrance is located on the left/east side of the road

Axiom Environmental, Inc.
Axiom Environmental
218 Snow Avenue
Raleigh, NC 27603
(919) 215-1693

SITE LOCATION
MUD LICK CREEK MITIGATION SITE
DMS PROJECT NUMBER 93482
Chatham County, North Carolina

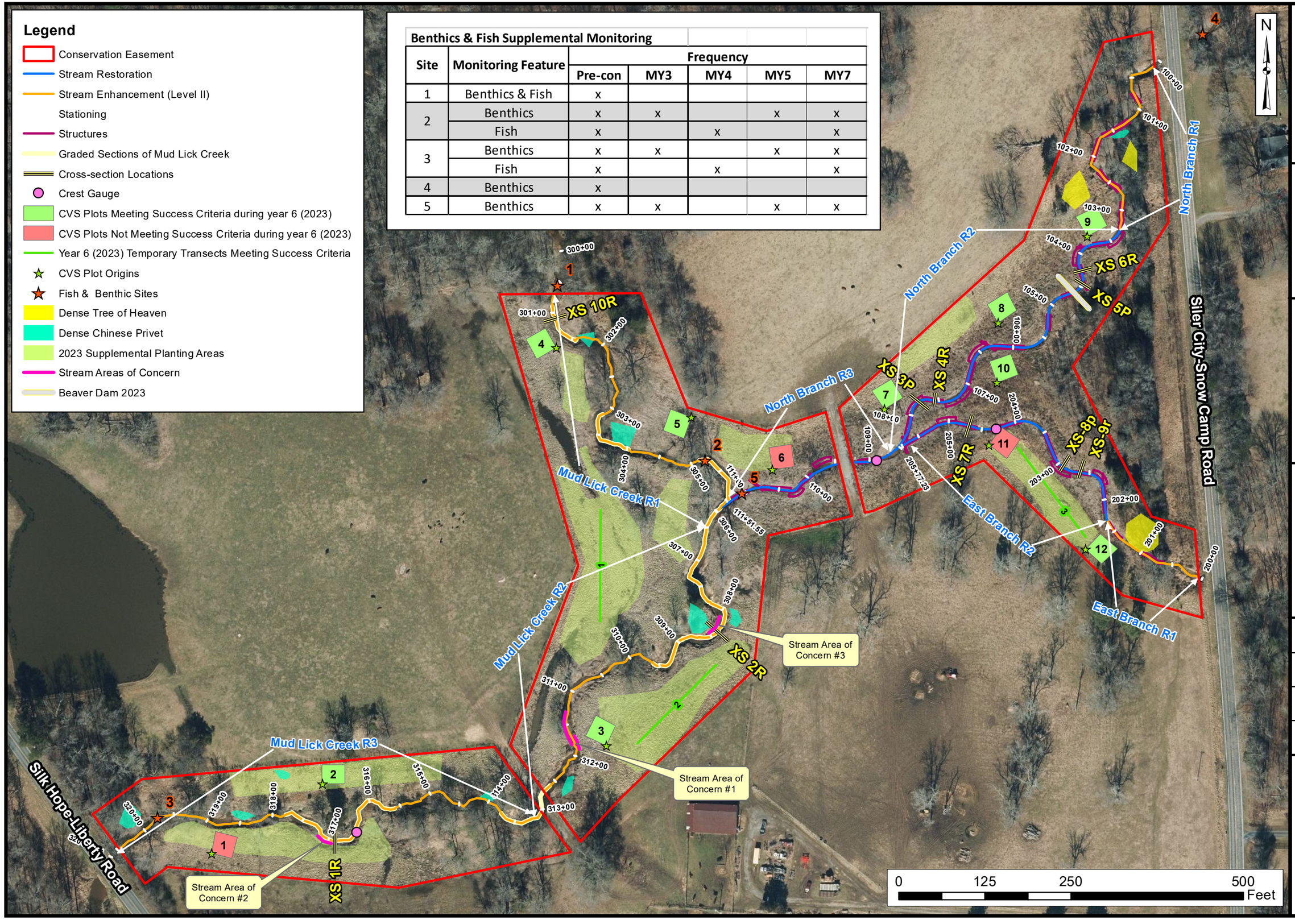
Dwn. by. CLF	FIGURE
Date: July 2018	1
Project: 12-004.22	

Legend

- Conservation Easement
- Stream Restoration
- Stream Enhancement (Level II)
- Stationing
- Structures
- Graded Sections of Mud Lick Creek
- Cross-section Locations
- Crest Gauge
- CVS Plots Meeting Success Criteria during year 6 (2023)
- CVS Plots Not Meeting Success Criteria during year 6 (2023)
- Year 6 (2023) Temporary Transects Meeting Success Criteria
- CVS Plot Origins
- Fish & Benthic Sites
- Dense Tree of Heaven
- Dense Chinese Privet
- 2023 Supplemental Planting Areas
- Stream Areas of Concern
- Beaver Dam 2023

Benthics & Fish Supplemental Monitoring

Site	Monitoring Feature	Frequency				
		Pre-con	MY3	MY4	MY5	MY7
1	Benthics & Fish	x				
2	Benthics	x	x		x	x
	Fish	x		x		x
3	Benthics	x	x		x	x
	Fish	x		x		x
4	Benthics	x				
5	Benthics	x	x		x	x



Axiom Environmental, Inc.

Prepared for:

North Carolina Department of Environmental Quality

Division of Mitigation Services

Project:

MUD LICK CREEK MITIGATION SITE

DMS Project Number 93482
Chatham County, NC

Title:

CURRENT CONDITIONS PLAN VIEW

Drawn by: PHP

Date: Dec 2023

Scale: 1:1,500

Project No.: 12-004.22

FIGURE

2

Table 5A **Visual Stream Morphology Stability Assessment**
Reach ID North Branch R-2
Assessed Length 538

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	8	8			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	8	8			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	8	8			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	8	8			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	8	8			100%			

Table 5B **Visual Stream Morphology Stability Assessment**
Reach ID North Branch R-3
Assessed Length 265

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	3	3			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	3	3			100%			

Table 5C **Visual Stream Morphology Stability Assessment**
Reach ID East Branch R-2
Assessed Length 412

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
2. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	5	5			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	5	5			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	5	5			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	5	5			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	5	5			100%			

Table 6 — Vegetation Condition Assessment

Planted Acreage 9.6

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	None	0.1 acres	None	0	0.00	0.0%
2. Low Stem Density Areas	None	0.1 acres	None	0	0.00	0.0%
			Total	0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	None	0.25 acres	None	0	0.00	0.0%
			Cumulative Total	0	0.00	0.0%

Easement Acreage 11.2

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern	Several small areas of dense Chinese privet and dense tree of heaven. Treatment is ongoing.	200 SF	blue and yellow polygons	13	0.20	1.8%
5. Easement Encroachment Areas	None	none	None	0	0.00	0.0%

Mud Lick Creek Stream Restoration Site
MY-06 Vegetation Monitoring Photographs
Taken July 2023

Plot 1

Plot 2

Plot 3

Plot 4

Plot 5

Plot 6

Plot 7

Plot 8

Mud Lick Creek Stream Restoration Site
MY-06 Vegetation Monitoring Photographs
Taken August 2023

Plot 9

Plot 10

Plot 11

Plot 12

Transect 1

Transect 2

Transect 3

Appendix C.
Vegetation Plot Data

Table 7. Planted Woody Vegetation
Table 8. Supplemental Planting List
Table 9. Total and Planted Stems by Plot and Species
Table 10. Temporary Transect Data

Table 7. Planted Woody Vegetation
Mud Lick Creek Restoration Project (#93482)

Species	Quantity
Green Ash (*Fraxinus pennsylvanica*)	300
Sycamore (*Platanus occidentalis*)	400
Eastern Redbud (*Cercis canadensis*)	400
Cottonwood *(Populus deltoides)*	300
River birch (*Betula nigra*)	300
Hackberry *(Celtis occidentalis)*	300
Black Gum *(Nyssa sylvatica)*	300
American Elm *(Ulmus americana)*	300
Eastern Hophornbeam *(Ostrya virginica)*	300
Elderberry *(Sambucus spp.)*	300
Black Locust *(Robinia psuedoaccia)*	300
Silky Dogwood *(Cornus ammomum)*	300
Witch Hazel *(Hamamelis virginica)*	550
Buttonbush *(Cephalanthus occidentalis)*	300
Persimmon (*Diospyros virginiana*)	300
Ironwood *(Carpinus caroliniana)*	400
Swamp Tupelo *(Nyssa biflora)*	100
Swamp Chestnut oak (*Quercus michauxii*)	100
Water oak (*Quercus nigra*)	100
Tulip Poplar *(Liridendron tulipifera)*	300
TOTAL	**5950**

Table 8. Supplemental Planting List 2023

Species	Quantity	Size (gallon)
Green Ash (*Fraxinus pennsylvanica*)	50	3
Sycamore (*Platanus occidentalis*)	50	3
Cottonwood *(Populus deltoides)*	50	3
River birch (*Betula nigra*)	50	3
Elderberry *(Sambucus spp.)*	50	3
Silky Dogwood *(Cornus ammomum)*	50	1
Witch Hazel *(Hamamelis virginica)*	50	1
Persimmon (*Diospyros virginiana*)	50	1
Swamp Chestnut oak (*Quercus michauxii*)	50	3
Tulip Poplar *(Liridendron tulipifera)*	50	3
TOTAL	50	3

Table 9. Total and Planted Stems by Plot and Species
DMS Project Code 93482. Project Name: Mud Lick Creek

			Current Plot Data (MY6 2023)																												
			93482-01-0001			93482-01-0002			93482-01-0003			93482-01-0004			93482-01-0005			93482-01-0006			93482-01-0007			93482-01-0008			93482-01-0009			93482-01-0010		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree																													
Acer rubrum	red maple	Tree																													
Alnus	alder	Shrub																													
Baccharis halimifolia	eastern baccharis	Shrub																													
Betula nigra	river birch	Tree										1	1	1	1	1	1	1	1	1				3	3	3	1	1	1			
Carpinus caroliniana	American hornbeam	Tree																						1	1	1	4	4	4			
Carya	hickory	Tree																													
Celtis laevigata	sugarberry	Tree	2	2	2																										
Celtis occidentalis	common hackberry	Tree																												1	1	1
Cephalanthus occidentalis	common buttonbush	Shrub																						1	1	1						
Cercis canadensis	eastern redbud	Tree										1	1	1																	
Cornus amomum	silky dogwood	Shrub										3	3	3				1	1	1				1	1	1	1	1	1			
Corylus americana	American hazelnut	Shrub				1	1	1																							
Diospyros virginiana	common persimmon	Tree										1	1	1													1	1	1	2	2	2
Fraxinus pennsylvanica	green ash	Tree	1	1	1	1	1	1				1	1	1	8	8	11	1	1	1												4
Juglans nigra	black walnut	Tree																													
Liquidambar styraciflua	sweetgum	Tree																													
Liriodendron tulipifera	tuliptree	Tree																1	1	2							1	1	1			
Nyssa	tupelo	Tree																												1	1	1
Nyssa biflora	swamp tupelo	Tree							1	1	1																					
Ostrya virginiana	hophornbeam	Tree																			2	2	2									
Platanus occidentalis	American sycamore	Tree	2	2	2				5	5	5	1	1	1							4	4	4							1	1	8
Populus deltoides	eastern cottonwood	Tree																													
Quercus	oak	Tree																													
Quercus lyrata	overcup oak	Tree																													
Quercus michauxii	swamp chestnut oak	Tree				1	1	1																3	3	3				1	1	1
Quercus nigra	water oak	Tree																									1	1	1	1	1	1
Quercus phellos	willow oak	Tree																													
Rhus copallinum	flameleaf sumac	shrub																													
Robinia pseudoacacia	black locust	Tree																													
Ulmus americana	American elm	Tree				3	3	3	1	1	1									1												
Ulmus rubra	slippery elm	Tree				1	1	1													1	1	1									
Unknown		Shrub or Tree																													
Viburnum dentatum	southern arrowwood	Shrub																													
		Stem count	5	5	5	7	7	7	7	7	7	8	8	8	9	9	12	4	4	6	7	7	7	9	9	9	9	9	9	7	7	18
		size (ares)	1			1			1			1			1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	3	3	3	5	5	5	3	3	3	6	6	6	2	2	2	4	4	5	3	3	3	5	5	5	6	6	6	6	6	7
		Stems per ACRE	202.3	202.3	202.3	283.3	283.3	283.3	283.3	283.3	283.3	323.7	323.7	323.7	364.2	364.2	485.6	161.9	161.9	242.8	283.3	283.3	283.3	364.2	364.2	364.2	364.2	364.2	364.2	283.3	283.3	728.4

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

PnoLS = Planted excluding livestakes
P-all = Planting including livestakes
T = All planted and natural recruits including livestakes
T includes natural recruits

Table 9. Total and Planted Stems by Plot and Species (continued)
DMS Project Code 93482. Project Name: Mud Lick Creek

			Current Plot Data (MY6 2023)						Annual Means																				
			93482-01-0011			93482-01-0012			MY6 (2023)			MY5 (2022)			MY4 (2021)			MY3 (2020)			MY2 (2019)			MY1 (2018)			MY0 (2018)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree												1			2			8			4	1	1	3	1	1	10
Acer rubrum	red maple	Tree																		3						2			10
Alnus	alder	Shrub																											3
Baccharis halimifolia	eastern baccharis	Shrub															2						2						
Betula nigra	river birch	Tree							7	7	7	7	7	7	8	8	8	8	8	8	8	8	8	6	6	6	4	4	4
Carpinus caroliniana	American hornbeam	Tree				2	2	2	7	7	7	9	9	9	10	10	10	10	10	10	11	11	11	12	12	12	15	15	15
Carya	hickory	Tree																											1
Celtis laevigata	sugarberry	Tree							2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1
Celtis occidentalis	common hackberry	Tree							1	1	1	3	3	3	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
Cephalanthus occidentalis	common buttonbush	Shrub							1	1	1	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4
Cercis canadensis	eastern redbud	Tree							1	1	1	1	1	3	2	2	2	2	2	2	3	3	3	8	8	8	6	6	6
Cornus amomum	silky dogwood	Shrub				2	2	2	8	8	8	7	7	8	7	7	7	7	7	7	9	9	9	9	9	9	8	8	8
Corylus americana	American hazelnut	Shrub							1	1	1	1	1	1	1	1	1												
Diospyros virginiana	common persimmon	Tree				1	1	1	5	5	5	6	6	7	6	6	6	7	7	8	5	5	5	4	4	4	5	5	5
Fraxinus pennsylvanica	green ash	Tree				1	1	1	13	13	20	12	12	17	12	12	12	11	11	12	11	11	11	14	14	15	12	12	13
Juglans nigra	black walnut	Tree												2			3			3			4			1			5
Liquidambar styraciflua	sweetgum	Tree												153			278			124			98			19			10
Liriodendron tulipifera	tuliptree	Tree							2	2	3	2	2	9	2	2	3	4	4	8	4	4	7						
Nyssa	tupelo	Tree							1	1	1	1	1	1				1	1	1	2	2	2						
Nyssa biflora	swamp tupelo	Tree							1	1	1	3	3	3	4	4	4	5	5	5	5	5	5	6	6	6	6	6	6
Ostrya virginiana	hophornbeam	Tree							2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1	1	1
Platanus occidentalis	American sycamore	Tree			10				13	13	30	13	13	18	13	13	36	11	11	13	12	12	14	7	7	7	7	7	7
Populus deltoides	eastern cottonwood	Tree																			3	3	3	4	4	4	3	3	3
Quercus	oak	Tree			1						1				1	1	1	1	1	1	1	1	1						
Quercus lyrata	overcup oak	Tree	1	1	1				1	1	1	1	1	1															
Quercus michauxii	swamp chestnut oak	Tree				1	1	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	7	7	7
Quercus nigra	water oak	Tree							2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3
Quercus phellos	willow oak	Tree						1			1																		
Rhus copallinum	flameleaf sumac	shrub												1															
Robinia pseudoacacia	black locust	Tree																1	1	1	1	1	1	1	1	1	1	1	1
Ulmus americana	American elm	Tree							4	4	5	4	4	5	5	5	5	5	5	5	5	5	5	4	4	5			
Ulmus rubra	slippery elm	Tree							2	2	2	2	2	2	2	2	2	2	2	2	2	2	2						
Unknown		Shrub or Tree																1	1	1	2	2	2	3	3	3	3	3	3
Viburnum dentatum	southern arrowwood	Shrub																2	2	2									
		Stem count	1	1	12	7	7	8	80	80	108	86	86	265	89	89	398	96	96	242	102	102	215	97	97	123	90	90	129
		size (ares)	1			1			12			12			12			12			12			12			12		
		size (ACRES)	0.02			0.02			0.30			0.30			0.30			0.30			0.30			0.30			0.30		
		Species count	1	1	3	5	5	6	20	20	22	20	20	24	19	19	23	22	22	26	22	22	26	19	19	22	18	18	23
		Stems per ACRE	40.47	40.47	485.6	283.3	283.3	323.7	269.8	269.8	364.2	290	290	893.7	300.1	300.1	1342	323.7	323.7	816.1	344	344	725.1	327.1	327.1	414.8	303.5	303.5	435

Color for Density

Exceeds requirements by 10%
Exceeds requirements, but by less than 10%
Fails to meet requirements, by less than 10%
Fails to meet requirements by more than 10%

PnoLS = Planted excluding livestakes
P-all = Planting including livestakes
T = All planted and natural recruits including livestakes
T includes natural recruits

Table 10. Temporary Transect Data

Mud Lick Creek Adaptive Management Plan Transects			
50m x 2m Temporary Plot			
Species	**T-1**	**T-2**	**T-3**
River birch (*Betula nigra*)		1	1
Silky Dogwood *(Cornus ammomum)*	1		2
Persimmon (*Diospyros virginiana*)	1	2	
Green Ash (*Fraxinus pennsylvanica*)		4	
Sycamore (*Platanus occidentalis*)		2	3
Swamp Chestnut oak (*Quercus michauxii*)	7		
Quercus spp.			2
American Elm *(Ulmus americana)*	1	2	2
Total Stems	**10**	**11**	**10**
Total Stems/Acre	**405**	**445**	**405**
Plot Height Average (ft)	**4**	**3.4**	**4.2**

Appendix D.
Stream Geomorphology Data

Tables 11a-11c. Baseline Stream Data Summary
Tables 12a-12f. Monitoring Data-Dimensional Data Summary
Cross-section Plots

Table 11a. Baseline Stream Data Summary (Mud Lick Creek)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (Mud Lick Creek)					Reference Reach(es) Data					Design (Mud Lick Creek)			Monitoring Baseline (Mud Lick Creek)					
Dimension and Substrate - Riffle Only		**LL**	**UL**	**Eq.**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Max**	**Med**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)					18.2		22.0	24.6		5.3		10.8	12.3					18.3		19.8	21		3
Floodprone Width (ft)					250.0		306.0	378.0		14		60	125					100		100	100		3
BF Mean Depth (ft)					1.9		2.1	2.3		0.8		1.0	1.8					1.6		2.0	2.7		3
BF Max Depth (ft)					3.0		4.0	4.2		1.0		1.5	2.6					3.6		3.7	3.8		3
BF Cross Sectional Area (ft^2)					41.3		46.3	47.5		5.4		10.6	19.7					33.0		40.4	49.8		3
Width/Depth Ratio					8.0		10.5	12.8		5.2		8.6	14.4					6.8		9.9	13.1		3
Entrenchment Ratio					12.4		13.7	17.2		1.7		4.3	>10.2					4.8		5.1	5.5		3
Bank Height Ratio					1.1		1.2	1.2		1.0		1.0	1.1					1.0		1.0	1.3		3
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704										
Pool length (ft)																							
Pool Max depth (ft)					3.7		4.4	5.2		1.2		1.8	3.3										
Pool spacing (ft)										9.0		46.0	73.0										
Pattern																							
Channel Beltwidth (ft)					26.1		52.9	69.9		10		41	102										
Radius of Curvature (ft)					9.9		24.8	58.8		11		21	85										
Rc:Bankfull width (ft/ft)					0.5		1.1	2.39		1.3		2	9.1										
Meander Wavelength (ft)					59.9		159.6	244.4		-		-	-										
Meander Width ratio					1.4		2.2	3.8		1.6		4.4	8.9										
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					E/C4					E/C4								E/C-type					
Bankfull Velocity (fps)					3.0 - 3.4					2.2 - 5.6													
Bankfull Discharge (cfs)					123.9 - 157.42					20 -97													
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1.20 - 1.37					1.0 - 2.3													
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 11b. Baseline Stream Data Summary (North Branch)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (North Branch)					Reference Reach(es) Data					Design (North Branch)			Monitoring Baseline (North Branch)					
Dimension and Substrate - Riffle Only		**LL**	**UL**	**Eq.**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Mean**	**Med**	**Max**	**SD**	**Min**	**Max**	**Med**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)					8.3			10.4		5.3		10.8	12.3		13.8	14.0		14.6		16.2	17.7		2
Floodprone Width (ft)					33.3			80.0		14		60	125		30	70		100		100	100		2
BF Mean Depth (ft)					0.7			1.5		0.8		1.0	1.8		1.0	1.2		0.8		0.9	1.0		2
BF Max Depth (ft)					1.5			2.3		1.0		1.5	2.6		1.3	2.0		1.8		1.8	1.8		2
BF Cross Sectional Area (ft^2)					7.7			12.7		5.4		10.6	19.7		14.4	16.3		14.2		14.4	14.5		2
Width/Depth Ratio					5.4			14.0		5.2		8.6	14.4		12.0	13.0		14.6		18.4	22.1		2
Entrenchment Ratio					1.9			10.1		1.7		4.3	>10.2		2.2	5.0		5.6		6.2	6.8		2
Bank Height Ratio					1.7			2.0		1.0		1.0	1.1		1.0	1.0		1.0		1.0	1.0		2
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704		0.0060	0.0340							
Pool length (ft)																							
Pool Max depth (ft)					2.1			2.7		1.2		1.8	3.3		1.3	4.7							
Pool spacing (ft)										9.0		46.0	73.0		19.0	92.0							
Pattern																							
Channel Beltwidth (ft)					11		26	38.5		10		41	102		41	125							
Radius of Curvature (ft)					6.1		17	37		11		21	85		25	42							
Rc:Bankfull width (ft/ft)					0.73		1.6	4.46		1.3		2	9.1		1.8	3							
Meander Wavelength (ft)					37.9		64.1	100.6		-		-	-		41	168							
Meander Width ratio					1.1		2.8	4.6		1.6		4.4	8.9		3	15							
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					E5/B5c					E/C4					C4			C-type					
Bankfull Velocity (fps)					3.3 - 3.5					2.2 - 5.6					2.4 - 4.3								
Bankfull Discharge (cfs)					25.41 - 44.45					20 -97					34.6 - 70.1								
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1.22 - 1.32					1.0 - 2.3					1.2 - 1.3								
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 11c. Baseline Stream Data Summary (East Branch)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Gauge	Regional Curve			Pre-Existing Condition (East Branch)					Reference Reach(es) Data					Design (East Branch)			Monitoring Baseline (East Branch)					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD	Min	Mean	Med	Max	SD	Min	Max	Med	Min	Mean	Med	Max	SD	n
BF Width (ft)						4.3				5.3		10.8	12.3				11.0	8.9		12.8	16.6		2
Floodprone Width (ft)						23.0				14		60	125		24	55		100		100	100		2
BF Mean Depth (ft)						1.1				0.8		1.0	1.8				0.9	0.6		0.7	0.8		2
BF Max Depth (ft)						1.4				1.0		1.5	2.6		0.9	1.5		1.2		1.4	1.5		2
BF Cross Sectional Area (ft^2)						4.8				5.4		10.6	19.7				9.7	6.7		8.7	10.6		2
Width/Depth Ratio						3.9				5.2		8.6	14.4				12.4	11.1		19.4	27.7		2
Entrenchment Ratio						2.1				1.7		4.3	>10.2		2.2	5.0		6.0		8.6	11.2		2
Bank Height Ratio						1.9				1.0		1.0	1.1		1.0	1.0		1.0		1.0	1.0		2
Profile																							
Riffle length (ft)																							
Riffle slope (ft/ft)										0.0040		0.0188	0.0704		0.0156	0.0442							
Pool length (ft)																							
Pool Max depth (ft)						1.6				1.2		1.8	3.3		1.0	3.5							
Pool spacing (ft)										9.0		46.0	73.0		15.0	73.0							
Pattern																							
Channel Beltwidth (ft)						--				10		41	102		22	98							
Radius of Curvature (ft)						--				11		21	85		20	30							
Rc:Bankfull width (ft/ft)						--				1.3		2	9.1		1.8	3							
Meander Wavelength (ft)						--				-		-	-		33	132							
Meander Width ratio						--				1.6		4.4	8.9		3	12							
Transport parameters																							
Reach Shear Stress (competency) lbs/ft^2																							
Max part size (mm) mobilized at bankfull																							
Stream Power (transport capacity) W/m^2																							
Additional Reach Parameters																							
Rosgen Classification					B4c					E/C4					C4			C-type					
Bankfull Velocity (fps)					4.2					2.2 - 5.6					3.3								
Bankfull Discharge (cfs)					20.2					20 -97					32								
Valley Length (ft)																							
Channel Thalweg Length (ft)																							
Sinuosity					1					1.0 - 2.3					1.20 -1.30								
Water Surface Slope (ft/ft)																							
BF slope (ft/ft)																							
Bankfull Floodplain Area (acres)																							
% of Reach with Eroding Banks																							
Channel Stability or Habitat Metric																							
Biological or Other																							

Table 12a. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 1 (Mud Lick Cr)								Cross Section 2 (Mud Lick Cr)								Cross Section 10 (Mud Lick Cr)							
	Riffle								Riffle								Riffle							
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY6+	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY6+	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY6+
BF Width (ft)	18.3	18.8	18.6	19.1	18.0	17.4	17.5		21.0	22.0	14.9	15.9	14.6	15.0	18.0		19.8	19.6	18.9	18.4	18.1	18.2	18.3	
Floodprone Width (ft) (approx)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0	100.0		100.0	100.0	100.0	100.0	100.0	100.0	100.0	
BF Mean Depth (ft)	2.7	2.6	2.7	2.6	2.8	2.9	2.8441		1.6	1.5	2.2	2.1	2.3	2.2	1.8		2.0	2.1	2.1	2.2	2.2	2.2	2.2	
BF Max Depth (ft)	3.8	3.8	3.8	3.6	3.7	4.0	3.7		3.7	3.6	3.3	3.5	3.3	3.4	2.295		3.6	3.4	3.5	3.7	3.8	3.8	4.1	
Low Bank Height	5.0	5.1	5.0	3.7	3.9	3.9	3.9		3.7	3.6	3.9	4.0	3.7	3.5	2.956		3.6	3.4	3.7	3.8	4.0	4.1	4.1	
BF Cross Sectional Area (ft^2)	49.8	49.8	49.8	49.8	49.8	49.8	49.8		33.0	33.0	33.0	33.0	33.0	33.0	33.023		40.4	40.4	40.4	40.4	40.4	40.4	40.4	
Area at Low Bank (ft^2)	49.8	NA	75.8	75.8	52.5	48.0	52.3		33.0	NA	42.6	42.6	39.8	34.4	45.208		40.4	NA	43.2	43.2	45.9	45.3	41.2	
Width/Depth Ratio	6.7	7.1	6.9	7.3	6.5	6.1	6.2		13.4	14.7	6.7	7.7	6.5	6.8	9.8		9.7	9.5	8.8	8.4	8.1	8.2	8.3	
Entrenchment Ratio	5.5	5.3	NA**	NA**	NA**	NA**	NA**		4.8	4.5	NA**	NA**	NA**	NA**	NA**		5.1	5.1	NA**	NA**	NA**	NA**	NA**	
Bank Height Ratio*	1.3	1.3	1.3	1.0	1.04	0.97	1.04		1.0	1.0	1.2	1.1	1.13	1.0	1.29		1.0	1.0	1.1	1.0	1.08	1.07	1.01	
d50 (mm)	9.9	4.4	4.3	4.3	3.8	NA^	NA^		9.9	4.4	4.3	4.3	3.8	NA^	NA^		9.9	4.4	4.3	4.3	3.8	NA^	NA^	

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.
^ Based on 2021 discussion with the NCIRT and NCDMS, it was determined that substrate data (d50) will no longer be reported.

Table 12b. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Baseline (Mud Lick Creek)						MY-1 (Mud Lick Creek)						MY-2 (Mud Lick Creek)						MY-3 (Mud Lick Creek)						MY-4 (Mud Lick Creek)						MY-5 (Mud Lick Creek)					
Dimension and Substrate - Riffle Only	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)	18.3		19.8	21		3	18.8		19.6	22		3	14.9		18.6	18.9		3	15.9		18.4	19.1		3	14.6		18.0	18.1		3	15.0		17.4	18.2		3
Floodprone Width (ft)	100		100	100		3	100		100.0	100		3	100		100	100		3	100		100	100		3	100		100	100		3	100		100	100		3
BF Mean Depth (ft)	1.6		2.0	2.7		3	1.5		2.1	2.7		3	2.1		2.2	2.7		3	2.1		2.2	2.6		3	2.2		2.3	2.8		3	2.2		2.2	2.9		3
BF Max Depth (ft)	3.6		3.7	3.8		3	3.4		3.6	3.8		3	3.3		3.5	3.8		3	3.5		3.6	3.7		3	3.3		3.7	3.8		3	3.4		3.8	4.0		3
BF Cross Sectional Area (ft^2)	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3	33.0		40.4	49.8		3
Area at Low Bank (ft^2)	33.0		40.4	49.8		3	NA		NA	NA		NA	42.6		43.2	75.8		3	42.6		43.2	75.8		3	48.4		54.9	71.2		3	34.4		45.3	48.0		3
Width/Depth Ratio	6.8		9.9	13.1		3	7.0		9.3	14.7		3	6.8		6.9	9.0		3	7.3		7.6	8.4		3	6.4		6.5	8.1		3	6.1		6.8	8.2		3
Entrenchment Ratio	4.8		5.1	5.5		3	4.5		5.1	5.3		3	NA**		NA**	NA**		3	NA**		NA**	NA**		3	NA**		NA**	NA**		3	NA**		NA**	NA**		3
Bank Height Ratio	1.0		1.0	1.3		3	1.0		1.0	1.3		3	1.1		1.2	1.3		3	1.0		1.0	1.1		3	1.0		1.1	1.1		3	1.0		1.0	1.1		3
Profile																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 2																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 3																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						Ce-type						Ce-type						Ce-type						Ce-type						Ce-type					
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%/P%/G%/S%																																				
SC%/SA%/G%/C%/B%/BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

Table 12c. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 3 (North Branch)								Cross Section 4 (North Branch)								Cross Section 5 (North Branch)								Cross Section 6 (North Branch)							
	Pool								Riffle								Pool								Riffle							
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7
BF Width (ft)	14.2	13.7	13.3	13.2	12.0	12.7	11.7		17.7	22.7	20.7	22.1	19.8	16.9	24.5		14.2	14.6	15.1	14.2	12.4	11.6	10.9		14.6	15.1	14.8	19.4	17.2	14.6	15.9	
Floodprone Width (ft) (approx)	NA	NA	NA	NA	NA	NA	NA		100.0	100.0	100.0	100.0	100.0	100.0	100.0		NA	NA	NA	NA	NA	NA	NA		100.0	100.0	100.0	100.0	100.0	100.0	100.0	
BF Mean Depth (ft)	1.1	1.1	1.2	1.2	1.3	1.2	1.3		0.8	0.6	0.7	0.6	0.7	0.8	0.6		1.3	1.3	1.2	1.3	1.5	1.6	1.7		1.0	1.0	1.0	0.7	0.8	1.0	0.9	
BF Max Depth (ft)	2.2	2.1	2.2	2.3	2.4	2.4	2.4		1.8	1.9	1.8	1.8	2.1	1.9	2.0		2.6	2.6	2.7	2.8	2.7	2.9	2.7		1.8	1.8	1.8	1.9	2.0	2.1	1.9	
Low Bank Height	2.2	2.1	2.3	2.5	2.7	2.4	2.4		1.8	1.9	1.8	1.8	2.0	1.8	1.9		2.6	2.6	2.8	2.9	2.8	2.8	2.9		1.8	1.8	1.8	2.1	2.2	2.1	2.1	
BF Cross Sectional Area (ft^2)	15.5	15.5	15.5	15.5	15.5	15.5	15.5		14.2	14.2	14.2	14.2	14.2	14.2	14.2		18.6	18.6	18.6	18.6	18.6	18.6	18.6		14.5	14.5	14.5	14.5	14.5	14.5	14.5	
Area at Low Bank (ft^2)	15.5	NA	18.0	18.0	19.9	16.1	41.2		14.2	NA	14.2	14.2	13.8	12.3	15.3		18.6	NA	20.3	20.3	19.7	17.7	20.2		14.5	NA	15.0	15.0	16.9	14.2	16.9	
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	NA		22.1	36.3	30.2	34.4	27.6	20.1	42.5		NA	NA	NA	NA	NA	NA	NA		14.7	15.7	15.1	26.0	20.4	14.8	17.4	
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	NA		5.6	4.4	NA**	NA**	NA**	NA**	NA**		NA	NA	NA	NA	NA	NA	NA		6.8	6.6	NA**	NA**	NA**	NA**	NA**	
Bank Height Ratio*	NA	NA	NA	NA	NA	NA	NA		1.0	1.0	1.0	1.0	1.0	0.94	0.98		NA	NA	NA	NA	NA	NA	NA		1.0	1.0	1.0	1.11	1.06	1.0	1.07	
d50 (mm)	--	--	--	--	--	--	--		18.8	8.0	8.4	4.0	4.9	NA^	NA^		--	--	--	--	--	--	--		18.8	8.0	8.4	4.0	4.9	NA^	NA^	

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.
^ Based on 2021 discussion with the NCIRT and NCDMS, it was determined that substrate data (d50) will no longer be reported.

Table 12d. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Baseline (North Branch)						MY-1 (North Branch)						MY-2 (North Branch)						MY-3 (North Branch)						MY-4 (North Branch)						MY-5 (North Branch)					
Dimension and Substrate - Riffle Only	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)	14.6		16.2	17.7		2	15.1		18.9	22.7		2	14.8		17.8	20.7		2	19.4		20.8	22.1		2	17.2		18.5	19.8		2	14.6		15.8	16.9		2
Floodprone Width (ft)	100		100	100		2	100		100.0	100		2	100		100	100		2	100		100	100		2	100		100	100		2	100		100	100		2
BF Mean Depth (ft)	0.8		0.9	1.0		2	0.6		0.8	1.0		2	0.7		0.9	1.0		2	0.6		0.8	1.0		2	0.7		0.8	0.8		2	0.8		0.9	1.0		2
BF Max Depth (ft)	1.8		1.8	1.8		2	1.8		1.9	1.9		2	1.8		1.8	1.8		2	1.8		1.8	1.9		2	2.0		2.1	2.1		2	1.9		2.0	2.1		2
BF Cross Sectional Area (ft^2)	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2	14.2		14.4	14.5		2
Area at Low Bank (ft^2)	14.2		14.4	14.5		2	NA		NA	NA		NA	14.2		14.6	15.0		2	14.2		14.6	15.0		2	11.6		11.6	13.8		2	12.3		13.3	14.2		2
Width/Depth Ratio	14.6		18.4	22.1		2	15.1		26.5	37.8		2	14.8		17.8	20.7		2	19.4		28.1	36.8		2	20.4		24.0	27.7		2	14.8		26.5	20.1		2
Entrenchment Ratio	5.6		6.2	6.8		2	4.4		5.5	6.6		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2
Bank Height Ratio	1.0		1.0	1.0		2	1.0		1.0	1.0		2	1.0		1.0	1.0		2	1.0		1.1	1.1		2	1.0		1.0	1.1		2	0.9		1.0	1.0		2
Profile																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 2																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 3																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						C-type						C-type						C-type						C-type						C-type					
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%/P%/G%/S%																																				
SC%/SA%/G%/C%/B%/BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

Table 12e. Monitoring Data - Dimensional Morphology Summary (Dimensional Parameters - Cross Sections)
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

Parameter	Cross Section 7 (East Branch)								Cross Section 8 (East Branch)								Cross Section 9 (East Branch)							
	Riffle								Pool								Riffle							
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7	MY0	MY1	MY2	MY3	MY4	MY5	MY6	MY7
BF Width (ft)	8.9	11.1	10.2	14.4	9.4	11.0	9.9		7.6	10.8	8.2	7.5	9.7	8.1	8.3		16.6	21.1	18.6	24.6	21.9	18.6	19.6	
Floodprone Width (ft) (approx)	100.0	100.0	100.0	100.0	100.0	100.0	100.0		NA	NA	NA	NA	NA	NA	NA		100.0	100.0	100.0	100.0	100.0	100.0	100.0	
BF Mean Depth (ft)	0.8	0.6	0.7	0.5	0.7	0.6	0.7		1.4	1.0	1.3	1.4	1.1	1.3	1.3		0.6	0.5	0.6	0.4	0.5	0.6	0.5	
BF Max Depth (ft)	1.2	1.4	1.3	1.4	1.4	1.4	1.4		2.4	1.5	2.1	2.4	2.0	2.2	2.1		1.5	1.6	1.5	1.5	1.7	1.6	1.6	
Low Bank Height	1.2	1.4	1.4	1.4	1.6	1.5	1.5		2.4	1.5	2.2	2.4	1.6	2.7	2.4		1.5	1.6	1.5	1.5	1.7	1.6	1.6	
BF Cross Sectional Area (ft^2)	6.7	6.7	6.7	6.7	6.7	6.7	6.7		10.5	10.5	10.5	10.5	10.5	10.5	10.5		10.6	10.6	10.6	10.6	10.6	10.6	10.6	
Area at Low Bank (ft^2)	6.7	NA	7.5	7.5	8.4	7.5	7.8		10.5	NA	11.7	11.7	7.6	15.1	13.1		10.6	NA	10.7	10.7	10.2	10.3	10.9	
Width/Depth Ratio	11.8	18.4	15.5	30.9	13.2	18.0	14.7		NA	NA	NA	NA	NA	NA	NA		26.0	42.0	32.6	57.1	45.2	32.8	36.2	
Entrenchment Ratio	11.2	9.0	NA**	NA**	NA**	NA**	NA**		NA	NA	NA	NA	NA	NA	NA		6.0	4.7	NA**	NA**	NA**	NA**	NA**	
Bank Height Ratio*	1.0	1.0	1.1	1.0	1.12	1.05	1.06		NA	NA	NA	NA	NA	NA	NA		1.0	1.0	1.0	1.0	1.0	1.0	1.01	
d50 (mm)	14.3	3.7	5.4	2.5	2.5	NA^	NA^		--	--	--	--	--	--	--		14.3	3.7	5.4	2.5	2.5	NA^	NA^	

*Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document produced by the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018).
** Based on the technical industry work group consisting of the NCIRT, NCDMS, and Industry Practitioners in NC (9/2018), entrenchment ratio is no longer reported for success criteria.
^ Based on 2021 discussion with the NCIRT and NCDMS, it was determined that substrate data (d50) will no longer be reported.

Table 12f. Monitoring Data - Stream Reach Data Summary
Mud Lick Creek Mitigation Project - NCDMS Project Number 93482

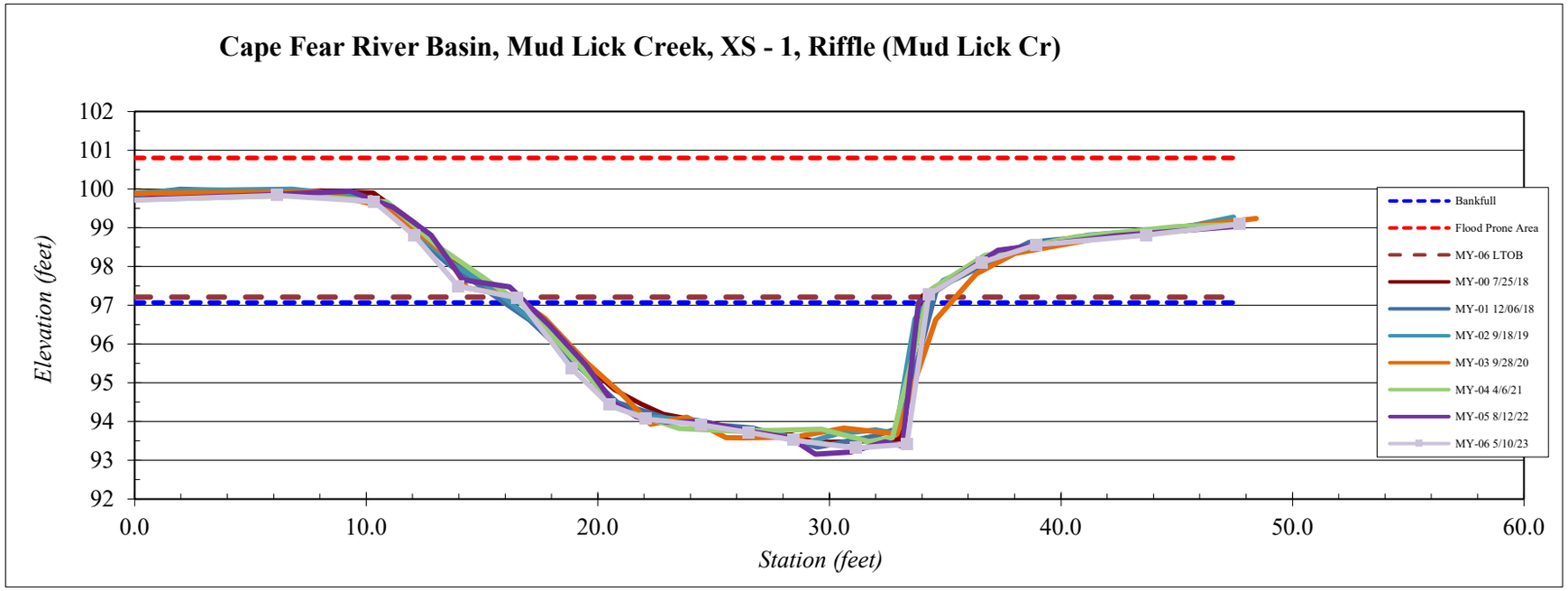
Parameter	Baseline (East Branch)						MY-1 (East Branch)						MY-2 (East Branch)						MY-3 (East Branch)						MY-4 (East Branch)						MY-5 (East Branch)					
Dimension and Substrate - Riffle Only	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**	**Min**	**Mean**	**Med**	**Max**	**SD**	**n**
BF Width (ft)	8.9		12.8	16.6		2	11.1		16.2	21.2		2	10.2		14.5	18.7		2	14.4		19.5	24.6		2	9.4		15.6	21.9		2	11.0		14.8	18.6		2
Floodprone Width (ft)	100		100	100		2	100		100	100		2	100		100	100		2	100		100	100		2	100		100	100		2	100		100.0	100		2
BF Mean Depth (ft)	0.6		0.7	0.8		2	0.5		0.6	0.6		2	0.6		0.7	0.7		2	0.4		0.5	0.5		2	0.5		0.6	0.7		2	0.6		0.6	0.6		2
BF Max Depth (ft)	1.2		1.4	1.5		2	1.4		1.5	1.6		2	1.3		1.4	1.5		2	1.4		1.5	1.5		2	1.4		1.6	1.7		2	1.4		1.5	1.6		2
BF Cross Sectional Area (ft^2)	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2	6.7		8.7	10.6		2
Area at Low Bank (ft^2)	6.7		8.7	10.6		2	NA		NA	NA		NA	7.5		9.1	10.7		2	7.5		9.1	10.7		2	8.4		8.6	8.8		2	7.5		8.9	10.3		2
Width/Depth Ratio	11.1		19.4	27.7		2	18.5		30.5	42.2		2	14.6		22.9	31.2		2	28.8		45.2	61.5		2	13.1		29.1	45.1		2	18.0		25.4	32.8		2
Entrenchment Ratio	6.0		8.6	11.2		2	4.7		6.9	9		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2	NA**		NA**	NA**		2
Bank Height Ratio	1.0		1.0	1.0		2	1		1	1		2	1.0		1.0	1.1		2	1.0		1.0	1.0		2	1.0		1.0	1.1		2	1.0		1.0	1.1		2
Profile																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 2																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Profile - Reach 3																																				
Riffle length (ft)																																				
Riffle slope (ft/ft)																																				
Pool length (ft)																																				
Pool Max depth (ft)																																				
Pool spacing (ft)																																				
Pattern																																				
Channel Beltwidth (ft)																																				
Radius of Curvature (ft)																																				
Rc:Bankfull width (ft/ft)																																				
Meander Wavelength (ft)																																				
Meander Width ratio																																				
Additional Reach Parameters																																				
Rosgen Classification	C-type						C-type						C-type						C-type						C-type						C-type					
Channel Thalweg Length (ft)																																				
Sinuosity																																				
Water Surface Slope (Channel) (ft/ft)																																				
BF slope (ft/ft)																																				
Ri%/RU%/P%/G%/S%																																				
SC%/SA%/G%/C%/B%/BE%																																				
d16/d35/d50/d84/d95																																				
% of Reach with Eroding Banks																																				
Channel Stability or Habitat Metric																																				
Biological or Other																																				

River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 1, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
-0.60	99.71
6.16	99.83
10.34	99.67
12.08	98.79
13.97	97.50
16.54	97.19
18.87	95.37
20.51	94.43
22.06	94.07
24.47	93.91
26.53	93.73
28.44	93.52
31.16	93.32
33.36	93.41
34.30	97.27
36.57	98.10
38.93	98.56
43.69	98.81
47.72	99.09

SUMMARY DATA	
Bankfull Elevation:	97.1
Bankfull Cross-Sectional Area:	49.8
Area at Low Bank:	52.3
Bankfull Width:	17.5
Flood Prone Area Elevation:	100.8
Flood Prone Width:	100.0
Max Depth at Bankfull:	3.7
Low Bank Height:	3.9
Mean Depth at Bankfull:	2.8
W / D Ratio:	6.2
Entrenchment Ratio:	NA
Bank Height Ratio:	1.04

Stream Type	E

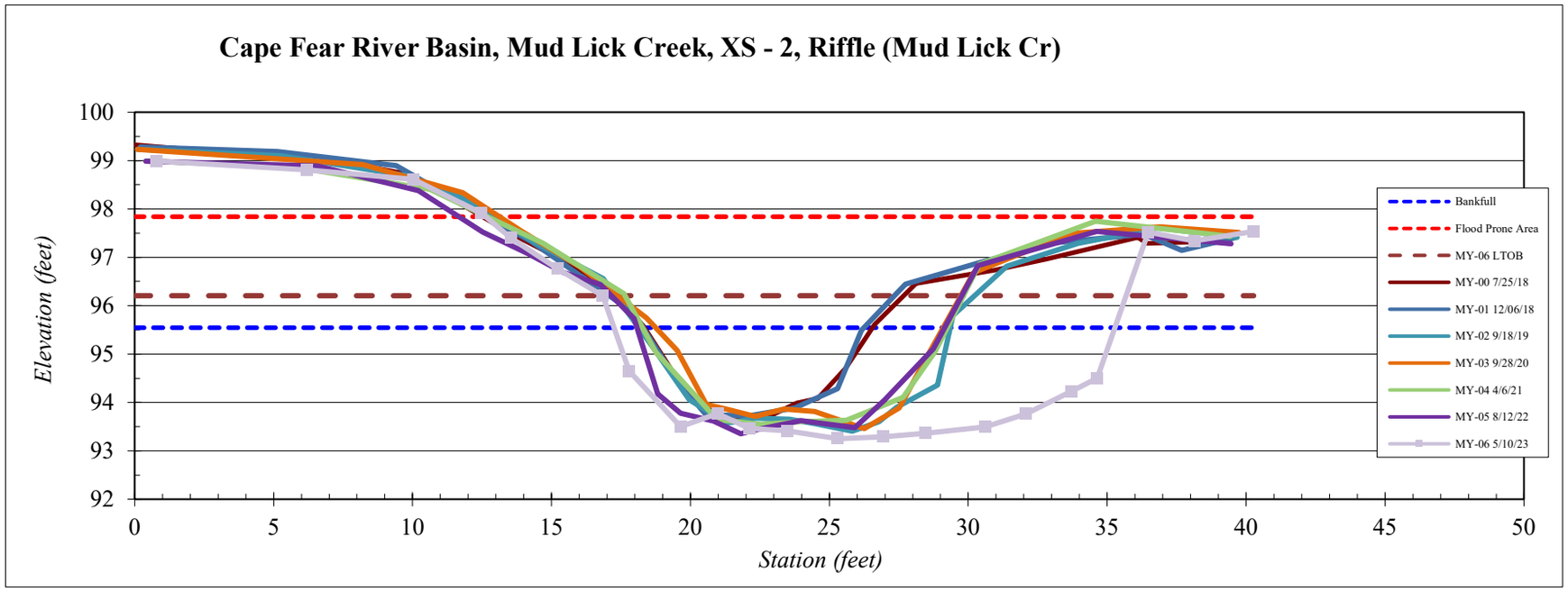


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 2, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.80	98.99
6.20	98.81
10.03	98.62
12.48	97.91
13.54	97.40
15.21	96.76
16.84	96.21
17.80	94.65
19.65	93.50
20.97	93.77
22.12	93.46
23.48	93.41
25.31	93.25
26.95	93.29
28.46	93.36
30.61	93.49
32.07	93.77
33.70	94.23
34.64	94.51
36.48	97.52
38.14	97.34
40.27	97.53

SUMMARY DATA	
Bankfull Elevation:	95.5
Bankfull Cross-Sectional Area:	33.0
Area at Low Bank:	45.2
Bankfull Width:	18.0
Flood Prone Area Elevation:	97.8
Flood Prone Width:	100.0
Max Depth at Bankfull:	2.3
Low Bank Height:	3.0
Mean Depth at Bankfull:	1.8
W / D Ratio:	9.8
Entrenchment Ratio:	NA
Bank Height Ratio:	1.29

Stream Type	E



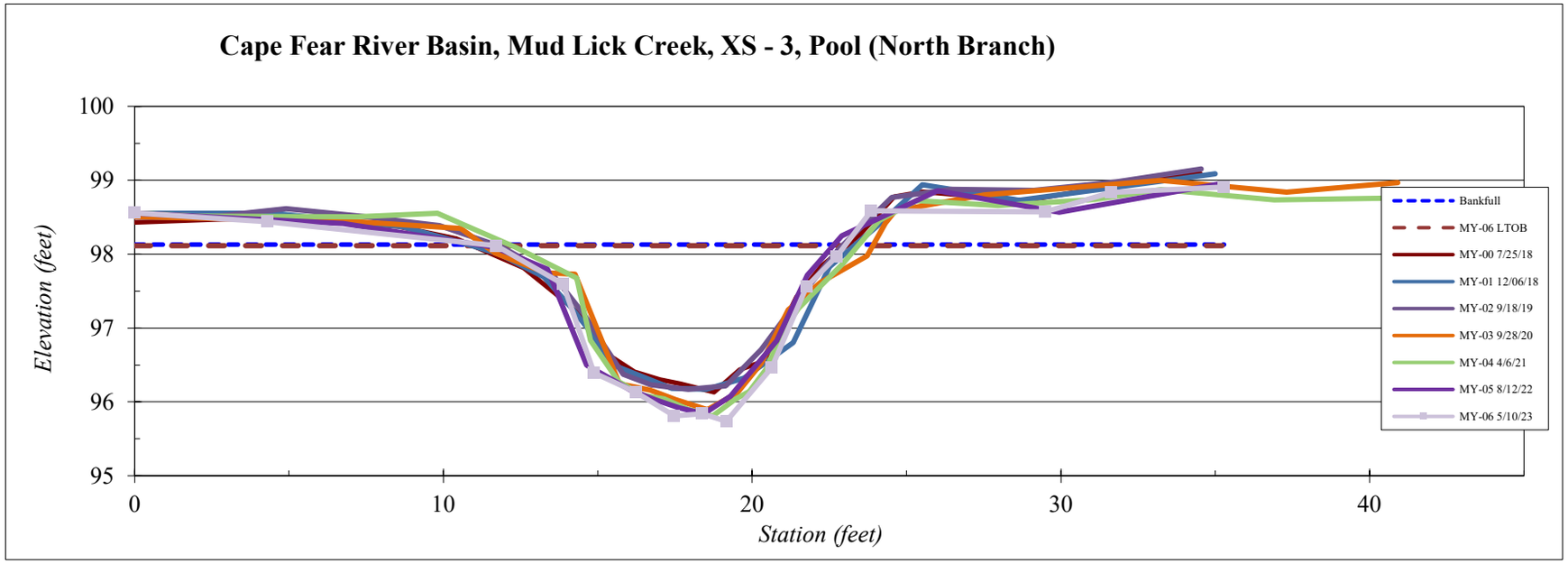
Scouring on the right bank of this cross-section is apparent, howerver this is an EII reach and localized at this location.

River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 3, Pool (North Branch)
Drainage Area (sq mi):	0.65
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.00	98.56
4.29	98.44
11.71	98.12
13.87	97.59
14.88	96.40
16.24	96.13
17.48	95.81
18.39	95.84
19.16	95.74
20.64	96.47
21.77	97.56
22.75	97.97
23.86	98.59
29.49	98.57
31.63	98.83
35.28	98.91

SUMMARY DATA	
Bankfull Elevation:	98.1
Bankfull Cross-Sectional Area:	15.5
Area at Low Bank:	41.2
Bankfull Width:	11.7
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.4
Low Bank Height:	2.4
Mean Depth at Bankfull:	1.3
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	E

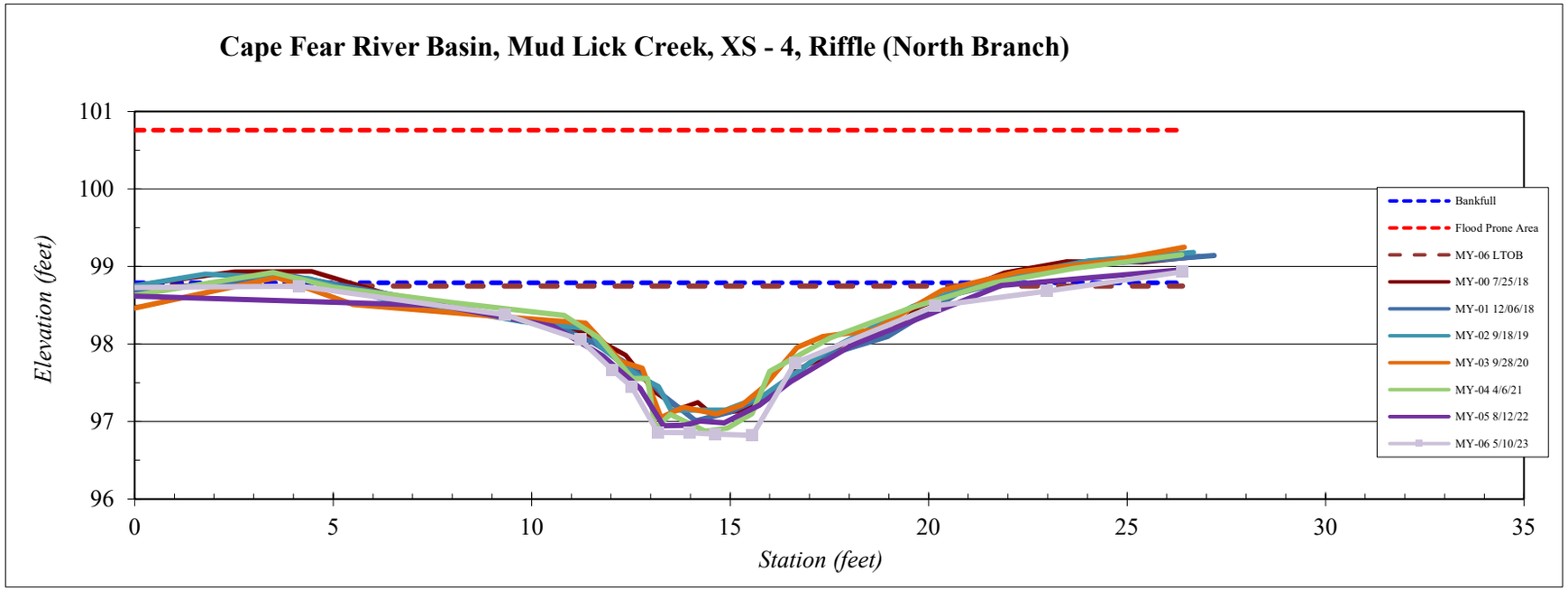


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 4, Riffle (North Branch)
Drainage Area (sq mi):	0.65
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
-0.10	98.73
4.15	98.75
9.34	98.38
11.22	98.06
12.04	97.66
12.52	97.45
13.18	96.86
13.97	96.85
14.62	96.84
15.56	96.82
16.64	97.76
20.17	98.49
22.98	98.69
26.40	98.93

SUMMARY DATA	
Bankfull Elevation:	98.8
Bankfull Cross-Sectional Area:	14.2
Area at Low Bank:	15.3
Bankfull Width:	24.5
Flood Prone Area Elevation:	100.8
Flood Prone Width:	100.0
Max Depth at Bankfull:	2.0
Low Bank Height:	1.9
Mean Depth at Bankfull:	0.6
W / D Ratio:	42.5
Entrenchment Ratio:	NA
Bank Height Ratio:	0.98

Stream Type	C

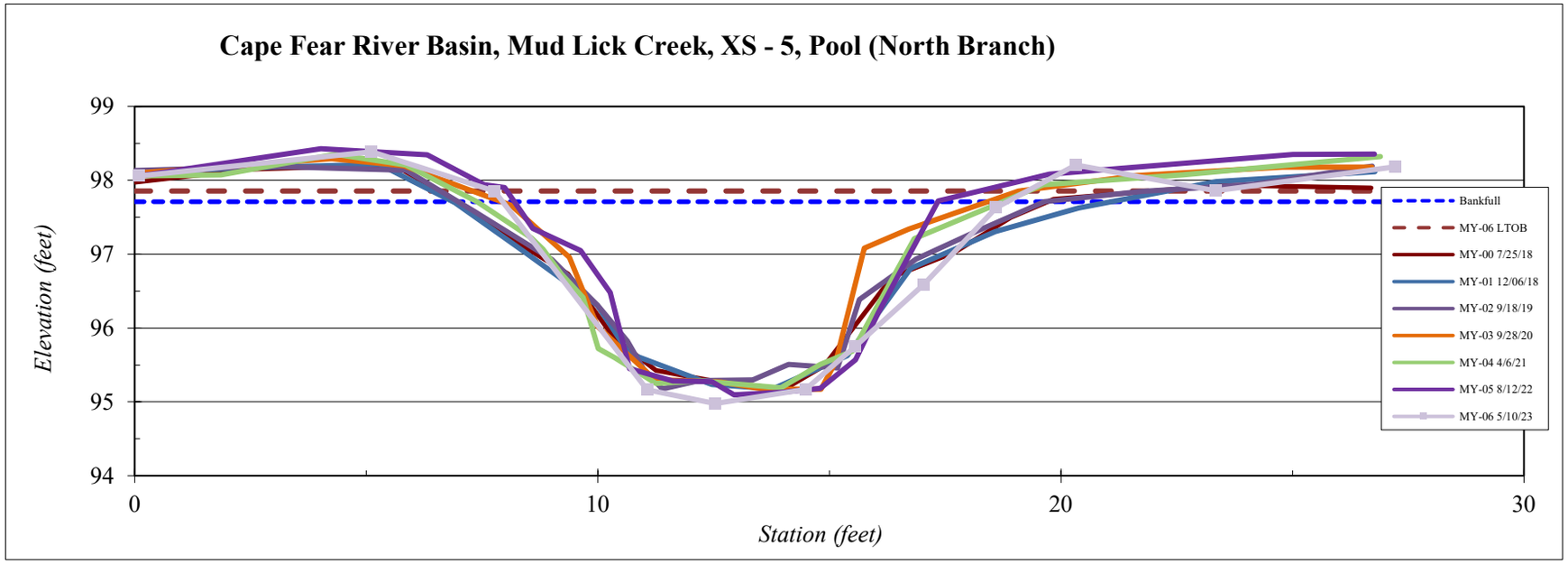


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 5, Pool (North Branch)
Drainage Area (sq mi):	0.65
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.10	98.06
5.11	98.39
7.77	97.86
11.07	95.16
12.53	94.98
14.48	95.17
15.56	95.76
17.04	96.59
18.60	97.63
20.32	98.21
23.34	97.86
27.23	98.18

SUMMARY DATA	
Bankfull Elevation:	97.7
Bankfull Cross-Sectional Area:	18.6
Area at Low Bank:	20.2
Bankfull Width:	10.9
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.7
Low Bank Height:	2.9
Mean Depth at Bankfull:	1.7
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	C

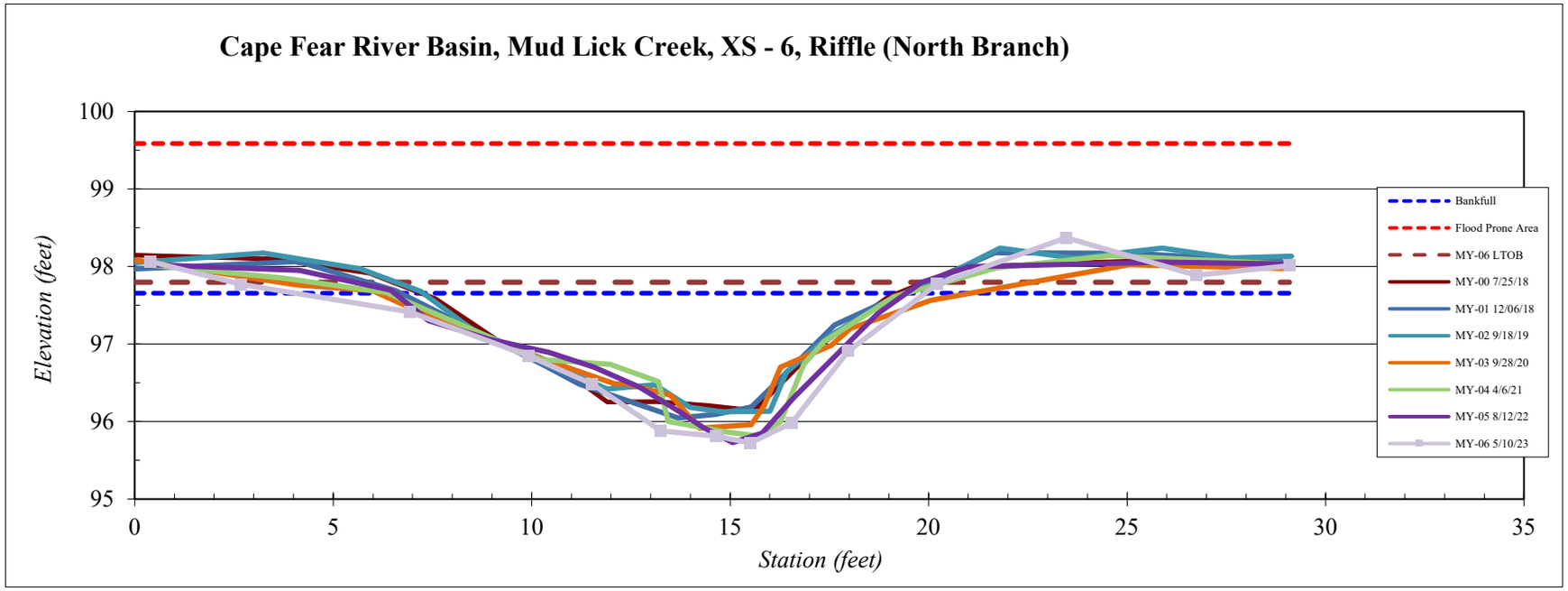


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 6, Riffle (North Branch)
Drainage Area (sq mi):	0.65
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.40	98.07
2.68	97.77
6.93	97.42
9.92	96.85
11.53	96.49
13.25	95.88
14.65	95.81
15.51	95.72
16.56	95.99
17.99	96.91
20.22	97.77
23.47	98.37
26.74	97.89
29.09	98.01

SUMMARY DATA	
Bankfull Elevation:	97.7
Bankfull Cross-Sectional Area:	14.5
Area at Low Bank:	16.9
Bankfull Width:	15.9
Flood Prone Area Elevation:	99.6
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.9
Low Bank Height:	2.1
Mean Depth at Bankfull:	0.9
W / D Ratio:	17.4
Entrenchment Ratio:	NA
Bank Height Ratio:	1.07

Stream Type	C

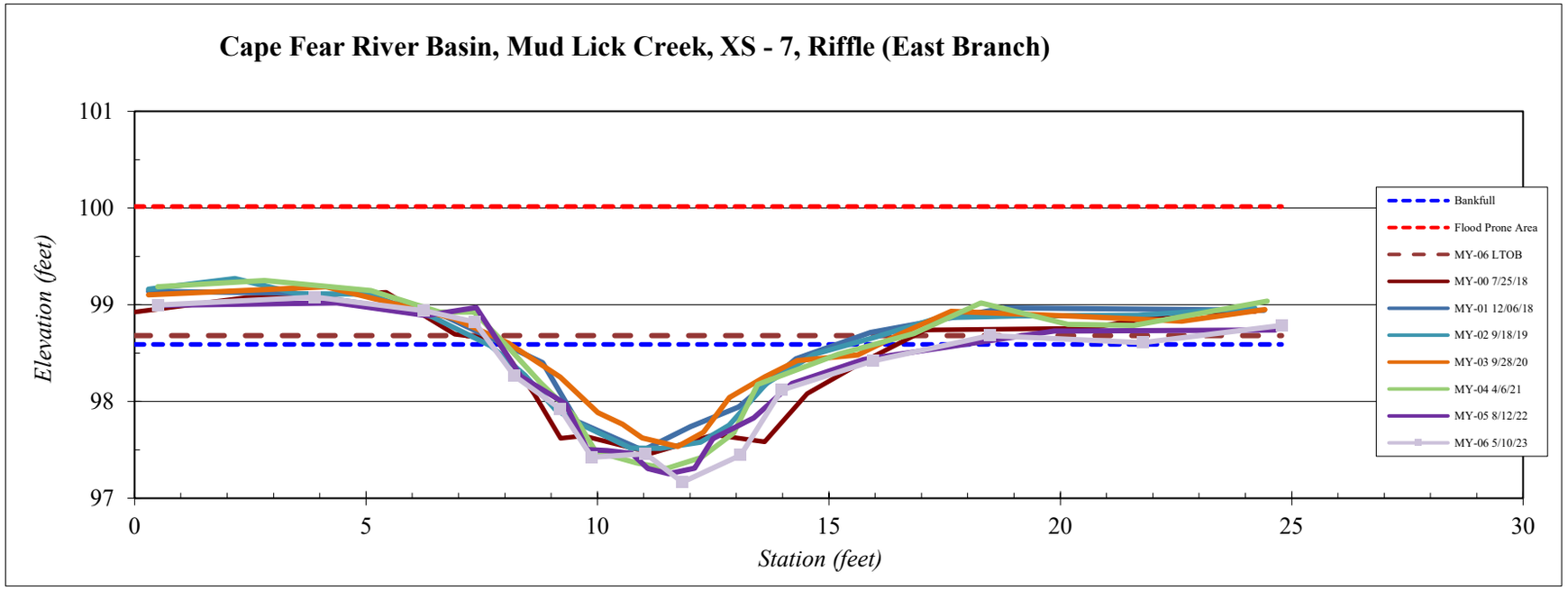


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 7, Riffle (East Branch)
Drainage Area (sq mi):	0.27
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.50	99.00
3.90	99.08
6.25	98.94
7.35	98.82
8.21	98.26
9.20	97.93
9.88	97.42
11.04	97.46
11.84	97.17
13.09	97.45
13.97	98.12
15.95	98.42
18.47	98.68
21.78	98.61
24.78	98.79

SUMMARY DATA	
Bankfull Elevation:	98.6
Bankfull Cross-Sectional Area:	6.7
Area at Low Bank:	7.8
Bankfull Width:	9.9
Flood Prone Area Elevation:	100.0
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.4
Low Bank Height:	1.5
Mean Depth at Bankfull:	0.7
W / D Ratio:	14.7
Entrenchment Ratio:	NA
Bank Height Ratio:	1.06

Stream Type	C

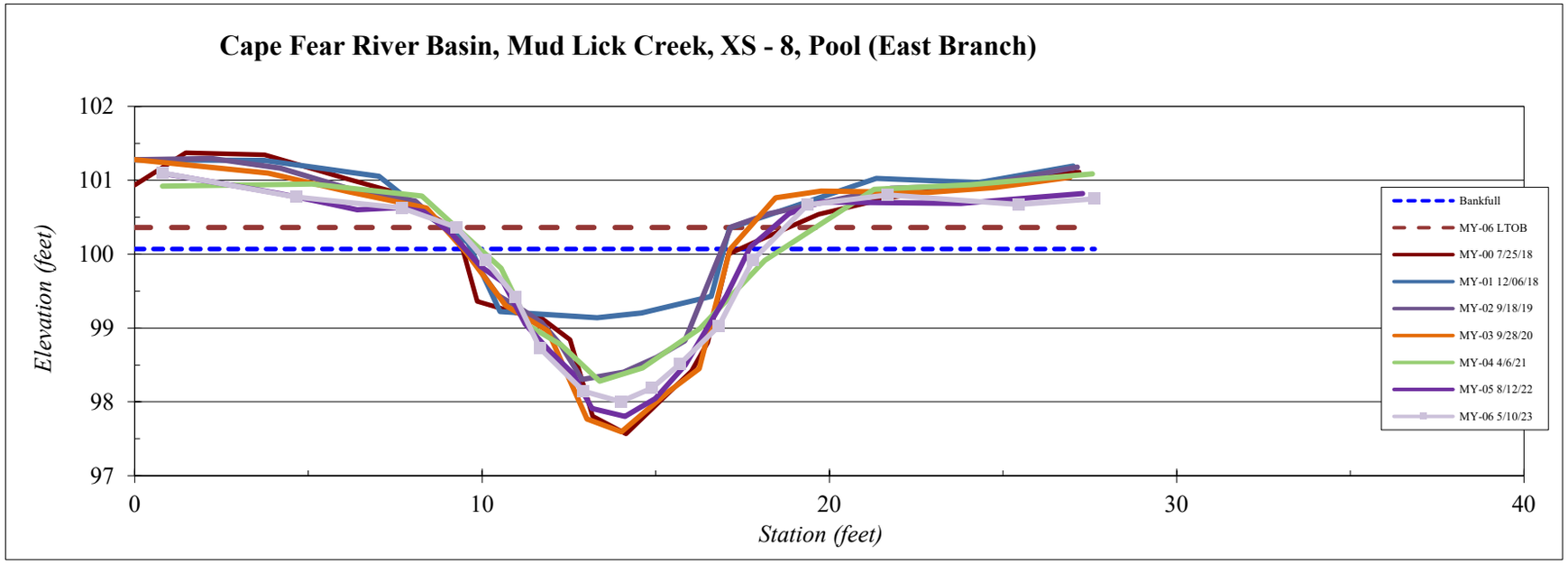


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 8, Pool (East Branch)
Drainage Area (sq mi):	0.27
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.80	101.10
4.66	100.77
7.69	100.62
9.27	100.36
10.10	99.92
10.96	99.42
11.67	98.73
12.92	98.15
13.99	98.00
14.89	98.19
15.71	98.52
16.81	99.02
17.80	99.92
19.38	100.67
21.69	100.80
25.44	100.67
27.64	100.75

SUMMARY DATA	
Bankfull Elevation:	100.1
Bankfull Cross-Sectional Area:	10.5
Area at Low Bank:	13.1
Bankfull Width:	8.3
Flood Prone Area Elevation:	NA
Flood Prone Width:	NA
Max Depth at Bankfull:	2.1
Low Bank Height:	2.4
Mean Depth at Bankfull:	1.3
W / D Ratio:	NA
Entrenchment Ratio:	NA
Bank Height Ratio:	NA

Stream Type	C

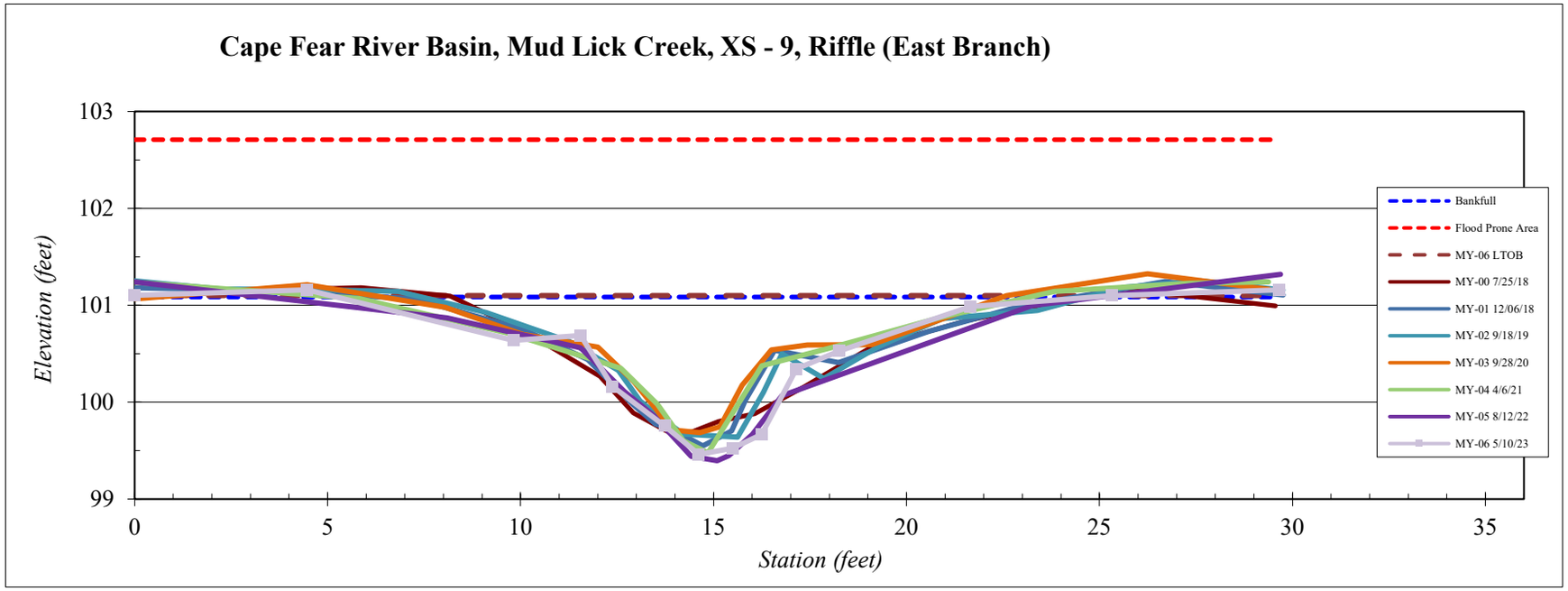


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 9, Riffle (East Branch)
Drainage Area (sq mi):	0.27
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.00	101.10
4.47	101.16
9.82	100.64
11.55	100.69
12.39	100.16
13.74	99.75
14.62	99.46
15.50	99.52
16.24	99.67
17.14	100.34
18.26	100.53
21.66	100.99
25.33	101.10
29.65	101.16

SUMMARY DATA	
Bankfull Elevation:	101.1
Bankfull Cross-Sectional Area:	10.6
Area at Low Bank:	10.9
Bankfull Width:	19.6
Flood Prone Area Elevation:	102.7
Flood Prone Width:	100.0
Max Depth at Bankfull:	1.6
Low Bank Height:	1.6
Mean Depth at Bankfull:	0.5
W / D Ratio:	36.2
Entrenchment Ratio:	NA
Bank Height Ratio:	1.01

Stream Type	C

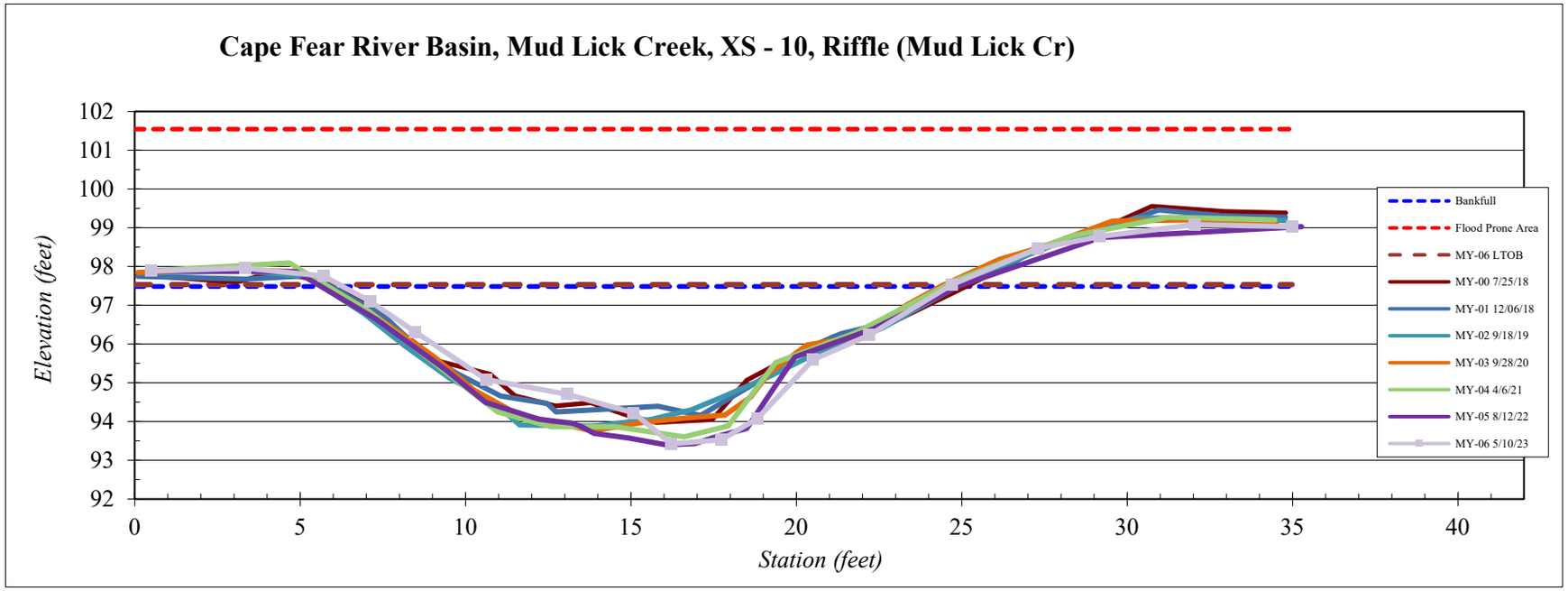


River Basin:	Cape Fear
Site Name	Mud Lick Creek
XS ID	XS - 10, Riffle (Mud Lick Cr)
Drainage Area (sq mi):	3.64
Date:	5/10/2023
Field Crew:	P. Perkinson, K. Jernigan

Station	Elevation
0.50	97.89
3.34	97.96
5.70	97.76
7.13	97.09
8.48	96.32
10.63	95.09
13.09	94.70
15.09	94.22
16.23	93.43
17.73	93.53
18.83	94.07
20.51	95.59
22.21	96.23
24.69	97.53
27.30	98.47
29.17	98.77
32.05	99.08
34.99	99.03

SUMMARY DATA	
Bankfull Elevation:	97.5
Bankfull Cross-Sectional Area:	40.4
Area at Low Bank:	41.2
Bankfull Width:	18.3
Flood Prone Area Elevation:	101.5
Flood Prone Width:	100.0
Max Depth at Bankfull:	4.1
Low Bank Height:	4.1
Mean Depth at Bankfull:	2.2
W / D Ratio:	8.3
Entrenchment Ratio:	NA
Bank Height Ratio:	1.01

Stream Type	E



Appendix E.
Hydrology Data

Table 13. Verification of Bankfull Events

Table 13. Verification of Bankfull Events
Mud Lick Creek Restoration Site (DMS Project No. 93482)

Date of Data Collection	Date of Occurrence	Method	Photo (if available)
December 6, 2018	October 16-17, 2018	Observations throughout floodplain and crest gauge indicate a bankfull event after 4.61 inches of rain fell over 48 hours.	1, 2
May 8, 2019	February 24, 2019	Observation of wrack in floodplain along North Branch R2 and crest gauge data from all site crest gauges indicate a bankfull event after 2.27 inches of rain fell over 48 hours.	3
September 18, 2019	July 24, 2019	Observation of wrack on Mud Lick Creek R2 floodplain fences and crest gauge data from all site crest gauges indicate a bankfull event after 3.02 inches of rain fell over 48 hours.	4
May 29, 2020	February 7, 2020	Observations of wrack throughout site along all stream reaches, and crest gauge data from all site crest gauges indicate a bankfull event after approximately 3.59 inches of rain fell over 24-hour period.	5, 6, 7
November 16, 2020	November 12, 2020	Observations of wrack throughout site along all stream reaches, and crest gauge data from all site crest gauges indicate a bankfull event after approximately 4.60 inches of rain fell over 48-hour period.	8, 9
August 12, 2022	July 9, 2022	Observation of wrack in floodplain along North Branch R2 and crest gauge data from all site crest gauges indicate a bankfull event after 2.80 inches of rain fell over 48 hours.	10
May 10, 2023	April 8, 2023	Observation of wrack in floodplain along East Branch R2 and crest gauge data from all site crest gauges indicate a bankfull event after 3.96 inches of rain fell over 48 hours.	11, 12, 13


Photo-3


Photo-4


Photo-5
2020/05/29


Photo-6
2020/05/29


Photo-7
2020/05/29


Photo-8


Photo-9


Photo-10


Photo-11
2023/05/10


Photo-12


Photo-13

Appendix F.
Adaptive Management

Attachment 1: Adaptive Management Plan

ROY COOPER
Governor
ELIZABETH S. BISER
Secretary
MARC RECKTENWALD
Director

NORTH CAROLINA
Environmental Quality

MEMORANDUM

DATE: October 25, 2022

TO: IRT Members

FROM: DMS, Jeremiah Dow

RE: Mud Lick Creek Project
Request for IRT Approval of Adaptive Management Plan for Supplemental Planting

Mud Lick Creek is a design-bid-build stream project that was instituted on 2/13/2013. Wildlands Engineering, Inc. prepared the mitigation plan in 2015 and Axiom Environmental, Inc. was contracted to perform project monitoring. In 2021 DMS contracted Michael Baker Engineering, Inc. (Baker) to manage invasive and nuisance vegetation. Baker will also provide the supplemental planting services. The project is currently in monitoring year 5. In MY4, four veg plots – 1, 6, 10, & 11 – out of 12 plots did not meet success criteria

On 6/4/2021, the IRT and DMS conducted a credit release site visit where areas of low density and/or low vigor were identified. No additional management activities were prescribed at that time and the IRT recommended continued monitoring of problematic areas with an understanding that supplemental planting may be necessary. Baker was contracted to manage fescue in low vigor areas and thin sweet gum on the eastern side of the project to reduce competition with existing planted stems. On August 30, 2022 DMS personnel visited the site to assess the invasive and nuisance vegetation management efforts and low stem density/vigor areas. During that site visit it was determined that supplemental planting would be necessary, and targeted planting areas were mapped with GPS.

Due to competition with dense herbaceous vegetation and sweet gum, and evidence of widespread deer browse, it was decided that the site should be supplementally planted with 1 gallon and 3 gallon containerized trees. Proposed planting list is attached. All listed species are from the approved Mitigation Plan.

2.04 acres are proposed for supplemental planting out of 9.6 total acres planted which accounts for 21% of the total planted area.

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Environmental Quality

Supplemental planting will include the following:

Size	Species	Quantity
3 Gall.	*Fraxinus pennsylvanica* (Green Ash)	50
3 Gall.	*Platanus occidentalis* (Sycamore)	50
3 Gall.	*Populus deltoides* (E. Cottonwood)	50
3 Gall.	*Betula nigra* (River Birch)	50
3 Gall.	*Sambucus canadensis* (Elderberry)	50
1 Gall.	*Cornus amomum* (Silky Dogwood)	50
1 Gall.	*Hamamelis virginiana* (Witch Hazel)	50
1 Gall.	*Diospyros virginiana* (Persimmon)	50
3 Gall.	*Quercus michauxii* (Swamp Chestnut Oak)	50
3 Gall.	*Liriodendron tulipifera* (Tulip Poplar)	50


Legend
Beaver Dam
Low Stem Density (2.04 acres)
MLC Reach Breaks
Fish/Benthic Site
Structures
Veg Plots
Did Not Meet in 2021
Met Success in 2021
Mitigation Approach
E2
R
1
2
3
4
5
6
7
8
9
10
11
12
N
0 50 100 200 300
Feet
NCCGIA, NC 911 Board