FINAL MITIGATION PLAN

The Best Site Stream and Wetland Restoration Project

Duplin County, North Carolina
EEP Project # 95353

Cape Fear River Basin
CU 03030007

Prepared for:

North Carolina Department of Environment and Natural Resources
Ecosystem Enhancement Program

1652 Mail Service Center
Raleigh, NC 27699-1652

October 2013

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EXECUTIVE SUMMARY

"This mitigation plan has been written in conformance with the requirements of the following:

- Federal rule for compensatory mitigation project sites as described in the Federal Register Title 33 Navigation and Navigable Waters Volume 3 Chapter 2 Section § 332.8 paragraphs (c)(2) through (c)(14).
- NCDENR Ecosystem Enhancement Program In-Lieu Fee Instrument signed and dated July 28, 2010.

These documents govern NCEEP operations and procedures for the delivery of compensatory mitigation."

The Best Site Stream & Wetland Mitigation Project is located within an agricultural watershed in Duplin County, North Carolina, approximately two miles east of Beulaville. The project streams proposed for restoration and/or enhancement have been significantly impacted by channelization and agricultural practices. The project will involve the restoration and protection of streams and wetlands in the Muddy Creek watershed. The purpose of this restoration project is to restore and enhance a stream/wetland complex located within the Cape Fear River Basin.

The project lies within USGS Hydrologic Unit Code 03030007060010 (USGS, 1998) and within the North Carolina Division of Water Quality (NCDWQ) Cape Fear River Sub-basin 03-06-22 (NCDENR, 2005). The 2009 Cape Fear River Basin Plan identified HUC 03030007060010 as a Targeted Local Watershed. The watershed is characterized by 52 percent agricultural land use area with Muddy Creek identified as Impaired for aquatic life because of a Fair benthic community rating. The plan listed water quality and animal operations as major stressors within this TLW, and the planning goals include identifying restoration and stormwater BMP needs.

The proposed Best stream and wetland mitigation project is located within the northern (upstream) portion of the TLW and includes sections of Muddy Creek (303d listed) and headwater streams that discharge into Muddy Creek. The project, through stream and wetland restoration and enhancement activities, will provide numerous ecological and water quality benefits within the Cape Fear River Basin. These benefits will address the degraded water quality and nutrient inputs from farming that were identified as major watershed stressors in the 2009 Cape Fear River Basin Plan.

The Best Site project consists of stream and wetland restoration on tributaries that are located directly adjacent to Muddy Creek and includes 19,882 linear feet of Stream Preservation and Buffer Enhancement along Muddy Creek and its tributaries. The Best Site Mitigation Project area is located directly on over 9,000 linear feet of Muddy Creek and includes over 18,500 linear feet of 10 unnamed tributaries. Stream restoration is proposed for two tributaries, headwater valley restoration along a portion of one tributary, stream enhancement along three tributaries, and stream preservation and buffer enhancement for the remaining streams.

The eastern portion of the project originates approximately 0.3 miles west of Edwards Road and includes the upstream portion of Muddy Creek and tributaries UT1 and UT2 flowing from the north and UT3 and UT4 flowing from the south. The western portion of the project is located southeast of the intersection of NC HWY 24 and Lyman Road and terminates approximately 0.4 miles south of Lyman Road. This area includes the lower section of Muddy Creek and its tributaries; UT5, UT6, UT7, UT8, UT9, and UT10.

The site consists of farmland, concentrated animal feeding operations (CAFO), and wooded areas. The total easement area is 142.7 acres, 116.4 acres of which are wooded. The remaining area is agricultural. The wooded areas along the corridor designated for restoration are classified as disturbed deciduous forest, and invasive species are prevalent throughout. Several ditches exist throughout the project and flow into the main channel. Each ditch contributes to the overall design discharge of the channel. Channels proposed for restoration or enhancement are degraded to a point where they no longer access their floodplain, lack riparian buffers, allow livestock access, and aquatic life is not supported. Little aquatic habitat is available to support aquatic life, and the riparian buffers are not maximizing their potential to filter nutrients.

The objective for this restoration project is to restore wetland areas and design natural waterways through stream/wetland complexes with appropriate cross-sectional dimension and slope that will provide function and meet the appropriate success criteria for the existing streams. Accomplishing this objective entails the restoration of natural stream characteristics, such as stable cross sections, planform, and in-stream habitat. The floodplain areas will be hydrologically reconnected to the channel to provide natural exchange and storage during flooding events. The design will be based on reference conditions, USACE guidance (USACE, 2005), and criteria that are developed during this project to achieve success. Additional project objectives, such as restoring the riparian buffer with native vegetation, ensuring hydraulic stability, and eradicating invasive species, are listed in Section 1.

The design approach for the Best Site is to combine the analog method of natural channel design with analytical methods to evaluate stream flows and hydraulic performance of the channel and floodplain. The analog method involves the use of a “template” stream adjacent to, nearby, or previously in the same location as the design reach. The template parameters of the analog reach are replicated to create the features of the design reach. The analog approach is useful when watershed and boundary conditions are similar between the design and analog reaches (Skidmore, et al., 2001). Hydraulic geometry was developed using analytical methods in an effort to identify the design discharge.

The headwater valley restoration approach is proposed along the upper section of UT4. The existing ditches/channels will be backfilled to the extent possible such that cut and fill is balanced along the reach. Priority Level I restoration is proposed on UT1 and UT2. For the majority of the restoration reaches, the channel will be rerouted form its current location to adjacent natural valley features. Enhancement Level I is proposed for UT6 and UT8, and Level II is proposed for UT3.

The restoration approach on UT1 and UT2 includes relocating the channel to either side of its current location within the natural valley. The existing channels will be plugged and filled to prevent continued flow within the ditches. By rerouting and raising the channel, the design will allow the channel frequent access to its floodplain and the opportunity for creating small depressional areas within the buffer to enhance habitat for wildlife and aquatic organisms. Relocating these channels will not impact any forested areas because the buffer along the restoration reaches is currently cultivated crop land or active pasture.

Enhancement Level I on UT6 and UT8 will include grading a floodplain bench, bank stabilization treatment, and habitat improvements. Enhancement Level II is proposed for reach UT3, where habitat and buffer improvements are proposed.

Wetlands are present adjacent to streams UT3, UT4, UT5, UT6, UT10, and Muddy Creek. The three wetland restoration areas proposed are located at the headwaters of UT1, on the floodplain adjacent to the proposed UT2 stream restoration, and on the floodplain of Muddy Creek. Wetland restoration activities will include plugging existing ditches, raising the elevation of the local groundwater, restoring natural drainage patterns both above and below the ground surface, roughing of the soil surface, planting wetland species, and permanent exclusion of livestock.

After completion of all construction and planting activities, the site will be monitored on a regular basis and a physical inspection of the site will be conducted at a minimum of twice per year throughout the seven-year post-construction monitoring period, or until performance standards are met. These site inspections will identify site components and features that require routine maintenance. Success criteria on the headwater valley reaches will include documented surface flow and vegetative success. The measure of stream restoration success will be documented bankfull flows and no change in stream channel classification. Sand bed channels are dynamic and minor adjustments to dimension and profile are expected. The measure of vegetative success for the site will be the survival of at least 210 seven-year old planted trees per acre with an average height of 10 feet at the end of year seven of the monitoring period. Successful establishment of wetland hydrology will be demonstrated by a wetland hydroperiod of seven percent (17 days) or greater of one growing season at each groundwater gauge location. Annual monitoring data will be reported using the EEP monitoring template.

Upon approval for closeout by the Interagency Review Team (IRT), the site will be transferred to the State of North Carolina (State). The State shall be responsible for periodic inspection of the site to ensure that restrictions required in the conservation easement or the deed restriction document(s) are upheld.

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1 RESTORATION PROJECT GOALS AND OBJECTIVES

The North Carolina Ecosystem Enhancement Program (EEP) develops River Basin Restoration Priorities (RBRP) to guide its restoration activities within each of the state's 54 cataloging units. RBRPs delineate specific watersheds that exhibit both the need and opportunity for wetland, stream and riparian buffer restoration. These watersheds are called Targeted Local Watersheds (TLWs) and receive priority for EEP planning and restoration project funds.

The 2009 Cape Fear River Basin RBRP identified HUC 03030007060010 as a Targeted Local Watershed (http://portal.ncdenr.org/c/document_library/get_file?uuid=e16e9d5a-a385-41ec-8969-44c8e10369ba&groupId=60329). The watershed is characterized by 52 percent agricultural land use area with Muddy Creek identified as Impaired for aquatic life because of a Fair benthic community rating.

The 2009 Cape Fear River Basin RBRP identified degraded water quality likely from existing animal operations as a major stressor within this TLW. The Best Stream and Wetland Restoration Project was identified as a stream and wetland opportunity to improve water quality, habitat, and hydrology within the TLW.

The project goals address stressors identified in the TLW and include the following:

- Nutrient removal,
- Sediment removal,
- Reducing runoff from animal operations,
- Filtration of runoff, and
- Improved aquatic and terrestrial habitat.

The project goals will be addressed through the following project objectives:

- Establishing riparian buffer areas adjacent to CAFOs,
- Converting active farm field to forested buffers,
- Stabilization of eroding stream banks,
- Improving and protecting portions of headwater systems that discharge to a 303d listed stream,
- Reduction in stream bank slope,
- Restoration of riparian buffer bottomland hardwood habitats, and
- Construction of in-stream structures designed to improve bedform diversity and trap detritus.

The proposed Best stream and wetland mitigation project is located within the northern (upstream) portion of the TLW and includes sections of Muddy Creek (303d listed) and headwater streams that discharge into Muddy Creek. Due to its location and proposed improvements, the project will provide numerous ecological and water quality benefits within the Cape Fear River Basin. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Many of the project design goals and objectives, including restoration of riparian buffers to filter runoff from agricultural operations and improve terrestrial habitat, and construction of in-stream structures to improve habitat diversity, will address the degraded water quality and nutrient input from farming that were identified as major watershed stressors in the 2009 Cape Fear RBRP.

2 SITE SELECTION

2.1 Directions to Site

The Best Site Stream and Wetland Site is located in Duplin County approximately two miles east of Beulaville, NC (**Figure 1**). To access the downstream end of the Site from the town of Beulaville, travel 0.6 miles east on NC HWY 24, take a right onto Lyman Road (SR 1801), and continue 1.6 miles southeast to the crossing with Muddy Creek. Reaches UT7, UT8, UT9, UT10 and the lower end of Muddy Creek may all be accessed from Lyman Road. Reaches UT5 and UT6 are located just south of NC HWY 24, approximately 1.9 miles east of Beulaville. The upstream portion of the site may be accessed from two locations. Reaches UT1, UT2 and Muddy Creek are located to the south of NC HWY 24, opposite of the intersection of NC HWY 24 and Penny Road (SR 1720), approximately 2.8 miles east of Beulaville. To access reaches UT3, UT4 and Muddy Creek, travel 3.2 miles east on NC HWY 24 from Beulaville to Edwards Road (SR 1835), continue south for approximately 1.0 mile, turn right onto Put Lane, and follow the road down to Reaches UT3 and UT4.

2.2 Site Selection

2.2.1 USGS Hydrologic Unit Code and NC DWQ River Basin

The site is located in the Cape Fear River Basin within Cataloging Unit 03030007 (NCDWQ sub-basin 03-06-22). The project is located within the Cape Fear River Basin (8-digit USGS HUC 03030007, 12-digit USGS HUC 030300070600 (USGS, 2012) and the NCDWQ Cape Fear 03-06-22 sub-basin (NCDWQ, 2002) (**Figure 2**).

2.2.2 Project Components

The project area is comprised of a single large easement area along Muddy Creek and 10 tributaries. The easement along Muddy Creek is separated by Lyman Road. The eastern portion of the project originates approximately 0.3 miles west of Edwards Road and includes the upstream portion of Muddy Creek and its tributaries UT1 and UT2 flowing from the north and UT3 and UT4 flowing from the south. The western portion of the project is located southeast of the intersection of NC HWY 24 and Lyman Road and terminates approximately 0.4 miles south of Lyman Road. This area includes the lower section of Muddy Creek and its tributaries (UT5, UT6, UT7, UT8, UT9, and UT10). The stream mitigation project components are summarized in **Table 1**.

The US Fish and Wildlife Service National Wetland Inventory Map (NWI) depicts wetlands within the project site (**Figure 7**). The floodplain along Muddy Creek is mapped as PFO1A (Palustrine Forested Broad-Leaved Deciduous Temporarily Flooded) and PFO1C (Palustrine Forested Broad-Leaved Deciduous Seasonally Flooded) in the watershed of UT2 north of NC HWY 24. Additional wetlands are shown above the headwaters wetland of UT3 and UT4, and mapped as PFO1/4A (Palustrine Forested Broad-Leaved Deciduous/ Needle-Leaved Temporarily Flooded). Wetland delineations performed in June 2012 identified three wetland mitigation areas. Two sites (W1 and W2) are adjacent to the stream restoration (UT1 and UT2) that contain relic hydric soil, and the third site (W3) is along the floodplain of Muddy Creek. Area W1 is within an active pasture, while W2 and W3 are within cultivated cropland. Area W3 consists of two adjacent areas that are similar (W3a and W3b). The wetland mitigation project components are summarized in **Table 2**.

Table 1. Best Site Project Components – Stream Mitigation

Reach	Mitigation Type*	Stationing (Existing)			Existing Length (LF)	Proposed Length (LF)	Mitigation Ratio	SMUs
UT1	P1 Restoration	0+47	to	18+00	1,551	1,723	1 : 1.0	1,723
UT1	SP & BE	18+00	to	21+03	303	303	1 : 5.0	61
UT2	P1 Restoration	2+30	to	30+30	2,552	2,770	1 : 1.0	2,770
UT2	SP & BE	30+30	to	33+39	309	309	1 : 5.0	62
UT3	Enhancement II	0+00	to	8+42	1,458	812	1 : 2.5	325
UT3	SP & BE	14+58	to	15+22	64	64	1 : 5.0	13
UT4	HV Restoration	5+63	to	11+03	534	510	1 : 1.0	510
UT4	SP & BE	11+03	to	17+58	655	655	1 : 5.0	131
UT5	SP & BE	0+00	to	40+86	4,086	4,043	1 : 5.0	809
UT6	Enhancement I	0+62	to	6+00	538	538	1 : 1.5	359
UT7	SP & BE	0+44	to	32+27	3,183	3,183	1 : 5.0	637
UT8	Enhancement I	0+75	to	9+00	825	825	1 : 1.5	550
UT8	SP & BE	9+00	to	12+13	313	313	1 : 5.0	63
UT9	SP & BE	0+00	to	11+71	1,171	1,171	1 : 5.0	234
UT10	SP & BE	3+37	to	11+05	768	768	1 : 5.0	154
Muddy Creek	SP & BE	0+35	to	92+49	9,214	9,073	1 : 5.0	1,815
		Total			**27,524**	**27,060**		**10,213**

*P1 = Priority 1, SP & BE= Stream Preservation and Buffer Enhancement, HV = Headwater Valley

Table 2. Best Site Project Components – Wetland Mitigation

Wetland	Mitigation Type	Mitigation Area (ac)	Mitigation Ratio	WMUs
W1	Restoration	3.66	1:1	3.66
W2	Restoration	0.29	1:1	0.31
W3A	Restoration	0.58	1:1	0.58
W3B	Restoration	0.59	1:1	0.59
	Total	**5.12**		**5.12**

2.2.3 Historical Land Use and Development Trends

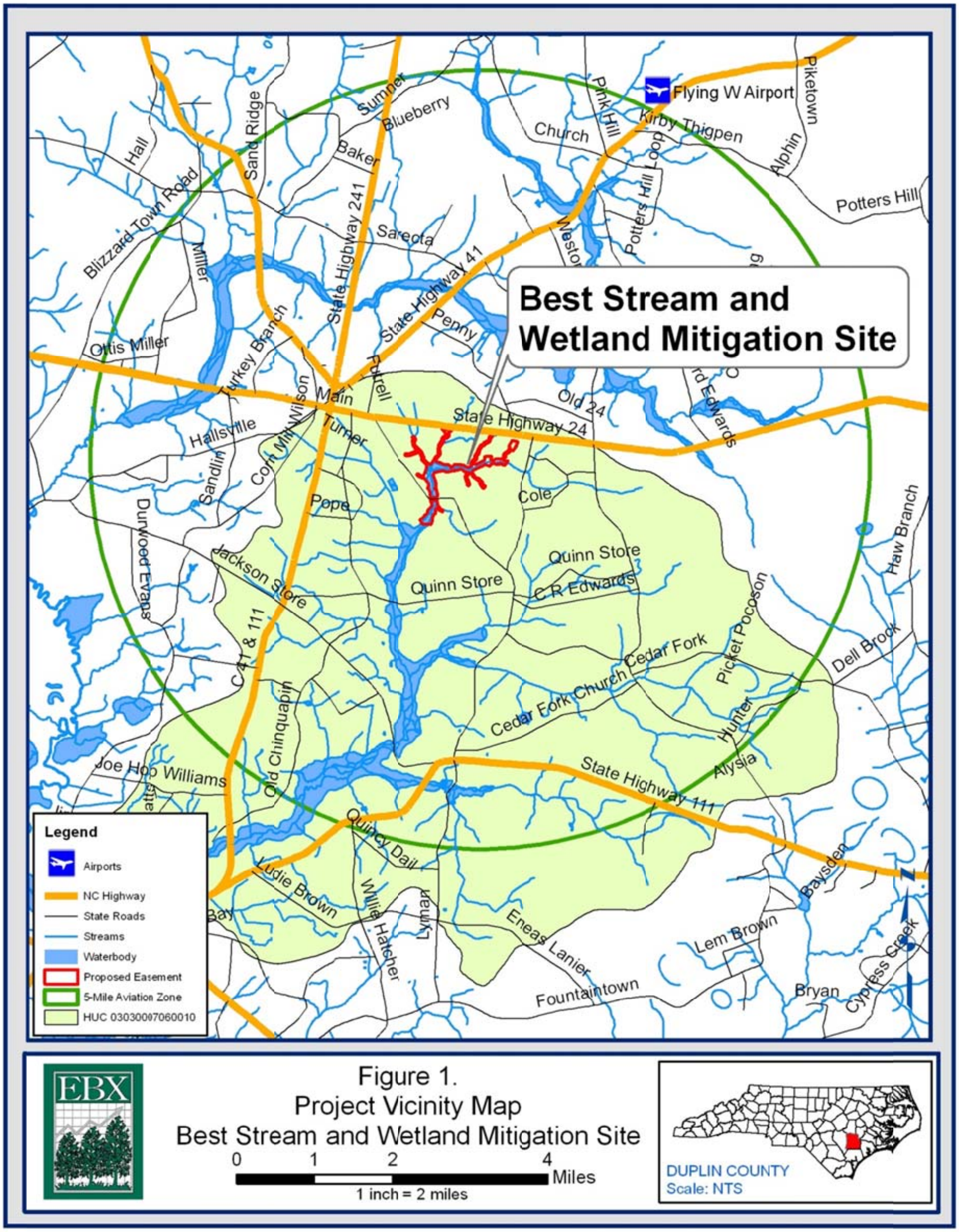
Aerial imagery and information provided by the property owners indicate that the subject site has been used extensively for agricultural purposes, and that the location of the stream has not changed in over 50 years (**Figure 4** and **Figure 6**). By 1958, the area was cleared and in agricultural production with the current ditch system mostly in place. Land use patterns have remained constant since then. Between 1958 and 1974 the CAFO in the watershed for UT2 (poultry) was built across NC HWY 24. Between 1977 and 1983 the CAFO on UT3 (swine) was constructed with a single lagoon beside the stream. Between 1983 and 1993 a CAFO was constructed in the watershed for UT4 (swine) having two lagoons with two additional houses added between 1993 and 1998. Also between 1983 and 1993, the headwater of UT1 was cleared and converted to pasture. Additional CAFOs have been constructed throughout the Muddy Creek drainage above the project. These swine operations total eleven swine houses with three waste lagoons and three poultry houses. Little has changed since 1983 in regards to the development of the project site and nearby surrounding property. The area remains in an agricultural community with some neighboring property forested. All of the facts in Section 4.1 (Watershed Summary Information) support the notion that several watershed characteristics, such as groundwater, vegetation, surface drainage, and potentially soil parameters, have been modified. Soil structure and surface texture have been altered from intensive agricultural operations. Although the soils characterized on the W1 restoration area are classified as poorly drained, the ditching system has caused these soils to be effectively drained. Historical land use and development trends on the Best Site are summarized in **Table 3**.

Table 3. Historical Land Use and Development Trends

Date	Land Use and Development Observations*
1958	Conditions consist of ditched agricultural fields throughout the project area except where wetlands W1 is proposed. This area is forested.
1974	Land use conditions have changed very little. A CAFO (poultry) in the watershed for UT2 was built across NC HWY 24.
1983	The CAFO on UT3 (swine) was constructed with a single lagoon beside the stream.
1993	A CAFO was constructed in the watershed for UT 4 (swine) having two lagoons. The headwater of UT1 was cleared and converted to pasture.
1998	Two additional swine houses added to CAFO above UT4.
2010	Depicts current site conditions.

* Observations based on aerial imagery and landowner communication

2.3 Project Site Vicinity Map



2.4 Project Site Watershed Map

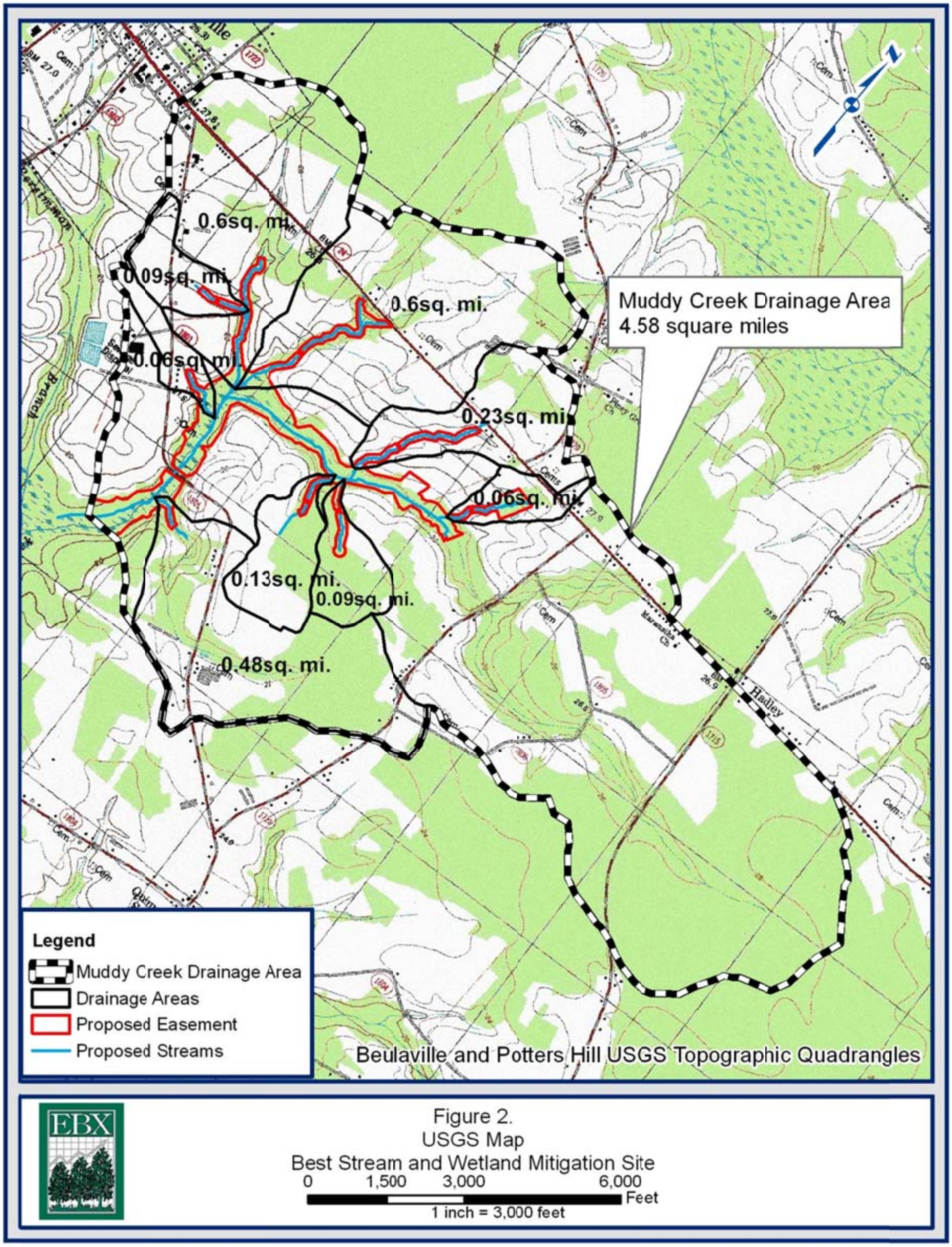


Figure 2.
USGS Map
Best Stream and Wetland Mitigation Site

2.5 Soil Survey

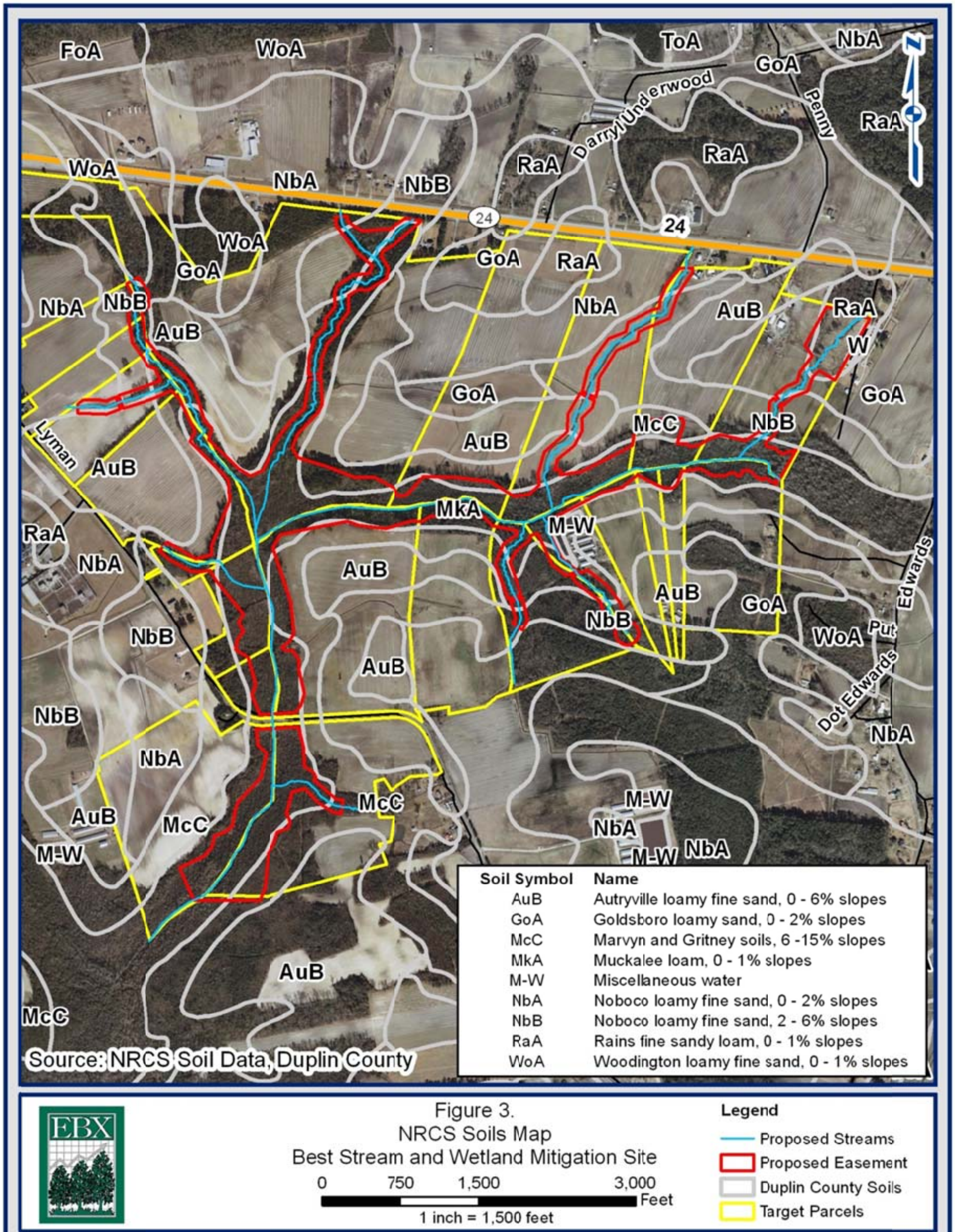
The Best Site is located in the Coastal Plain Physiographic Province. The watershed is underlain by the Castle Hayne aquifer. The Castle Hayne aquifer is composed of limestone, sandy limestone, and sand. It is the most productive aquifer in North Carolina. The topography of the area is generally gently rolling with nearly flat floodplain. Elevations range from 45 to 65 feet.

The Duplin County Soil Survey depicts six soil types as present within the project area (**Figure 3**). The six series present are: Autryville loamy fine sand, 0 to 6 percent slopes; Marvyn and Gritney soils, 6 to 15 percent slopes; Muckalee loam, 0 to 1 percent slopes; Woodington loamy fine sand, 0 to 1 percent slopes; Noboco loamy fine sand, 0 to 2 percent slopes; and Rains fine sandy loam, 0 to 1 percent slopes. Of the mapped soil series that occur throughout the project, the Muckalee loam dominates the floodplain of Muddy Creek and the lower reaches of many of its tributaries. The Rains series is mapped at the headwater of UT1 and Wetland 1. The Marvyn and Gritney soils are found on the low terrace along Muddy Creek. The Autryville and Woodington series are mapped in the remaining areas of the project. The Rains and Woodington soils are poorly drained with slow to negligible runoff. None of these soils are subject to ponding, and only Rains may experience flooding. The Natural Resource Conservation Service (NRCS) considers the Muckalee, Rains, and Woodington soils to be hydric when undrained.

A detailed soil investigation of the site verified the existence of sandy soils similar to Muckalee throughout much of the floodplain on Muddy Creek and the floodplains along its tributaries. A soil similar to Rains was found at the headwaters of UT1 where wetland restoration is proposed. The investigation identified hydric soil indicators in areas in the lowest part of UT2. The common hydric soil indicators outside of the floodplain are S7-*Dark Surface*, S9-*Thin Dark Surface*, F3-*Depleted Matrix*, and F4-*Depleted Below Dark Surface*.

The cultivated fields appear to have sandy/sandy loam deposition or fill along the dredged channel, and the resulting buried horizons would meet hydric indicator criteria. The fill in these areas appears to be spoil from excavated channels combined with deposition resulting from cultivation practices higher in the landscape.

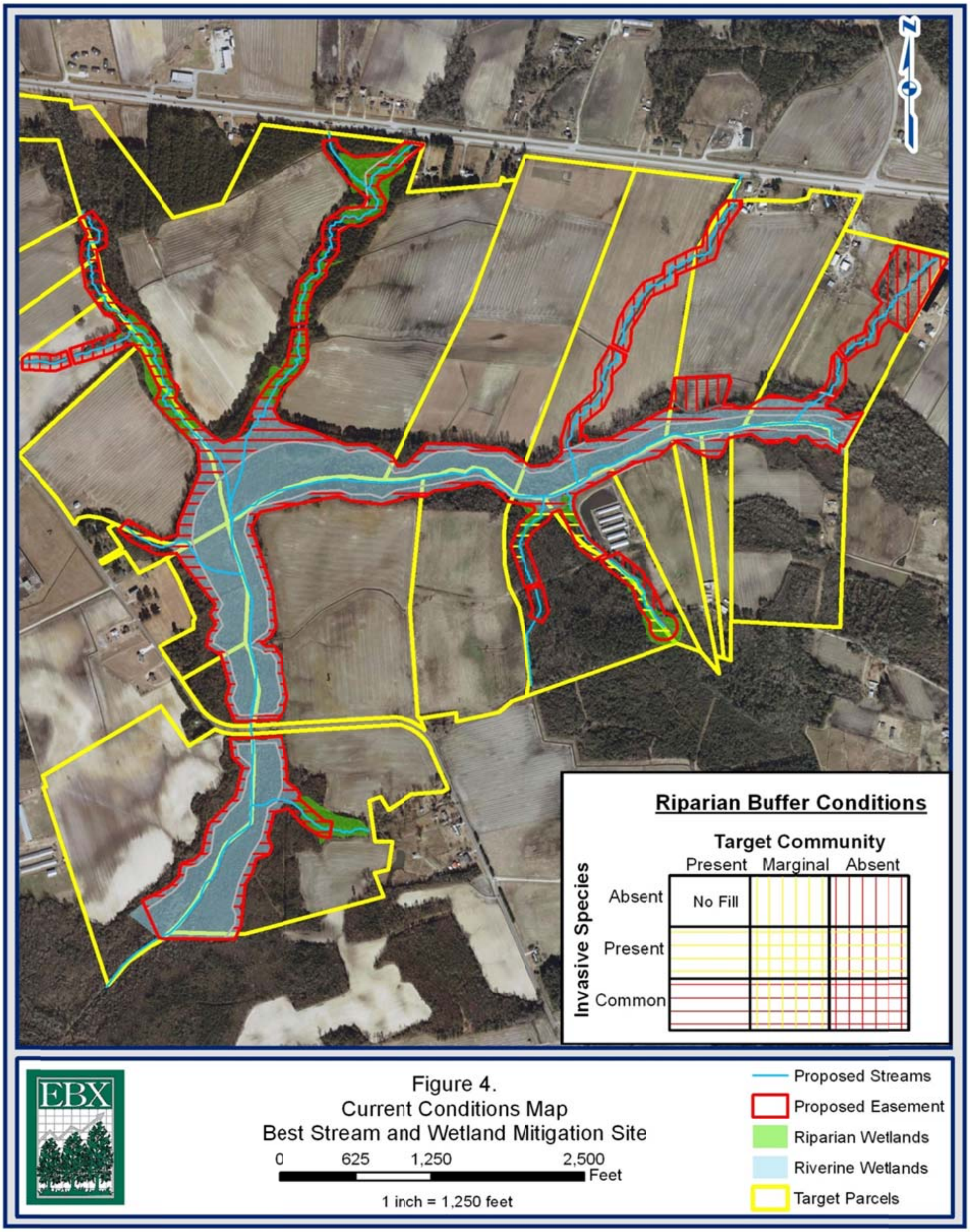
2.6 Project Site NRCS Soil Survey Map



Soil Symbol	Name
AuB	Autryville loamy fine sand, 0 - 6% slopes
GoA	Goldsboro loamy sand, 0 - 2% slopes
McC	Marvyn and Gritney soils, 6 -15% slopes
MkA	Muckalee loam, 0 - 1% slopes
M-W	Miscellaneous water
NbA	Noboco loamy fine sand, 0 - 2% slopes
NbB	Noboco loamy fine sand, 2 - 6% slopes
RaA	Rains fine sandy loam, 0 - 1% slopes
WoA	Woodington loamy fine sand, 0 - 1% slopes

Figure 3.
NRCS Soils Map
Best Stream and Wetland Mitigation Site

2.7 Project Site Current Condition Plan View



2.8 Project Site LIDAR

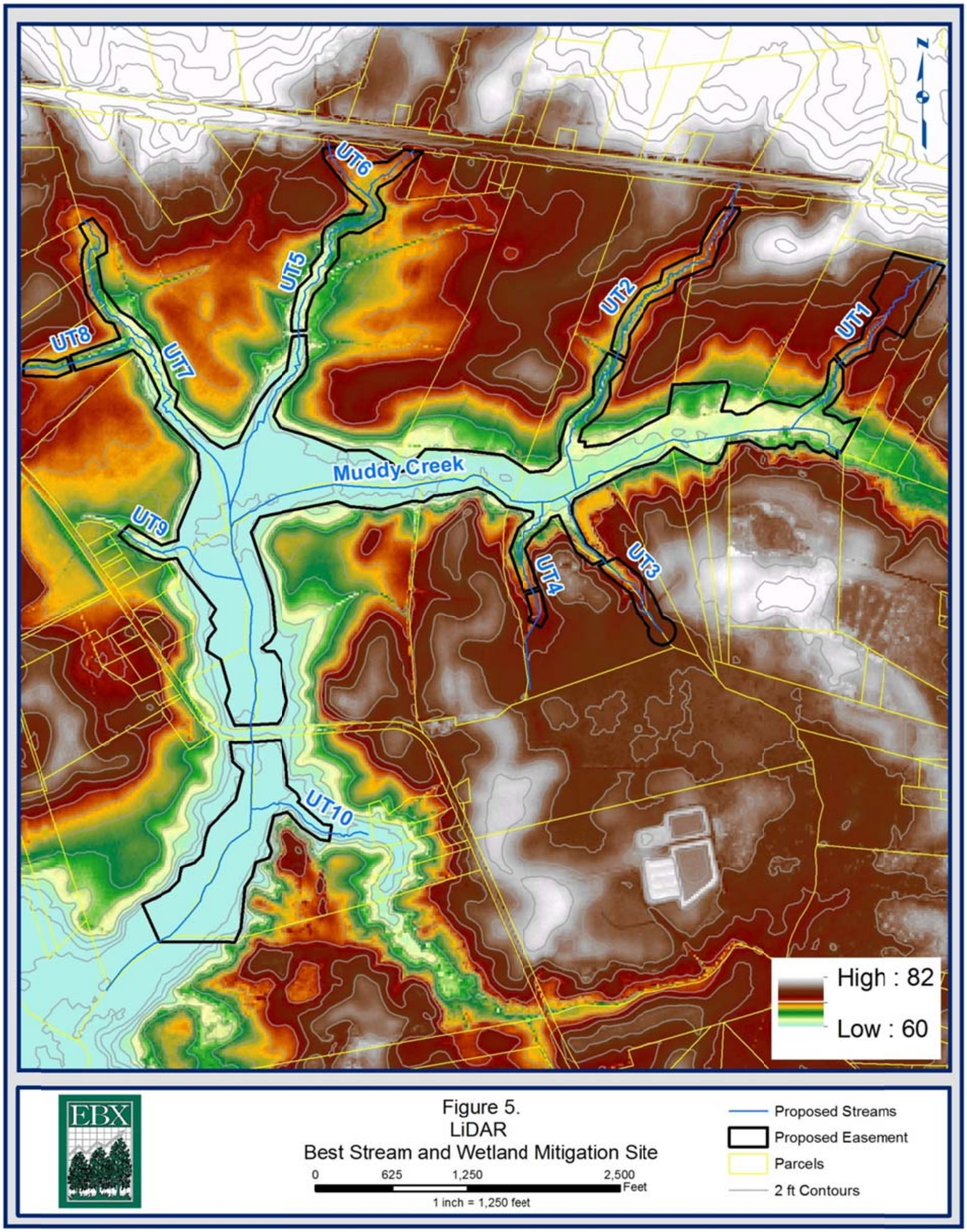


Figure 5.
LiDAR
Best Stream and Wetland Mitigation Site

2.9 Project Site Historical Condition Plan View

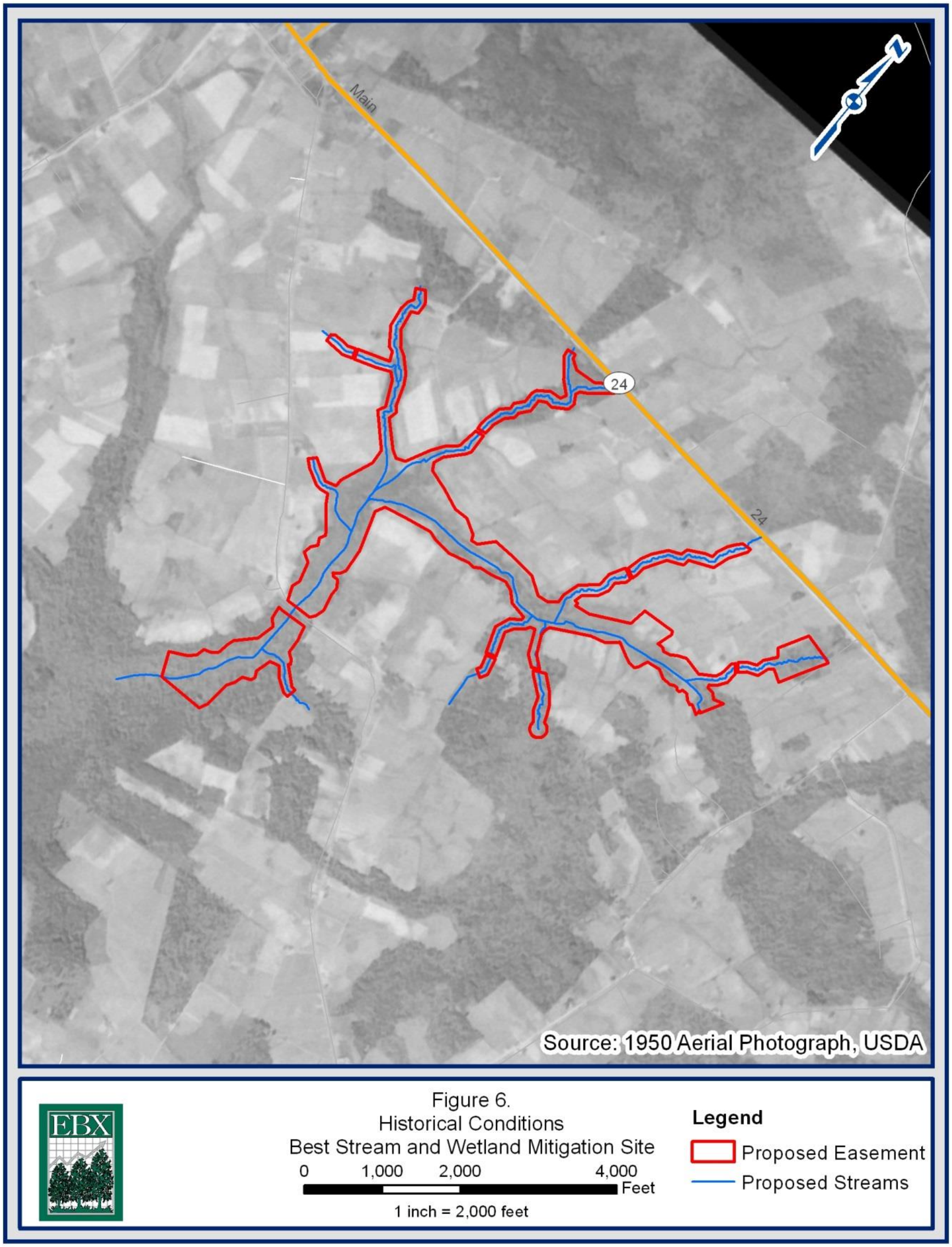


Figure 6.
Historical Conditions
Best Stream and Wetland Mitigation Site

2.10 Site Photographs

 Facing upstream on UT1. 6/28/2012	 Facing downstream on UT1. 6/28/2012
 Facing upstream on UT2. 6/27/2012	 Facing downstream on UT2. 6/27/2012
 Facing downstream on UT3; upstream of crossing. 6/28/2012	 Facing downstream on UT3; downstream of crossing. 6/28/2012

 Facing upstream on UT4; upstream of crossing. 6/28/2012	 Facing downstream on UT4; downstream of crossing. 6/28/2012
 Facing downstream on UT5. 8/2/2012	 Facing downstream on UT6. 8/2/2012
 Facing downstream on UT7. 8/1/2012	 Facing downstream on UT8. 8/1/2012


Facing upstream on UT9. 8/1/2012


Facing upstream on UT10. 8/2/2012


Facing downstream on Muddy Creek; upstream of Lyman Rd. 8/2/2012

3 SITE PROTECTION INSTRUMENT

3.1 Site Protection Instrument(s) Summary Information

The land required for the construction, management, and stewardship of this mitigation project includes portions of the following parcels. A copy of the land protection instrument(s) is included in the appendices.

Table 4. Project Parcel and Landowner Information

	Landowner	PIN	County	Site Protection Instrument	Deed Book and Page Number	Acreage Protected
Parcel A	Batts, Gerald T	347200520581	Duplin		1174@ 50	13.76
Parcel B	Batts, Gerald T	347200542344	Duplin		965@ 658	13.47
Parcel C	Clark, Emmett Ted	347200442322	Duplin		839@ 571	7.65
Parcel D	Edwards, Dexter Burl & Wife Pamela Edwards	347200743294	Duplin		1231@ 132	5.03
Parcel E	Edwards, Dexter Burl & Wife Pamela Edwards	347200644319	Duplin		1231@ 132	2.12
Parcel F	Edwards, Dexter Burl & Wife Pamela T. Edwards	347200747685	Duplin		950@ 90	4.14
Parcel G	Edwards, Dexter Burl & Wife Pamela T.Edwards	347200840796	Duplin		995@ 270	0.85
Parcel H	Edwards, Jonas Jefferson	347200844788	Duplin		1068@ 724	0.91
Parcel I	Edwards, Jonas Jefferson	347200843820	Duplin		1034@ 169	0.55
Parcel J	Lanier, Robert H.		Duplin			1.01
Parcel K	Miller, Joseph Craig Jr Etal	347209252506	Duplin		1302@ 55	3.42
Parcel L	Price, Jerry Linwood & Durwood Mckinley Price	347200560642	Duplin		1258@ 271	29.42
Parcel M	Quinn, Ruth Ann Rhodes	347200767766	Duplin		816@ 607	13.92
Parcel N	Sandlin, Isaac Jerome Jr (Farm)	347200356369	Duplin			6.09
Parcel O	Sharpe, Benny S & Wife Linda And Emmett Ted Clark	347200327543	Duplin		1006@ 754	8.34
Parcel P	Sharpe, Benny S & Wife Linda And Emmett Ted Clark	347200433660	Duplin		1006@ 754	3.08
Parcel Q	Smith, Patsy A	347200964488	Duplin		1159@ 484	12.38
Parcel R	Thigpen, Mary P.	347200867827	Duplin		98E@ 31	7.30
Parcel S	Whaley, Kathleen T	347200668774	Duplin		1083@ 701	5.34
Parcel T	Whaley, Kathleen T	347200266808	Duplin		957@ 536	0.55
Parcel U	Whaley, Kathleen T	347200267586	Duplin			0.97
Parcel V	Whaley, Ronald Kenneth & Wife Rachel K. Whaley	347200940919	Duplin		947@ 557	2.40
					TOTAL	**142.70**

When available, the recorded document(s) will be provided. If the recorded document(s) are not available, the template documents will be provided.

All site protection instruments require 60-day advance notification to the Corps and the State prior to any action to void, amend, or modify the document. No such action shall take place unless approved by the State.

3.2 Site Protection Instrument Figure

Site protection instrument figures will be provided as easement plats become available.

4 BASELINE INFORMATION

Table 5. Project Information

Project Name	Best Site Stream and Wetland Mitigation Project
County	Duplin
Project Area (acres)	142.7
Project Coordinates (latitude and longitude)	34° 54' 44.011" N

4.1 Watershed Summary Information

4.1.1 Drainage Area

The easement totals 142.7 acres and the project streams include ten unnamed tributaries to Muddy Creek and a portion of Muddy Creek extending from approximately 0.3 miles west of Edwards Road to 0.4 miles past Lyman Road. The total drainage area at the downstream limits of the project is 2,928 acres (4.58 mi^2). The land use in the project watershed is approximately 47 percent cultivated cropland, 21 percent evergreen and deciduous forest, 13 percent shrub/scrub, ten percent bottomland forest/hardwood swamp, three percent developed, and six percent managed herbaceous cover and pasture.

4.1.2 Surface Water Classification

The current State classification for the Best Site restoration reaches is undefined. Tributaries of the project run directly into Muddy Creek. Muddy Creek is defined as Class C S*w* (NCDWQ 2012a). Class C waters are suitable for aquatic life, secondary recreation, and agricultural usage. The *Sw* is a designation for swamp waters – waters that have low velocities and other natural characteristics that are different from adjacent streams. Muddy Creek is listed on the 2012 303d list for impaired waters (NCDWQ 2012b). It is impaired for aquatic use, receiving a Fair Bioclassification rating for benthic ecological/biological integrity.

Table 6. Project Watershed Summary Information

Physiographic Province	Outer Coastal Plain
River Basin	Cape Fear
USGS Hydrologic Unit 8-digit	03030007
USGS Hydrologic Unit 14-digit	03030007060010
DWQ Sub-basin	03-06-22
Project Drainage Area (acres)	2,928
Project Drainage Area Percentage of Impervious Area	6%
CGIA Land Use Classification	woody wetlands, emergent herbaceous wetlands, cultivated crops, evergreen forest

4.1.3 Endangered/Threatened Species

Plants and animals with a federal classification of endangered or threatened are protected under provisions of Sections 7 and 9 of the Endangered Species Act of 1973, as amended. Rare and protected species listed for Duplin County, and any likely impacts to the species as a result of the project construction, are discussed in the following sections.

The US Fish and Wildlife Service (USFWS) database (updated 22 September 2010) lists one endangered species for Duplin County, North Carolina: red-cockaded woodpecker

(*Picoides borealis*). The American alligator (*Alligator mississippiensis*) is listed as Threatened due to similarity of appearance, but is not protected. No protected species or potential habitat for protected species were observed during preliminary site evaluations.

In addition to the USFWS database, the NC Natural Heritage Program (NHP) GIS database was consulted to determine whether previously cataloged occurrences of protected species were mapped within one mile of the project site. Results from NHP indicate that there are no known occurrences within a one-mile radius of the project area. Based on initial site investigations, no impacts to federally protected species are anticipated as a result of the proposed project.

WK Dickson submitted a request to USFWS for review and comments on the proposed Best Site Stream Restoration Project on June 7, 2012 in regards to any potential impacts to threatened and endangered species. No response was received within a 30-day period; therefore, it is assumed that the initial determination of no effect to endangered and threatened species will result from the proposed project.

The proposed project offers some potential to improve or create suitable habitat for several Federal Species of Concern. Habitat may be improved or created for species that require riverine habitat by improving water quality, in-stream and near-stream forage, and providing stable conditions not subject to regular maintenance. Improved stream habitat may benefit American eel (*Anguilla rostrata*) and broadtail madtom (*Noturus* sp. cf. *leptacanthus*).

4.1.4 Cultural Resources

Cultural resources include historic and archeological resources located in or near the project area. WK Dickson completed a preliminary survey of cultural resources to determine potential project impacts. A review of the North Carolina State Historic Preservation Office GIS Web Service database did not reveal any listed or potentially eligible historic or archeological resources in the proposed project area. No architectural structures or archeological artifacts have been observed or noted during surveys of the site for restoration purposes. In addition, the majority of the site has historically been disturbed due to agricultural practices and channel modifications.

WK Dickson submitted a request to the NC State Historic Preservation Office (SHPO) to search records to determine the presence of any areas of architectural, historic, or archaeological significance that may be affected by the Best Site Stream Restoration Project on June 7, 2012. In a letter dated July 3, 2012 (**Appendix B**), the SHPO stated that they had "conducted a review of the project and are aware of no historic resources which would be affected by the project."

4.2 Reach Summary Information

The project area is comprised of a single large easement area along Muddy Creek and ten tributaries. The easement along Muddy Creek is separated by Lyman Road. The eastern portion of the project originates approximately 0.3 miles west of Edwards Road and includes the upstream portion of Muddy Creek and its tributaries UT1 and UT2 flowing from the north and UT3 and UT4 flowing from the south. The western portion of the project is located southeast of the intersection of NC HWY 24 and Lyman Road and terminates approximately 0.4 miles south of Lyman Road. This area includes the lower section of Muddy Creek and its tributaries; UT5, UT6, UT7, UT8, UT9, and UT10.

Best Site stream channels include unnamed tributaries to Muddy Creek. Muddy Creek ultimately flows into the Northeast Cape Fear River (**Figure 1**). The Best Site Mitigation Site is located in a FEMA mapped floodzone (**Figure 10**), but all restoration is proposed outside of the mapped floodzone. Invasive control and stabilization will be performed in select segments of the project, including portions of the floodzone. NCDWQ Stream Classification Forms and USACE Stream Quality Assessment Worksheets were completed at representative locations throughout the project area and are included in **Appendix B**. Results of the preliminary data collection are presented in **Figure 4**, **Table 7** and **Table 8** below, and the Stream Morphology Table in **Appendix B**.

Reach UT1 is an oversized perennial ditch with moderately unstable banks that discharges to the north side of Muddy Creek near the upstream end of the project. The upper section flows through an active cow pasture, while the downstream section is surrounded by agricultural fields. UT1 lacks a forested buffer and banks.

Reach UT2 is a channelized and oversized perennial ditch that discharges along the north side of Muddy Creek near the upstream end of the project. The channel exhibits moderately unstable banks, and agricultural production occurs up to the top of bank. The bedform diversity is low and the buffer is devoid of appropriate hardwood vegetation.

Reach UT3 is a headwater system that originates along the south side of Muddy Creek near the upstream end of the project. This perennial channel is dimensionally stable, but is impacted by direct cattle access in the upper reach and an adjacent hog waste lagoon on the right bank of the lower reach. The riparian buffer is well vegetated along the left bank and is sparse along the right. Undergrowth is sparse throughout due to cattle access.

Reach UT4 is an oversized perennial ditch with moderately unstable banks that discharges to the south side of Muddy Creek near the upstream end of the project. This channel has been significantly altered by ditching and agricultural activities, moving the channel west from the historic valley.

Reach UT5 is a stable, perennial channel throughout the proposed project and provides a variety of aquatic habitats. The project channel begins at NC HWY 24 and discharges to Muddy Creek near the middle of the project area. The riparian buffer is an intact hardwood forest with few localized areas of dense privet.

Reach UT6 is a perennial channel impaired by channelization. The banks are vertical and un-vegetated, and the buffer is comprised of mature vegetation and a dense privet understory. The project channel flows southeast from NC HWY 24 to the confluence with UT5.

Reach UT7 is a stable, perennial channel throughout the proposed project area and provides a variety of aquatic habitats. The buffer is intact and stable, dominated by hardwoods with a few localized areas of dense privet. The project channel begins at NC HWY 24 and discharges to Muddy Creek near the middle of the project area.

Reach UT8 is a perennial channel impaired by channelization to promote agricultural activities. The channel is oversized, exhibits localized bank instability, and cleared agricultural land in the buffer up to top of bank for the majority of the reach. The project channel flows east from an agricultural crossing to the confluence with UT7.

Reach UT9 is a perennial, channelized stream, but is stable throughout the proposed easement. The active channel is meandering within the larger excavated channel bottom. The riparian buffer is intact hardwood forest with localized areas of privet. The project channel begins at a culvert outlet east of Lyman Road and discharges to Muddy Creek near the middle of the project area.

Reach UT10 is a perennial channel that is stable throughout the proposed easement and provides a variety of aquatic habitats. The riparian buffer is intact hardwood forest. The project channel flows west from an agricultural crossing to the confluence with Muddy Creek near the downstream end of the project area.

Muddy Creek is a stable swamp stream system (perennial) with an intact hardwood forest floodplain that provides diverse terrestrial and aquatic habitats. The existing channels are highly variable in size due to numerous branching channels and relic beaver impoundments. There are limited areas of buffer encroachment and invasive species (privet). The project channel flows west from an agricultural crossing to the confluence with Muddy Creek near the downstream end of the project area.

In general, all or portions of UT1, UT2, UT3, UT4, UT6, and UT8 do not function to their full potential. Having been channelized in the past and/or ditched to drain nearby fields for agricultural activities, the streams do not access their floodplains as frequently as they naturally would have prior to farming operations. In most cases, these streams are hydraulically unstable, and are devoid of bedform diversity. Habitat along the majority of the restoration reaches is poor in that there is little woody debris or overhanging vegetation for fish cover or protection for other aquatic species. Vegetative and habitat diversity is poor along the reaches, as well, and offers little benefit to the wildlife in the area. Site photographs and morphological parameters are located in **Appendix B**.

Table 7. Summary of Existing Channel Characteristics

Reach	Drainage Area (ac)	A_{BKF} [1] (ft^2)	Width (ft)	Mean Depth (ft)	Width:Depth Ratio	Sinuosity	Slope (ft/ft)
UT1	41	3.2	5.1	0.6	8.1	1.04	0.0066
UT2	146	4.6	4.8	1.0	5.0	1.02	0.0044
UT3	59	9.1	10.1	0.9	11.2	1.07	0.0093
UT4	82	6.2	7.5	0.8	9.1	1.13	0.0042
UT5	380	6.0	11	0.5	20.2	1.14	0.0040
UT6	79	4.3	5.1	0.8	6.2	1.05	0.0012
UT7	387	6.1	10.1	0.6	16.7	1.20	0.0040
UT8	56	4.9	9.5	0.5	18.2	1.06	0.0029
UT9	36	3.6	6.5	0.6	11.8	1.06	0.0080
UT10	306	7.8	13.7	0.6	24.0	1.06	0.0040
Muddy Creek	2930	21.2	15.7	1.4	11.6	1.09	0.0011

[1] A_{BKF}= cross-sectional area (measured at approximate bankfull stage as estimated using existing conditions data and NC Regional Curve equations where field indicators were not present)

Table 8. Reach Summary Information

Parameters	UT1	UT2	UT3	UT4	UT5	UT6	UT7	UT8	UT9	UT10	Muddy Creek
Length of reach (linear feet)	1,854	2,861	1,522	1,189	4,086	593	3,183	1,138	1,171	1,096	9,214
Valley Classification	X	X	X	X	X	X	X	X	X	X	X
Drainage area (acres)	41	146	56	82	380	79	387	56	36	306	2930
NCDWQ stream identification score	32.50	31.50	33.00	33.75	36.75	30.50	38.50	30.50	32.00	34.00	43.25
NCDWQ Water Quality Classification	N/A	C Sw	N/A	N/A	C Sw	N/A	C Sw	N/A	N/A	C Sw	C Sw
Morphological Description (stream type)	G5c	G5c	E5	G5c/E5	C5	E5	C5	F5	E5	C5	E5
Evolutionary trend	Stage II	Stage II	Stage VI	Stage II/VI	Stage I	Stage II	Stage I	Stage II	Stage VI	Stage VI	Stage VI
Underlying mapped soils	GoA MkA NbB RaA	AuB McC MkA NbA NbB	McC MkA NbB	McC MkA NbB	MkA NbB	NbA NbB	McC MkA NbB	McC NbA NbB	McC MkA	McC MkA	McC MkA
Drainage class	well; mod. well; poorly	well; poorly	well; poorly	well; poorly	well; poorly	well	well; poorly	well	well; poorly	well; poorly	well; poorly
Soil Hydric status	Hydric	Hydric	Hydric	Hydric	Hydric	Not hydric	Hydric	Hydric	Hydric	Hydric	Hydric
Slope	0.66%	0.44%	0.93%	0.42%	0.40%	0.12%	0.40%	0.29%	0.80%	0.40%	0.11%
FEMA classification	N/A	N/A	N/A	N/A	AE (high risk)	N/A	AE (high risk)	N/A	AE (high risk)	AE (high risk)	AE (high risk)
Native vegetation community	pasture, cultivated	cultivated	pasture	mixed hardwood forest	mixed hardwood forest	mixed hardwood forest	mixed hardwood forest	cultivated	mixed hardwood forest	mixed hardwood forest	mixed hardwood forest
Percent composition of exotic invasive vegetation	<5	<5	5	15	55	45	65	<5	15	20	5-85*

*Exotic invasive species are concentrated within a 50- to 100-foot fringe on the outer edges of Muddy Creek's wide flood plain.

4.2.1 Channel Classification

The streams have been classified as intermittent and perennial streams using the NCDWQ Stream Identification Form version 4.11 (**Appendix B**) and are a mix of E5, C5, G5c, or F5 stream types as classified using the Rosgen stream classification system (Rosgen, 1994). The design reaches have been separated into eleven distinct sections that are described in **Section 4.2.3**. Channel characteristics are summarized in **Table 7**, **Table 8**, and **Appendix B**.

4.2.2 Discharge

Estimating flows (discharge) for the Best Site is difficult due to the existing network of ditches and low, depressional areas located throughout the site. Several models, regression equations, and the Coastal Plain regional curves were used to develop existing discharges. Land use and slope were considered when the discharge calculations were developed. All hydraulic and hydrologic analyses are discussed in **Section 7.3.1**. Data and analysis of the hydrologic and hydraulic models are included as **Appendix C**.

4.2.3 Channel Morphology

4.2.3.1 UT1

Downstream view of UT 1.

UT1 has a drainage area of 0.06 square miles (41 acres), and flows in a southerly direction through cultivated fields and pasture to the confluence with Muddy Creek. The planform of this G-type channel is generally straight and is entrenched throughout. The approximate bankfull cross-sectional area is 3.2 square feet with approximate dimensions of 5.1 feet wide and 0.6 feet deep, while the cross-sectional area of the channel at top of bank is 22.8 square feet. The existing length of UT1 is 1,854 linear feet, and the dominant bed material is fine sand. The gradient of the reach is approximately 0.0066 ft/ft. The reach is severely oversized and exhibits moderately unstable banks. The riparian buffer is primarily comprised of pasture grasses with some shrubby vegetation growing within the channel. The channel scored 32.5 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.2 UT2

UT2 is a significantly oversized perennial channel located in a cultivated field. The reach is approximately 2,861 linear feet, and flows south to its confluence with Muddy Creek. It has a drainage area of 0.23 square miles (146 acres). UT2, a G-type channel, is typically 4.8 feet wide and 1.0 feet deep near bankfull, and 16.5 feet wide with a max depth of 4.0 feet at top of bank. The approximate bankfull cross sectional area is 4.6 square feet. The existing slope of UT2 is 0.0044 ft/ft, and the dominant bed material is fine sand. The channel scored 31.5 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.3 UT3

UT3 is located to the south of Muddy Creek, opposite of UT2, and flows to the north and into Muddy Creek. This reach has a drainage area of 0.09 square miles (56 acres). Widths range from 2.6 feet along the upper segment that exhibits characteristics of a headwater system, to 9.8 feet along the lower end where there is a well-defined single thread channel. The existing cross-sectional area changes from approximately 1.6 square feet upstream, to 8.1 square feet downstream. The existing slope is 0.0093 ft/ft and is classified as an E/C5 stream type with an existing length of 1,522 linear feet. The buffer is impacted along the entire reach; cattle have access to the upper end, and there is a hog waste lagoon adjacent to the right bank along the lower end. The banks are stable, and mature hardwood vegetation is present along the left bank. The channel scored 33 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.4 UT4

UT4 is a stable to moderately stable channel located to the west of UT3 and discharges to Muddy Creek. This reach has a drainage area of 0.13 square miles (82 acres) and has a slope of 0.0042 ft/ft. The upstream of a farm crossing has been significantly altered by ditching and agricultural activities. The historic valley is present, but has been hydrologically isolated from the contributing watershed by ditching. In addition, cattle access has led to habitat degradation and sediment input to the downstream channel. This section is a G-type channel and has an approximate bankfull cross-sectional area of 6.4 square feet and an area of 26.8 square feet at top of bank.

Downstream view of UT4.

The channel downstream of the crossing is relatively stable and exhibits a meandering pattern. UT4 has a fine sand bed and is an E5 stream type downstream of the culvert. The channel is typically 7.5 feet wide and 1.0 foot deep. Due to the stable nature of the downstream reach of UT4, Stream Preservation and Buffer Enhancement is proposed from just downstream of the crossing to the confluence with Muddy Creek. Headwater Valley Restoration is proposed upstream of the crossing. The channel scored 33.75 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.5 UT5

UT5 is a stable, meandering channel that flows in a southerly direction from NC HWY 24 to Muddy Creek. UT5 has a drainage area of 0.59 square miles (380 acres) and has an existing length 4,086 linear feet. The riparian buffer is comprised of an intact hardwood forest with localized areas of privet, and provides a variety of aquatic and terrestrial habitats. The reach is a C5 stream type, has an average cross-sectional area of 6.0 square feet, and a slope of 0.0040 ft/ft. The channel scored 36.75 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.6 UT6

UT6 is a straightened, oversized perennial channel located adjacent to a cultivated field. The reach is approximately 593 linear feet, and flows southeast to its confluence with UT5. It has a drainage area of 0.12 square miles (79 acres). UT6, a G-type channel, is typically 5.1 feet wide and 1.2 feet deep near bankfull, and 9.3 feet wide with a max depth of 1.7 feet at top of bank. The approximate bankfull cross sectional area is 4.3 square feet. The existing slope of UT6 is 0.0012 ft/ft, and the dominant bed material is fine sand. The existing channel is characterized by vertical un-vegetated banks and a dense privet understory within the forested buffer. The channel scored 30.5 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.7 UT7

UT7 is a stable, meandering channel that flows in a southerly direction east of Lyman Road down to its confluence with UT5 before discharging to Muddy Creek. UT7 has a drainage area of 0.60 square miles (387 acres) and has an existing length 3,183 linear feet. The riparian buffer is comprised of an intact hardwood forest with localized areas of privet and provides a variety of aquatic and terrestrial habitats. The reach is a C5 stream type, has an average cross-sectional area of 6.1 square feet, and a slope of 0.0040 ft/ft. The channel scored 38.5 points on the NCDWQ Stream Identification Form (Version 4.11).

Downstream view of UT7.

4.2.3.8 UT8

UT8 has a drainage area of 0.09 square miles (56 acres), and flows in an easterly direction through a cultivated field east of Lyman Road down to the confluence with UT7. This reach has previously been straightened and enlarged and is a G-type channel. The approximate bankfull cross-sectional area is 4.9 square feet with approximate dimensions of 9.5 feet wide and 0.7 feet deep, while the cross-sectional area of the channel at top of bank is 29.0 square feet. The existing length of UT8 is 1,138 linear feet, and the dominant bed material is fine sand. The gradient of the reach is approximately 0.0029 ft/ft. The reach is severely oversized and exhibits moderately unstable banks. The riparian buffer is primarily comprised cleared agricultural land. The channel scored 30.5 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.9 UT9

UT9 is a stable, channelized channel located just east of a small residential area and adjacent to a cultivated field. The reach is approximately 1,171 linear feet, and flows southeast to its confluence with Muddy Creek. It has a drainage area of 0.06 square miles (36 acres). UT9, a E/C-type channel, is typically 6.5 feet wide and 1.1 feet deep with a cross-sectional area of 3.6 square feet. The gradient of the reach is approximately 0.0080 ft/ft. The active channel is meandering within the larger excavated channel bottom, and the riparian buffer is an intact hardwood forest with localized areas of privet. The channel scored 32 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.10 UT10

UT10 is the downstream-most tributary within the Best Site and flows in a westerly direction from a farm crossing west of Lyman Road down to Muddy Creek. UT10 has a drainage area of 0.48 square miles (306 acres) and has an existing length 1,096 linear feet. The riparian buffer is comprised of a mature hardwood forest that provides a variety of aquatic and terrestrial habitats. The reach is a C5 stream type, has an average cross-sectional area of 7.8 square feet, and a slope of 0.0040 ft/ft. The channel scored 34 points on the NCDWQ Stream Identification Form (Version 4.11).

4.2.3.11 Muddy Creek

Muddy Creek is a stable swamp stream system with intact hardwood forest floodplain, extending from approximately 0.3 miles west of Edwards Road to 0.5 miles south of Lyman Road. Muddy Creek has a drainage area of 4.6 square miles (2,930 acres) at the downstream limits and has an existing length of 9,214 linear feet. The gradient of the reach is approximately 0.0011 ft/ft. The existing channels are highly variable in size due to numerous branching channels and relic beaver impoundments. The channel displays characteristics of either E5 or C5 stream types, except where beaver impacts are present. The Muddy Creek floodplain is a swamp complex composed of many side channels, relic beaver impoundments, and high quality riverine wetlands. There are a limited number of areas of buffer encroachment and invasive species (privet) along the riparian corridor. The channel upstream of the confluence with UT5 scored 43 points on the NCDWQ Stream Identification Form (Version 4.11) and scored 43.5 points downstream of UT5.

4.2.4 Channel Stability Assessment

A modified version of the channel stability assessment method (CSA) provided in "Assessing Stream Channel Stability at Bridges in Physiographic Regions" by Johnson (2006) was used to assess channel stability for the Best Site existing channels and reference reach. This method may be rapidly applied on a variety of stream types in different physiographic regions having a range of bed and bank materials.

The original CSA method was designed to evaluate thirteen stability indicators in the field. These parameters are: watershed characteristics, flow habit, channel pattern, entrenchment/channel confinement, bed material, bar development, presence of obstructions/debris jams, bank soil texture and coherence, average bank angle, bank vegetation/protection, bank cutting, mass wasting/bank failure, and upstream distance to bridge. As this method was initially developed to assess stability at bridges, a few minor adjustments were made to remove indicators that contradict stability characteristics of natural channels in favor of providing hydraulic efficiency at bridges. First, the "channel pattern" indicator was altered such that naturally meandering channels scored low as opposed to straightened/engineered channels that are favorable for stability near bridges. Secondly, the last indicator, "upstream distance to bridge," was removed from the assessment as bridges are not a focus of channel stability for this project. Lastly, the "bed material" indicator was removed since all project streams are sand bed channels and would subsequently score high (poorly), as this indicator focuses on coarse substrate. The eleven indicators were then scored in the field, and a rating of excellent, good, fair, or poor was assigned to each project reach based on the total score. (See **Appendix B** for the CSA field form.)

The CSA results (scores and ratings) for the Best Site project and reference reaches are provided in **Table 9**. Project Reaches UT1, UT2, UT3, UT4, UT6, and UT8 all received "Fair" ratings, while Reaches UT5, UT7, UT9, UT10, and Muddy Creek received a "Good" rating. Overall, the existing project streams appear to be physically stable as there is little active erosion present; however, all channels proposed for either restoration or Enhancement Level I have been straightened and entrenched, and some are actively maintained. These characteristics are reflected in the poor CSA scores for channel pattern and bank vegetation/protection. Most reaches scored poorly for watershed characteristics since the surrounding land use is dominated by agriculture activities or recent clear cutting up to top of bank (**Figure 4**).

Table 9. Channel Stability Assessment Results

		UT1	UT2	UT3	UT4 HWV	UT4 Pres	UT5	UT6	UT7	UT8	UT9	UT10	MC	Ref Reach
1	Watershed characteristics	11	10	11	10	10	11	11	7	10	10	11	10	4
2	Flow habit	7	7	10	8	7	7	7	5	6	4	6	3	1
3	Channel pattern	10	10	3	10	3	4	10	3	8	2	7	1	2
4	Entrenchment/channel confinement	7	8	3	10	8	3	7	2	8	2	2	2	1
5	Bed material	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
6	Bar development	10	2	10	10	11	5	9	4	8	3	5	2	1
7	Obstructions/debris jams	3	2	9	3	5	6	3	5	2	4	4	2	5
8	Bank soil texture and coherence	10	10	7	10	11	11	11	7	10	10	9	11	3
9	Average bank angle	10	10	10	10	11	2	11	6	10	9	5	7	4
10	Bank vegetation/protection	10	11	7	5	5	6	3	6	9	7	3	2	4
11	Bank cutting	8	6	5	8	7	4	5	6	6	5	4	2	2
12	Mass wasting/bank failure	3	6	6	6	7	3	3	4	4	3	4	1	3
13	Upstream distance to bridge	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
	Score	**85**	**82**	**81**	**90**	**82**	**62**	**80**	**55**	**81**	**59**	**60**	**43**	**30**
	Rating*	**Fair**	**Fair**	**Fair**	**Fair**	**Fair**	**Good**	**Fair**	**Good**	**Fair**	**Good**	**Good**	**Good**	**Excellent**

*****Excellent (0 < Score <= 33), Good (33 < Score <= 66), Fair (66< Score <= 99), Poor (99 < Score <= 132)

4.2.5 Bankfull Verification

Bankfull is difficult and often times impossible to accurately identify on actively maintained channels and agricultural ditches. The usual and preferred indicators rarely exist, and other factors may be taken into consideration in order to approximate a bankfull stage. Other factors that may be used are wrack lines, vegetation lines, scour lines, or top of a bankfull bench; however, complete confidence should not be placed on these indicators. Along the proposed restoration and enhancement reaches, the channel is generally entrenched and actively maintained, which means bankfull indicators were very limited or non-existent. Therefore, bankfull stage was estimated by using Coastal Plain Regional Curves and other hydrologic analyses, existing cross-sections, and in-house spreadsheets to estimate bankfull area and bankfull discharge.

4.2.6 Vegetation

Current land use around the project is primarily agricultural and forestry. Land use immediately surrounding the project consists of CAFOs, livestock grazing, row crop production, and forestry. The CAFOs consist of 11 active hog houses. There are two lagoons storing waste upslope of the project area and a single lagoon immediately adjacent to one proposed restoration reach. The remaining channels are adjacent to cultivated fields, active pasture, or disturbed forested areas. The channels have been straightened and dredged in the past to promote drainage. Ditches have been constructed to remove surface water.

Areas in actively managed pasture appear to be Bermuda or similar perennial warm season grass over seeded with a cool season grass. The cultivated fields are cotton, corn and soybeans. Many of the cultivated fields in the project area are alternated annually between corn and soybeans. The actively managed hay fields appear to be Bermuda or similar perennial warm season grass over-seeded with a cool season grass. The upland forested community is young, mixed pine-hardwood forest. Areas at higher elevations are typically dominated by loblolly pine (*Pinus taeda*) and have a dense understory. Lower and wetter landscapes have a forest of mixed loblolly pine and hardwoods or are predominately hardwoods. The hardwood species include willow oak (*Quercus phellos*), laurel oak (*Quercus laurifolia*), tulip poplar (*Liriodendron tulipifera*), green ash (*Fraxinus pennsylvanica*), American elm (*Ulmus Americana*), and sweet gum (*Liquidambar styraciflua*). A mid-story layer is comprised of water oak (*Quercus nigra*), tulip poplar, red maple (*Acer rubrum*), and swamp chestnut oak (*Quercus michauxii*). Shrubs and woody vines are locally dense and include sweet bay (*Magnolia virginiana*), redbay (*Persea borbonia*), American holly (*Ilex opaca*), large gallberry (*Ilex coriacea*), wax myrtle (*Morella cerifera*), muscadine (*Vitis rotundifolia*), roundleaf greenbrier (*Smilax rotundifolia*), and swamp greenbriar (*Smilax laurifolia*). Some exotics were noted, including Chinese privet (*Ligustrum sinense*) and Japanese honeysuckle (*Lonicera japonica*). The common herbaceous plants observed are giant cane (*Arundinaria gigantea*), smallspike false nettle (*Boehmeria cylindrical*), netted chainfern (*Woodwardia areolata*), lizard's tail (*Saururus cernuus*), and cinnamon fern (*Osmunda cinnamomea*). All naturally vegetated areas were classified by their community type, and their boundaries were approximately located on field maps (**Figure 9**). Detailed observations of vegetation species, soils, and hydrology were recorded in each community type. **Table 10** describes each natural community.

Table 10. Natural Community Summary

Existing Land Use	Percent of Study Area	Natural Community (Schafale and Weakley Community)
Agriculture – Development	< 1	NA
Agriculture – Row Crops	7	NA
Agriculture – Pasture/Hayfields	6	NA
Bottomland Hardwood Forest	80	Coastal Plain Bottomland Hardwoods (Blackwater Subtype)
Concentrated Animal Feeding Operation	< 1	NA
Mixed Pines/Hardwoods	7	Mesic Mixed Hardwood Forest-Coastal Plain
Pine Plantation	< 1	NA
Residential	< 1	NA

4.2.7 Quantitative Habitat Assessment

A quantitative habitat assessment was performed in November 2011 on the reference reach and in June 2012 for existing Best Site Reaches UT1 and UT2 to measure the volume of woody debris and fish cover. These data were used to establish a baseline for measuring functional uplift and to determine the placement and volume of woody debris in the design reaches. The total available woody debris (not buried) in the design reaches exceeds the reference reach on a per linear foot basis. In addition, surveys conducted pre- and post-construction in the restoration reaches will enable EBX to quantify habitat gains over time.

The length of each sample reach was thirty to forty times the base-flow wetted width of the channel with a minimum reach size of 150 feet. The sample reach was divided into ten transects spaced evenly over the entire reach. Transect length was five feet upstream and five feet downstream of the transect midpoint, and extend the full width of the channel. Parameters measured at each transect were small woody debris (SWD), fish cover, substrate material, and riparian composition. At each transect, the channel bed form was noted and an average width and depth recorded. The following is an analysis of the habitat assessment data.

4.2.7.1 Small Woody Debris Methods and Results

Small woody debris was measured at the reference reach in order to design SWD habitat structures similar to those found in the reference reach (**Appendix B**). SWD greater than 0.2 inches in diameter were measured in each reference reach transect. Large woody debris was eliminated from analysis since these are analogous to structures such as log vanes and log toes currently applied to most restoration designs.

Transects were identified as either shallow or pool bed form types resulting in three pools and ten shallows measured at the reference reach. Measurements of SWD were summed for each bed form type and divided by the number of corresponding transects to get the average volume of SWD per pool or shallow. The average volume was then divided by the average transect area to get the volume of SWD per square foot. The average design reach bed form area was calculated by assuming a length of ten feet (based on reference transects) and multiplying that by the average bottom cross section width. The average volume was multiplied by the ratio of average reference reach transect area to the average area in the design reach to obtain the volume of SWD to be installed at each fixed pool and at select locations along the design shallows.

WK Dickson currently uses wattles, dead brush, and woody debris bundles in the design of restoration channels. Based on the reference reach SWD analysis, these SWD structures will be concentrated in pool habitats and throughout shallows in volumes and size classes similar to those found in the reference reach. Wattles are woody branch structures tied together and embedded into the bank so that the free ends stick out into the wetted channel. Dead brush structures are shrub or tree tops that are anchored to the bottom of the channel. Woody debris bundles are bundles of sticks one to four inches in diameter and one to four feet long that are anchored to the streambed. Although root wads serve as bank stability structures, they also provide a significant amount of SWD volume to the restoration reach. The average volume of each SWD structure is presented in **Table 11**. A combination of structures listed in **Table 11** will be used in the design to attempt to achieve the calculated average volume per bed form type listed in **Table 12**.

Table 11. Average volume (cubic inches) of SWD structures used in the design reach.

SWD	Average Volume
Woody Debris Bundle	509
Dead Brush	589
Wattle	42
Root Wad	562
Leaf Pack	120

Table 12. Small Woody Debris calculations for the reference and design reach.

Channel bed form	Total volume (in^3)	Average volume in reference reach (in^3)	Percent of WD	Average volume to be applied to design Reach 1 per 10 LF of channel (in^3)	Average volume to be applied to design Reach 2 per 10 LF of channel (in^3)
Shallow	3219	460	39%	453	712
Pool	5115	1705	61%	1175	1743
Total	8334	2165	100%	1628	2455

In addition to the habitat assessment conducted at the reference site, Reaches UT1 and UT2 of the project site were assessed in order to measure representative habitat gains over time post-construction. Based on these assessments, there is a large disparity of SWD volume between the reference reach and the design reaches (**Chart 1**). Small woody debris assessment results for Reaches UT1 and UT2 were very low compared to the reference reach results. Due to Reaches UT1 and UT2 flowing through open agricultural fields, no adjacent buffers are present to contribute woody debris. The only woody debris present is washed in from upstream.

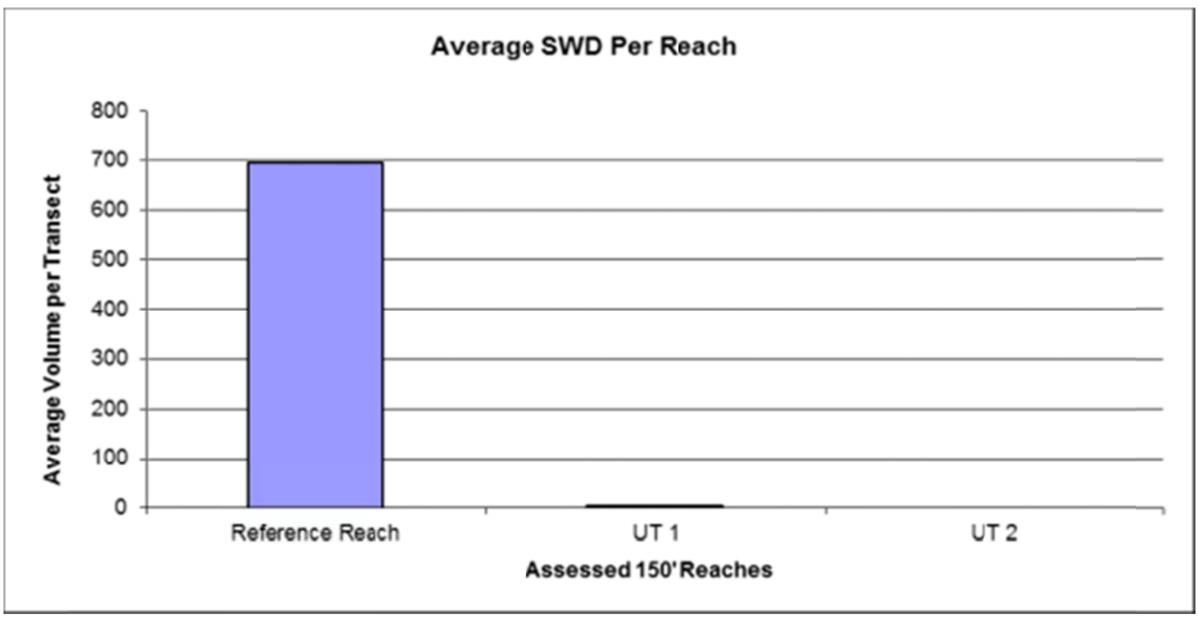


Chart 1. Average volume (cubic inches) of SWD per assessed reach. This chart represents existing conditions in all assessed reaches.

Woody debris collected in streams provides habitat for macroinvertebrates, fish, and amphibians, and increases stream productivity by retaining carbon in the channel. While it would be difficult to replicate the volume and spatial distribution of SWD found in the reference channel, this quantitative habitat assessment provides guidance for improving habitat conditions through specifically placed and sized SWD structures, and provides a means for assessing functional gains over time. WK Dickson has included these structures in the design plans (**Appendix D**).

4.2.7.2 Fish Cover Methods and Results

Fish cover measurements were taken at each transect along the reference reach and Best Site Reaches UT1 and UT2. Fish cover area was visually calculated within the ten-foot transect length. Fish cover types include small woody debris and brush, aquatic macrophytes, overhanging vegetation, undercut banks, and boulders. For each transect a percentage of total fish cover and individual cover type areas were calculated (**Chart 2**). Location and general habitat data was recorded for each fish cover measurement to assess spatial distribution.

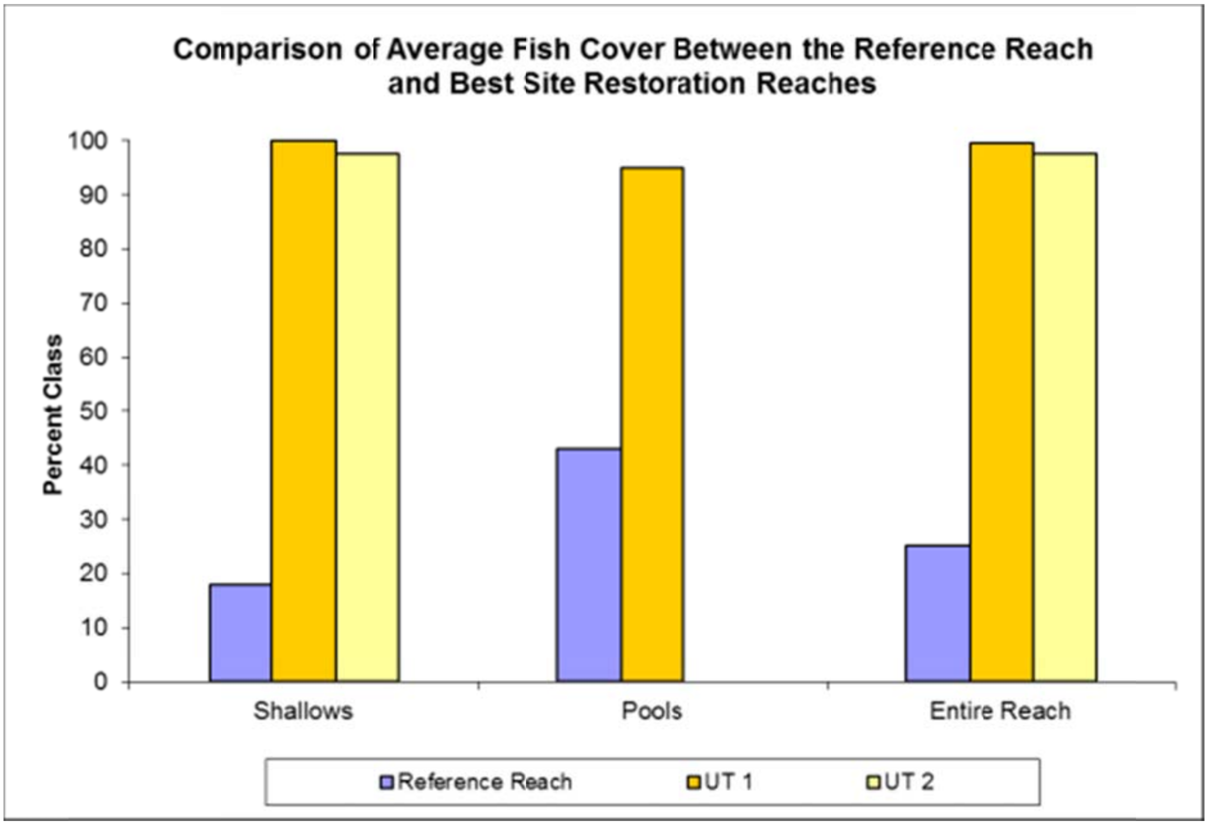


Chart 2. Average percent of fish cover per channel bed form type in the reference reach

The fish cover analysis revealed that the average area of fish cover is nearly four times as high in Best Site Reaches UT1 and UT2 as in the reference reach. This is because the streambed along the assessed portion of Reach UT1 and UT2 was mostly covered by macrophytic vegetation and was devoid of any significant woody debris or undercut banks. Fish cover from low growing brush will increase in the restoration reaches after the riparian planting occurs. Woody debris structures will also provide additional fish cover habitat and resting areas for fish swimming upstream.

4.2.7.3 Substrate Composition

Substrates were divided into eight classes as follows: coarse/fine particulate organic matter, silt/clay/muck, fine sand, coarse sand, gravel, cobble, boulder, and bedrock (**Chart 3**). Channel width and water depth were measured at each transect in four equally spaced intervals from bank to bank. Substrate coverage was visually determined between widths measured at each major change in substrate type.

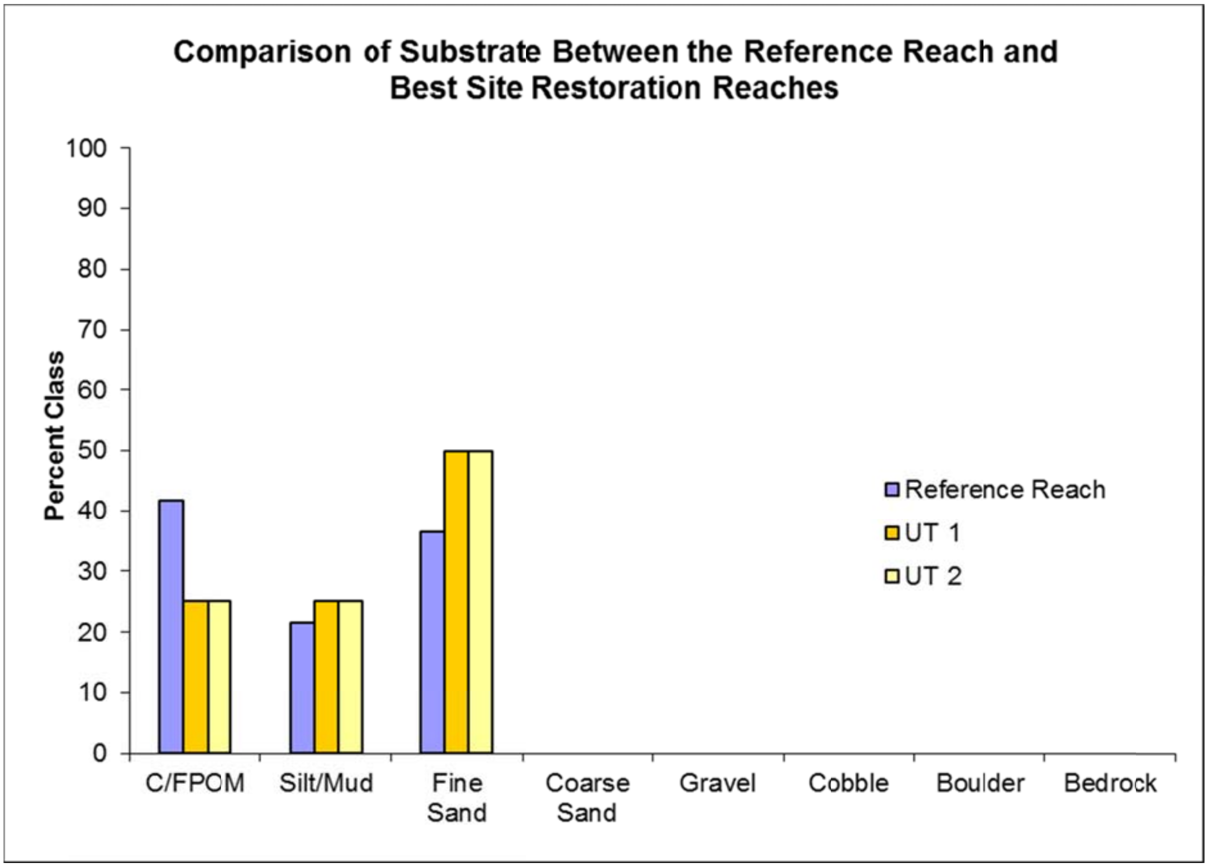


Chart 3. Comparison of substrate composition between the reference reach and the restoration reaches.

The substrate composition analysis revealed that the reference reach has slightly more organic matter substrate (C/FPOM) than UT1 and UT2. These differences may be attributed to a couple of factors, including the maturity and close proximity of riparian plants to the reference reach, and channelization of UT1 and UT2 which typically results in flushing of organic matter and a lack of carbon retention. Macroinvertebrate abundance and diversity has been tied to the ability of a channel to retain carbon. Several design structures and vegetation plantings can be used to increase organic substrate composition. Constructed leaf packs will be installed in select locations for immediate macroinvertebrate colonization. SWD bundles will serve to collect organic matter flowing downstream increasing carbon retention. By adding sinuosity and creating a better floodplain connection, adding SWD in select locations, and creating pool habitats, substrate composition will more closely resemble reference reach conditions.

4.3 Wetland Summary Information

4.3.1 Existing Wetlands

The US Fish and Wildlife Service National Wetland Inventory Map (NWI) depicts wetlands within the project site (**Figure 7**). The floodplain along Muddy Creek is mapped as PFO1A (Palustrine Forested Broad-Leaved Deciduous Temporarily Flooded) and PFO1C (Palustrine Forested Broad-Leaved Deciduous Seasonally Flooded) in the watershed of UT2 north of NC HWY 24. Additional wetlands are shown above the headwaters wetland of UT 3 and UT 4, and mapped as PFO1/4A (Palustrine Forested Broad-Leaved Deciduous/ Needle-Leaved Temporarily Flooded).

A wetland delineation was performed in June 2012. Wetland boundaries were delineated using current methodology outlined in the 1987 Army Corps of Engineers Wetland Delineation Manual (DOA 1987) and Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (Version 2.0) (U.S. Army Corps of Engineers 2010). Soils were characterized and classified using the Field Indicators of Hydric Soils in the United States, Version 7.0 (USDA-NRCS 2010). Wetland boundaries were marked with sequentially numbered wetland survey tape (pink/black striped). Flag locations were surveyed under the direction of a Professional Licensed Surveyor (PLS) with GPS and conventional survey (**Figure 4; Table 13**).

Table 13. Wetland Summary Information

Parameters	Muddy Creek Floodplain	Wetland UT1	Wetland UT3	Wetland UT4	Wetland UT5/6	Wetland UT7	Wetland UT10
Size of Wetland (acres)	90.65	0.21	2.09	0.51	5.79	3.6	1.63
Wetland Type	Riparian Riverine	Riparian Riverine	Riparian Riverine	Riparian Riverine	Riparian Riverine	Riparian Riverine	Riparian Riverine
Mapped Soil Series	Muckalee	Rains	Rains	Muckalee Marvyn Gritney Noboco	Muckalee Noboco	Muckalee Marvyn Gritney Noboco	Muckalee Marvyn Gritney
Drainage Class	Poorly	Poorly	Poorly	Poorly Well Mod. well	Poorly Mod. well	Poorly Well Mod. well	Poorly Well Mod. well
Soil Hydric Status	Hydric	Hydric	Hydric	Hydric with Hydric Inclusions	Hydric with Hydric Inclusions	Hydric with Hydric Inclusions	Hydric with Hydric Inclusions
Source of Hydrology	Runoff & Flooding	Runoff & Groundwater Discharge	Runoff & Groundwater Discharge	Flooding, Runoff & Groundwater Discharge	Runoff & Groundwater Discharge	Runoff & Groundwater Discharge	Runoff & Groundwater Discharge
Hydrologic Impairment	Minimal impairments, Minor ditching, dredging, Roadway crossing	Grazing	Grazing, Culvert	Grazing, Culvert, Incised channel	Grazing, Culvert, Dredging, Incised channel	Grazing, Culvert, Incised channel	Grazing, Culvert, Incised channel
Native vegetation community	Forested	Forested	Forested	Forested	Forested	Forested	Forested
Percent composition of exotic invasive vegetation	5%	0%	1 to 2%	1 to 2%	15%	15%	5%

Figure 7. Project Site NWI Wetlands Map

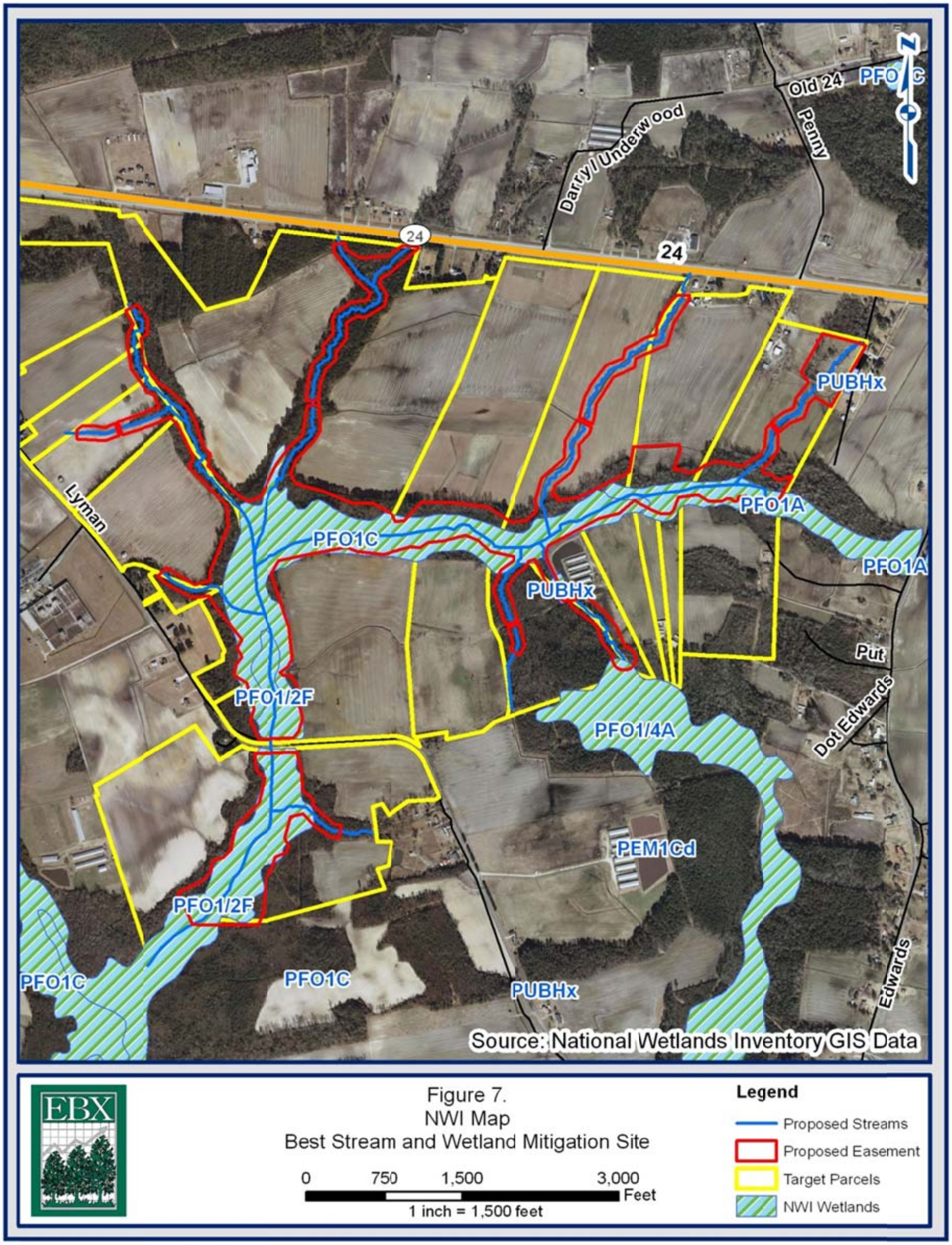


Figure 8. Project Site Land Use

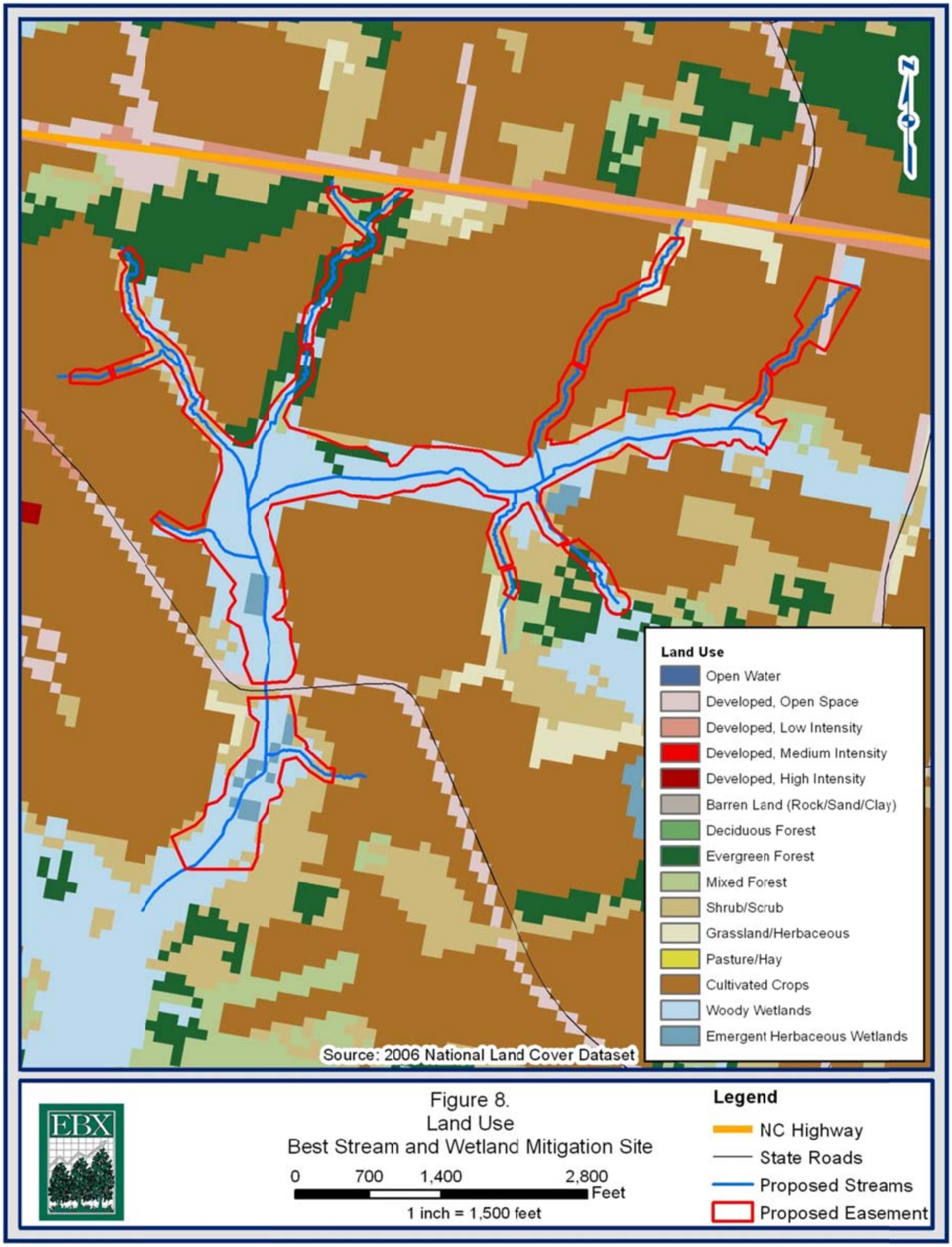
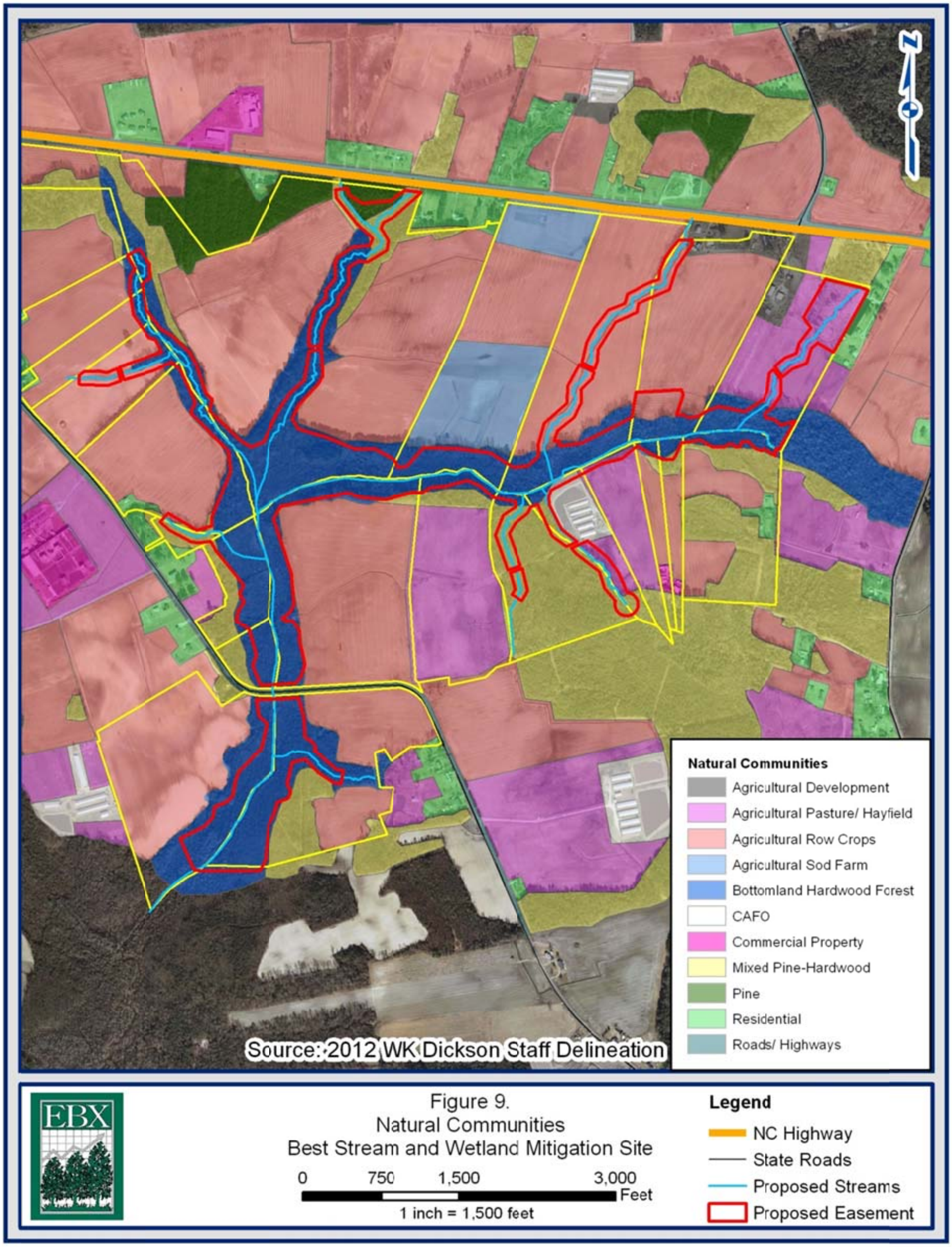


Figure 9. Project Site Natural Communities



4.3.1.1 Riverine Wetland on Floodplain Muddy Creek

The Muddy Creek floodplain is a riverine wetland swamp complex composed of many side channels, relic beaver impoundments, and shallow temporal habitat. In all areas of Stream Preservation and Buffer Enhancement on Muddy Creek, the permanent conservation easement will extend outward a minimum of 50 feet from the outermost channel or outward to the edge of the riverine wetland, whichever is greater. As a result, the protected corridor will range from 200 feet to 500 feet wide, far in excess of the standard preservation corridor width. Although significant elevation changes are absent, this wetland system has a diverse range of habitat, including sloughs, backwater depressions, and beaver impoundments, many of which are temporal and ephemeral. The current natural community is mature forest with a well-developed shrub stratum. Herbaceous cover occurs in the relatively open areas created by beaver impoundments and canopy gaps. This wetland is seasonally saturated to permanently inundated. Hydrology is primarily elevated groundwater table, temporal depressional storage, and overbank flow from Muddy Creek. The only constraint appears to be a single road crossing at Lyman Road.

4.3.1.2 Riparian Wetland on UT 1

This disturbed wetland is located along UT1 outside of the W1 restoration area on the east side of the channel. The current land use is pasture. Vegetation is a mix of pasture grass/weeds with smartweed (*Polygonum* sp.) and soft rush (*Juncus effusus*) common. This wetland is seasonally saturated by runoff and seepage from an upslope pond.

4.3.1.3 Riparian Wetland on UT 3

This linear wetland is located along UT3 on both sides of the channel. The current land use is pasture. The stream is currently within its historic flow pattern and stable despite cattle access. Vegetation is a mix of trees and pasture grass/weeds. Future stability of the channel may be compromised due to loss of woody regeneration and continued cattle impacts. This wetland is seasonally saturated. Due to its lower landscape position, this wetland collects runoff and seepage from an upslope wetland.

4.3.1.4 Riparian Wetland on UT 4

This wetland is located along both sides of UT4 where the channel descends to the Muddy Creek floodplain. This wetland extends from the floodplain of Muddy Creek up the valley of UT 4, terminating at the base of a sharper topographic break. This wetland is seasonally saturated and hydrology is from groundwater seepage along the slope and overbank flows from Muddy Creek and UT4. The current land use is forested with access by livestock. Vegetation is a mix of trees and saplings. Few shrubs are present. A low density of herbaceous vegetation consists of various grasses, sedges, and rushes as well as common weeds.

4.3.1.5 Riparian Wetland on UT 5/6

This wetland is located along UT5 in two segments. The nearly level lower segment occurs on both sides of the channel and connects to the Muddy Creek floodplain. The upper segment is located on both sides of UT5 and extends to the left bank of UT 6. This wetland is seasonally saturated from high groundwater. Evidence of overbank flows is present where the channel is shallow. The current natural community is mature forest. This wetland is buffered by a narrow forest buffer between cultivated fields. Vegetation is a mix of trees, saplings, and shrubs. Chinese privet is common along much of the wetland and the adjacent forested buffer. Due to the dense canopy and shrub stratum, only a low density of herbaceous vegetation is present.

4.3.1.6 Riparian Wetland on UT 7

This wetland is located along the floodplain of UT7, connecting to the Muddy Creek floodplain downstream. The nearly level topography exhibits evidence of flooding in many places, and this wetland is seasonally saturated from high groundwater. The current land use is mature forest with a narrow forest buffer between cultivated fields. Vegetation is a mix of trees, saplings, and shrubs. Chinese privet is common along the edge of this wetland and the adjacent buffer. Due to the dense canopy and shrub stratum, only a low density of herbaceous vegetation is present.

4.3.1.7 Riparian Wetland on UT 10

This wetland is located along the floodplain of UT10, connecting to the Muddy Creek floodplain downstream. This wetland has nearly level topography, and is seasonally saturated from high groundwater. The current vegetation is mature forest with a dense shrub/sapling stratum. It has a narrow buffer with cultivated row crops adjacent to the upper segment of the reach. Due to the dense canopy and shrub stratum, only a low density of herbaceous vegetation is present.

A jurisdictional determination of the wetlands has not been made by the US Army Corps of Engineers (USACE), but the USACE has visited the restoration site. Wetland forms are included in **Appendix B**. Onsite wetlands include riverine wetlands along Muddy Creek and riparian wetlands along UT2, UT3, UT5, UT6, UT7, and UT10 (**Figure 4**).

4.3.2 Existing Hydric Soil

There are two sites adjacent to the stream restoration of UT1 and UT2 and one site along the floodplain of Muddy Creek that contain relic hydric soil. Hydric soils within the proposed wetlands (W1, W2, and W3) were verified through auger borings by a licensed soil scientist (**Appendix B**).

Soil borings confirmed the proposed wetland restoration areas W1 and W2 have a thin sandy horizon underlain by clayey textured subsoil and W3 has a deep sandy surface above the clayey subsoil. The clayey subsoil functions as a restrictive horizon. All proposed wetland restoration areas are near deeply incised and dredged stream channels. Ongoing agricultural activities are present at each of the three proposed wetland restoration sites. Area W1 is located within a pasture and W2 and W3 are located within a cultivated field.

The Best Site offers a total ecosystem restoration opportunity. The proposed wetland restoration is located on the floodplains and landscape adjacent to the proposed stream restoration. Wetland W1 also has adjacent ditching that further lowers the water table.

4.3.2.1 Proposed Wetland W1

Within W1, the majority of the mapped soils are Rains with limited Goldston soils. The Rains soil is mapped within a shallow, concave –concave feature along the slope. This 3.66-acre wetland is located along the upstream portions of Reach UT1. The current land use is pasture along the dredged channel. The typical hydric soils are loamy with a black loamy surface and underlain by a grayish-brown clayey subsoil having dark yellowish brown mottles. Soil in this area meets the hydric indicator for Depleted Matrix (F3) and Depleted

Below Dark Surface (F4). Some areas meet the sandy indicator for Dark Surface (S7). Along the eastern property line, fill material appears to have been placed over hydric soil.

4.3.2.2 Proposed Wetland W2

Within W2, three soil map units are present, including Noboco, Autryville, and Marvyn, and Gritney soils. The Noboco unit is narrowly linear along the drainage feature. The Autryville, and Marvyn and Gritney soils parallel the lower slope and are likely remnants of old terrace landforms to Muddy Creek. This 0.29 acre wetland is located along the downstream portion of Reach UT2 and connects to the riverine wetland along Muddy Creek. The current land use is row crop along the dredged channel. The site is located within a low lying terrace adjacent to UT2 and the floodplain of Muddy Creak. Hydrology will be restored by removing dredge material along the channel and raising the streambed elevation, bringing the water table closer to the ground surface.

The typical hydric soils are sandy with a black surface and meet the hydric indicator for Thin Dark Surface (S9). Within 24 inches is a very dark gray clayey horizon with common dark yellowish brown mottles.

4.3.2.3 Proposed Wetland W3

Within W3, two soil map units are present, including Marvyn, and Gritney soils and Muckalee loam. The Autryville, and Marvyn and Gritney soils parallel the lower slope and are likely remnants of old terrace landforms to Muddy Creek. the Muckalee loam lies on the floodplain of Muddy Creek. The current land use is row crop. This is broken into two similar areas, W3a and W3b, each approximately 0.57 acres. These wetlands are located within a shallow concave-concave landform at the edge of the Muddy Creek floodplain. Both proposed wetlands were found to have similar soils. A shallow ditch has been constructed upslope to redirect a shallow groundwater discharge and divert surface water runoff directly to Muddy Creek. The site is located within a low lying terrace adjacent to and on the floodplain of Muddy Creak and is connected to the riverine wetland along Muddy Creek. Hydrology will be restored by filling and plugging the ditch, restoring the seepage discharge to bring the water table closer to the ground surface and allow flooding by Muddy Creek.

Additional temporal habitat will be constructed to ameliorate surface leveling and smoothing for agricultural use. The temporal habitat will be variable to mimic sloughs, oxbows, root-tips and other shallow natural features.

The typical hydric soils are sandy with a black surface and meet the hydric indicator for Dark Surface (S7). A loamy sand texture extended to at least 29 inches, indicating fill or deposition. Indications of disturbance were observed throughout W3a and W3b. The adjacent upland soil dividing W3a and W3b typically exhibited a shallow five inches or less sandy loam surface above a sandy clay, supporting the potential for leveling of the surface for agricultural use. Wetland W3 is described as a single wetland for qualitative interpretation as they are adjacent, but are divided into two areas for the hydrologic water balance calculation.

Table 14. Proposed Hydric Soils Parameter and Characteristics

Parameters	Wetland W1	Wetland W2	Wetland W3
Size of Wetland within Easement (Acres)	3.66	0.29	1.17
Proposed Wetland Type	Riparian	Riparian	Riparian
Mapped Soil Series	Rains	Marvyn and Gritney soils,	Marvyn and Gritney soils, / Muckalee
Drainage Class	Poorly	Well	Well / Poorly
Hydric Soil Status	Yes	Yes, Hydric inclusions	No / Yes
Source of Hydrology	Runoff / overbank flows	Runoff / overbank flows	Runoff / Seepage / / Flooding
Hydrological Impairment	Ditched/Incised channel	Ditched/Leveled/Incised channel	Ditched/Leveled
Native Vegetation Community	Pasture	Cultivated	Cultivated
Percent composition of exotic/invasive species	75% (Pasture grasses)	N/A	N/A

The existing wetlands have been historically disturbed and lack the typical vegetation of hardwood wetlands. Disturbance includes clearing and grubbing, cultivation, ditching, and crowning. The wetlands are pasture or cultivated row crop and are effectively drained. Two areas of hydric soil are proposed for wetland restoration.

4.4 Regulatory Considerations and Potential Constraints

4.4.1 Property Ownership, Boundary, and Utilities

Due to multiple landowners and scattered agricultural operations, numerous crossings are required. Preliminary survey elevations have been measured to determine hydrologic constraints to channel restoration. There are no known topographic constraints to raising the channel bed elevation on UT1, UT2, and UT3. UT6 and UT8 are proposed as Enhancement I due to elevation constraints associated with Priority Level 1 restoration and channel condition. The existing spray configuration of the land-applied animal waste will need to be adjusted to prevent spray occurring within the stream buffer. The hog waste lagoon adjacent to UT3 will be relocated to an upland area outside the proposed buffer enhancement. There are no overhead or underground utility conflicts with the proposed mitigation. The Best Site is not located within five miles an air transport facility.

4.4.2 Site Access

There are no access constraints to the Best Site. To access the Site from the town of Beulaville, travel east on NC HWY 24, go 1.75 miles past Lyman Road and take the farm driveway on the right across from Penny Road. Go approximately 0.1 miles to the barn. The Site begins through the gate on the left (UT1/Wetland 1). The project also crosses Lyman Road approximately 1.3 miles from NC HWY 24. The site protection instrument can be found in **Appendix A**.

4.4.3 FEMA/ Hydrologic Trespass

Hydrologic trespass is a not a major concern for this project. The Best Site Stream Preservation and Buffer Enhancement is located within a FEMA Zone AE, and the Restoration reaches are outside of any FEMA floodway area (**Figure 10**). While designing the Best Site project, appropriate measures were taken to reduce the chances of hydrologic trespass of the adjacent agricultural fields and animal operations. The adjacent land use will not be affected by the proposed design, and the property owners have been notified of any potential impacts from hydrologic trespass within existing ditches. No detrimental impacts are expected beyond the easement limits.

Table 15. Regulatory Considerations

Regulation	Applicable?	Resolved?	Supporting Documentation
Waters of the United States - Section 404	Yes	Yes	Appendix B
Waters of the United States - Section 401	Yes	Yes	Appendix B
Endangered Species Act	Yes	Yes	Section 4.1.3; Appendix B
Historic Preservation Act	Yes	Yes	Section 4.1.4; Appendix B
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	No	N/A	N/A
FEMA Floodplain Compliance	Yes	Yes	Section 4.4.3; Appendix B
Essential Fisheries Habitat	No	N/A	N/A

Figure 10. Project Site FEMA Map

5 DETERMINATION OF CREDITS

Mitigation credits presented in these tables are projections based upon site design. Upon completion of site construction, the project components and credits data will be revised to be consistent with the as-built condition.

The Best Site Stream and Wetland Restoration Project EEP Project # NC-95353						
Mitigation Credits						
	Stream	Riparian Wetland	Non-riparian Wetland	Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Totals	10,213	5.12	N/A	N/A	N/A	N/A

Project Components						
Project Component or Reach ID	**Stationing/ Location**	**Existing Footage or Acreage**	**Approach (PI, PII, etc.)**	**Restoration or Restoration Equivalent**	**Restoration Footage or Acreage**	**Mitigation Ratio**
STREAM						
UT1	0+47 to 18+00	1,551	PI	1,723	1,723	1 : 1.0
UT1	18+00 to 21+03	303	Preservation & Buffer Enhancement	61	303	1 : 5.0
UT2	2+30 to 30+30	2,552	PI	2,770	2,770	1 : 1.0
UT2	30+30 to 33+39	309	Preservation & Buffer Enhancement	62	309	1 : 5.0
UT3	0+00 to 8+42	1,458	EII	325	812	1 : 2.5
UT3	14+58 to 15+22	64	Preservation & Buffer Enhancement	13	64	1 : 5.0
UT4	5+63 to 11+03	534	PI (Headwater Valley)	510	510	1 : 1.0
UT4	11+03 to 17+58	655	Preservation & Buffer Enhancement	131	655	1 : 5.0
UT5	0+00 to 40+86	4,086	Preservation & Buffer Enhancement	809	4,043	1 : 5.0
UT6	0+62 to 6+00	538	EI	359	538	1 : 1.5
UT7	0+44 to 32+27	3,183	Preservation & Buffer Enhancement	637	3,183	1 : 5.0
UT8	0+75 to 9+00	825	EI	550	825	1 : 1.5
UT8	9+00 to 12+13	313	Preservation & Buffer Enhancement	63	313	1 : 5.0
UT9	0+00 to 11+71	1,171	Preservation & Buffer Enhancement	234	1,171	1 : 5.0
UT10	3+37 to 11+05	768	Preservation & Buffer Enhancement	154	768	1 : 5.0
Muddy Creek	0+35 to 92+49	9,214	Preservation & Buffer Enhancement	1,815	9,073	1 : 5.0
WETLAND						
W1	Adjacent to UT1	3.66	Restoration	3.66	3.66	1 : 1.0
W2	Adjacent to UT2	0.29	Restoration	0.29	0.29	1 : 1.0
W3A	Between UT1 & UT2	0.58	Restoration	0.58	0.58	1 : 1.0
W3B	Between UT1 & UT2	0.59	Restoration	0.59	0.59	1 : 1.0

Component Summation						
Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-Riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	5,003		5.12			
Enhancement						
Enhancement I	1,363					
Enhancement II	812					
Creation						
Preservation	19,882					
High Quality Preservation						

6 CREDIT RELEASE SCHEDULE

All credit releases will be based on the total credit generated as reported by the as-built survey of the mitigation site. Under no circumstances shall any mitigation project be debited until the necessary DA authorization has been received for its construction or the District Engineer (DE) has otherwise provided written approval for the project in the case where no DA authorization is required for construction of the mitigation project. The DE, in consultation with the Interagency Review Team (IRT), will determine if performance standards have been satisfied sufficiently to meet the requirements of the release schedules below. In cases where some performance standards have not been met, credits may still be released depending on the specifics of the case. Monitoring may be required to restart or be extended, depending on the extent to which the site fails to meet the specified performance standard. The release of project credits will be subject to the criteria described as follows:

Table 16. Forested Wetlands Credits

Monitoring Year	Credit Release Activity	Interim Release	Total Released
0	Initial Allocation - see requirements below	30%	30%
1	First year monitoring report demonstrates performance standards are being met.	10%	40%
2	Second year monitoring report demonstrates performance standards are being met.	10%	50%
3	Third year monitoring report demonstrates performance standards are being met.	10%	60%
4	Fourth year monitoring report demonstrates performance standards are being met.	10%	70%
5	Fifth year monitoring report demonstrates performance standards are being met; Provided that all performance standards are met, the IRT may allow the NCEEP to discontinue hydrologic monitoring after the fifth year, but vegetation monitoring must continue for an additional two years after the fifth year for a total of seven years.	10%	80%
6	Sixth year monitoring report demonstrates performance standards are being met.	10%	90%
7	Seveth year monitoring report demonstrates performance standards are being met, and project has received close-out approval.	10%	100%

Table 17. Stream Credits

Monitoring Year	Credit Release Activity	Interim Release	Total Released
0	Initial Allocation - see requirements below	30%	30%
1	First year monitoring report demonstrates performance standards are being met.	10%	40%
2	Second year monitoring report demonstrates performance standards are being met.	10%	50% (65%*)
3	Third year monitoring report demonstrates performance standards are being met.	10%	60% (75%*)
4	Fourth year monitoring report demonstrates performance standards are being met.	10%	70% (85%*)
5	Fifth year monitoring report demonstrates performance standards are being met.	10%	80% (95%*)
6	Sixth year monitoring report demonstrates performance standards are being met.	10%	90% (100%*)
7	Seventh year monitoring report demonstrates performance standards are being met, and project has received close-out approval.	10%	100%

6.1 Initial Allocation of Released Credits

The initial allocation of released credits, as specified in the mitigation plan can be released by the NCEEP without prior written approval of the DE upon satisfactory completion of the following activities:

a) Approval of the final Mitigation Plan
b) Recordation of the preservation mechanism, as well as a title opinion acceptable to the USACE covering the property
c) Completion of project construction (the initial physical and biological improvements to the mitigation site) pursuant to the mitigation plan; per the NCEEP Instrument, construction means that a mitigation site has been constructed in its entirety, to include planting, and an as-built report has been produced. As-built reports must be sealed by an engineer prior to project closeout, if appropriate but not prior to the initial allocation of released credits.
d) Receipt of necessary DA permit authorization or written DA approval for projects where DA permit issuance is not required.

6.2 Subsequent Credit Releases

All subsequent credit releases must be approved by the DE, in consultation with the IRT, based on a determination that required performance standards have been achieved. For stream projects a reserve of 15 percent of a site's total stream credits shall be released after two bank-full events have occurred, in separate years, provided the channel is stable and all other performance standards are met. In the event that less than two bank-full events occur during the monitoring period, release of these reserve credits shall be at the discretion of the IRT. As projects approach milestones associated with credit release, the NCEEP will submit a request for credit release to the DE along with documentation substantiating achievement of criteria required for release to occur. This documentation will be included with the annual monitoring report.

7 MITIGATION WORK PLAN

7.1 Target Stream and Wetland Types

7.1.1 Reference Stream Studies

7.1.1.1 Target Reference Conditions

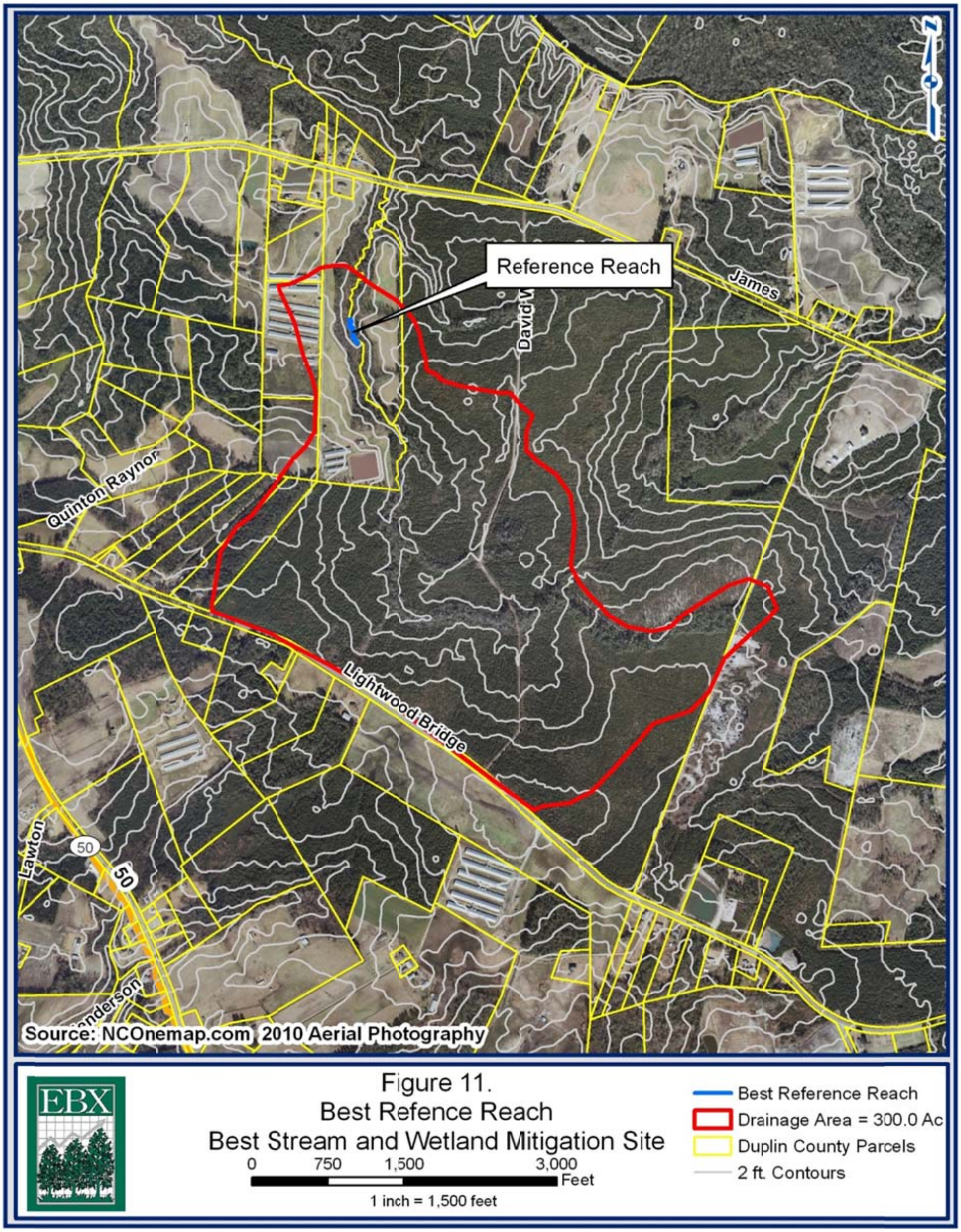
The restoration portions of the project site are characterized by agricultural and livestock practices. Several ditches exist in the watershed and contribute to the project site. Physical parameters of the site were used, as well as other reference materials, to determine the target stream type. An iterative process was used to develop the final information for the site design.

To develop the target reference conditions, physical site parameters were reviewed. This included the drainage area, land use, soils mapping units from the Duplin County Soil Survey for the watershed and Site, typical woody debris and habitat available and for the area, as well as general topography. The "Classification of the Natural Communities of North Carolina" was also used to narrow the potential community types that would have existed at the site (Shafale and Weakley, 2003).

Targeted reference conditions included the following:

- Located within the Physiographic Region – Outer Coastal Plain,
- Similar drainage area,
- Similar land use onsite and in the watershed,
- Similar watershed soil types,
- Similar site soil types,
- Ideal, undisturbed habitat – several types of woody debris present,
- Similar topography,
- Similar slope,
- Pattern common among coastal plain streams, and
- Minimal presence of invasive species.

Figure 11. Reference Reach Site Map



7.1.1.1 Reference Site Search Methodology

All the parameters used in Section 4.1 were used to find appropriate reference stream sites. Obtaining property owner information and owner authorization for access was another factor in locating suitable reference sites for the project. For this project, there was no predetermined amount of reference sites needed as long as the site was suitable and met nearly all the parameters. Eight potential reference sites were visited, and their characteristics were noted. It is difficult to find reference sites on the coastal plain because many have been disturbed by farming or urban development. Most streams tend to be modified ditches and may have some of the characteristics that are sought in a reference, but too few to make it an ideal reference for the project site. One reference stream site that proves to be ideal in both geomorphology and habitat is located approximately six miles southeast of the restoration site in a wooded corridor.

A GIS-based search was initially conducted for the identification of reference stream sites in the outer coastal plain. The GIS process was based on a search through quadrangle maps, aerial photography, and topography. Drainage areas for each reference site were delineated. Soils and land use were considered for each site, as well as accessibility and location in comparison to the restoration reach. Once sites were identified, all eight sites were visited and assessed. Many of the references were affected by farming practices, dense invasive species, and disturbed or altered floodplains along the streams. This was the case for a few of the sites visited, and, therefore, the sites were not considered. One site was identified for use as a reference site.

7.1.1.2 Reference Watershed Characterization

The reference stream flows northwest and drains into Cypress Creek (**Figure 11**). The reach that was surveyed and analyzed is approximately 300 feet long. The drainage area for the unnamed tributary to Cypress Creek (UT) is 0.47 square miles (300 acres). The land use in the watershed is characterized by mostly southern yellow pine (86 percent), bottomland hardwood forest/hardwood swamps (six percent), broadleaf evergreen forest (three percent), managed herbaceous cover (three percent), and cultivation (two percent). Site photographs of the reference stream are located in **Appendix B**.

The current State classification for the UT to Cypress Creek is undefined. However, Cypress Creek is defined as Class C *Sw* (NCDWQ, 2005). Class C waters are suitable for aquatic life, secondary recreation, and agricultural usage. The *Sw* is a designation for swamp waters—waters that have low velocities and other natural characteristics that are different from adjacent streams. Using Rosgen stream classification, the stream is classified as an E5 stream type.

7.1.1.3 Reference Soils Characterization

The soils found in and around the reference reach are mapped as Muckalee, Blanton, and Murville, all of which are hydric soils. Muckalee is a Hydric B, loam soil, typically found on slopes ranging from 0 to 1 percent slopes. Blanton is a Hydric B sandy soil, found on flats, marines, and terraces with slopes from 1 to 6 percent. Murville soils are mucky fine sand generally found in depressions with slopes of 0 to 2 percent. The soils immediately adjacent to the reference reach have similar characteristics and properties to the soils found at the Best Site Restoration Site.

7.1.1.4 Reference Discharge

Several hydrologic models/methods were used to develop a bankfull discharge for the reference site. Existing drainage area, land use, slope, roughness, and cross-sectional area were all factors considered when performing the calculations. Using a combination of Coastal Plain Regional Curves, in-house spreadsheet tools, and a project specific regional flood frequency analysis, the existing discharge was found to be around 12 cubic feet per second (ft^3/s). See **Section 7.3.1.1** for a more detailed description of the hydrologic analyses performed for this project.

7.1.1.5 Reference Channel Morphology

In comparison to the restoration reaches, the reference reach is slightly larger than UT1 and smaller than UT2 when comparing pattern, dimension and profile, which is the reason for using a scaling factor for the design. The scaling factor is based on the difference in bankfull area of the reference channel. The new reach would then have the necessary dimensions of that of either a smaller or larger stream corresponding to differences in drainage area. The stream was typically five to eight feet wide and one to two feet deep. The cross sectional area was typically around 6.7 square feet with a width to depth ratio around 9.0.

7.1.1.6 Reference Channel Stability Assessment

The reference reach was stable and showed no evidence of incision or erosion in the portion that was surveyed and analyzed. The stream appeared to maintain its slope and had sufficient amounts of vegetation to secure its banks. Riparian buffer widths exceeded fifty feet on each side. The CSA results (scores and ratings) for the reference reach are provided above in **Table 9** (**Section 4.2.4**). The reference reach received an "Excellent" rating as the channel demonstrates a stable meandering pattern and a well vegetated riparian buffer.

7.1.1.7 Reference Bankfull Verification

Typical indicators of bankfull include vegetation at the bankfull elevation, scour lines, wrack lines, vegetation lines, benches/inner berm, and point bars. Throughout the entire length of the reference reach, bankfull is located at the top of bank elevation. The accuracy of this bankfull stage is verified by the Coastal Plain Regional Curves and hydrologic analyses using existing cross sections to calculate area and discharge. Evidence that can further support the location of bankfull is the lack of any bench or berm features within the channel, and wrack lines present within the floodplain.

7.1.1.8 Reference Riparian Vegetation

The reference reach riparian community is characteristic of a coastal plain small stream swamp community. This community is approximately 15 to 20 years old, as evidenced by the representative diameter at breast height (DBH) measurements. This community was determined to have had past disturbance altering the species composition. Most of the canopy species recorded are high dispersal species and have been observed to occur near the restoration site. The following table lists the coverage estimates and species encountered. The right bank is denoted as RB and the left bank is denoted as LB.

Table 18. Tree Communities at the Reference Reach for Best Site.

Transect	Location	Percent Coverage	Percent Evergreen	Percent Deciduous	Representative DBH (")	Species
1	LB	80	15	85	8	*Nyssa biflora, Magnolia virginiana, Ilex opaca, Acer rubrum, Liriodendron tulipifera*
	RB	90	15	85	12.5	*Liriodendron tulipifera, Liquidambar styraciflua, Nyssa biflora, Ilex opaca,*
2	LB	65	10	90	9	*Liriodendron tulipifera, Ilex opaca, Liquidambar styraciflua*
	RB	80	10	90	15	*Liquidambar styraciflua, Nyssa biflora, Liriodendron tulipifera*
3	LB	90	10	90	10	*Nyssa biflora, Acer rubrum, Liriodendron tulipifera, Ilex opaca, Magnolia virginiana*
	RB	60	30	70	7	*Ilex opaca, Magnolia virginiana, Nyssa biflora, Liquidambar styraciflua*
4	LB	85	10	90	10	*Liquidambar styraciflua, Liriodendron tulipifera, Ilex opaca*
	RB	35	50	50	3	*Ilex opaca, Magnolia virginiana, Liquidambar styraciflua*
5	LB	90	10	90	8	*Liriodendron tulipifera, Magnolia virginiana, Acer rubrum, Fagus grandifolia, Nyssa biflora, Liquidambar styraciflua*
	RB	60	25	75	9	*Nyssa biflora, Liquidambar styraciflua, Ilex opaca, Liriodendron tulipifera*
6	LB	90	10	90	8	*Liriodendron tulipifera, Magnolia virginiana, Acer rubrum, Fagus grandifolia, Nyssa biflora, Liquidambar styraciflua*
	RB	70	50	50	6	*Magnolia virginiana, Ilex opaca, Nyssa biflora*
7	LB	75	10	90	10	*Liriodendron tulipifera, Acer rubrum, Ilex opaca, Q. michauxii*
	RB	60	40	60	8	*Ilex opaca, Liriodendron tulipifera, Liquidambar styraciflua*
8	LB	55	20	80	7	*Liriodendron tulipifera, Acer rubrum, Pinus taeda, Ilex opaca, Ligustrum japonicum*
	RB	80	40	60	6	*Quercus nigra, Liriodendron tulipifera, Ilex opac, Acer rubrum*
9	LB	70	25	75	10	*Nyssa biflora,Ilex opaca, Liriodendron tulipifera, Pinus taeda*
	RB	80	20	80	6	*Liriodendron tulipifera , Ilex opaca, Quercus nigra, Acer ruburm*
10	LB	60	25	75	11.5	*Nyssa biflora,Ilex opaca, Liriodendron tulipifera, Pinus taeda*
	RB	80	15	85	11	*Pinus taeda, Quercus michauxii,Ilex opaca, Acer rubrum, Liquidambar styraciflua, Liriodendron tulipifera, Ligustrum japonicum*

It is anticipated that a local seed source for these high dispersal species is present and will disperse across much of the mitigation site. These species are often found in early successional communities and quickly fill disturbance gaps. Because many of these high dispersal species often become aggressive in these sites, they are not included in the Restoration Planting List (**Section 7.2.3**). Hardwood species typical of the target community were observed in adjacent and nearby communities, and were judged to be more appropriate for this site.

7.1.1.9 Stream Habitat Assessment – Woody Debris

The habitat assessment for the reference stream channel is included in the habitat assessment discussion for Best Site (**Section 4.2.7**).

7.1.2 Reference Wetland Studies

Reference wetlands were not studied for similar hydrology or habitat. A reference wetland site adjacent to the stream evaluated for habitat was evaluated for species composition, but was determined to be impacted by timber management and was not a suitable community to reference. A reference wetland within the proposed conservation easement will be determined before construction is complete so groundwater monitoring can begin before or at the same time as wetland restoration monitoring. Potential reference wetlands are located along preservation reaches within the conservation easement.

7.2 Design Parameters

7.2.1 Stream Restoration Approach

Stream restoration efforts along the tributaries to Muddy Creek will be accomplished through a combination of analytical and analog and/or reference reach-based design methods. The result will be a combination of Priority Level I and headwater valley restoration for UT1, UT2, and UT3. The cross-section geometry, planform, and profile will be modified to restore appropriate capacity and sinuosity to the channelized, sand bed streams. The Priority Level I stream restoration will incorporate the design of a single-thread meandering channel, with parameters based on data taken from NC Coastal Plains Regional Curve tables and from reference sites and hydrologic analyses described herein. Approximately 4,493 LF of stream channel will be reconstructed. An additional 510 LF of headwater valley restoration will bring the total restoration SMUs to 5,003. Enhancement Levels I and II will be applied to UT3, UT6, and UT8 for an additional 2,087 LF of channel that is relatively stable and forested. Stream Preservation and Buffer Enhancement will be applied to 19,882 LF of Muddy Creek, UT5, UT7, UT9, UT10 and the downstream portions of UT1, UT2, UT3, UT4, and UT8.

Stream buffers throughout the project site will be restored and protected in perpetuity. Proposed mitigation for the Best Site involves headwater valley restoration and Priority Level I stream restoration. The proposed mitigation design divides the site into eleven distinct drainage features (**Figure 12**). Priority Level I restoration is proposed along two tributaries and headwater valley restoration is proposed on one tributary.

Priority I restoration reaches will typically include a meandering stream pattern constructed to mimic the natural planform of low-gradient, sand bed channels. The proposed sinuosity is 1.1, which is based on local reference reach conditions, existing site constraints, and hydraulic modeling. As a result of the restoration of planform and dimension, frequent overbank flows and a restored riparian buffer will provide the appropriate hydrology and sediment transport throughout this coastal plain watershed.

Headwater valley restoration will follow current regulatory guidance and published research. This restoration approach will result in a fully vegetated valley bottom following natural existing contours. Any ditches or channels present will be backfilled and stabilized. Vegetation will be enhanced across the entire headwater valley.

The proposed mitigation design divides the site into 11 distinct stream reaches and three wetland restoration areas (Figures 12a and 12b). Priority Level I restoration is proposed on two reaches, headwater valley restoration is proposed on one reach, Enhancement Level I is proposed on two reaches, Enhancement Level II is proposed on two reaches, and Stream Preservation and Buffer Enhancement is proposed on nine reaches. Best Site has been broken into the following design reaches:

- **UT1 (STA 0+47 to STA 21+03)** – Eastern most tributary of the project totaling 1,723 linear feet of Priority 1 restoration and 303 linear feet of Stream Preservation and Buffer Enhancement. Pasture and cultivated fields are located adjacent to the reach through the restoration section, while mature hardwoods surround the downstream Stream Preservation and Buffer Enhancement section.

- **UT2 (STA 2+30 to STA 33+39)** – Tributary just west of UT1 totaling 2,770 linear feet of Priority 1 restoration and 309 linear feet of Stream Preservation and Buffer Enhancement. Agricultural fields are located adjacent to the reach through the restoration section, while mature hardwoods surround the downstream Stream Preservation and Buffer Enhancement section.

- **UT3 (STA 0+00 to STA 15+22)** – Western most tributary of the project totaling 812 linear feet of Enhancement Level II and 64 linear feet of Stream Preservation and Buffer Enhancement. The upper end originates as a headwater valley system where there is cattle access, and a hog waste lagoon is located adjacent to the right bank in the downstream section. Mature hardwoods are present along the western side of the channel and surround the downstream Stream Preservation and Buffer Enhancement section.

- **UT4 (STA 5+63 to STA 17+58)** – A headwater reach adjacent to UT3 totaling 510 linear feet of headwater valley restoration, and 655 linear feet of Stream Preservation and Buffer Enhancement. The headwater valley portion has previously been channelized and relocated to the west side of the valley. This reach is surrounded by a hardwood forest.

- **UT5 (STA 0+00 to STA 40+86)** – Tributary located in the middle of the project totaling approximately 4,043 linear feet of Stream Preservation and Buffer Enhancement. This reach is surrounded by forest comprised of mature hardwoods and localized areas of privet and flows into Muddy Creek.

- **UT6 (STA 1+50 to STA 6+00)** – Tributary just west of UT5 totaling approximately 450 linear feet of Enhancement Level I. This reach is adjacent to an agricultural field, but has mature forested buffer with a dense understory of privet.

- **UT7 (STA 0+44 to STA 32+27)** – Tributary located near the middle of the project totaling approximately 3,183 linear feet of Stream Preservation and Buffer

Enhancement. This reach is surrounded by forest comprised of mature hardwoods and localized areas of privet and flows into UT5 before discharging to Muddy Creek.

- **UT8 (STA 0+75 to STA 12+13)** – Tributary just west of UT5 totaling approximately 825 linear feet of Enhancement Level I and 313 linear feet of Stream Preservation and Buffer Enhancement. This reach is flat with agricultural fields located along both sides of the channel.

- **UT9 (STA 0+00 to STA 11+71)** – Tributary located just south of the confluence of UT5 and Muddy Creek totaling approximately 1,171 linear feet of Stream Preservation and Buffer Enhancement. This reach has been straightened, but is stable and surrounded by mature hardwoods and localized areas of privet.

- **UT10 (STA 3+37 to STA 11+05)** – Downstream most tributary located just south of the south of Lyman Road totaling approximately 768 linear feet of Stream Preservation and Buffer Enhancement. This reach originates at a farm crossing, is stable, and is buffered by an intact hardwood forest.

- **Muddy Creek (STA 0+35 to STA 92+49)** – Primary drainage feature spanning the entire project totaling approximately 9,073 linear feet of Stream Preservation and Buffer Enhancement. This reach is a stable swamp system surrounded by swamp complexes, beaver impoundments, and riverine wetlands within the floodplain corridor.

UT1
Priority Level 1 restoration is proposed for UT1 to address all existing impairments, particularly the greatly oversized channel and lack of bedform diversity. The design approach will include meandering the proposed channel within the natural valley and backfilling the existing stream. A minimum 50 foot buffer will be established and planted with native riparian vegetation. Because the buffer is devoid of significant woody vegetation, woody debris will be installed along the bed to improve in-stream habitat. Livestock will be excluded with fencing installed along the easement boundary. An existing CMP culvert located along the middle of the reach will be removed and relocated further downstream to allow the landowner access to both sides of the property. Stream Preservation and Buffer Enhancement is proposed for the downstream section of the channel where it flows through a forested buffer down to the confluence with Muddy Creek.

UT2
Similar to UT1, Priority 1 restoration is proposed for UT2 to address historic straightening and channel enlargement. The existing ditch will be backfilled, and the channel will be relocated such that it meanders within the existing valley. A diffuse flow structure will be installed at the ditch adjacent to the proposed crossing. The structure will be placed such that flows from the existing ditch will be attenuated to establish sheet flow as the water enters the restored channel. All areas within the minimum 50 foot buffer will be planted with native riparian vegetation. An existing CMP culvert located along the middle of the reach will be removed and replaced to allow the landowner access to the entire property. Additionally, the existing culvert at the upstream end of UT2 will be upgraded and reset to more effectively transition the existing channel upstream into the project stream. Priority Level I restoration is appropriate for this channel because it is the only mitigation approach that will address bed and bank instability, establish a forested riparian buffer, and significantly

enhance aquatic habitat. Stream Preservation and Buffer Enhancement is proposed for the most downstream section, where the channel enters the existing forested buffer, down to its confluence with Muddy Creek.

UT3

Enhancement Level II is proposed on Reach UT3 due to the channel's current stability and appropriate size. The design approach on this reach will focus on improving the riparian buffer. The existing hog lagoon located within buffer on the west side of the reach will remain in place, preventing the generation of stream credits for approximately 600 linear feet. Through this section, the left buffer will be extended out to a minimum of 75 feet along the left bank, and the right buffer will extend just past top of bank. The existing crossing located near the middle of the reach will be replaced and upgraded with an HDPE pipe, allowing the landowner continued access across his property. Additional bank grading and stabilization will be included in the culvert replacement. The grading of pools and the installation of woody debris structures will be performed along the reach to improve aquatic habitat. Upstream of the crossing, a 75-foot buffer will be restored along the east bank where the channel currently flows through an active pasture. A 100-foot buffer is proposed for the headwater origin point to further protect water quality from cattle access. Cattle will also be excluded with fencing. All areas within the proposed buffer will be planted with native riparian vegetation. Stream Preservation and Buffer Enhancement is proposed along the downstream end where the channel enters the Muddy Creek floodplain.

UT4

Headwater valley restoration is proposed for the upper section of UT4. The existing channel will be backfilled, and flow will be directed from its current position east back to the historic valley location. A minor amount of earthwork is anticipated in the headwater valley restoration apart from ditch plugging to tie the existing ditch back to the natural valley. Areas within the 100 foot buffer that are disturbed or lack riparian vegetation will be planted. Cattle will be excluded from the buffer through the installation of fencing. An existing CMP culvert crossing located along the middle of the reach will be removed and relocated to the low spot in the valley to allow the landowner continued access to an agricultural field west of the channel. Downstream of the crossing, a smaller low flow channel will be constructed within the natural valley. This segment will connect the upstream headwater valley section to the existing channel approximately 200 feet below the crossing. Due to the stable nature of the buffer along the downstream reach of UT4, Stream Preservation and Buffer Enhancement is proposed from just downstream of the crossing to the confluence with Muddy Creek.

UT5

Stream Preservation and Buffer Enhancement is proposed on UT5. The channel is stable throughout the proposed easement and provides a variety of aquatic habitats. The riparian buffer is intact hardwood forest with localized areas of privet. Privet will be treated, and disturbed areas will be re-vegetated with direct seeding of hardwood trees. The proposed easement boundary will extend a minimum of 50 feet outward from the stream channel, or the limit of adjacent riparian wetlands, whichever is wider.

UT6

Enhancement Level I is proposed on UT6. The design approach on this reach will focus on bank stabilization, bedform diversity, and improving the riparian buffer. The existing channel is impaired by channelization, vertical un-vegetated banks, and a dense privet understory in the buffer. The grading of pools, grade control structures, and the installation of woody debris structures will be performed along the reach to improve aquatic habitat. All disturbed areas within the proposed buffer will be planted with native riparian vegetation.

UT7

Stream Preservation and Buffer Enhancement is proposed on UT7. The channel is stable throughout the proposed easement and the riparian buffer is an intact hardwood forest with localized areas of privet. Privet will be treated, and disturbed areas will be re-vegetated with direct seeding of hardwood trees. The proposed easement boundary will extend a minimum of 50 feet outward from the stream channel, or to the limit of adjacent riparian wetlands, whichever is wider.

UT8

Enhancement Level I is proposed on UT8. The design approach on this reach will focus on bank stabilization, bedform diversity, and riparian buffer restoration. The existing channel is impaired by channelization, localized bank instability, and cleared agricultural land in the buffer. Stabilization activities will include grading a floodplain bench, installing grade control structures, and installing woody debris structures to improve hydraulic efficiency and aquatic habitat. All disturbed areas within the proposed buffer will be planted with native riparian vegetation.

UT9

Stream Preservation and Buffer Enhancement is proposed on UT9. The stream is channelized, but is stable throughout the proposed easement. The active channel is meandering within the larger excavated channel bottom. The riparian buffer is intact hardwood forest with localized areas of privet. Privet will be treated, and disturbed areas will be re-vegetated with direct seeding of hardwood trees. The proposed easement boundary will extend a minimum of 50 feet outward from the stream channel, or to the limit of adjacent riparian wetlands, whichever is wider.

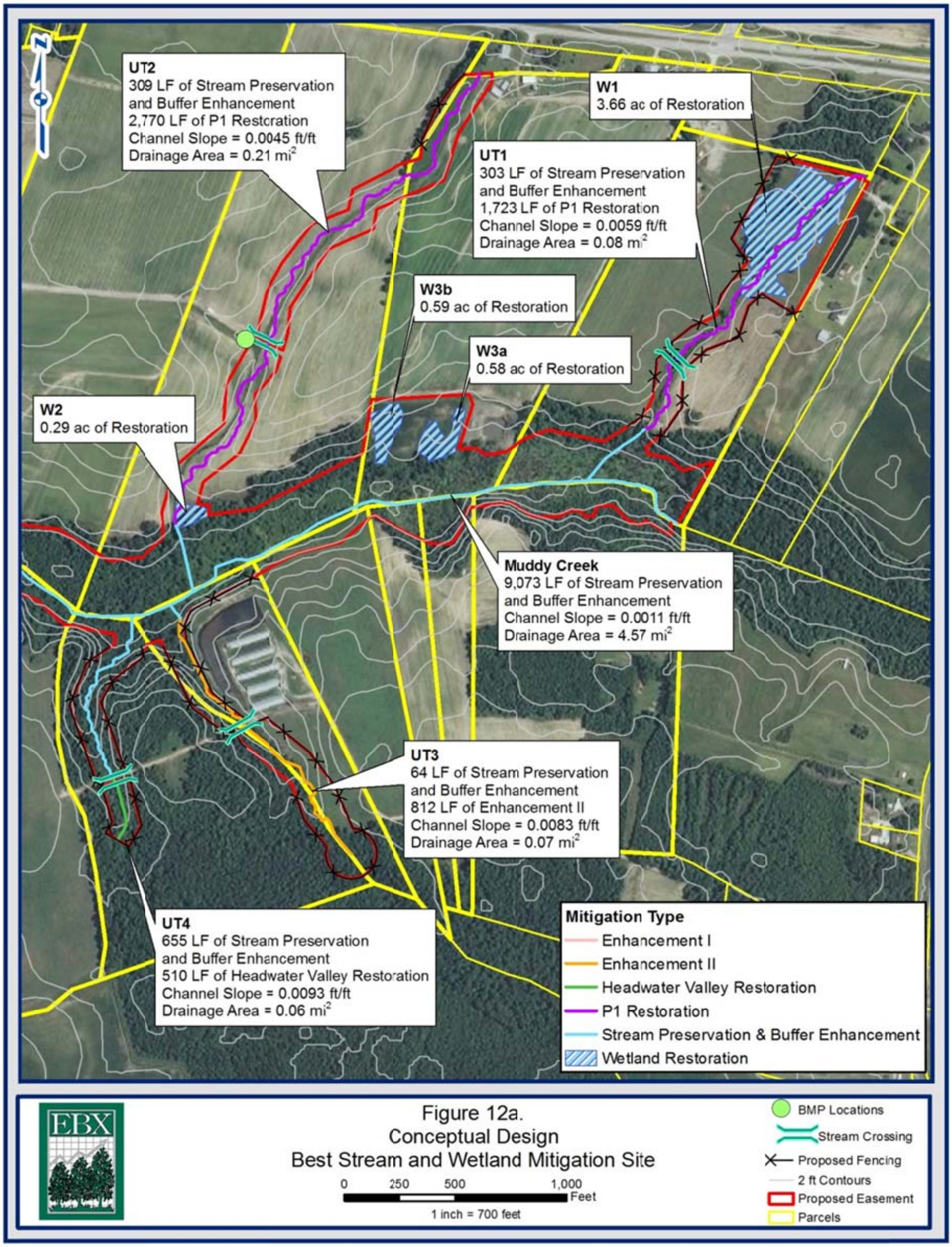
UT10

Stream Preservation and Buffer Enhancement is proposed on UT10. The channel is stable throughout the proposed easement and provides a variety of aquatic habitats. The riparian buffer is intact and is comprised of mature hardwoods. The proposed easement boundary will extend a minimum of 50 feet outward from the stream channel or to the limit of adjacent riparian wetlands, whichever is wider.

Muddy Creek

Stream Preservation and Buffer Enhancement is proposed for the majority of Muddy Creek. Invasive species management is proposed throughout the buffer areas where privet infestation is severe. Privet treatment areas will be re-vegetated with direct seeding of hardwood trees. The buffer will be restored and increased to a width of 75 feet along the south side.

Figure 12. Project Site Conceptual Plan Design



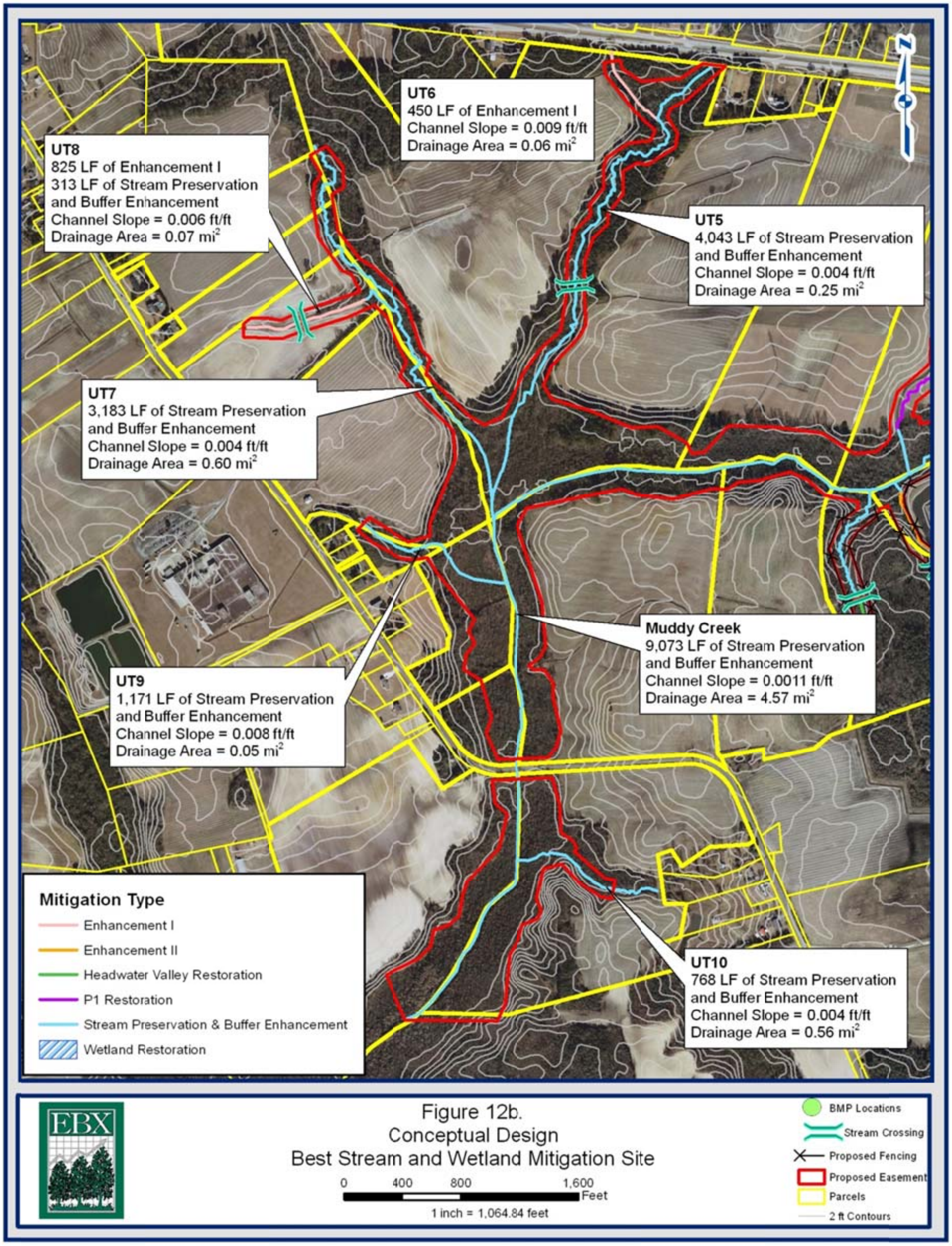


Figure 12b.
Conceptual Design
Best Stream and Wetland Mitigation Site

7.2.1.1 Design Discharge

Based upon the hydrologic analyses described below, design discharges were selected that fall between model results for the 1-year storm and the 1.5-year flood frequency analysis for each reach. The selected flows for the restoration reaches are 6ft^3/s for UT1 and 15ft^3/s for UT2. Design flows selected for the enhancement reaches are 7ft^3/s, 11ft^3/s, 9ft^3/s, and 8ft^3/s for Reaches UT1, UT2, UT3, UT4, UT6, and UT8, respectively. These discharges will provide frequent inundation of the adjacent floodplain.

The design discharges were selected based on the following rationale:

- The calculated bankfull discharge for the analog/reference reach closely matches the results of the 1.1-year flood frequency analysis,
- The results of the Hydraflow Hydrographs for the 1-year storm fell above the results of the 1.1 and 1.5-year flood frequency analysis and takes factors in the high percentage of agricultural land use,
- The results of the 1.1-year flood frequency analysis matched well with the NC regional curve (Doll et al., 2003), and
- Selecting design discharges around the 1.5-year storm events allows frequent inundation of the floodplain, while also preventing adjacent active agriculture land from flooding at a high frequency.

7.2.1.2 Design Methods

There are three primary methods that have demonstrated success in stream restoration: analog, empirical, and analytical. All three methods have advantages and limitations, and it is often best to utilize more than one method to address site-specific conditions or to verify the applicability of design elements. This is particularly true in developed watersheds where existing conditions do not always reflect current inputs and events, and sediment and hydrologic inputs may remain unstable for some time. Combinations of analytical and analog methods were used to develop the stream designs for Best Site.

Analytical Approach

Analytical design is based on principles and processes considered universal to all streams, and can entail many traditional engineering techniques. The analytical approach utilizes continuity, roughness equations, hydrologic and hydraulic models, and sediment transport functions to derive equilibrium conditions. Since the project is located within a rural watershed, restoration designs are based on hydrologic and hydraulic analyses, including rainfall-runoff models to determine design discharges coupled with reference reach techniques.

Analog Approach

The analog method of natural channel design involves the use of a “template” or reference stream located near the design reach, and is particularly useful when watershed and boundary conditions are similar between the design and analog reaches (Skidmore et al., 2001). In an analog approach, the planform pattern, cross-sectional shape, longitudinal profile, and frequency and locations of woody debris along the analog reaches are mimicked when developing the design parameters for the subject stream. A scaling factor was calculated from the survey data in order to correctly size the planform design parameters for the project site. The scaling factors for each design reach were derived from the design cross-sectional area and topwidth of each reach as follows:

1. The appropriate bankfull cross-sectional area (CSA) of each design reach was calculated using an in-house spreadsheet based on Manning's Equation. The input parameters included the design discharge as determined by the hydrologic analysis described above, and proposed slope based on site conditions and the sinuosity measured for the analog reach.

2. The cross-sectional shape was adjusted within the spreadsheet to replicate the width-depth ratios and side slopes surveyed along the analog reach, while also maintaining the CSA necessary to convey the design discharge.

3. The scaling factor is determined from the ratio of the design topwidth to the analog topwidth (**Table 19**). For this project, several sections and planform geometry were obtained at the analog site, resulting in an average width of 7.8 feet.

4. Pool cross-sectional areas were calculated using both typical reference reach techniques and the analog approach. Design CSA areas were determined using the measured analog ratios of shallow/ripple CSA to pool CSA as applied to the design CSAs. The pool cross-sectional shape was adjusted within the in-house spreadsheet as described above in step 2.

Table 19. Scaling Factors for Sizing Planform Design Parameters

Reach	Drainage Area (ac)	Proposed Bankfull CSA (ft^2)	Design Topwidth (ft)	Analog Reach Topwidth (ft)	Scaling Factor
UT1	41	3.90	6.4	7.8	0.8
UT2	146	8.90	9.2	7.8	1.2
UT4*	82	22.7	6	7.8	0.8

* The design for UT4 involves the construction of a small channel to convey flow through the natural valley and does not involve full restoration.

7.2.1.3 Typical Design Sections

Typical cross sections for shallows and pools are shown on the design plan sheets in **Appendix D**. The cross-section dimensions were developed for the three design reaches by using a WK Dickson in-house spreadsheet described in **Section 7.2.1.2** of this report. The cross-sections were altered slightly to facilitate constructability; however, the cross-sectional area, width to depth ratio, and side slopes were preserved. Typical pool sections include pools located on straight reaches and pools on meander bends.

7.2.1.4 Typical Meander Pattern

The design plans showing the proposed channel alignment are provided in **Appendix D**. The meander pattern was derived directly from the analog reach and sized using the scaling factors described in **Table 19**. The analog meander pattern was altered in some locations to provide variability in pattern, to avoid onsite constraints, to follow the valley pattern, and to make the channel more constructible. The morphologic parameters summarized in the **Appendix C** were applied wherever these deviations occurred.

7.2.1.5 Longitudinal Profiles

The design profiles are presented in **Appendix C**. These profiles extend throughout the entire project for the proposed channel alignment. The profiles were designed using the analog reach bed features that were sized with the scaling factors. The bed slopes and bankfull energy gradients were determined for each design reach based on the existing valley slope and the sinuosity of the design reach. Log structures will be utilized in the design to control grade, divert flows, and provide additional habitat diversity and stability.

7.2.1.6 In-Stream Structures


Sod mats blanket the top of bank of this stream in Bertie County.

Structures will be incorporated into the channel design to provide additional stability and improve aquatic habitat. Native materials and vegetation will be used for revetments and grade control structures where applicable. Additionally, woody debris will be placed throughout the channel at locations and at a frequency that is similar to those mapped in the analog reaches. The analog reach has woody debris throughout the length of the channel, providing grade control for shallows and forcing scour pools. Woody habitat features installed will include leaf packs, dead brush, woody debris bundles, root wads, and wattles. Sod mats harvested onsite will be installed along stream banks during construction if and when feasible. Sod mats will only be harvested and used if comprised of appropriate vegetation. The use of sod mats that include aggressive turf grasses will be avoided. Sod mats (see photo above) are natural sections of vegetation taken from the banks when they were cut during construction, and are about nine inches thick. Before installation, proposed banks are graded lower than specified to accommodate the thickness of the mat. The mats are placed on top of the bank to act as a natural stabilizer of native species, and they grow much faster than the combination of coir fiber matting and seeding (see detail **Appendix D**). Other bank stability measures include the installation of cuttings bundles at three to five foot intervals along the tops of banks, live staking, root wads, and log toes. Typical details for proposed in-stream structures and revetments are in **Appendix D**.

7.2.2 Wetland Restoration Approach

The Best Site offers a total ecosystem restoration opportunity. As such, the wetland restoration is closely tied to the stream restoration and raising the elevation of the groundwater. The three wetland restoration areas proposed are located at the headwaters of UT1, on the floodplain adjacent to the proposed UT2 stream restoration of Best Site, and on the floodplain of Muddy Creek. Two of the proposed wetlands are near incised and dredged stream channels and one is surrounded by ditches to divert surface and ground water. Wetland W1 also has ditching that further lowers the water table. Hydrologic modifications include channel dredging, drainage ditches, and crowning to promote rapid surface drainage and increase subsurface drainage. These modifications effectively lower the groundwater table and decrease the natural hydroperiod.

7.2.2.1 Wetland Restoration Summary

Wetland restoration activities will include plugging existing ditches, raising the elevation of the local groundwater, restoring natural drainage patterns both above and below the ground surface, roughing of the soil surface, planting wetland species, and permanent exclusion of livestock. Grading will include filling and plugging ditches, removing crowned/fill material, and surface roughing to create hydrologic retention and encourage species diversification. Temporal habitat will be constructed create shallow aquatic habitat and water storage. This will eliminate the surface leveling and smoothing for agricultural use. Combined with the proposed stream restoration these actions will result in a sufficiently high water table and flood frequency to support hydrophytic vegetation and wetland hydrology, resulting in restored riparian wetlands.

The primary restoration activities will include restoring/constructing a stream channel that floods the adjacent wetlands frequently (as described above) and construction of ditch plugs (W1). A typical ditch plug will be 15 feet wide and extend above the ditch bank elevation approximately six inches. Plugs are to be constructed of compacted fill (clay or sandy clay) in 12 inch lifts with the upper 18 inches minimally compacted to facilitate plant growth. Plugs are spaced such that successive plugs are no more than 12 inches in elevation below the next plug up gradient. The existing stream channel will be partially filled, leaving unfilled areas that will provide deeper pools for increased storage and to create diverse habitat. Temporal habitat will be shallow with variable perimeter area and shape. Depth of the temporal pool will be 8 to 14 inches deep to provide a range of water depth. Fencing will be constructed to exclude livestock. The wetland and all disturbed areas will be disced and planted.

7.2.2.2 Proposed Wetland Hydrology

In general, hydrology of a small stream swamp wetland system is derived from seasonal or temporary overbank flooding of the adjacent stream channel and the seasonal high water table elevation controlled by the stream water surface elevation. Many resources describe the duration and frequency of flooding as highly inconsistent. As described by Schafale and Weakley (1990), small stream swamp systems have highly variable flow regimes with floods of short duration and periods of very low flow; however, smaller watersheds lead to a more variable flooding regime. Additionally, the influence of channel overbank flow may vary seasonally to yearly in magnitude, duration, and frequency (WRP Technical Note HY-EV-2.1, 1993). It may be anticipated that the majority of flooding of riparian wetlands occurs during the winter months and the early portions of the growing season. Surface water of riparian wetlands may be present for extended periods during the growing season and usually greater than 14 consecutive days, but is typically absent by the end of the growing season in most typical years (EPA, 1995).

The Best Site was once an interconnected Coastal Plain small stream swamp system subject to prolonged inundation as indicated by soils mapping, historical aerial photography, and personal communication with landowners. Based upon the historical NRCS aerial photography, the proposed wetland restoration areas were historically cleared, ditched, and the streams channelized. The local land use patterns were established prior to 1958. The W1 Site was cleared prior to 1993, with the dates of the ditching/channel incision less clear, but appear to be established by 1977. Stream incision appears to have been progressive and likely due to channel vegetation removal and maintenance. Based upon landowner communication, this channel and the proposed W1 frequently have high flows and flooding after rainfall events. Although frequently flooded, the drainage on this site removes surface water rapidly and likely has a significant impact on lowering the local groundwater table. The W2 and W3 sites were cleared and dredged prior to 1958 with little change apparent in the historic aerial photography. Based upon similar landscape position, the project sites were likely Coastal Plain small stream swamps.

The restoration plan for the Best Site wetlands consists of reconstructing the stream channel with a higher bed elevation and plugging existing drainage ditches. The ditch plugs will lengthen wetland hydroperiods by halting artificial subsurface drainage and preventing rapid surface drainage. The stream design parameters will reconnect the stream to the floodplain and provide seasonal overbank flows. These periodic flows will provide surface and subsurface hydrology support to the newly restored Coastal Plain small stream swamp system. This periodic flooding is vital to sustain plants and wildlife characteristic of riverine wetlands (Ainslie, 2002).

The drainage area for the upstream portion of the project for Wetland W1 is approximately 35.6 acres square miles, for Wetland W2 approximately 1.4 acres, for Wetland W3a is 15.8 acres, and for Wetland W3b is 3.3 acres. The restored wetlands will have a variable flooding regime due to the size of the drainage areas. The stream design modeling indicates that a 2.8 inch six-hour rainfall event will produce an out-of-bank flow for Wetlands W1 and W2. Analysis of daily rainfall totals indicates that a 2.29 inch or greater daily rainfall total occurs on average two times per year. The use of historic rainfall and stream modeling to estimate flood events demonstrates that the wetland restoration area will be subject to inundation and function as a riparian wetland system. However, limitations with the rainfall data set did not allow for statistically rigorous analysis of flooding depth or return interval. A conventional water balance was performed in addition to the above discussion.

7.2.2.3 Soils

Hydric soils within the proposed wetlands were verified through auger borings by a licensed soil scientist (**Appendix B**). The soil in Wetlands W1 and W3 is mapped as Rains with Wetland W2 mapped as Marvyn and Gritney soils. The stream channel bed will be raised, reconnecting the floodplain with seasonal out-of-bank flows. Raising the stream bed will also lessen the “dry shoulder” effect near the stream channel. BMPs will treat stormwater flows from offsite ditches prior to entering the wetlands. A preliminary assessment of hydrologic trespass was performed on the site. It appears that the adjacent agricultural fields are topographically elevated sufficient to provide drainage onto the floodplain without impacting existing drainage. Restoration activities will include:

- Reconnecting low lying areas of hydric soil with the floodplain through stream restoration;
- Plugging/filling agricultural drainage ditches to raise the seasonal groundwater elevations;
- Constructing temporal habitat features;
- Planting native tree and shrub species commonly found in small stream swamp ecosystems; and
- Creating a rough soil surface to aid in infiltration and storage by ripping and discing.

These hydrology restoration activities will result in an elevated seasonal high water table, increased flood frequency and duration, and increased precipitation infiltration across all of the restored wetlands.

It is estimated that riparian wetland restoration will be 3.66 acres for Wetland W1, 0.29 acres for Wetland W2, 0.58 acres for Wetland W3a, and 0.59 acres for Wetland W3b. Minor grading along the restored channels is proposed to remove fill excavated from channel dredging and remove crowning in Wetlands W2 and W3. No fill is proposed beyond plugging previously excavated channels and ditches. Soils in the wetland restoration area will be tested for fertility, and soil amendments may be specified as needed. These wetlands expand habitat along the easement and provide habitat diversity. Once constructed, these wetlands will be monitored to document the success of hydrologic and vegetative restoration.

Wetland W1

Proposed Wetland W1 is located in a concave-concave landform at the headwater of UT1 and has a natural constriction at the outlet. The soil is a sandy loam/loamy sandy underlain by clayey textured subsoil that forms an effective restrictive layer to groundwater loss. This area receives runoff from NC HWY 24. Based upon soil and landscape position, it is likely this area has as a seasonal seepage along the upper boundary, but no evidence of seepage was observed during the site evaluation. Therefore, no additional groundwater input was used in the water balance.

Site modifications include removal of dredged and excavated materials, plugging the ditch, and raising the streambed elevation to bring the water table closer to the ground surface. Additional temporal habitat will be constructed to eliminate surface leveling and smoothing for agricultural use. The temporal habitat will be variable to mimic sloughs, oxbows, root-tips and other shallow natural features. During monitoring, beaver activity will be controlled to allow the site to stabilize and vegetative community to establish. After the monitoring period, the site is designed to promote and tolerate beaver activity. No hydrologic trespass is anticipated due to beaver activity in this wetland. These modifications will increase storage and eliminate the rapid loss of surface water. This area may receive limited overbank flows due to location in the headwater of UT1. Subsoil ripping and roughing of the soil surface will be performed to ameliorate soil compaction and create an uneven surface more conducive for surface water retention, infiltration, and increase storage that would be present in natural wetland systems.

Wetland W2

Proposed Wetland W2 is located in concave-convex landform at the toe slope along Muddy Creek and UT2. The soil is a sandy loam/loamy sandy underlain by sandy clay loam and sandy clay. This site is at a low elevation and is influenced by the water table on the floodplain of Muddy Creek. It is unlikely that groundwater loss is significant during most of the year. Therefore, no additional groundwater loss was used in the water balance. This area has a small watershed, but flooding from UT2 and Muddy Creek will increase water for available storage.

Hydrology will be restored by removing dredge material along the channel and raising the streambed elevation, bringing the water table closer to the ground surface. Site modifications include subsoil ripping, crown removal, and surface roughing of the area. Additional temporal habitat will be constructed to eliminate the surface leveling and smoothing for agricultural use. The temporal habitat will be variable to mimic sloughs, root-tips and other shallow natural features. This will ameliorate past soil leveling and compaction and create an uneven surface more conducive of infiltration and storage that would be present in natural wetland systems.

Wetland W3

Proposed Wetland W3 is composed of two similar area (W3a and W3b) located in a concave-concave landform at the toe slope along Muddy Creek. A low finger of soil separates them. The soil in these areas is a loamy sand/sandy loam. The surrounding upland is underlain by clayey subsoil that forms an effective restrictive layer that lateral flow rides provide additional hydrological input. A ditch is located upslope of these areas and alongside W3a that drains to Muddy Creek.

The soil is a sandy loam/loamy sand. The surrounding upland has a sandy clay loam and sandy clay that form an effective restrictive layer that lateral flow rides provide additional hydrological input. Both areas have small watersheds, but W3b receives groundwater seepage along the toe of slope currently diverted by the upslope ditch.

Hydrology will be restored by filling ditches and enhancing the concave topography by removing soil material where cultivation has filled low features and leveled the surface to facilitate cultivation. Additional groundwater seepage currently diverted by the ditch will be restored to these wetlands. Temporal habitat will be constructed to eliminate the surface leveling and smoothing for agricultural use. Subsoil ripping and surface roughing of the area will be performed to ameliorate soil compaction and create an uneven surface more conducive of infiltration and storage that would be present in natural wetland systems.

7.2.3 Natural Plant Community Restoration

7.2.3.1 Plant Community Restoration

The restoration of the plant communities is an important aspect of the restoration project. The selection of plant species is based on what was observed at the reference reach, species present in the forest surrounding the restoration site, and what is typically native to the area. Several sources of information were used to determine the most appropriate species for the restoration project. The reference stream is located within a disturbed Coastal Plain Small Stream Swamp – Blackwater subtype. Dominant species included sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), swamp tupelo (*Nyssa biflora*), and red maple (*Acer ruburm*) in the canopy. Shrubs included sweetbay (*Magnolia virginiana*) and American holly (*Ilex opaca*). The absence of bald cypress (*Taxodium distichum*) likely indicates past logging with poor regeneration at the site. The reference site was chosen due to the stability of the channel, the physical structure of the forest community, and to evaluate stream habitat. The species present are indicative of early successional species that have high dispersal rates. The mitigation site also supports many species typical of this community type due to its past disturbance history. The adjacent Muddy Creek wetland contains areas of bald cypress, indicating the appropriateness of including this species. Typically, a Coastal Plain Small Stream Swamp would occur along the stream banks and adjacent floodplain of the proposed restoration site.

The restoration site has a relatively uniform topography, and three planting zones will be utilized outside of the stream banks. The zones vary slightly in species composition and percentage to ensure appropriate species are planted for the expected hydrologic regime. The variation more closely mimics the natural range seen in this community type. Therefore, Coastal Plain Small Stream Swamp will be the target community type and will be used for all areas within the project, as well as for buffer around the site. The plant species list has been developed and can be found in **Table 20**. Species with high dispersal rates are not included because of local occurrence, adjacent seed sources, and the high potential for natural regeneration. The high dispersal species include red maple, tulip poplar, and sweetgum.

The restoration of plant communities along Best Site will provide stabilization and diversity. For rapid stabilization of the stream banks (primarily outside meanders), silky dogwood, silky willow, and black willow were chosen for live stakes along the restored channel because of their rapid growth patterns and high success rates. Willows will also be quicker to contribute organic matter to the channel. Willows grow at a faster rate than the species planted around them, and they stabilize the stream banks. When the other species are bigger, the black willows and silky willows will slowly stop growing or die out because the other species would outgrow them and create shade that the willows do not tolerate. The live stake species will be planted along the outside of the meander bends three feet from the top of bank, creating a three-foot section along the top of bank. The live stakes will be spaced one per linear foot with alternate spacing vertically. See **Appendix D** for a detailed planting plan. Zone 1 will be upland and non-wetland areas and consist of species that tolerate dryer zones, but tolerate some wet periods. Zone 2 will consist of wetland species tolerant of longer hydroperiods. The Zone 3 species are the most tolerant of long hydroperiods and will be planted in the lowest topography and in the temporal habitat areas. In W1 the more tolerant species will be planted centrally and less tolerant species concentrated along the fringes due to the likelihood of a future beaver impoundment.

After construction activities, the subsoil will be scarified and any compaction will be deep tilled/ripped before the topsoil is placed back over the site. Any topsoil that is removed during construction will be stockpiled and placed over the site during final soil preparation. This process should provide favorable soil conditions for plant growth. Rapid establishment of vegetation will provide natural stabilization for the site.

Table 20. Proposed Plant List

Bare Root Planting Tree Species - Riparian Areas			
Common Name	**Scientific Name**	**Wetland Indicator***	**Percent Composition**
River birch	*Betula nigra*	FACW	10%
Green ash	*Fraxinus pennsylvanica*	FACW	10%
Swamp Tupelo	*Nyssa biflora*	OBL	5%
Laurel oak	*Quercus laurifolia*	FACW	20%
Overcup oak	*Quercus lyrata*	OBL	20%
Swamp chestnut oak	*Quercus michauxii*	FACW	10%
Water oak	*Quercus nigra*	FAC	5%
American sycamore	*Platanus occidentalis*	FACW	10%
Bald cypress	*Taxodium distichum*	OBL	10%

Bare Root Planting Tree Species - Wetland Areas			
Common Name	**Scientific Name**	**Wetland Indicator***	**Percent Composition**
River Birch	*Betula nigra*	FACW	15%
Green ash	*Fraxinus pennsylvanica*	FACW	20%
Swamp tupelo	*Nyssa biflora*	OBL	10%
Laurel oak	*Quercus laurifolia*	FACW	15%
Overcup oak	*Quercus lyrata*	OBL	20%
Bald cypress	*Taxodium distichum*	OBL	20%

Bare Root Planting Tree Species – Temporal Habitat Features

Common Name	Scientific Name	Wetland Indicator*	Percent Composition
Tag alder	*Alnus serrulata*	FACW	5%
Green ash	*Fraxinus pennsylvanica*	FACW	20%
Swamp tupelo	*Nyssa biflora*	OBL	15%
Laurel oak	*Quercus laurifolia*	FACW	20%
Overcup oak	*Quercus lyrata*	OBL	20%
Bald cypress	*Taxodium distichum*	OBL	20%

Planting density approximately 680 bare root stems per acre.
Planted on a diamond grid to limit preferential linear flow.

Live Staking and Live Cuttings Bundle Tree Species			
Common Name	**Scientific Name**	**Wetland Indicator***	**Percent Composition**
Silky dogwood	*Cornus amomum*	FACW+	45%
Silky willow	*Salix sericea*	OBL	45%
Black willow	*Salix nigra*	OBL	10%

*National Wetland Indicator Status from Draft Rating 2012-Atlantic Gulf Coastal Plain.

7.2.3.2 On-Site Invasive Species Management

Control for invasive species will be required within all grading limits associated with stream restoration, stream Enhancement Level I, and wetland restoration. Three areas outside the grading limits are designated for invasive species control and consist of spot treatment or full invasive control based upon density of aerial coverage: low (less than 10 percent aerial coverage; medium (10 to 50 percent aerial coverage; and, high (greater than 50 percent aerial coverage). Full invasive control will be required within all areas designated as high density. (Where invasive coverage is greater than 50 percent, mechanical removal of top growth and spraying of herbicide may be used.) Spot treatment will be required within all areas designated as moderate density. (Where stems and coverage are greater than 10 percent, but less than 50 percent, individuals shall be cut and stumps sprayed with appropriate herbicide.) Areas of low coverage will be evaluated on a case by case basis and may be reclassified for spot treatment.

Invasive species will require different and multiple treatment methods, depending on plant phenology and the location of the species being treated. All treatment will be conducted so as to minimize its effectiveness and reduce chances of detriment to surrounding native vegetation. Treatment methods will include mechanical control (cutting with loppers, clippers, or chain saw and chemical control (foliar spray, cut stump, and hack and quirt techniques). Plants containing mature, viable seeds will be removed from the site and properly disposed of. All herbicide applicators will be supervised by a certified ground pesticide applicator with a North Carolina Department of Agriculture and Consumer Services (NCDA&CS) license and adhere to all legal and safety requirements according to herbicide labels and NC and Federal laws. Management records will be kept on the plant species treated, type of treatment employed, type of herbicide used, application technique, and herbicide concentration and quantities used. These records will be included in all reporting documents. In areas where full invasive control is performed, seed from appropriate bottomland mast producing species will be planted in the fall following the first full year after invasive control is performed. Records will be kept of date collected, species, provenance, approximate density of each species (pounds/acre), and location planted. Mast seed planted will be recorded. These records will be included in all reporting documents.

Areas where full invasive species control is performed will be direct seeded with bottomland mast-producing species. The seeding will take place the first fall after invasive species control is performed. These areas will be monitored for additional invasive species control.

7.2.4 Best Management Practices

Due to the rural nature of this project, individual stormwater best management practices (BMPs) will not be required. However, diffuse flow structures will be applied at locations where ditches or other forms of concentrated flow enter the conservation easement. These structures will consist of a pool (forebay) located just outside the conservation easement that will attenuate runoff combined with grading and stabilization techniques that will diffuse flow upon entering the buffer. All diffuse flow structures will be installed within the conservation easement so that landowners will not have access to the structures. Failure or maintenance of the structures is not anticipated as these structures will be installed in low-gradient areas, and the areas proposed to diffuse flow will be well vegetated and matted.

Stormwater management issues resulting from future development of adjacent properties will be governed by the applicable state and local ordinances and regulations. It is recommended that any future stormwater entering the site maintain pre-development peak flow. Any future stormwater diverted into the project should be done in a manner as to prevent erosion, adverse conditions, or degradation of the project in any way.

7.2.5 Soil Restoration

After construction activities, the subsoil will be scarified and any compaction will be deep tilled before the topsoil is placed back over the site. Any topsoil that is removed during construction will be stockpiled and placed over the site during final soil preparation. This process should provide favorable soil conditions for plant growth. Rapid establishment of vegetation will provide natural stabilization for the site.

7.3 Data Analysis

7.3.1 Stream Data Analysis

7.3.1.1 Stream Hydrologic Analysis

Hydrologic evaluations were performed for the design reaches using multiple methods to determine and validate the design bankfull discharge and channel geometry required to provide regular floodplain inundation. The use of various methods allows for comparison of results and eliminates reliance on a single model. Peak flows (**Table 21**) and corresponding channel cross-sectional areas were determined for comparison to design parameters using the following methods:

- Regional Flood Frequency Analysis,
- Intellisolve's Hydraflow Express Hydrographs,
- NC and VA/MD Regional Curves for the Coastal Plain, and
- USGS regional regression equations for rural conditions in the Coastal Plain.

<u>Regional Flood Frequency Analysis</u>

A flood frequency analysis was completed for the study region using historic gauge data on all nearby USGS gauges with drainage areas less than 6,400 acres (10 mi^2) which passed the Dalrymple homogeneity test (Dalrymple, 1960). This is a subset of gauges used for

USGS regression equations. Regional flood frequency equations were developed for the 1.1-, 1.5-, and 2-year peak discharges based on the gauge data. Discharges were then computed for the design reach. These discharges were compared to those predicted by the discharge regional curve and USGS regional regression 2-year discharge equations.

Intellisolve's Hydraflow Express Hydrographs

Hydraflow Express was used to simulate the rainfall-runoff process and establish peak flows for the watersheds. This model was chosen over the U.S. Army Corps of Engineers model HEC-1 because it allows the user to adjust the peak shape factor for the Coastal Plain conditions. Using a standard Type III distribution in HEC-1, the model will use a 284 peak shape factor, which is the outdated standard for a coastal environment. This results in conservatively high peak flows that may not be appropriate for a stream restoration design. NRCS staff has recommended using peak shape factors between 60 and 100 for the Coastal Plain. Hydraflow Express allows the user to make this adjustment to the peak shape factor.

Regional Curve Regression Equations

The North Carolina Coastal Plain regional curves by Doll et al. (2003) and Sweet and Geratz (2003) and the Virginia/Maryland (Krstolic et al., 2007) Coastal Plain regional curves for discharge were used to predict the bankfull discharge for the site. The NC regional curves predicted flows that are similar to those predicted by the 1.1-year flood frequency, while the VA/MD curves are comparable to flows predicted by the 1.5-year flood frequency equation. The regional curve equations for NC discharges by Doll et al. (2003) (1) and Sweet and Geratz (2003) (2) and VA/MD (3) discharges are:

(1) $Q_{bkf}=16.56*(DA)^{0.72}$ (Doll et al., 2003)
(2) $Q_{bkf}=8.49*(DA)^{0.76}$ (Sweet and Geratz, 2003)
(3) $Q_{bkf}= 28.3076*(DA)^{0.59834}$ (Krstolic et al., 2007)

Where Q_{bkf}=bankfull discharge (ft^3/s) and DA=drainage area (mi^2).

USGS Regional Regression Equations

USGS regression equations estimate the magnitude and frequency of flood-peak discharges (Gotvald, et al., 2009). The regression equations were developed from gauge data in different physiographic regions of the Southeastern United States. For this analysis, there was only concern for the 2-year return interval. The equation for the rural Coastal Plain (Hydrologic Region 4) is:

(4) $Q_2=60.3*(DA)^{0.649}$

Table 21. Peak Flow Comparison

Reach	Drainage Area (Ac)	Hydraflow Hydrographs Q_1	FFQ $Q_{1.1}$	FFQ $Q_{1.5}$	NC Regional Curve Q (1)	NC Regional Curve Q (2)	VA/MD Regional Curve Q (3)	Regional Regression Eqns. Q_2	Design/ Calculated Q
Analog	285	---	11	23	9	5	17	36	13
UT1	41	10	2	5	2	1	5	10	6
UT2	146	22	6	14	6	3	12	23	15
UT3	59	8	2	7	3	1	7	13	7

Reach	Drainage Area (Ac)	Hydraflow Hydrographs Q_1	FFQ $Q_{1.1}$	FFQ $Q_{1.5}$	NC Regional Curve Q (1)	NC Regional Curve Q (2)	VA/MD Regional Curve Q (3)	Regional Regression Eqns. Q_2	Design/ Calculated Q
UT4	82	14	3	9	4	2	8	16	11
UT6	79	11	3	8	4	2	8	16	9
UT8	56	9	2	6	3	1	7	12	8

The fact that the regional curves predict flows similar to the 1.1-year flood frequency analysis indicates that the bankfull flows occur in the region with a frequency of approximately once a year. The developers of the NC Coastal Plain regional curves report an average recurrence interval of 1.12 years for the gauged streams included in their study.

7.3.1.2 Sediment Transport Analysis

An erosion and sedimentation analysis was performed to confirm that the restoration design creates a stable sand bed channel that neither aggrades nor degrades over time. Typically, sediment transport is assessed to determine a stream's ability to move a specific grain size at specified flows. Various sediment transport equations may be easily applied when estimating entrainment for gravel bed streams; however, these equations are not as effectively applied to sand bed channels where the entire bed becomes mobile during geomorphically significant flows. Therefore, more sophisticated modeling techniques were used to analyze the stream design for this project. The following methods and functions were utilized during the sediment transport analysis:

- Stable Channel Design Function – Copeland Method (HEC-RAS),
- Shear Stress, and
- Velocity.

<u>Stable Channel Design</u>

Design cross-section dimensions as determined from the analog approach were evaluated using the stable channel design functions within HEC-RAS. These functions are based upon the methods presented in the SAM Hydraulic Design Package for Channels developed by the USACE Waterways Experiment Station. The Copeland Method was developed specifically for sand bed channels (median grain size restriction of 0.0625 mm to 2 mm) and was selected for application at Best Site. The method sizes stable dimensions as a function of slope, discharge, roughness, side slope, bed material gradation, and the inflowing sediment discharge. Results are presented as a range of widths and slopes, and their unique solution for depth, making it easy to adjust channel dimensions to achieve stable channel configurations. The stable design output parameters are listed in **Table 22**. The results are acceptable and match closely with the design reach parameters.

Table 22. Stable Channel Design Output

Reach	Q (ft/s^3)	Bottom Width (ft)	Depth (ft)	Energy Slope (ft/ft)	Composite n value	Velocity (ft/s)	Shear Stress (lbs/ft^2)
UT1	6	4	0.7	0.0052	0.040	1.7	0.21
UT2	15	4	1.3	0.0028	0.045	1.6	0.24

<u>Shear Stress Approach</u>

Shear stress is a commonly used tool for assessing channel stability. Allowable channel shear stresses are a function of bed slope, channel shape, flows, bed material (shape, size, and gradation), cohesiveness of bank materials, and vegetative cover. The shear stress approach compares calculated shear stresses to those found in the literature. Shear stress is the force exerted on a boundary during the resistance of motion as calculated using the following formula:

(1) $\tau = \gamma RS$
τ = shear stress (lb/ft^2)
γ = specific gravity of water (62.4 lb/ft^3)
R = hydraulic radius (ft)
S = average channel slope (ft/ft)

Table 23. Comparison of Allowable and Proposed Shear Stresses

Reach	Proposed Shear Stress at Bankfull Stage (lbs/ft^2)	Critical Shear Stress (lbs/ft^2)	Allowable Shear Stress[1]	
			Sand/Silt/Clay (lbs/ft^2)	Vegetation (lbs/ft^2)
UT1	0.18	>0.003	0.03 to 0.26	0.2 to 0.95
UT2	0.15	>0.003	0.03 to 0.26	0.2 to 0.95

[1](Fischenich, 2001)

Review of the above table shows that the proposed shear stresses for the Best Site design reaches fall between the critical shear stress (shear stress required to initiate motion) and the allowable limits. Therefore, the proposed channel should remain stable.

Velocity Approach

Published data are readily available that provide entrainment velocities for different bed and bank materials. A comparison of calculated velocities to these permissible velocities is a simple method to aid in the verification of channel stability. **Table 24** compares the proposed velocities calculated using Manning's equation with the permissible velocities presented in the Stream Restoration Design Handbook (NRCS, 2007).

Table 24. Comparison of Allowable and Proposed Velocities

Reach	Manning's "n" value	Design Velocity (ft/s)	Allowable Velocity[1] (ft/s)	
			Fine Sand	Coarse Sand
UT1	0.05	1.7	2.0	4.0
UT2	0.05	1.6	2.0	4.0

[1](NRCS, 2007)

Sediment Supply

In addition to the stability assessment, a qualitative analysis of sediment supply was performed by characterizing watershed conditions. A combination of field reconnaissance and windshield surveys, existing land use data, and historical aerial photography were analyzed to assess existing and past watershed conditions and to determine if any changes occurred that would significantly impact sediment supply. As discussed in **Section 2.2.3**, the land use throughout the site, and primarily around restoration reaches UT1 and UT2, has changed little since 1958. Much of the project area has been used extensively for agricultural purposes over the past 50 years; and current land use is composed of approximately 44 percent forest cover and hardwood swamp, 47 percent cultivated land, three percent residential and six percent managed herbaceous cover and pasture. Since 1958, there have been several significant land disturbing events. During the 1980's and 1990's, two separate CAFOs with lagoons were constructed near reaches UT3 and UT4. The other event occurred between 1983 and 1993 when portions of the forested headwaters of UT1 were cleared and converted to pasture. Overall, the project watershed is stable and is largely forested where the majority of the forested areas are located within the headwaters of the project watershed and along many of the tributaries to Muddy Creek. Land use has remained relatively constant within this rural watershed, and significant land disturbing activities are not anticipated for the future.

A large percentage of the cultivated areas are located in the middle and lower portions of the project watershed. Additionally, the land use within the watersheds of restoration reaches UT1 and UT2 is comprised of over 60 percent agriculture fields and less than 20% forest. Observations and assessments of these reaches show little signs of aggradation or degradation and that the streams are physically stable. Much of the headwaters of the project watershed (upstream of the project site) are largely a mix of forest, scrub/shrub, and cultivation, where the majority of the forested areas are located adjacent to streams. All of the existing project streams appear to be physically stable and show little to no signs of deposition, indicating that the reaches are able to effectively transport the sediment supplied by their respective watersheds. It is anticipated that sediment supply will decrease as buffers are enhanced and widened, and flow from existing agricultural ditches will be diffused before entering the proposed channel. Since sand bed streams are mobile, and therefore more sensitive to changes in flow and sediment regimes, a design approach has been used where the proposed channel is designed to maintain geometry and handle stresses slightly greater than what will be applied under the design conditions. Additionally, grade controls have been integrated throughout the design to provide vertical stability.

7.3.1.1 Hydraulic Analyses

Hydraulic evaluations were performed for the restoration design reaches of UT1 and UT2. These analyses were performed to confirm that the restoration designs will convey the design discharge, provide more frequent overbank flooding, and that significant structures will perform as designed.

<u>HEC-RAS Analysis</u>
A hydraulic analysis was performed to confirm that the restoration design results in a channel that will convey the design discharge and provide for frequent flooding of the adjacent riparian floodplain and wetlands. Channel characteristics, including cross-sectional dimension, slope, and roughness, were used to analyze and adjust design parameters calculated by the analog/reference reach approach.

HEC-RAS was used to perform the hydraulic analysis. This model is a hydraulic model developed by the US Army Corps of Engineers' Hydrologic Engineering Center to perform one-dimensional (1-D) steady and unsteady flow calculations. The model uses representative geometric data (cross-sections) and hydraulic computation routines.

Design cross-sectional dimensions determined through the analog/reference reach approach were evaluated using the 1-D steady flow analysis component and the channel design functions within the HEC-RAS Model (Version 4.0.0). The cross-sectional dimensions for reaches UT1 and UT2 were iteratively adjusted based on the model results to produce a channel design that will regularly flood the adjacent riparian areas. Model results are presented in **Appendix C.** The results are organized by reach, discharge, and STA number and include water surface elevation, velocity, flow area, stream power, and shear stress.

7.3.2 Wetland Data Analysis

7.3.2.1 Wetland Hydrologic Analysis

In general, hydrology of a small stream swamp wetland system is derived from seasonal or temporary overbank flooding of the adjacent stream channel and the seasonal high water table elevation controlled by the stream water surface elevation. Many resources describe the duration and frequency of flooding as highly inconsistent. As described by Schafale and Weakley (1990), small stream swamp systems have highly variable flow regimes with floods of short duration and periods of very low flow; however, smaller watersheds lead to a more variable flooding regime. Additionally, the influence of channel overbank flow may vary seasonally to yearly in magnitude, duration, and frequency (WRP Technical Note HY-EV-2.1, 1993). It may be anticipated that the majority of flooding of riparian wetlands occurs during the winter months and the early portions of the growing season. Surface water of riparian wetlands may be present for extended periods during the growing season and usually greater than 14 consecutive days, but is typically absent by the end of the growing season in most typical years (EPA, 1995). Field indicators of surface inundation include water-stained leaves, drifts lines and water marks on trees (EPA, 1995). In the absence of surface water, the water table is often near the ground elevation.

Due to the direct relationship between stream flow and riparian wetland hydrology the proposed stream was designed to provide periodic overbank flow within the bounds of the proposed wetland.

7.3.2.2 Wetland Water Balance

The proposed wetland restoration areas are located adjacent to the headwater of UT1 and at the downstream end of UT2 and on the floodplain of Muddy Creek. Runoff from the local watershed will also provide hydrologic input and will provide the opportunity for nutrient and pollutant removal in these wetlands. To determine the general input from the watershed in terms of providing significant hydrology needed to sustain saturated conditions, a general water balance analysis was performed.

In order to determine suitable hydrology for the proposed Wetland Creation/ Enhancement Coastal Plain Small Stream Swamp, existing hydrologic conditions were evaluated through a water balance analysis. This water balance is a model for water depths and potential drawdown for the proposed wetland construction. A watershed approach was applied and methods outlined in *Planning hydrology for constructed wetlands* (Pierce, 1993) were followed.

The water balance presented in this report was determined from the following equation:
$S = P + R + G - ET - I$. Where S is storage, P is precipitation, R is runoff, G is groundwater, ET is evapotranspiration, and I is infiltration (Pierce, 1993).

It is expected that regular occurrences of overbank flooding will provide significant hydrologic input into these wetlands that is not shown in these water balance calculations. Long-term rainfall was obtained from the North Carolina Climate Office, and potential runoff was estimated using methodology detailed in Urban Hydrology for Small Watershed-Technical Release 55 (USDA-NRCS 1986).

Groundwater

Due to landscape position and the geology of the coastal plain, groundwater can provide significant input to a wetland system. Where present, the amount of groundwater input is difficult to estimate. Within the lower landscape positions it was assumed that any groundwater is relatively static, any discharge elevation is just below the wetland and does not provide direct hydrologic input, but prevents infiltration, resulting in both values being zero. For Wetland 3b, groundwater discharge was determined to be a large enough quantity to estimate. A conservative estimate of 117 cubic feet/day was used across the wetter period extending from January through April with May at two thirds and November-December at one half to approximate drawdown and replenishment periods of the hydrological cycle.

Precipitation

Daily precipitation data and temperature data from the Warsaw (COOP) weather station has been compiled for a 28-year period of record from January 1, 1984 through September 31, 2012 (The North Carolina State Climatologist http://www.nc-climate.ncsu.edu/; Attachment A). The Warsaw Station was used, as it is the closest station to the site with a large portion of the records available. Out of 330 months, 18 were absent, primarily before 1996. Average monthly precipitation values were then calculated from these data and applied to the water balance calculations.

Precipitation only calculates runoff from the small local watershed to the wetland restoration. The larger drainage area encompassed by the adjacent channel is not evaluated, but will contribute overbank flows to provide additional input to wetland hydrology.

Evapotranspiration

A long-term record of weather data for the area is missing or not collected. (Daily temperature data available from the Warsaw (COOP) weather station has been compiled for a 28-year period of record from January 1, 1984 through September 31, 2012 (The North Carolina State Climatologist http://www.nc-climate.ncsu.edu/; Attachment A). An alternative estimate for Evapotranspiration was calculated based on daily temperatures by a method defined by Richard Allen et al. (2006).

$$ET_o = 0.0023(Tmean + 17.8)\ (Tmax - Tmin\ )^{0.5}R_a$$

Where;

ET_o	reference crop evapotranspiration [mm day-1]
Tmean	daily mean air temperature [°C]
Tmax	daily maximum air temperature [°C]
Tmin	daily minimum air temperature [°C]
R_a	extraterrestrial radiation [MJ m-2 day-1]

Values for R_a for different latitudes are given in a table provided by the authors, where values “deviate from values that are averaged over each day of the month by less than one percent for all latitudes during non-frozen periods ...”

Runoff Calculations

Runoff onto the wetland creation/enhancement site was determined by using the TR-55 Curve Number Method as described by Pierce 1993. Rainfall is defined as each 24-hour rainfall total as recorded by the local weather station. The drainage area for the local watershed of each proposed wetland was delineated using 7.5 Minute USGS topographic quadrangle for Drake, North Carolina; (**Figure 2**).

Determination of days producing runoff is based upon the minimum rainfall amount needed to produce runoff (*Q*). The value of Q for the drainage area was calculated from daily precipitation values over the period of record. The equation for calculating runoff is as follows:

$$Q = \frac{(P_{24} - 0.2S)^2}{(P_{24} + 0.8S)}$$

$$S = \left(\frac{1000}{CN}\right) - 10$$

$$Q = \frac{\left[P_{24} - 0.2\left(\left(\frac{1000}{CN}\right) - 10\right)\right]^2}{\left[P_{24} + 0.8\left(\left(\frac{1000}{CN}\right) - 10\right)\right]}$$

P_{24}

A 24-hour rainfall record was determined using precipitation data.

Q

Runoff determined using precipitation data and watershed characteristics specific to the site.

S

The potential maximum retention after runoff begins (inches). This is related to soil and soil cover conditions of the watershed through the Curve Number (see below).

Where P_{24} is the maximum rainfall occurring in a 24-hour period (over the period of record), CN is the composite curve number, and S is the storage capacity of the soil. A composite curve was calculated by subdividing the watershed with respect to soil hydrologic group and land use then determining the appropriate curve number for each subdivision using tables published by the USDA (1986). The area and curve number were multiplied, summed and divided by the total watershed area to calculate the composite curve number as described below.

$$CN = \frac{\sum(CN * SubdividedArea)}{(WatershedArea)}$$

By this method the composite curve number for proposed wetland creation/enhancement site was;

Wetland	Composite CN
1	74.7
2	75.9
3a	71.8

3b..78.3

Runoff

Daily runoff (R) was calculated from the amount of precipitation (P) for each day. Those days that returned positive values (i.e. runoff occurred) were then summed to return the monthly runoff (R) produced within the watershed area. Those events that return positive values (i.e. runoff occurred) are then summed to return the amount of *runoff* (*R*) produced by each acre in the watershed. Once runoff values were calculated for the drainage area, it was necessary to adjust these values to reflect the amount of water seen on the site as follows:

*R = (Watershed Runoff) * (Watershed Area) / (Site Area)*

These runoff values are then summed each month for the entire period and averaged for the watershed. Runoff for each wetland is summarized in **Appendix C**.

Infiltration

The proposed wetland creation / enhancement area is mapped as Rains and Goldsboro soil. Soil borings in these areas indicates the soil is closer to Rains. The Rains mapping unit is poorly drained and has a loamy surface underlain by clayey subsoil found in lower landscape positions. The Goldsboro mapping unit is moderately well drained and has a loamy surface underlain by clayey subsoil found in higher landscape positions.

Infiltration into the soil on the site was based upon the permeability range (0.0 to 0.05 in/hr) indicated for hydrologic soil group D soils (USDA 1986). During months where the seasonal high water table is above 12 inches, the infiltration was assumed to be negligible and set to zero. The Rains soil typically has a seasonal high water table from December through April ranging from zero to 12 inches in depth. Infiltration is calculated by converting permeability from centimeters per second (cm/sec) to inches per month (in/mo). Infiltration is expected to be low or near zero during these months, and was estimated to be zero for the water balance calculation.

Hydrograph

The calculated data has been compiled and a hydrograph has been plotted illustrating the monthly average flow of water in and out of the proposed wetland construction area (**Appendix C**). These values are represented in acre-inches. Results of this analysis indicate that there is a period of drawdown during the months of April and November. These results also indicate that runoff and direct precipitation will, in average years, provide adequate wetland hydrology during most of the growing season at the wetland restoration area.

Conclusions

This water balance analysis was conducted to evaluate the existing hydrology of the proposed wetland restoration area and to determine if the proposed wetland design is appropriate for this site. The modeling presented in this report indicates that there is sufficient hydrology at appropriate times of the year to support wetland vegetation.

Field observations indicate that existing conditions of the proposed wetland restoration area includes hydric soils and proximity to the floodplain. These observations suggest that overbank flows from the restored stream channel will play a significant role in overall site hydrology, especially Wetland W2. However, without more detailed data with regards to the fluctuating groundwater table, this information is unreliable and also unpredictable. Therefore, conducting a water balance analysis assures a minimum water source to the site. It is expected that regular occurrences of overbank flooding will provide significant hydrologic input into these wetlands not shown in these water balance calculations.

7.3.3 Mitigation Summary

Natural channel design techniques have been used to develop the restoration designs described in this document. The combination of the analog and analytical design methods was determined to be appropriate for this project because the watershed is rural, the causes of disturbance are known and have been abated, and there are minimal infrastructure constraints. The original design parameters were developed from the measured analog/reference reach data and applied to the subject stream. The parameters were then analyzed and adjusted through an iterative process using analytical tools and numerical simulations of fluvial processes. The designs presented in this report provide for the restoration of natural Coastal Plain sand-bed channel features and stream bed diversity to improve benthic habitat. The proposed design will allow flows that exceed the design bankfull stage to spread out over the floodplain, restoring a portion of the hydrology for the existing wetlands.

A large portion of the existing stream will be filled using material excavated from the restoration channel and from the farm path built adjacent to the channel. However, many segments will be left partially filled to provide habitat diversity and flood storage. Native woody material will be installed throughout the restored reach to reduce bank stress, provide grade control, and increase habitat diversity.

Forested riparian buffers of at least fifty feet on both sides of the channel will be established along the project reach. An appropriate riparian plant community, a Coastal Plain Small Stream Swamp – Blackwater subtype community, will be established to include a diverse mix of species. Three zones will be used depending upon expected hydrologic conditions. Replanting of native species will occur where the existing buffer is impacted during construction.

Reductions in nutrients and other pollutants will be achieved with the buffer restoration work, providing substantial benefits to the watershed. The proposed Best Site Mitigation Site includes a large Stream Preservation and Buffer Enhancement area along the floodplain of Muddy Creek and hydrologically connects the proposed restoration areas. Wetlands W1, W2, and W3 are proposed adjacent to the stream restoration of the Best Site Mitigation Site.

8 MAINTENANCE PLAN

NCEEP shall monitor the site on a regular basis and shall conduct a physical inspection of the site a minimum of once per year throughout the post-construction monitoring period until performance standards are met. These site inspections may identify site components and features that require routine maintenance. Routine maintenance should be expected most often in the first two years following site construction and may include the following:

Table 25. Maintenance Plan

Component/Feature	Maintenance through project close-out
Stream	Routine channel maintenance and repair activities may include chinking of in-stream structures to prevent piping, securing of loose coir matting, and supplemental installations of live stakes and other target vegetation along the channel. Areas where stormwater and floodplain flows intercept the channel may also require maintenance to prevent bank failures and head-cutting.
Wetland	Routine wetland maintenance and repair activities may include securing of loose coir matting and supplemental installations of live stakes and other target vegetation within the wetland. Areas where stormwater and floodplain flows intercept the wetland may also require maintenance to prevent scour.
Vegetation	Vegetation shall be maintained to ensure the health and vigor of the targeted plant community. Routine vegetation maintenance and repair activities may include supplemental planting, pruning, mulching, and fertilizing. Exotic invasive plant species shall be controlled by mechanical and/or chemical methods. Any vegetation control requiring herbicide application will be performed in accordance with NC Department of Agriculture (NCDA) rules and regulations.
Site Boundary	Site boundaries shall be identified in the field to ensure clear distinction between the mitigation site and adjacent properties. Boundaries may be identified by fence, marker, bollard, post, tree-blazing, or other means as allowed by site conditions and/or conservation easement. Boundary markers disturbed, damaged, or destroyed will be repaired and/or replaced on an as needed basis.
Utility Right-of-Way	Utility rights-of-way within the site may be maintained only as allowed by Conservation Easement or existing easement, deed restrictions, rights of way, or corridor agreements.
Ford Crossing	Ford crossings within the site may be maintained only as allowed by Conservation Easement or existing easement, deed restrictions, rights of way, or corridor agreements.
Road Crossing	Road crossings within the site may be maintained only as allowed by Conservation Easement or existing easement, deed restrictions, rights of way, or corridor agreements.

9 PERFORMANCE STANDARDS

The success criteria for the Best Site stream restoration will follow accepted and approved success criteria presented in the USACE Stream Mitigation Guidelines and subsequent NCEEP and agency guidance. Specific success criteria components are presented below.

9.1 Stream Restoration Success Criteria

9.1.1 Bankfull Events

Two bankfull flow events must be documented within the seven-year monitoring period. The two bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

9.1.2 Cross Sections

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections shall be classified using the Rosgen stream classification method, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

9.1.3 Digital Image Stations

Digital images will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal images should not indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral images should not indicate excessive erosion or continuing degradation of the banks over time. A series of images over time should indicate successional maturation of riparian vegetation.

9.2 Wetland Success Criteria

The NRCS does not have a current WETs table for Duplin County upon which to base a normal rainfall amount and average growing season. The closest comparable data was determined to be from Sampson County. The growing season is from March 26 to November 14. Based on a daily minimum temperature greater than 28 degrees Fahrenheit occurring in five of ten years, the growing season for Sampson County is 242 days long. Successful establishment of wetland hydrology will be demonstrated by a wetland hydroperiod of nine percent or greater of one growing season (22 days) at each groundwater gauge location. In growing seasons with less than normal rainfall, no hydrology data will be used.

If a gauge location fails to meet these success criteria in the seven year monitoring period then monitoring may be extended, remedial actions may be undertaken, or groundwater modeling may be used to demonstrate the limits of wetland restoration.

9.3 Vegetation Success Criteria

Specific and measurable success criteria for plant density within the riparian buffers on the site will follow NCEEP Guidance. Vegetation monitoring plots will be a minimum of 0.02

acres in size, and cover a minimum of two percent of the planted area. Vegetation monitoring will occur annually in the fall of each year. The interim measures of vegetative success for the site will be the survival of at least 320 planted three-year old trees per acre at the end of Year 3, 260 five-year old trees at the end of Year 5, and the final vegetative success criteria will be 210 trees per acre with an average height of 10 feet at the end of Year 7.

9.4 Scheduling/Reporting

A mitigation plan and as-built drawings documenting stream restoration activities will be developed within 60 days of the planting completion on the mitigation site. The report will include all information required by NCEEP mitigation plan guidelines, including elevations, photographs and sampling plot locations, gauge locations, and a description of initial species composition by community type. The report will also include a list of the species planted and the associated densities. Baseline vegetation monitoring will follow CVS-NCEEP Protocol for Recording Vegetation Version 4.0. Level 1 and Level 2 monitoring will be conducted. The baseline report will follow Baseline Monitoring Report Template and Guidance version 2.0 (10/14/10).

The monitoring program will be implemented to document system development and progress toward achieving the success criteria. The restored stream morphology will be assessed to determine the success of the mitigation. The monitoring program will be undertaken for five years or until the final success criteria are achieved, whichever is longer.

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCEEP. The monitoring reports will include all information, and be in the format required by NCEEP in Version 2.0 of the NCEEP Monitoring Report Template.

10 MONITORING REQUIREMENTS

Annual monitoring data will be reported using the EEP monitoring template. The monitoring report shall provide a project data chronology that will facilitate an understanding of project status and trends, population of EEP databases for analysis, research purposes, and assist in decision making regarding project close-out. The success criteria for the Best Site stream and wetland mitigation will follow current accepted and approved success criteria presented in the USACE Stream Mitigation Guidelines, NCEEP requirements, and subsequent agency guidance. Specific success criteria components are presented **Table 26**. Monitoring reports will be prepared annually and submitted to EEP.

Table 26. Monitoring Requirements

Required	Parameter	Quantity	Frequency	Notes
	Pattern	As per April 2003 USACE Wilmington District Stream Mitigation Guidelines	Baseline	Additional surveys will be performed if monitoring indicates instability or significant channel migration
	Dimension	As per April 2003 USACE Wilmington District Stream Mitigation Guidelines	Baseline, Years 1,2,3,5, and 7	Surveyed cross sections and bank pins
	Profile	As per April 2003 USACE Wilmington District Stream Mitigation Guidelines	Baseline	Additional surveys will be performed if monitoring indicates instability
	Surface Water Hydrology	As per April 2003 USACE Wilmington District Stream Mitigation Guidelines	Annual	Crest Gauges and/or Pressure Transducers will be installed on site; the devices will be inspected on a quarterly/semi-annual basis to document the occurrence of bankfull events on the project
	Groundwater Hydrology		Annual	Groundwater monitoring gauges with data recording devices will be installed on site; the data will be downloaded on a quarterly basis during the growing season
	Vegetation		Annual	Vegetation will be monitored using the Carolina Vegetation Survey (CVS) protocols
	Exotic and Nuisance Vegetation		Annual	Locations of exotic and nuisance vegetation will be mapped
	Project Boundary		Semi-annual	Locations of fence damage, vegetation damage, boundary encroachments, etc. will be mapped
	Stream Visual		Annual	Semi-annual visual assessments
	Wetland Visual		Annual	Semi-annual visual assessments

10.1 As-Built Survey

An as-built survey will be conducted following construction to document channel size, condition, and location. The survey will include a complete profile of Thalweg, water surface, bankfull, and top of bank to compare with future geomorphic data. Longitudinal profiles will not be required in annual monitoring reports unless requested by NCEEP or USACE. Stream channel stationing will be marked with stakes placed near the top of bank every 100 feet.

10.2 Visual Monitoring

Visual monitoring of all mitigation areas will be conducted a minimum of twice per monitoring year by qualified individuals. The visual assessments will include vegetation density, vigor, invasive species, and easement encroachments. Visual assessments of stream stability will include a complete streamwalk and structure inspection. Digital images will be taken at fixed representative locations to record each monitoring event, as well as any noted problem areas or areas of concern. Results of visual monitoring will be presented in a plan view exhibit with a brief description of problem areas and digital images. Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal photos should indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the banks over time. A series of photos over time should indicate successional maturation of riparian vegetation.

10.3 Cross Sections

Permanent cross-sections will be installed at a minimum of one per 20 bankfull widths with half in pools and half in shallows. All cross-section measurements will include bank height ratio and entrenchment ratio. Cross-sections will be monitored annually. There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Bank height ratio shall not exceed 1.2, and the entrenchment ratio shall be no less than 2.2 within restored reaches. Channel stability should be demonstrated through a minimum of two bankfull events documented in the seven-year monitoring period.

10.4 Bank Pin Arrays

Bank pin arrays will be used as a supplemental method to monitor erosion on selected meander bends where there is not a cross section. Bank pin arrays will be installed along the outer bend and upstream third and downstream third of the meander. Bank pins will be installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with the bank.

10.5 Surface Flow

UT1, W1, and the headwater valley restoration area on UT4 will be monitored to document intermittent or seasonal surface flow. This will be accomplished through direct observation, photo documentation of dye tests, and installation of groundwater gauges and continuous flow monitoring devices (pressure transducers).

10.6 Wetland Hydrology

Wetland hydrology will be monitored to document hydric conditions in the wetland restoration areas. This will be accomplished with automatic recording pressure transducer gauges installed in representative locations across the restoration areas and reference wetland. The gauges will be downloaded quarterly and wetland hydroperiods will be calculated during the growing season. Gauge installation will follow current regulatory and EEP guidance. Visual observations of primary and secondary wetland hydrology indicators will also be recorded during quarterly site visits.

10.7 Vegetative Success Criteria

Vegetative monitoring success criteria for plant density within the riparian buffers on the site will follow NCEEP Guidance dated 7 November 2011. Vegetation monitoring plots will be a minimum of 0.02 acres in size, and cover a minimum of two percent of the planted area. The following data will be recorded for all trees in the plots: species, height, planting date (or volunteer), and grid location. Monitoring will occur each year during the monitoring period. The interim measures of vegetative success for the site will be the survival of at least 320 planted three-year old trees per acre at the end of Year 3 and 260 five-year old trees per acre at the end of Year 5. The final vegetative success criteria will be the survival of 210 trees per acre with an average height of 10 feet at the end of Year 7 of the monitoring period.

Invasive and noxious species will be monitored and controlled so that none become dominant or alter the desired community structure of the site. If necessary, EBX will develop a species-specific control plan.

10.8 Remedial Actions

The Mitigation Plan will include a detailed adaptive management plan that will address how potential problems are resolved. In the event that the site, or a specific component of the site, fails to achieve the defined success criteria, EBX will develop necessary adaptive management plans and/or implement appropriate remedial actions for the site in coordination with NCEEP and the review agencies. Remedial action required will be designed to achieve the success criteria specified previously, and will include identification of the causes of failure, remedial design approach, work schedule, and monitoring criteria that will take into account physical and climatic conditions. If tree mortality affects 40 percent or greater of the canopy in a stream or wetland restoration area, then a remedial/supplemental planting plan will be developed and implemented for the affected area(s).

11 LONG-TERM MANAGEMENT PLAN

Upon approval for closeout by the Interagency Review Team (IRT), the site will be transferred to the State of North Carolina (State). The State shall be responsible for periodic inspection of the site to ensure that restrictions required in the conservation easement or the deed restriction document(s) are upheld. Endowment funds required to uphold easement and deed restrictions shall be negotiated prior to site transfer to the responsible party.

The NCDENR Division of Natural Resource Planning and Conservation’s Stewardship Program currently houses EEP stewardship endowments within the non-reverting, interest-bearing Conservation Lands Stewardship Endowment Account. The use of funds from the Endowment Account is governed by North Carolina General Statute GS 113A-232(d)(3). Interest gained by the endowment fund may be used only for the purpose of stewardship, monitoring, stewardship administration, and land transaction costs, if applicable. The NCDENR Stewardship Program intends to manage the account as a non-wasting endowment. Only interest generated from the endowment funds will be used to steward the compensatory mitigation sites. Interest funds not used for those purposes will be re-invested in the Endowment Account to offset losses due to inflation.

12 ADAPTIVE MANAGEMENT PLAN

Upon completion of site construction, EEP will implement the post-construction monitoring protocols previously defined in this document. Project maintenance will be performed as described previously in this document. If, during the course of annual monitoring, it is determined that the site's ability to achieve site performance standards are jeopardized, EEP will notify the USACE of the need to develop a Plan of Corrective Action. The Plan of Corrective Action may be prepared using in-house technical staff or may require engineering and consulting services. Once the Corrective Action Plan is prepared and finalized EEP will:

1. Notify the USACE as required by the Nationwide 27 permit general conditions.
2. Revise performance standards, maintenance requirements, and monitoring requirements as necessary and/or required by the USACE.
3. Obtain other permits as necessary.
4. Implement the Corrective Action Plan.
5. Provide the USACE a Record Drawing of Corrective Actions. This document shall depict the extent and nature of the work performed.

13 FINANCIAL ASSURANCES

Pursuant to Section IV H and Appendix III of the Ecosystem Enhancement Program's In-Lieu Fee Instrument dated July 28, 2010, the North Carolina Department of Environment and Natural Resources has provided the U.S. Army Corps of Engineers Wilmington District with a formal commitment to fund projects to satisfy mitigation requirements assumed by EEP. This commitment provides financial assurance for all mitigation projects implemented by the program.

14 OTHER INFORMATION

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14.2 Appendix A – Site Protection Instrument(s)

Conservation Easement Deeds
Preliminary Plats

Note: This appendix will be updated as the easement deeds and plats become available.

14.3 Appendix B – Baseline Information Data

Best Baseline Information Table
Best USACE Routine Wetland Data Forms
Best Mapped Soil Series and Boring Logs
Best NCDWQ Stream Determination Data Forms
Reference Reach NCDWQ Stream Determination Data Forms
Best Existing Conditions Cross Section Charts
Best NCDWQ Habitat Assessment Data Forms
Best Aquatic Habitat Assessment
Best Channel Stability Assessment Forms
Best EDR Report
Best Environmental Screening and Resource Agency Correspondence

- Best CE
- Farmland Conversion Impact Rating (Form AD 1006)
- EDR Reports
- FEMA Floodplain Checklist
- Best Correspondence

(See included CD for Appendix B)

14.4 Appendix C – Mitigation Work Plan Data and Analyses

Best Morphological Parameters
Reference Reach Existing Cross Section and Profile Charts
Best Stable Channel Hydraulic Design Output
HEC-RAS Data Output
Best Water Balance

14.5 Appendix D – Best Design Plan Sheets (11”x17”)