Glade Creek II Restoration Project
Alleghany County, North Carolina
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Restoration Plan

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Ecosystem Enhancement
PROGRAM

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11.0 Figures

Executive Summary

Glade Creek is a perennial stream located within the "Upper New" sub-basin of the New River Basin in Alleghany County, North Carolina. The project site is at elevation 2574 feet MSL. The reach of Glade Creek and UT to Glade Creek to be restored is approximately 2029 feet in length owned by Sharon W. Beck. The North Carolina Ecosystem Enhancement Program (NCEEP) has a project on Glade Creek located upstream of the Beck property. These two projects will provide localized benefits on Glade Creek and are two links in the overall goal of watershed restoration for this basin.

Existing Glade Creek is an incised gravel bed C4/G4 stream. The 8.0 square mile watershed contributing drainage to the stream restoration segment is located in a rural setting. The land adjacent to Glade Creek is currently under forestry production of White Pine trees. Throughout the restoration stream length the floodplain has an average width of approximately 250 feet. The existing stream's width ranges from 21 feet to 39 feet at the top of bank with steep side slopes undergoing heavy erosion in the outsides of bends. The channel is very sinuous with severe bends and has incised throughout the reach approximately two feet.

One unnamed tributary (UT) to Glade Creek is included in the project. UT to Glade Creek is a degraded B4/C4 stream with a watershed area of approximately 0.016 square miles (10 acres). The watershed to UT to Glade Creek is being significantly impacted by cattle. The cattle have access to the stream and sediment is being deposited downstream within the project reach due to this disturbance. The existing tributary's width ranges from 9.5 feet to 15.5 feet at the top of bank and the channel incises to a depth of approximately 3 feet adjacent to Glade Creek.

The restoration goals for this project are:

- Improve water quality with the construction of stable stream banks and the establishment of a protective buffer.
- Improve the community structure of the buffer.
- Improve the stream function and habitat with the connection of the channelized and incised stream back to its floodplain.
- Restore long-term stability with the restoration of channel pattern, profile and dimension.
- Improve in-stream habitat with the installation of root wads, constructed riffles and rock cross vanes to enhance pool depths.
- Removal of exotic invasive species.

The project objectives will include:

- The restoration of 1580 linear feet of Priority I in order to raise the stream elevation, reconnect the floodplain, restore pattern, and re-establish channel dimension on Glade Creek and 441 linear feet on UT to Glade Creek.
- Restoration of 0.16 acres of wetlands by improved hydrology.
- Enhancement of 0.13 acres of wetlands by planting of wetland vegetation.

- Preservation of 0.79 acres of existing jurisdictional wetlands.
- Establish a riparian buffer with a variety of native vegetation for an improved community for a distance that ranges from 30 to 100 feet in width. Buffer enhancement on 5.37 acres along the stream length will be established with the planting of riparian vegetation.
- Within the buffer the removal of exotic invasives will be completed with acceptable methods to reclaim the invasive areas with native species.

Summary		
Stream Reach	Existing Length (feet)	Proposed Length (feet)
Glade Creek	2055	1580
UT Glade Creek	145	441
Total	2200	2021

The total proposed stream length of the project is 2051 linear feet. The lack of vegetation due to farming practices over time has resulted in unstable stream banks and down cutting of the channel. The reduction of stream length is appropriate for the Glade Creek. The stressors over time have caused stream incision and very sharp meander bends that have lengthened the flow path resulting in an unstable sinuosity of 1.6. Introducing longer radius of curvatures to establish a better pattern and vertical grade controls will help restore the system towards pre-disturbed conditions.

The project will also include 0.16 acres of wetland restoration, wetland enhancement of 0.16 acres, and preservation of 0.76 acres. The restoration project will impact 0.032 acres (Wetland 6) of the existing wetlands on the project site that are located within the existing channel. These impacts consist of grading for the new channel and floodplain.

Through its Local Watershed Planning program, EEP focuses resources in specific 14-digit hydrologic units in order to address critical watershed issues. This process involves conducting a detailed assessment of the condition of the watershed, involving the local community in identifying solutions to water quality, aquatic habitat and flooding problems, and working to get consensus solutions implemented, preferably within prioritized sub-watersheds. EEP's Little River/Brush Creek Local Watershed Plan (March 2007) identified the sub-watershed Middle Glade Creek I, where this project is located, as a priority sub-watershed. Stream restoration along this portion of Glade Creek is expected to help alleviate water quality degradation issues by establishing riparian buffers and preventing nutrient and sediment input, and is expected to provide substantially improved aquatic habitat.

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1.0 Introduction

The North Carolina Ecosystem Enhancement Program (EEP) will complete a stream restoration project along Glade Creek of approximately 1,580 linear feet of stream restoration along the main channel, in Allegheny County, North Carolina. Approximately 449 linear feet of an unnamed tributary to Glade Creek will also be restored. The restoration portion of the project begins approximately 500 feet downstream of the crossing with Sheriff Road and extends to the fence line perpendicular to the stream as it runs at the base of the hill next to Barrett Road/Fox Ridge Road.

Along with the restoration of the channel, approximately .92 acres of riparian wetland will be preserved/enhanced and approximately 0.16 acres of riparian wetland will be restored adjacent to Glade Creek.

1.1 Directions to Project Site

The Glade Creek Project Site is located approximately 4.4 miles southeast along US-21 from the center of Sparta in Allegheny County, North Carolina. From Raleigh, take Interstate 40 West to US-421 North (exit 188) and go 27.5 miles. Next take Interstate 77 North (exit 265A) for 10 miles before making a left onto US-21 North towards Roaring Gap/Sparta. After traveling 23.9 miles on US-21, up the mountain road past Roaring Gap and past the Blue Ridge Parkway, take a right onto Sheriff Road. After 0.2 miles on Sheriff Road cross over Glade Creek and turn left onto Barrett Road/Fox Ridge Road and the upstream site access is a path through the pine trees approximately 200 feet ahead on the left. The coordinates of this location are: 36° 28' 37" N and 81° 03' 40" W.

1.2 USGS Hydrologic Unit Code

The United States Geological Survey (USGS) uses a multi-tiered system to divide and sub-divide the country's watersheds into successively smaller hydrological units. Each hydrologic unit is identified by a unique hydrologic unit code (HUC), consisting of various numbers of digits depending on the level of classification within the hydrologic unit system. Under the USGS system, the New River basin has only one 8-digit hydrologic unit and that is called the Upper New and its HUC number is 05050001.

The 8-digit units are further sub-divided into smaller 14-digit hydrologic units that are used for smaller scale planning. The Glade Creek Project Site is located in the 14-digit HUC 05050001030020.

1.3 NCDWQ River Basin Designations

The North Carolina Division of Water Quality (NCDWQ) uses a two-tiered system to divide the state into watershed units. The state is divided into seventeen major river basins with each basin further subdivided into sub-basins (NCDWQ 6-digit sub-basins). The project area is located within the "Upper New" sub-basin 05-07-03 of the New River Basin (DWQ 2005). This area is part of USGS Hydrologic Unit 05050001 of the Ohio Region. The "Upper New" river basin covers 2,900 square miles (7,511 square kilometers).

1.4 Project Vicinity Map

The project vicinity map is included in Section 11, Figure 1. An aerial vicinity map is included on Section 11, Figure 2.

2.0 Watershed Characterization

2.1 Drainage Area

The drainage area for Glade Creek is approximately 8.00 square miles at the downstream limit of the project. The watershed consists approximately of sixty one percent (61%) forested land, thirty five percent (35%) cleared land for agriculture and livestock use, and the remaining in either residential or commercial use. The sub-watershed of UT to Glade Creek has a drainage area of approximately 0.016 square miles. The project watershed drains towards the northeast and is bounded by a series of both ridgelines and roads. From the end of the project site moving counter clockwise, the boundary follows a ridgeline to Andrews Ridge Road and then to Chestnut Grove Church Road followed by a ridge to US-21. Once across US-21, the western border is comprised by parts of Joines Road and Pine Swamp Road mixed with ridgelines and continues to Wooten Road followed by a ridgeline to part of Bullhead Road and across the Blue Ridge Parkway. The southern edge again crosses the Blue Ridge Parkway and then follows the very prominent ridgeline of Bullhead Mountain and follows a rather straight line until it crosses over US-21. The eastern boundary continues up Stoker Road on the east side of US-21 and then follows part of a ridgeline before continuing on Glade Valley Road back to the end of the project site.

2.2 Surface Water Classification / Water Quality

The project area is located within sub-basin 05-07-03 of the New River Basin. This area is part of USGS Hydrologic Unit 05050001 (Upper New Basin) of the Ohio Region. The Upper New River Basin covers 2,900 square miles (7,511 square kilometers). Glade Creek is one of two perennial streams located within the project area (DWQ Stream Index Number 10-9-9). The other perennial stream is Wolf Branch (DWQ Stream Index Number 10-9-9-1). DWQ classifies both Glade Creek and Wolf Branch as **C;Tr**. The "**C**" classification indicates waters protected for uses such as secondary recreation, fishing, wildlife, fish consumption, aquatic life including propagation, survival and maintenance of biological integrity, and agriculture. Secondary recreation includes wading, boating, and other uses involving human body contact with water where such activities take place in an infrequent, unorganized, or incidental manner. The "**Tr**" classification is a supplemental classification intended to protect freshwaters which have conditions which shall sustain and allow for trout propagation and survival of stocked trout on a year-round basis. This classification is not the same as the NC Wildlife Resources Commission's *Designated Public Mountain Trout Waters* designation (DWQ 2007). After Glade Creek leaves the project area, it flows into Little River approximately 3.5 river miles (RM) downstream.

2.3 Physiography, Geology and Soils

2.3.1 Physiography

The site is located within the Blue Ridge physiographic province, which is a rugged mountainous area with steep ridges, inter-mountain basins, and valleys. This province contains the highest mountains in eastern North America.

2.3.2 Geology

North Carolina is divided into a variety of geologic belts. The site is part of the Blue Ridge Belt. The Blue Ridge Belt is a mountainous region characterized by a mixture of granite, gneiss, schist, volcanic rock, and sedimentary rock that are from over one billion to about one-half billion years old. These rocks have repeatedly been squeezed, fractured, faulted, and twisted into folds creating ridges and valleys.

2.3.3 Soils

The major soil series identified by the NRCS within the proposed conservation easement are Suncook and Chandler. Both soils are relatively young soils that are comprised of alluvial deposits. See below for a soil series description.

Suncook: These soils are mapped as the soils encompassing Glade Creek. This soil series consists of excessively drained, nearly level sandy soils of the floodplain and are subject to frequent flooding. The surface layer is typically a dark brown loamy sand to about 14 inches. The subsurface layer is a brown sand to a depth of 84 inches. These soils are very low in fertility and organic matter content. Erosion potential is low due to the nearly level slope and location with the landscape.

Chandler (25-45 % slope): These soils are mapped to be on the south side of Little Pine Creek within the Mesic-Mixed Hardwood forest. This series consists of somewhat excessively drained stony, micaceous soil located on side slopes bordering drainageways. The surface layer is dark grayish–brown silt loam 4-8 inches thick. The subsoil is 8-16 inches thick composed of a friable silt loam. These soils are low to medium in natural fertility and low to high in organic matter content. These soils are high in erodibility and in some areas as much as 75% of the original surface layer has been removed from erosion. In this county, most of these soils are forested because these soils are unsuitable for cultivation and pastureland due to the stoniness and the slope gradient.

2.4 Historical Land Use and Development Trends

The main watershed stressors have been farming and clearing practices. Many of the valleys within this area were previously swamps with mucky braded systems having ample access to the floodplain. The clearing and farming operations within the watershed have over time caused large deposits of unconsolidated soils to end up in the valleys burying the hydric soils. The stream systems became confined and unstable within the deposited materials as their access to the floodplain was restricted.

Historic aerial photographs of the site were collected and examined. Photographs were available from 1964, 1976, 1983, 1998, and 2005. These photographs are included in Appendix 13. A 1964 photograph of the site shows that the property was cleared and under cropland similar to the current state. Glade Creek shows a sinuous pattern that is similar to the existing stream location with no vegetated buffer. The Unnamed Tributary (UT) to Glade Creek exhibits a young forested buffer.

The 1976 photograph shows no change in land use from 1964. However, the wooded buffer along the UT has grown.

By 1983, the photograph indicates that Glade Creek has straightened significantly from the existing bridge downstream to the start of the proposed construction. An existing bend in this area was cut off from the channel on the adjacent property. Some bends have become sharper; however, there was not a great shift in the overall plan form of the stream.

Between 1983 and 1998, the morphology of the bend in Glade Creek at the western property line developed into a smoother curve.

The 2005 photograph shows the most movement in the stream form of Glade Creek between photo years. Stream bends have narrowed and expanded throughout the reach as the portions of the stream have moved laterally within the floodplain; the stream has shifted as much as 50 feet some in locations.

The watershed is rural and is comprised mainly of woods and open grassy meadows (Figure 4). The main development in the watershed has been for farming and there are very few residential-only areas. The lower part of the watershed is undisturbed forest on the steep northern face of Bullhead Mountain. The watershed may undergo more residential development in its eastern corner based on some access roads and small-sized parcels that appear on the property map but do not appear on the aerial photograph.

2.5 Endangered/Threatened Species

Some populations of fauna and flora have been in, or are in the process of, decline due to either natural forces or their inability to coexist with human activities. Federal law (under the provisions of the Endangered Species Act of 1973, as amended) requires that any action likely to adversely affect a species classified as federally protected, be subject to review by the USFWS. Other species may receive additional protection under separate state laws.

2.5.1 Federally Listed Species

2.5.1.1 Site Evaluation Methodology

A July 2, 2008 search of the North Carolina Natural Heritage Program (NCNHP) digital database of rare plants, animals, and natural areas for records of threatened and endangered species or federally designated habitat found within one mile (1.6 kilometers) of the project site resulted in five elemental occurrences, none of which were federally protected species (Table 1, Figure 8). None of the occurrences were on the subject property nor are they likely to be affected by the proposed actions.

Table 1. NCNHP Elemental Occurrences within 1 mile of site.

Common Name	Scientific Name	Federal Status[a]	State Status[b]
Bog turtle	*Clemmys muhlenbergii*	T(S/A)	T
Canada reed grass	*Calamagrostis canadensis*	-	SR-P
Gray's lily	*Lilium grayi*	FSC	T-SC
Kanawha darter	*Etheostoma kanawhae*	-	SR
Kanawha minnow	*Phenacobius teretulus*	FSC	SC

a: T(S/A) – Threatened due to similarity of appearance; FSC – Federal Species of Concern
b: T – Threatened; SR-P – Significantly Rare-Proposed; T-SC – Threatened-Special Concern; SR – Significantly Rare; SC – Special Concern

The US Fish and Wildlife Service website was consulted to obtain a listing of all threatened and endangered species for Alleghany County and the results are in Table 2.

Table 2: Federally listed species, Alleghany County, North Carolina (11/15/2007)

Common Name	Scientific Name	Status
Bog turtle	*Clemmys muhlenbergii*	T(S/A)*

*Threatened due to similarity of appearance[1]

The entire site was then traversed to determine if any suitable habitat existed for these species.

2.5.2 Threatened and Endangered Species

Plants and animals with federal classifications of Endangered, Threatened, Proposed Endangered, and Proposed Threatened are protected under provisions of Sections 7 and 9 of the Endangered Species Act of 1973, as amended. There is only one federally listed species listed for Alleghany County (Table 2).

2.5.2.1 Species Description and Biological Conclusion

Bog turtle ***Clemmys muhlenbergii***

Status: Threatened (S/A)

Family: Emydidae

Listed: November 4, 1997

The bog turtle is distinguished from other turtles by its small size and the bright orange or yellow blotch on each side of its head. The bog turtle is a small semi-aquatic reptile, measuring 7.5-11.4 cm in length, with a weakly keeled, dark brown carapace and a blackish plastron with lighter markings along the midline. This species exhibits sexual dimorphism; the males have concave plastrons and longer, thicker tails, while females have flat plastrons and shorter tails. The bog turtle is found in the eastern United States, in two distinct regions. The northern population, in Massachusetts, Connecticut, southern New York, New Jersey, Pennsylvania, Maryland, and Delaware is listed as Threatened and protected by the Endangered Species Act. The southern population, occurring in Virginia, North Carolina, South Carolina, Tennessee, and Georgia is listed as Threatened Due to Similarity of Appearance.

Preferred bog turtle habitat consists of fens, sphagnum bogs, swamps, marshy meadows and pastures. Areas with clear, slow-flowing water, soft mud substrate, and an open canopy are

[1] In the November 4, 1997 Federal Register (55822-55825), the northern population of the bog turtle (from New York south to Maryland) was listed as T (threatened), and the southern population (from Virginia south to Georgia) was listed as T(S/A) (threatened due to similarity of appearance). The T(S/A) designation bans the collection and interstate and international commercial trade of bog turtles from the southern population. The T(S/A) designation has no effect on land management activities by private landowners in North Carolina, part of the southern population of the species. In addition to its official status as T(S/A), the U.S. Fish and Wildlife Service considers the southern population of the bog turtle as a Federal species of concern due to habitat loss (USFWS website: http://www.fws.gov/nc-es/es/countyfr.html)

ideal. Clumps of vegetation such as tussock sedge and sphagnum moss are important for nesting and basking. This species hibernates from October to April, hiding just under the frozen surface of mud. The diet consists of beetles, moth and butterfly larvae, caddisfly larvae, snails, nematodes, millipedes, seeds, and carrion (Nemuras 1967).

Mating takes place in May and June, and the female deposits the clutch of 2-6 eggs in a sedge tussock, a clump of sphagnum moss, or loose soil about a month after mating. The eggs hatch in 42-56 days. A female may not nest every year and probably only produces one clutch per reproductive year. The primary threats to the bog turtle are loss of habitat (from increased residential and commercial development as well as draining, clearing, and filling wetlands) and illegal collecting for the pet trade. Nest predation and disease may also play a role in the population decrease (USFWS 2001).

The bog turtle is listed as T/SA, which is not subject to the provisions of Section 7. Suitable habitat for bog turtle is present on site, but this area will not be impacted by restoration activities.

2.6 Federal Species of Concern

There are 20 Federal Species of Concern (FSC) listed by the USFWS for Alleghany County (Table 3). FSC are not afforded federal protection under the Endangered Species Act of 1973, as amended, and are not subject to any of its provisions, including Section 7, until they are formally proposed or listed as Threatened or Endangered.

Table 3. Federal Species of Concern, Alleghany County, North Carolina

Common Name	**Scientific name**	**Federal Status**
Vertebrate:		
Allegheny woodrat	*Neotoma magister*	FSC
Appalachian cottontail	*Sylvilagus obscurus*	FSC
Eastern small-footed bat	*Myotis leibii*	FSC
Golden-winged warbler	*Vermivora chrysoptera*	FSC
Hellbender	*Cryptobranchus alleganiensis*	FSC
Kanawha minnow	*Phenacobius teretulus*	FSC
Invertebrate:		
Diana fritillary	*Speyeria diana*	FSC
Grayson crayfish	*Ascetocythere cosmeta*	FSC
Green floater	*Lasmigona subviridis*	FSC
Grizzled skipper	*Pyrgus wyandot*	FSC
Midget snaketail	*Ophiogomphus howei*	FSC
Regal fritillary	*Speyeria idalia*	FSC
Vascular Plant:		
Butternut	*Juglans cinerea*	FSC
Cuthbert turtlehead	*Chelone cuthbertii*	FSC
Fen sedge	*Carex sp.2*	FSC
Gray's lily	*Lilium grayi*	FSC
Gray's saxifrage	*Saxifraga caroliniana*	FSC
Large-leaved Grass-of-Parnassus	*Parnassia grandifolia*	FSC
Sweet pinesap	*Monotropsis odorata*	FSC
Tall larkspur	*Delphinium exaltatum*	FSC

2.7 Cultural Resources

Letters were sent to State Historic Preservation Office (SHPO) and the Eastern Band of Cherokee Indians (EBCI) on April 1 and April 28, 2008, respectively, requesting information concerning significant cultural resources on the project site (Appendix 5). No response has been received from EBCI to date. Multiple site visits were made and no evidence of significant cultural resources was noted. An archaeological survey of the Glade Creek Stream and Wetland restoration area was completed by Archaeological Consultants of the Carolinas, Inc. in compliance with cultural resource regulations. One isolated find was recorded however it was not considered to be significant (Appendix 12). No recommendations have been received from SHPO to date, however they will be included as an addendum to this restoration plan.

2.8 Potential Constraints

2.8.1 Property Ownership and Boundary

The restoration segment of Glade Creek is located within one parcel of land owned by Sharon W. Beck totaling approximately 44 acres of land located approximately 4.4 miles southeast of the Town of Sparta in Allegheny County, North Carolina. The PIN number of the parcel is 3999492451. Glade Creek enters the property at the upstream end of the restoration reach and flows eastward to the east edge of the property which is the end of the restoration reach.

Glade Creek and one tributary are located on the project site which extends from the southwest edge of the property parcel and travels east along the southern boundary to where it exits at the parcel's southeastern corner. The stream restoration project includes approximately 2,345 feet of the existing Glade Creek and 150 feet of the existing UT to Glade Creek to be restored.

UT to Glade Creek is located on the parcel's western edge and currently converges with Glade Creek at the beginning of the project site. The Tributary enters Glade Creek from the north. This degraded B/C tributary is entrenched with bankfull heights that are 1 to 2 feet below the floodplain. The tributary drops approximately two feet in elevation slightly upstream from where it connects to Glade Creek. The tributary is set at the base of a hillside, has very little floodplain and has small trees and briars grown up around much of it. The tributary has low sinuosity due to its steep valley slope and narrow floodplain.

2.8.2 Site Access

Two entrances to the site will be made available for construction off of Fox Ridge Road. The first will be located at the upstream end of the site and is the existing gravel road approximately 180 feet north of Sheriffs Road. The second is a proposed entrance that will be constructed on Fox Ridge Road approximately 770 feet north of Sheriffs Road. This constructed entrance outside of the conservation easement will remain after completion of the project for future access by the landowner. The North Carolina Department of Transportation Division office stated that no permits would be required for construction of this access.

2.8.3 Utilities

The only utility that exists on site is an overhead transmission power line. One pole is located with the project area approximately 21 feet from the existing top of bank. Grading is proposed in proximity to the pole however no disturbance will be made to the pole. Vegetation within the 30 foot power easement will be limited to low height plantings as required by the power company.

2.8.4 FEMA/Hydrologic Trespass

Glade Creek is not regulated by the Federal Emergency Management Agency (FEMA) and therefore there are no FEMA constraints. No hydrologic trespass is anticipated for this project.

3.0 Project Site Streams (Existing Conditions)

3.1 Channel Classification

The existing Glade Creek classifies as a degraded C4/G4 channel. The “C” stream type is a slightly entrenched, meandering, riffle/pool channel. Portions of the channel are trending towards or already are a “G” channel. The "G" or "gully" stream type is an entrenched, narrow, and deep, step/pool channel with a low to moderate sinuosity. The "G" stream types typically have very high erosion rates and a high sediment supply (Rosgen, 1996). The “4” in the classification describes the channel further as a gravel bed stream.

The existing UT to Glade Creek classifies as a B4/C4 channel. The “B” stream type exists primarily on moderately steep to gently sloped terrain, with the predominant landform seen as a narrow and moderately sloping basin. "B" stream types are moderately entrenched, have a cross-section width/depth ratio (greater than 12), display a low channel sinuosity, and exhibit a "rapids" dominated bed morphology. (Rosgen, 1996).

3.2 Discharge

The drainage area to the end of the project limits is approximately 8.00 square miles and mainly consists of both steep wooded terrain and hilly farmlands with some woods. The floodplain in the project site is well defined by hills that rise quickly at its outer edges and the stream meanders across its entire width. The estimated bankfull discharge is approximately 469 cubic feet per second (cfs). The discharge was estimated from twelve (12) field cross sections that were taken along the channel. Bankfull was located within the existing channel banks approximately 1.5 to 3.5 feet below the existing top of bank and floodplain along the entire reach. The bankfull areas were used along with the bankfull slope to determine the stream bankfull discharge.

3.3 Channel Morphology

The morphological characteristics of the twelve cross sections surveyed on Glade Creek are shown in Section 10, Table 4. The morphological characteristics for UT to Glade Creek are shown in Section 10, Tables 5 & 6. The field cross-section locations are shown in Section 12, Restoration Plans, on Sheets 3 & 4. The tables show the existing and proposed Glade Creek and UT Glade Creek conditions along with the morphological characteristics of the reference reaches Basin Creek, UT to Little Pine Creek and UT to South Fork Cane Creek.

The project site is currently under agricultural use with at pine plantation. The stream is very sinuous along the entire reach. Some of the bends in the reach are being cut off by newly forming channels. The insides of the bends typically have lower more accessible floodplains. The stream is entrenched throughout the reach.

There is beaver evidence throughout the reach indicated by the presence of beaver dams. The existing dams have impacted the reach. The dam’s effects are in the creation of ponded water upstream of the structures and steep drops on the down stream side.

The stream dimension has widened almost along the entire reach as the channel has entrenched and the stream banks have eroded. Debris in the channel has also cause the channel to widen and form two channels either side of the debris in the lower end of the channel.

3.4 Channel Stability Assessment

The channel stability assessment was based on observations made in evaluating bank erosion potential with the Rosgen method of completing a Bank Erosion Hazard Index (BEHI). BEHI indexes were evaluated along each side of the stream bank for over 2,000 feet of existing stream. The stability assessment indicated a high bank erosion potential for the study reach. The bank erosion rate for the restoration segment of Glade Creek was estimated to be 399 tons per year based on the current bank conditions. The channel stability assessment for Glade Creek is listed in Section 10.0, Table 7.

3.5 Bankfull Verification

Bankfull Verification on both Glade Creek and UT to Glade Creek was completed with a comparison of field surveyed cross sections along the streams to typical bankfull width, area, depth, and discharge relationships. The watershed predicted discharges were compared with the bankfull channel capacities as well for verification. The Rural Mountain Regional Curves developed by the North Carolina State University (NCSU) Water Quality Group were used to verify acceptable limits of morphological characteristics based on a hydro-physiographic region and drainage area. The average bankfull discharge, cross sectional area, width, and depth for Glade Creek fell within the confidence limits of the North Carolina Rural Regional curves. UT to Glade Creek has too small of a watershed for the regional curves to reasonably apply to.

3.6 Vegetation

Plant community classifications follow those presented by Schafale and Weakley (1990) where possible (Section 11, Figure 9). The dominant flora observed, or likely to occur, in each community are described and discussed below.

Scientific nomenclature and the common names (when applicable) are provided. Plant taxonomy typically follows Weakley (2008). All subsequent references to the same organism will include the common name only. Published range distributions and habitat analysis are used in estimating flora expected to be present within the project site. Chestnut Oak Forest, Disturbed/Cutover, Fallow Field, Acidic Cover Forest, White Pine Plantation, and a Floodplain Pool were the observed communities and are discussed in detail below.

3.6.1 Chestnut Oak Forest

This chestnut oak forest community is located on the south facing slope north of Glade Creek. This community sits at an elevation of 2680 feet. The dominant canopy species observed were chestnut oak (*Quercus montana*), scarlet oak (*Quercus coccinea*), white oak (*Quercus alba*), hickory (Carya sp.) red maple (*Acer rubrum*), white pine (*Pinus strobus*). Subcanopy species observed include red maple, black birch (*Betula lenta*), flowering dogwood (*Cornus florida*), yellow buckeye (*Aesculus octandra*), Carolina silverbell (*Halesia carolina*), American holly (*Ilex opaca*), and the American crabapple (*Malus coronaria*). Shrub species observed within this community include mountain laurel (*Kalmia laurifolia*), and Great Rhododendron (*Rhododendron maximum*), and Japanese barberry (*Berberis thunbergii*). Herbaceous species observed in this community include rattlesnake weed (*Hieracium venosum*) and spotted wintergreen (*Chimaphila maculata*).

3.6.2 Disturbed/Cutover

The disturbed/cutover community is situated on the slope in the northwest quadrant of the project area. This community was logged recently within the last ten years and is in succession dominated by young trees, vines and herbaceous vegetation. This community was probably part of the chestnut oak forest located to the east. Tree and shrub species observed include scarlet oak (*Quercus coccinea*), white pine, tulip poplar (*Liriodendron tulipifera*), red maple, American holly (*Ilex opaca*), painted buckeye (*Aesculus sylvatica*), black cherry (*Prunus serrotina*), Smooth sumac (Rhus glabra), and multiflora rose. Herbaceous species observed include broom sedge (*Andropogon virginicus*), goldenrod, catbriar (*Smilax glauca*), fragrant rabbit tobacco (*Pseudognaphalium obtusifolium*), common rush, deer-tongue witchgrass, blackberry, common mullein (*Verbascum thapsus*), pokeweed (*Phytolacca americana*), dog fennel (*Anthemis arvensis*), Indian strawberry (*Duchesnea indica*), and the invasive exotic vine species, Japanese honeysuckle (*Lonicera japonica*).

3.6.3 Fallow Field

The fallow field is located north of the Chestnut oak forest and the disturbed/cutover community. This area is maintained through mowing. The vegetation is mainly composed of various grasses and herbs such as tall fescue (*Schedonurus arundinaceas*), crabgrass (*Digitaria* sp.), goldenrod, blackberry, multiflora rose, broomsedge, sowthistle (*Sonchus* sp.), and milkweed (*Asclepias syrica*).

3.6.4 Acidic Cove Forest

This community type is located in two different areas (southeast quadrant and northwest quadrant) of the project area. Canopy species observed include red maple, river birch (*Betula nigra*), white pine, black birch, black locust (*Robinia pseudoacacia*), eastern red cedar (*Juniperus virginiana*), eastern hemlock (*Tsuga canandensis*), and black cherry. Great rhododendron (*Rhododendron maximum*) was the dominant shrub species observed within this community. Herbaceous species were sparse with the dominant species being Christmas fern (*Polystichum acrostichoides*). Invasive species such as Japanese honeysuckle and Japanese knotweed (*Rheynoutria japonica*) were observed along the margin of this community on the roadside within the powerline corridor traversing the project area.

3.6.5 White Pine Plantation

This community is located adjacent to Glade Creek encompassing the floodplain throughout the project area. White pines are the dominant canopy species throughout. Shrub species observed within the plantation include swamp rose, multiflora rose, and steeplebush (*Spiraea tomentosa*).

Directly adjacent to Glade Creek a very narrow to absent riparian complex of small tree and shrub species such as black willow, silky willow, silky dogwood, tag alder, eastern ninebark, and red maple were observed. The herbaceous layer was dominated with various grasses and forbs such as tall fescue, crabgrass, goldenrod, sedges, and the invasive vine kudzu (*Pueria montana* var. *lobata*.

3.6.6 Floodplain Pool

This community is located within the Glade Creek floodplain and is encompassed within the white pine plantation. See section the description of Wetland 2 in Section 5.1 for a detailed description of this community.

3.6.7 Montane Alluvial Forest

The scrub shrub community is situated north of Glade Creek on the slope near the western boundary of the project site. This community was logged within the last ten years and is in succession dominated by young trees, vines, and herbaceous vegetation. This community was probably part of the chestnut oak forest located to the east. Tree and shrub species observed include scarlet oak, white pine, tulip poplar (*Liriodendron tulipifera*), red maple, American holly, painted buckeye (*Aesculus sylvatica*), black cherry (*Prunus serrotina*), smooth sumac (*Rhus glabra*), and multiflora rose (*Rosa multiflora*). Herbaceous species observed include broom sedge (*Andropogon virginicus*), goldenrod (*Solidago* sp.), catbriar (*Smilax glauca*), fragrant rabbit tobacco (*Pseudognaphalium obtusifolium*), common rush (*Juncus effusus*), deer-tongue witchgrass (*Dicanthelium clandestinum*), blackberry (*Rubus* sp.), common mullein (*Verbascum thapsus*), pokeweed (*Phytolacca americana*), dog fennel (*Anthemis arvensis*), Indian strawberry (*Duchesnea indica*), and the invasive exotic vine species Japanese honeysuckle (*Lonicera japonica*).

3.6.8 Maintained/Disturbed Communities

The maintained/disturbed land is located north of the Chestnut oak forest and the scrub/shrub community. This area is a fallow field maintained through mowing. The vegetation is mainly composed of various grasses and herbs such as tall fescue (*Schedonurus arundinaceas*), crabgrass (*Digitaria* sp.), goldenrod, blackberry, multiflora rose, broomsedge, sowthistle (*Sonchus* sp.), and milkweed (*Asclepias syrica*).

4.0 Reference Streams

Three reference streams were used in the Glade Creek restoration design. These were Basin Creek, an unnamed tributary (UT) to Little Pine Creek, and an unnamed tributary to South Fork Cane Creek.

4.1 Basin Creek

Basin Creek, in Wilkes County, was used as a reference reach for Glade Creek.

4.1.1 Watershed Characterization

Basin Creek is located in Doughton State Park in Wilkes County within the Yadkin Pee Dee River basin. The reach length surveyed extends 464 feet downstream from the stream's confluence with Cove Creek (Section 11, Figure 10). The confluence is located approximately 1.6 miles up Grassy Gap Road, which is a trail north off of Longbottom Road (SR 1730). This reach classifies as a C4 stream type with a drainage area of 6.8 square miles and is located within the Mountain Physiographic Province of North Carolina. The stream has a bankfull width of 30.7 feet and a water surface slope of 0.0141 ft/ft. The entire watershed is located within State Park boundaries (Section 11, Figure 11). Basin Creek is a colluvial stream with dense shrub and deciduous vegetation lining the banks and adjacent hillslopes. Bankfull indicators include high scour lines, breaks in bank slope, changes in vegetation, moss lines, and depositional benches. The bank height ratio of Basin Creek is typically less than 1.1, and the entrenchment ratio is 2.8.

4.1.2 Channel Classification

Basin Creek classifies as a C4 stream type. The "C" stream types are located in narrow to wide valleys, constructed from alluvial deposition. They have a well-developed floodplain that is slightly entrenched, are relatively sinuous with a channel slope of 2% or less and bedform morphology indicative of a riffle/pool configuration. The C-type streams also exhibit a sequencing of steps (riffles) and flats (pools) that are linked to the meander geometry of the river where the riffle/pool sequence or spacing is approximately 5-7 bankfull channel widths. The primary morphological features of the "C" stream type are the sinuous, low relief channel, the well developed floodplains built by the river, and characteristic "point bars" within the active channel. The channel aggradation/degradation and lateral extension processes, notably active in "C" stream types, are dependent on the natural stability of stream bank, the existing upstream watershed conditions and flow and sediment regime. These channels can be significantly altered and rapidly de-stabilized when the effects of imposed changes in bank stability, watershed conditions, or flow regime are combined to cause an exceedance of a channel stability threshold (Rosgen, 1996). The 4 in the classification system further identifies the stream as having a gravel bed.

4.1.3 Discharge

The drainage area at the downstream limit of the reference reach is approximately 6.8 square miles. Data for this reference reach was collected by others and the morphological data table assembled by others was applied to this project. Discharge was provided in the morphological data table. Bankfull is located at the top of the channel.

4.1.4 Channel Morphology

The morphological data used for this study for the Basin Creek reverence reach was collected by Daniel Clinton, Jan Patterson, Louise O'Hara and Jon Williams of NC State University prior to 2001. A site visit by WCE was conducted to confirm that the stream is adequate for use as a reference on the Glade Creek restoration project.

The morphological characteristics from the Basin Creek survey are shown in Section 10.0, Table 4, along with those from Glade Creek. The stream has the same watershed characteristics as and is located nearby Glade Creek even though it is situated in a different River Basin. The channel has a high bankfull width/depth ratio and a low bank height that allows floodwater to access the floodplain. The profile consists of a well developed riffle pool sequence located at the appropriate locations within the channel.

4.1.5 Channel Stability Assessment

Visual observations of Basin Creek show that the stream has adequate root depth and density, moderate bank slopes, low bank heights and good vegetative surface protection. This indicates that the creek is contributing very little sediment to the stream.

4.1.6 Bankfull Verification

Bankfull verification on Basin Creek was completed by others during the data acquisition. The Rural Mountain Curves developed by the North Carolina State University (NCSU) Water Quality Group were used to verify acceptable limits of morphological characteristics based on a hydro-physiographic region and drainage area. Basin Creek's average cross sectional values for bankfull area, width, depth and discharge fell within the confidence limits on the North Carolina Rural Regional Curves.

4.1.7 Vegetation

4.1.7.1 Vegetative Communities for Basin Creek

Plant community classifications follow those presented by Schafale and Weakley (1990) where possible (Section 11, Figure 13). The dominant flora observed, or likely to occur, in each community are described and discussed.

Scientific nomenclature and the common names (when applicable) are provided. Plant taxonomy typically follows (Weakley 2008). All subsequent references to the same organism will include the common name only. Published range distributions and habitat analysis are used in estimating flora expected to be present within the project site.

4.1.7.1.1. Montane Alluvial Forest

Basin Creek is a reference reach for the Glade Creek Stream Restoration Project in Alleghany County. Located in Wilkes County, Basin Creek is a tributary to Middle Prong Roaring River of the Yadkin-Pee-Dee River Basin. It flows parallel to Grassy Gap Road in Doughton Park. The reference reach portion of this creek begins at the confluence of Cove Creek and Basin Creek and ends 464 feet downstream. The vegetative community contiguous to this portion of Basin Creek is classified as a Montane Alluvial Forest. This community has an open to dense shrub layer with a dense herb layer. The canopy is composed of bottomland and mesophytic tree species including but not limited to tulip tree, red maple, sycamore (*Platanus occidentalis*), black walnut (*Juglans nigra*), cucumber magnolia (*Magnolia acuminata*), black birch, white pine, persimmon (*Diospyros virginiana*), and white oak. Subcanopy and shrub species observed include flowering dogwood, witch hazel (*Hamemalis virginiana var. virginiana),* spice bush (*Lindera benzoin*), red maple, eastern hemlock (*Tsuga canadensis*), and sycamore. Herbaceous species observed in this community include southern crownbeard (*Verbesina occidentalis*), Virginia spiderwort (*Tradescantia virginiana*), smartweed (*Polygonum* sp.), witch grass (*Dicanthelium* sp.), summer grape (*Vitis aestivalis*), Virginia creeper (*Parthenocissus quiquifolia*), ironweed (*Vernonia gigantea*), false nettle (*Boehmeria cylindrica*), virginia bugleweed (*Lycopus virginicus*), black snakeroot (*Sanicula canadensis var. canadensis*), sedges (Carex sp.), great yellow wood sorrel (*Oxalis grandis*), Indian turnip (*Arisaema triphyllum*), hog peanut (*Amphicarpaea bracteata*), Ebony spleenwort (*Asplenium platyneuron*), (*Trillium* sp.), eastern bottlebrush (*Elymus hystrix*), bedstraw (*Galium* sp.), rushes (*Juncus* sp.), Invasive species observed were stink tree (*Ailanthus altissima),* multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), Japanese stiltgrass (*Microstegium vimineum*).

4.1.7.1.2. Acidic Cove Forest

The acidic cove forest is located on the surrounding slopes within this portion of the Basin Creek watershed (Figure 2). This community has a dense canopy with a well developed shrub layer. The herbaceous layer is not well developed and contains a few acid loving species. The canopy was dominated by tulip poplar, red maple, American beech (*Fagus grandifolia*), white oak, northern red oak (*Quercus rubra*), scarlet oak, and white hickory (*Carya alba*). Subcanopy species observed include white pine, American holly, Sassafras (*Sassafras albidum*), Fraser magnolia (*Magnolia fraseri*), flowering dogwood, witch hazel, black birch, sourwood (*Oxydendrum arboreum*), red maple, eastern hemlock, and American beech. Shrubs observed include white rosebay (*Rhododendron maximum*) and mountain laurel (*Kalmia laurifolia*). Herbaceous species observed in this community include southern New York fern (*Thelypteris novaborensis*), common greenbriar (*Smilax rotundifolia*), Christmas fern (*Polystichum acrostichoides*), and witch grass.

4.2 UT to Little Pine Creek Reference Reach

UT to Little Pine Creek, in Allegheny County, was used as a reference reach for the "B" type stream portion of UT to Glade Creek.

4.2.1 Watershed Characterization

The reference reach for the B type portion of UT to Glade Creek is an unnamed tributary that flows into Little Pine Creek. It is a first order stream located in Allegheny County approximately 4 miles east-northeast of the Glade Creek restoration site. The tributary is approximately 900 feet north from Glade Valley Road approximately 650 feet to the east after the intersection with Big Oak Road (Section 11, Figure 14). The drainage area is approximately 0.051 square miles and consists mostly of woods and some grassy areas (Section 11, Figure 15). The floodplain soils for UT Little Pine Creek consist primarily of Watauga and Codorus soils. Watauga soils are described as very deep, well drained soils on gently sloping to very steep ridges and side slopes of the Blue Ridge. The slopes of the Watauga in this watershed range from 6 to 25 percent. Codorus soils are described as very deep, moderately well drained and somewhat poorly drained soils. The slopes of the Codorus soils in this watershed are 0 to 2 percent. The other soil type present in the watershed is Chester. The reference site is located in the 14-digit HUC 05050001030030.

4.2.2 Channel Classification

UT to Little Pine Creek classifies as a B4a/C4a stream type. The "B" stream types exist primarily on moderately steep to gently sloped terrain, with the predominant landform seen as a narrow and moderately sloping basin. Many of the "B" stream types are the result of the integrated influence of structural contact zones, faults, joints, colluvial-alluvial deposits, and structurally controlled valley side slopes, which tend to result in narrow valleys that limit the development of a wide floodplain. "B" stream types are moderately entrenched, have a cross-section width/depth ratio (greater than 12), display a low channel sinuosity, and exhibit a "rapids" dominated bed morphology. Bedform morphology, which may be influenced by debris constructions and local confinement, typically produces scour pools (pocket water) and characteristic "rapids." (Rosgen, 1996) The 4 in the classification further identifies the stream as having a gravel bed and the "a" indicates the stream has a channel slope between 0.04 and 0.099.

4.2.3 Discharge

The drainage area at the downstream limit of the reference reach is approximately 0.051 square miles and the discharge is approximately 23 cfs. The stream discharge was predicted by determining bankfull indicators along the channel at surveyed cross sections. Bankfull is located at or slightly above the top of the channel.

4.2.4 Channel Morphology

The morphological characteristics of the eight cross sections surveyed on UT to Little Pine Creek are shown in Section 10.0, Table 5, along with those from UT to Glade Creek. The stream is located in the same physiographic region, the Ohio River Basin, as Glade Creek. UT to Little Pine Creek classifies as a "B4a/C4a" type channel and was used to design the "B" type portion of UT to Glade Creek. By using the range of numbers from the morphological tables that are more closely associated with a "B" type channel, the designed channel will fall into that classification. The "B" type portion of the reference channel has a moderate entrenchment ratio, a high width/depth ration and a low sinuosity which is appropriate for a step-pool system.

4.2.5 Channel Stability Assessment

Visual observations of UT to Little Pine Creek show that the stream has adequate root depth and density, moderate bank slopes, low bank heights and good vegetative surface protection. This assessment determined that UT to South Fork Cane Creek has low bank erosion potential, degrades slowly and contributes little sediment to the stream waters.

4.2.6 Bankfull Verification

Bankfull verification on UT to Little Pine Creek was completed with a comparison of field surveyed stream cross sections for typical bankfull width, area, depth, and discharge relationships. The watershed predicted discharges were compared with the bankfull channel capacities generated from field cross sections for verification. UT to Little Pine Creek has too small of a watershed for the rural mountain regional curves to reasonably apply to.

4.2.7 Vegetation

4.2.7.1 Vegetative Communities of UT to Little Pine Creek Reference Reach

Plant community classifications follow those presented by Schafale and Weakley (1990) where possible (Section, Figure 17). The dominant flora observed, or likely to occur, in each community are described and discussed.

Scientific nomenclature and the common names (when applicable) are provided. Plant taxonomy typically follows (Weakley 2008). All subsequent references to the same organism will include the common name only. Published range distributions and habitat analysis are used in estimating flora expected to be present within the project site.

4.2.7.1.1. Acidic Cove Forest

UT to Little Pine Creek is a reference reach for the UT to Glade Creek. Located in Alleghany County, UT to Little Pine Creek is a tributary to Little Pine Creek of the New River Basin. It flows parallel into Little Pine Creek just west of the project site. The reference reach portion of this creek is situated within an acidic cove forest. The canopy is dominated by tulip poplar, red maple, and white pine. Subcanopy and shrub species observed include red maple, white pine, black birch, black locust (*Robinia pseudoacacia*), American holly, spicebush, black cherry (*Prunus serotina*), hawthorn (*Crateaegus* sp.), witch hazel (*Hamamelis virginiana)*, alternate leaf dogwood (*Cornus alternifolia*), white rosebay, and Election pink (*Rhododendron periclymenoides*). Herbaceous species observed in this community include greenfruit clearweed (*Pilea pumila*), yellow wood-sorrel (*Oxalis stricta*), tree club-moss (*Dendrolycopodium obscurum*), Christmas fern, Skunk cabbage (*Simplocarpus foetidus*), New York fern, and (*Hexastylis* sp.). Japanese stiltgrass was the only observed invasive exotic species.

4.2.7.1.2. Mesic Mixed Hardwood Forest

This community encompasses the Acidic Cove Forest and is situated on the slope south of Little Pine Creek. Canopy species observed include scarlet oak white pine, mockernut hickory, tulip poplar, white oak (*Quercus alba*), red maple, black oak (*Quercus vellutina*), and scarlet oak. Small tree and shrub species observed include American holly, mountain laurel, smooth highbush blueberry, earleaf umbrella tree (*Magnolia fraseri*), black cherry (*Prunus serrotina*), American beech, flowering dogwood, and hawthorn (*Crataegus* sp.). Herbaceous species observed include catbriar (*Smilax glauca*), poison ivy (*Toxicodendron radicans*), New York fern, little brown jug (*Hexastylis arifolia*), Virginia creeper (*Parthenocissus quinquifolia*), mayapple (*Podophyllum peltatum*), common greenbriar, Indian strawberry (*Duchesnea indica*), and Soloman's seal (*Polygonatum* sp.).

4.3 UT to South Fork Cane Creek

UT to South Fork Cane Creek, in Chatham County, was used as a reference reach for the "C" type stream portion of UT to Glade Creek.

4.3.1 Watershed Characterization

The reference reach for the C type portion of UT to Glade Creek is an unnamed tributary that flows into South Fork Cane Creek. It is a second order stream located in Chatham County that crosses under Tom Stevens Road (SR 1343) approximately 5,600 feet south of the Alamance/Chatham County line (Section 11, Figure 18). The reference site is located in the 14-digit HUC 03030002050050.

4.3.2 Channel Classification

The reference reach classifies as a C4 stream type and has an average bankfull width of 15 feet, cross sectional area of 11.6 sq. ft., mean depth of 0.88 ft., and a water surface slope of 0.0079 ft/ft. It is located in a wooded area approximately 350 feet downstream of the culvert under Tom Stevens Road, 400 linear feet of stream was measured. The stream is a slate bed stream. The floodplain is moderate to wide along the surveyed length. The 4 in the classification system further identifies the stream as having a gravel bed.

4.3.3 Discharge

The drainage area at the downstream limit of the reference reach is approximately 0.41 square miles and the discharge is approximately 33.9 cfs. The stream discharge was predicted by determining bankfull indicators along the channel at surveyed cross sections. Bankfull is located at or near the top of the channel.

4.3.4 Channel Morphology

The morphological characteristics of the surveyed cross sections on UT South Fork Cane Creek are shown in Section 10.0, Table 5, along with those from UT to Glade Creek. The stream has similar watershed characteristics as UT to Glade Creek. The channel has a high bankfull width/depth ratio and a low bank height that allows floodwater to access the floodplain. The profile consists of an adequately developed ripple pool sequence located appropriately within the stream's sinuous pattern.

4.3.5 Channel Stability Assessment

Visual observations of UT to South Fork Cane Creek show that the stream has adequate root depth and density, moderate bank slopes, low bank heights and good vegetative surface protection. This assessment determined that UT to South Fork Cane Creek has low bank erosion potential, degrades slowly and contributes little sediment to the stream waters.

4.3.6 Bankfull Verification

Bankfull verification on UT to South Fork Cane Creek was completed with a comparison of field surveyed stream cross sections for typical bankfull width, area, depth, and discharge relationships. The watershed predicted discharges were compared with the bankfull channel capacities generated from field cross sections for verification. The Rural Piedmont Curves developed by the North Carolina State University (NCSU) Water Quality Group were used to verify acceptable limits of morphological characteristics based on a hydro-physiographic region and drainage area. The average cross sectional areas for UT to South Fork Cane Creek fell within the confidence limits for the bankfull discharge, area, width, and depth on the North Carolina Rural Regional Curves.

4.3.7 Vegetation

4.3.7.1 Vegetative Communities of UT to South Fork Cane Creek

Plant community classifications follow those presented by Schafale and Weakley (1990) where possible (Section 11, Figure 21). The dominant flora observed, or likely to occur, in each community are described and discussed.

Scientific nomenclature and the common names (when applicable) are provided. Plant taxonomy typically follows (Weakley 2008). All subsequent references to the same organism will include the common name only. Published range distributions and habitat analysis are used in estimating flora expected to be present within the project site.

4.3.7.1.1. Mesic Mixed Hardwood Forest

UT to South Fork Creek is a reference reach for the UT to Glade Creek. Located in Alamance County, UT to South Fork Creek is a tributary to South Fork Creek of the greater Cape Fear River Basin. The reference reach portion of this creek is situated within a mesic mixed hardwood forest-piedmont subtype. The canopy is dense and dominated by tulip poplar, American beech, white oak (*Quercus alba*), northern red oak (*Quercus rubra*), white hickory (*Carya alba*), Subcanopy and shrub species observed include red maple, flowering dogwood, blackhaw viburnum (*Viburnum prunifolium*), sugarberry (*Celtis laevigata),* blackgum (*Nyssa sylvatica*), willow oak (*Quercus phellos*), green ash (*Fraxinus pennsylvanica)*, black walnut, ironwood (*Carpinus caroliniana*), black cherry, American holly, and Eastern red cedar

(*Juniperus virginiana*). Herbaceous species observed in this community include grape fern (*Botrychium* sp.), Agrimone sp., Eastern bottlebrush grass (*Elymus hystrix*), sedge (*Carex* sp.), Ebony spleemwort (*Asplenium platyneuron*), yellow wood sorrel (*Oxalis stricta*), poison ivey (*Toxicodendron radicans)*, common greenbriar (*Smilax rotundifolia*), netted chain fern (*Woodwardia aereolata*), false nettle (*Boehmeria cylindrica*), wingstem (*Verbesina occidentalis*), Christmas fern, *Hexastylis* sp., and the invasive exotic Japanese stiltgrass.

4.3.7.1.2. Fallow Field

This community borders east side of the mesic mixed hardwood forest. No canopy species were observed within this community. Herbaceous species were dominant here including tall fescue (*Lolium arundinacium*), various milkweeds (*Asclepias* sp.), dog fennel (*Eupatorium* sp.), goldenrods (*Solidago* sp.), are a few of the species observed within this fallow field successional community.

5.0 Project Site Wetlands (Existing Conditions)

Wetlands were delineated according to guidelines set forth by the Corps of Engineers Wetland Delineation Field Manual, dated January 1987(USACE 1987). This manual identifies the mandatory technical criteria for wetland identification, which includes determining the presence of hydrophytic vegetation, hydric soils, and wetland hydrology. Wetland boundaries were flagged and surveyed using GPS equipment (Section 11, Figure 8).

5.1 Jurisdictional Wetlands

Jurisdictional delineations were performed using the three-parameter approach as prescribed in the *1987 Corps of Engineers Wetlands Delineation Manual* (Environmental Laboratories 1987). Supplementary technical literature describing the parameters of hydrophytic vegetation, hydric soils, and hydrological indicators was also utilized. The USACE wetland routine determination forms are included in Appendix 2.

Field teams used USGS topographic quadrangle mapping (7.5-minute) with the property boundary on Trimble global positioning system (GPS) handheld units with sub-meter accuracy for navigation and mapping.

Six wetlands (W1-W6) were observed within the project site:

- Wetland 1 is a small riparian wetland system contiguous to UT 1
- Wetland 2 is a floodplain pool community and is the largest wetland on the site
- Wetland 3 is contiguous to the north side of Glade Creek and appears to be a relic location of the channel
- Wetland 4 is located at the toe of the slope on the north side of Glade Creek
- Wetland 5 and 6 are both small wetlands contiguous to the south side of Glade Creek (Section 11, Figure 8).

All three wetland criteria were observed in each Wetland.

Wetland 1- Wetland 1 (81° 3’ 43”W, 36° 28’ 39”N) is a complex of small riparian wetlands contiguous to UT 1 to Glade Creek. Regional indicator F3 was used to determine hydric soils. The major source of hydrology is from the high water table within the valley of UT 1. This wetland is 0.082 acre and is composed of herbaceous vegetation. Herbs observed include orange jewelweed (*Impatiens capensis*), sedges (*Carex* sp.), Eastern bottlebrush grass (*Elymus hystrix*), netted chain fern (*Woodwardia aereolata*), deer-tongue witchgrass (*Dicanthelium clandestinum*), common rush (*Juncus effusus*), Alleghany buttercup (*Ranunculus alleghaniensis*), and blue eyed grass (*Sisyrinchium mucronatum*).

Wetland 2- Wetland 2 (81° 3' 40"W, 36° 28' 40"N) is located in the north side of Glade Creek within floodplain. Regional indicator F3 was used to determine hydric soils. The major source of hydrology is from a high water table and some overbank flooding. This wetland is 0.74 acre and is mainly composed of herbaceous vegetation with some small trees and shrubs located along the wetland margin. The wetland community is classified as a floodplain pool community (Schafale and Weakley 1994). During the site visit, hydrology was clearly evident with drainage patterns and areas of standing water. Amphibian larvae were abundant throughout the pools. Vegetation observed consisted of common rush, common bulrush (*Scirpus cyperinus*), giant ironweed (*Vernonia gigantea*), alternate-leaf seedbox (*Ludwigia alternifolia*), arrowleaf tearthumb (*Persicaria sagittata*), sedges. Small tree and shrub species observed were tag alder (*Alnus serrulata*), Eastern ninebark (*Physocarpus opulifolius*), silky dogwood (*Cornus amomum*), multiflora rose (*Rosa multiflora*), swamp rose (*Rosa palustris*), and some white pines (*Pinus strobus*), from the white pine plantation were observed along the wetland margins.

Wetland 3- Wetland 3 (81° 3' 38"W, 36° 28' 42"N) is contiguous to the north side of Glade Creek and, based on aerial photography, appears to be a relic location of the channel. The hydrology is mainly driven from overbank flooding and a high water table. This wetland is 0.042 acre and is mainly composed of herbaceous vegetation with some small trees and shrubs located along the wetland margin. Small tree species observed within this wetland were black willow (*Salix nigra*), silky willow (*Salix sericea*), tag alder, and silky dogwood. Herbaceous species observed include common rush, orange jewelweed, sedges, deer-tongue witchgrass, and goldenrod (*Solidago* sp.).

Wetland 4- Wetland 4 (81° 3' 30"W, 36° 28' 42"N) is located at the toe of the slope on the north side of Glade Creek. Regional indicator F3 was used to determine hydric soils. Hydrology is mainly due to a high water table and stormwater retention from overbank flooding. This wetland is 0.021 acre and is composed only of herbaceous vegetation with some small shrubs located along the wetland margin. The only shrub observed was a multiflora rose plant along the margin. Herbaceous species observed include common rush, sensitive fern (*Onoclea sensibilis*), goldenrod, blackberry (*Rubus* sp.), and sedges.

Wetland 5- Wetland 5 (81° 3' 34"W, 36° 28' 40"N) is a small wetland contiguous to the south side of Glade Creek. The hydrology is mainly driven from overbank flooding and a high water table. Regional indicator F3 was used to determine hydric soils. This wetland is 0.034 acre and is composed only of herbaceous vegetation with some small shrub species. Small tree and shrub species observed includes tag alder and black willow. Herbaceous species consist of orange jewelweed, goldenrod, sedges, knotweed (*Polygonum* sp.), deer tongue witchgrass, and wild garlic (*Allium vineale*).

Wetland 6- Wetland 6 (81° 3' 29"W, 36° 28' 40"N) is contiguous to the south side of Glade Creek in the southeastern portion of the project site. The hydrology is mainly driven from overbank flooding and a high water table. Regional indicator F3 was used to determine hydric soils. This wetland is 0.032 acre and is composed of only herbaceous vegetation with some small shrub species. Small tree and shrub species observed includes red maple (*Acer rubrum*), eastern ninebark, silky dogwood, and black willow. Herbaceous species consist of orange jewelweed, goldenrod, sedges, arrowleaf tearthumb, deer tongue witchgrass, and fescue.

5.2 Non-Jurisdictional Wetlands

The project site encompasses a relatively large floodplain area of Glade Creek. An area within the floodplain reflects morphological evidence of potentially becoming a wetland but does not have hydric soil. The surrounding uplands are relatively steep, especially the northern slope, and appear to contribute a fairly consistent flow of groundwater. It is recommended to remove limited amounts of the fill soil in conjunction with re-routing the UT to Glade Creek through this area to increase the hydrology. Native hydrophytic vegetation will be planted to restore the montane alluvial forest plant community. This buffer restoration effort will improve wildlife habitat, attenuate stormwater runoff .

5.2.1 Hydrological Characterization of Non-Jurisdictional Wetlands

Three groundwater gauges (Gauge 1, 2, & 4,) were installed within non-jurisdictional wetland areas of the project area on April 3, 2008 (Figure 22). These gauges record a groundwater levels daily and the data is collected bi-monthly. Hydrologic regimes are monitored to determine if groundwater levels are within 12 inches of the soil surface for at least 5% of the growing season. These areas will be considered wetlands if the groundwater is within 12 inches for at least 5% of the growing season, the area supports hydrophytic vegetation, and it meets the hydric soil requirements. In this region, the average growing season is 147 days from May 11 to October 5 therefore the groundwater table needs to be within 12 inches of the soil surface for at least 7.35 days in order to consider the soils hydric.   The water table for Gauges 1, 2, and 4 were all well below the required 12 inches, averaging around 40 inches below the soil surface during the growing season.   The data from these gauges are shown in Appendix 9.

This area used to have a wetland hydrologic regime, as expressed by the buried hydric soil. It is believed that the incising of Glade Creek and the UT have caused a drainage effect. The groundwater elevation is expected to be raised by re-routing the UT through the area into a more natural, elevated stream channel.

5.3 Groundwater Modeling of Restoration Site

No groundwater modeling is recommended for this project.

5.4 Surface Water Modeling at Restoration Site

No surface water modeling is recommended for this project.

5.5 Hydrologic Budget for Restoration Site

A hydrologic budget is not anticipated for this project. However the groundwater gauges were installed March 2, 2008. This groundwater data will be analyzed to make a final determination as to the need for the hydrologic budget.

5.6 Soil Characterization of Existing Wetland

Accordingly, an overall site assessment consisting of a series of hand auger borings were conducted throughout the site (Section 11, Figure 6). The most notable feature throughout the majority of the study area was a buried hydric soil horizon. The depth to this horizon ranged from 8 to 30+ inches. This feature is NOT noted in any of the county soils mapped by NRCS, as such, any associations with a particular mapped soil would be inappropriate.

The soil deposited on top of the buried horizon has begun to develop morphological features. These features were used to identify the current hydric/ non-hydric soil boundary. The current hydric soil met hydric regional indicator F3, which states:

F3. Depleted Matrix. *For use in all LRRs, except for W, X, and Y.* A layer that has a depleted matrix with 60 percent or more chroma of 2 or less and that has a maximum thickness of either:

a. 5 cm (2 inches) if the 5 cm is entirely within the upper 15 cm (6 inches) of the soil, or
b. 15 cm (6 inches), starting within 25 cm (10 inches) of the soil surface.
(USDA, NRCS 2006)

Two representative soil borings, non-hydric GC2 and hydric GC3, are provided below:

Boring GC2. Typical Non Hydric Profile

Horizon name	Depth (in)	Soil Color*	Texture
A	0-5	dark brown (10YR 3/3)	sandy loam
Bw1	5-12	dark brown (10YR 3/3)	sandy loam
Bw2	12-18	dark yellowish brown (10YR 4/4) with few faint strong brown (7.5YR 5/8) and common prominent (5YR 4/6) concentrations.	sandy clay loam
Ab	18-48+	very dark grayish brown (10YR 3/2)	silt loam

*Munsell soil color notation

Boring GC3. Typical Hydric Profile

Horizon name	Depth (in)	Soil Color*	Texture
A	0-6	very dark grayish brown (10YR 3/2) with common distinct dark yellowish brown (10YR 4/6) concentrations	silt loam
Bw1	6-18	brown (10YR 4/3) with common distinct dark yellowish brown (10YR 4/6) concentrations	sandy loam
Ab	18-48+	black (10YR 2/1) with common distinct dark yellowish brown (10YR 4/6) concentrations	silt loam

* Munsell soil color notation

See section 2.3.3 for a description of soils soils mapped within the project site according to the Alleghany County NRCS soil survey.

5.7 Soil Characterization of Non-Jurisdictional Wetland

There is a buried hydric soil throughout this non-jurisdictional wetland at approximately 19 inches. The soil that has filled this wetland appears to have come from a well drained upland. However, it has begun to develop some morphological features giving evidence that the groundwater level / wetland hydrologic regime has re-adjusted to a point above the old hydric surface. As such, it is recommended that some of the approximately 19 inches of soil be removed in conjunction with the stream restoration efforts to restore the area to a jurisdictional wetland.

5.7.1 Taxonomic Classification of Wetlands and Non-Jurisdictional Wetlands

The NRCS Soil Survey for Alleghany County has two soil series mapped within the proposed conservation easement: the Chandler and Suncook soil series. Chandler soils are somewhat excessively drained, strongly sloping to very steep, micaceous soils found mainly in forests and pastures. Suncook soils are excessively drained, nearly level soils of the flood plains and are subject to very frequent flooding. Most of this series is in pasture or cultivation with the rest of the area forested. The soils in Wetland 1 are mapped as the Chandler and Suncook series. Wetland 2, 3, 4, 5, and 6 are mapped as the Suncook series.

5.7.2 Soil Profile Descriptions

See section 5.6 for a typical soil profile description for hydric soils observed within jurisdictional wetlands.

5.7.3 Hydraulic Conductivity

Hydraulic conductivity tests are not recommended for this project.

5.7.4 Organic Matter Content

In fertility testing performed by the NCDA, the organic matter content in two different samples was 0.66%. It is anticipated that this will increase once the area is restored.

5.7.5 Bulk Density

Calculation of bulk density is not recommended for this project.

5.8 Plant Community Characterization

Wetland 1 is a small wetland complex that is contiguous to UT to Glade Creek. It is located within a white pine plantation. Wetland 2 is a floodplain pool community encompassed within the white pine plantation that occupies the floodplain within the project site. Wetland 3, 4, 5, and 6 all are located within the white pine plantation. See Section 5.1 Jurisdictional Wetlands for wetland community descriptions.

6.0 Reference Wetlands

Wetland 2 will be used as the on site reference wetland. A reference wetland gauge was installed within the wetland (Figure 22). For a detailed description of this wetland see section 5.1 Jurisdictional Wetlands.

6.1 Hydrological Characterization of Jurisdictional Wetland

One Remote Data Systems (RDS) groundwater monitoring gauge (Gauges 3) was installed within Wetland 2 on April 3, 2008 (Figure 22). These gauges record a groundwater levels daily and the data are collected bi-monthly. Hydrologic regimes are monitored to determine if groundwater levels are within 12 inches of the soil surface for at least 5% of the growing season. These areas will be considered wetlands if the groundwater is within 12 inches for at least 5% of the growing season, the area supports hydrophytic vegetation, and it meets hydric soil requirements.

In this region, the average growing season is 147 days from May 11 to October 5; for the soil to be considered hydric, the groundwater table needs to be within 12 inches of the soil surface for at least 7.35 consecutive days. The hydrological requirements for Wetland 2 were met multiple times during the growing season. The data from all the gauges are shown in Appendix 9.Gauge Data Summary

6.1.1 Gauge Summary Data

The data from the four gauges are shown in Appendix 9. Gauge 1 and 2 were both placed in upland areas of the floodplain of Glade Creek near Wetland 6 and 2, respectively. Groundwater levels at these locations react to major storm events but do not meet hydric soil requirements, as was expected. Gauge 3 was placed in reference wetland (Wetland 3) and is described in section 6.1. Gauge 4 was placed outside of but near the tip of Wetland 1. While this area does not currently meet hydric soil requirements, groundwater levels are highly responsive to rain events.

6.2 Soil Characterization

The soil characterization is as noted for Wetland 2 in Section 5.7.

6.2.1 Taxonomic Classification

The taxonomic classification is as noted for Wetland 2 in Section 5.7.1.

6.2.2 Profile Description

The soil profile description is as noted for Wetland 2 in Section 5.7.2.

6.2.3 Hydraulic Conductivity

No hydraulic conductivity tests are recommended for this project.

6.2.4 Organic Matter Content

In fertility testing performed by the NCDA, the organic matter content in two different samples was 0.66%. It is anticipated that this will increase once the area is restored.

6.2.5 Bulk Density

Calculation of bulk density is not recommended for this project.

6.3 Plant Community Characterization

6.3.1 Community Description

This wetland is located on the north side of Glade Creek within the white pine plantation encompassing the floodplain of the project site. Regional indicator F3 was used to determine hydric soils. This wetland is mainly composed of herbaceous vegetation with some small trees and shrubs located along the wetland margin. This wetland community is classified as a floodplain pool community (Schafale and Weakley 1990). This wetland is 0.73 acre and is dominated with herbaceous vegetation with some shrub and small trees located along the wetland margin. During the site visit hydrology was clearly evident with drainage patterns and areas of standing. Amphibian larvae were ubiquitous throughout the pooled areas. Vegetation observed consisted of common rush (*Juncus effusus*), common bulrush (*Scirpus cyperinus*), giant ironweed (*Vernonia gigantea*), alternate-leaf seedbox (*Ludwigia alternifolia*), arrowleaf tearthumb (*Persicaria sagittata*), sedges (*Carex* sp.). Small tree and shrub species observed were tag alder (*Alnus serrulata*), Eastern ninebark (*Physocarpus opulifolius*), silky dogwood (*Cornus amomum*), multiflora rose (*Rosa multiflora*), swamp rose (*Rosa palustris*), and some white pines (*Pinus strobus*) part of the white pine plantation were observed along the wetland margins.

6.3.2 Basal Area

The reference wetland is basically devoid of canopy trees. As such, basal area is not addressed.

7.0 Project Site Restoration Plan

7.1 Restoration Project Goals and Objectives

The restoration plan for Glade Creek includes Priority I stream restoration as well as wetland restoration, enhancement, and preservation. Glade Creek within the project limits will have a restored stream length of 1580 feet. A portion of UT to Glade Creek will undergo a Priority I restoration for a total length of 441 linear feet. The total project restored stream length is 2021 linear feet. Approximately 0.16 acres of wetlands are to be restored, 0.13 acres enhanced, and 0.79 acres preserved as a part of the project.

7.1.1 Designed Channel Classification

The proposed Glade Creek channel will be restored as a C4 stream. The restoration will remove a number of severe bends within the stream pattern and as a result will shorten the existing stream length.

Through the restoration the stream pattern, profile, and dimension will be adjusted to allow the stream to efficiently transport its water and sediment load through a combination of changes to the channel dimension, pattern, and profile. The channel dimension will be modified to provide for a shallower and wider stream that is designed for the bankfull cross sectional area. The new stream channel will have access to the floodplain for storm events greater than the bankfull return period. The pattern of the stream will also be adjusted.

The installation of structures and vegetation will be an important part of the restoration plan to lend long-term stabilization. Clay plugs will be installed in the old channel on either side of where the new channel passes through it in order to prevent future breaches. Rock toe protection is proposed on outside bends which are high stress locations. Single wing vanes and rootwads have been included into the design to assist in bank stabilization. Constructed riffles and cross vanes have been added to the project to reinforce the vertical stability of the new stream elevations. Vegetated soil lifts have been included in the project at locations in which the outer bank in a bend will be constructed with fill soils.

Grading of the floodplain bench will provide additional flood capacity during the 100-year storm event to compensate for the change in channel configuration. The proposed grading is shown on the restoration plans Section 12, Sheets 3&4.

UT to Glade Creek will be restored with a priority one restoration. The tributary will tie into the existing channel on a steep slope. The new channel is designed as a B4 for the first 125 feet and then will become a C4 channel as it runs through the floodplain for the last 316 feet.

UT to Glade Creek currently runs straight to Glade Creek. The proposed new alignment will provide for a more sinuous channel and relocate the stream back onto the top of the floodplain. This alignment is also anticipated to provide a surface water connection to the 0.16-acre area for which wetland restoration is proposed. As detailed in the Mitigation Plan, the fill soil covering the buried hydric soil in the 0.16-acre area shows indications of a shallow water table such that it could be restored to hydric status. The new channel alignment of UT to Glade Creek, in conjunction with limited fill soil removal, is anticipated to restore the area to wetland status. A larger contiguous wetland will be formed between the existing Wetland 2 (a 0.79-acre wetland) and Wetland 1 (a 0.05-acre wetland).

The property directly upstream of the UT to Glade Creek is currently accessed by cattle for grazing. The cattle roam freely through the UT which is an A-type stream in a very steep terrain under a heavily wooded canopy on this property, which results in high velocities that are causing erosion. The resulting sediment is being conveyed downstream into Glade Creek. The new stream alignment will allow much of the sediment to be deposited onto the floodplain and not directly into Glade Creek.

The new alignment will connect the tributary to existing Wetland 3 that would have otherwise been isolated except for overbank flows from Glade Creek. The existing stream is pushed next to a terrace slope and was likely relocated there to maximize farming opportunities in the floodplain. The new alignment will be constructed as a B-type channel from the tie in with the existing channel to the end of the terrace slope, elevation 2575 feet. The existing floodplain contours slope to the northeast through the floodplain towards Wetland 3. The proposed C type stream will follow the contours east through the floodplain to connect with Wetland 3. A short segment of stream approximately 50 feet will connect this wetland with Glade Creek at a stable riffle location.

The proposed tributary will be constructed in alluvial floodplain soils. The stream channel will be held vertically with constructed riffles. The channel banks will be stabilized with herbaceous material and erosion control matting which will provide stability until the vegetation establishes. The anticipated bankfull velocity for the stream within the floodplain is 2.12 feet/second which is below the allowable velocity for sandy loam at 2.5 feet/second. Storm events larger than bankfull will have access to the floodplain. Therefore the proposed channel will be stable immediately after construction and in the long term.

7.1.2 Target Wetland Communities/Buffer Communities

The enhanced and restored wetland areas will be planted with canopy and understory plant species typical of a montane alluvial forest. Herbaceous vegetation will not be planted with the anticipation of present native species and volunteers giving rise from the seedbank. See Section 10, Table 9 below for a list of tree and shrub species that will be planted within the enhanced and restored floodplain areas. The restoration planting plan is shown in Section 12, Sheet 5.

7.2 Sediment Transport Analysis

7.2.1 Methodology

A stable stream has the capacity to move its sediment load without aggrading or degrading. The total load of sediment can be divided into wash load and bed load. Wash load is normally composed of fine sands, silts and clay and transported in suspension at a rate that is determined by availability and not hydraulically controlled by the size and nature of the bed material and hydraulic conditions (Hey 1997).

The critical shear stress for the proposed channels has to be sufficient to move the particle size diameter value at the 84th percentile (D84) of the bed material. Shear stress was computed using the shear stress equation below and compared to the Shield's Curve of the threshold of grain diameter motion.

$$\mathcal{T} = \Upsilon R s$$

Where:

$\mathcal{T}$ = shear stress (lb/sqft)

Υ = specific gravity of water (62.4 lb/cubic ft.)

R = hydraulic radius (ft)

s = water surface slope (ft/ft)

Additional sediment transport analysis was completed using the Rosgen method of using bed materials and sub surface material D50 particle sizes to determine the critical dimensionless shear stress. The critical shear stress along with the channel slope and largest sub-pavement moving particle made available by the watershed as measured on a depositional feature were used to predict the mean depth for the design channel at bankfull. If the channel design depth is too small the channel sediment will be deposited. If the depth is too large the channel will need energy deposition.

$$\Upsilon ci = 0.0834\left(\frac{di}{D\hat{\ }50}\right)\hat{\ } -0.872$$

$$Depth = \frac{(Tci)\ 1.65\ (D)}{slope}$$

Where:

Tci = critical shear stress (lb/sqft)

di = D50 pavement bed material

d^50 = D50 sub-pavement

D = Largest sub-pavement particle (ft)

Depth = Mean depth at bankfull (ft)

Slope = Average water surface slope at bankfull (ft/ft)

7.2.2 Calculations and Discussion

The shear stress calculated for sediment samples in Glade Creek 0.70 lbs/sq ft when entered into Shield's Curve, predicted a range of particle motion of 3.54 inches small cobble. The D84 in Glade Creek is small cobble and therefore will move as a bed load. The Rosgen analysis showed that with the mean channel depth designed for Glade Creek, a particle between 120 mm to approximately 150 mm (small to medium cobble) will pass through the system. This is consistent with the shields diagram analysis of the range of particle motion in the system. The bankfull depth of 1.88 to 2.17 feet for the proposed stream was designed to pass the cobble sediment that is moving through Glade Creek.

Two channel segments of UT to Glade Creek were evaluated for sediment transport in the tributary. The upper channel reach of the tributary is a "B" type channel, which is a step pool system typically on a steep slope. The shear stress calculated for sediment samples in this upper reach is 0.66 lbs/sq ft when entered into Shield's Curve, predicted a range of particle motion of 3.3 inches small cobble. The D84 in UT to Glade Creek is very coarse gravel and therefore will move as a bed load. The Rosgen analysis showed that with the mean channel depth designed for UT to Glade Creek, a particle 80 mm (small cobble) will pass through the "B" type stream system. This is consistent with the shields diagram analysis of the range of particle motion in the system. The bankfull depth of 0.23 feet for the proposed "B" type stream was designed to pass the very coarse gravel sediment that is moving through UT to Glade Creek.

The lower channel reach of UT to Glade Creek is a "C" type channel within a broad floodplain. The shear stress calculated for sediment samples in this lower reach is 0.6 lbs/sq ft when entered into Shield's Curve, predicted a range of particle motion of 3.3 inches small cobble. The D84 in UT to Glade Creek is very coarse gravel and therefore will move as a bed load. The Rosgen analysis showed that with the mean channel depth designed for UT to Glade Creek, a particle 40 mm (very course gravel) will pass through the "C" type stream system. This is consistent with the shields diagram analysis of the range of particle motion in the system. The bankfull depth of 0.28 feet for the proposed "C" type stream was designed to pass the very coarse gravel sediment that is moving through UT to Glade Creek.

7.3 HEC-RAS Analysis

7.3.1 Hydrologic Trespass

Although Glade Creek is not a FEMA regulated stream, a flood study was conducted using a HEC-RAS model to determine potential Hydrologic Trespass. Cross sections were located at 500 feet or less intervals along the stream with sections extending upstream and downstream of the project to determine off site impacts. Pre and post-project models were run and the predicted water surface elevations compared to determine the effects of the designed channel within the floodplain during selected storm events.

As a result of the stream channel relocation no rise in water surface elevations occurs on adjacent properties during the 10 or 100-year storm events. A slight rise in water surface elevation did occur with in the project site.

7.4 Hydrological Modifications

7.4.1 Narrative of Modifications

This area used to have a wetland hydrologic regime, as expressed by the buried hydric soil. It is believed that the incising of Glade Creek and the UT have caused a drainage effect. The groundwater elevation is expected to be raised by re-routing the UT through the area into a more natural, elevated stream channel.

7.4.2 Scaled Schematic of Modifications

The restoration and enhancement are shown on sheet 3 and 4 of the restoration plans as well as sheet 5 the planting plan.

7.5 Soil Restoration

7.5.1 Narrative & Soil Preparation and Amendment

The Alleghany County Soil Survey has the floodplain within the study site mapped as either Chandler or Suncook soils. (Note – Suncook has been reclassified as Biltmore). These soils are very deep, excessively drained sandy soils formed in alluvial sediments. They are nearly level soils on flood plains, subject to common flooding. However, there is a buried hydric soil horizon throughout most of the study site, the depth to which ranged from 18 to 23 inches. This feature is NOT noted in any of the county soils mapped by NRCS. As such, any associations with a particular mapped soil would be inappropriate.

Two soil fertility samples (GC01and CG02) were taken within the floodplain to determine soil amendment recommendations for the proposed planting zones. Sample GC01 represents the soils approximately within 50 ft of Glade Creek. GC02 represents the soils within the pine plantation. Due to soil disturbing activities during construction, it is recommended that samples be collected post construction activities to ensure accurate soil amendment recommendations. See the attached soil test results in Appendix 10 for additional information.

7.6 Natural Plant Community Restoration

7.6.1 Narrative & Plant Community Restoration

The target vegetative community for the stream buffer along Glade Creek is a montane alluvial forest as define by Schafale and Weakley (1990). The wetland enhancement and restoration areas will be planted with wetland species typically observed within a montane alluvial forest.

The restoration plan consists of three planting zones: Zone 1 (Stream Bank), Zone 2 (Stream Buffer/Montane Alluvial Forest), Zone 3 (Wetland Enhancement/Restoration), Zone 4 (Chestnut Oak Forest), and Zone 5(Power Line Easement-Montane Alluvial Forest Shrubs Only). Zone 1 will consist of small tree and shrub suitable for planting along stream banks. Zone 2 will consist of canopy, subcanopy, and shrub species typical for a montane alluvial forest. Zone 3 will consist of a canopy, subcanopy, and shrub species typically found in wetland communities of a montane alluvial forest. Zone 4 will consist of canopy and shrub species that were observed within the relatively undisturbed Chestnut Oak Forest within the project site. Zone 5 lies within the powerline easement and will consist only of shrub species typical for a montane alluvial forest. Tree species will not be planted within this area. A list of species for each zone is provided in Section 10, Table 11. The herbaceous species seed mix specifications will be determined and provided in the construction plan.

7.6.2 On-site Invasive Species Management

There were 4 invasive exotic plant species observed throughout the project site; kudzu, Japanese honeysuckle, tall fescue, Japanese knotweed, and multiflora rose. Where ground disturbing activities occur within the project site, invasive exotic species management strategies will be conducted. Prior to construction, locations of invasive exotic plants within the proposed conservation easement will be flagged to ensure that all plants are removed from the site. Manual or mechanical removal of invasive exotic plants should always be considered as the first method of control where feasible. Life history and alternative management strategies that are species specific are presented below.

Multiflora rose: This aggressive shrub, native to Asia, can out-compete native vegetation and become the dominant shrub layer of an invaded habitat resulting in a lower species composition and an alteration in the natural community structure. It can shade out the herbaceous layer of the community it inhabits. This deciduous shrub colonizes by prolific sprouting stems that root and the seeds are spread widely by wildlife such as birds. Control efforts during early stages of colonization have a higher potential for successful management. Between the months of April and October a foliar herbicidal application should be used. Use glyphosate between May and October for a less effective treatment that has no soil activity of damage to surrounding plants. For stem to tall for a foliar spray, an herbicidal application in a basal oil, diesel fuel, or kerosene can be applied to the bark as a basal spray. The cut stump method, which entails cutting large stems and immediately treating the stumps with an herbicide should be used.

Japanese Honeysuckle: Manual or mechanical removal should always be considered as the first method of control where feasible. Japanese honeysuckle occurs as dense infestations along forest margins, rights-of-ways, and under canopies. This vine is shade tolerant and spreads from a large root stock, rooting at vine nodes, and from seeds dispersed by animals. Control procedures to consider should include broadcast spraying between June and October while avoiding desirable plants. For larger vines cut them just above the soil surface and immediately treat the freshly cut stem with an herbicide between the months of July and October.

Japanese knotweed: This native to eastern Asia is an upright shrub like herbaceous perennial that grows to a height of 10 feet. It spreads by water, seeds are found in fill dirt, vegetatively due to its stout rhizomes. Manual removal is effective for small colonies which is the case for the few plants seen within the project site. All parts of the plant must be removed to ensure no chance for re-sprout.

Kudzu: This plant was observed within the White Pine plantation near the road within the powerline corridor. Manual remove the root crown followed by a foliar herbicidal application during late summer for successive years.

Tall fescue: This grass is found in the maintained/disturbed area of the project site. Currently it is being maintained through mowing however post restoration management strategies will need to be implemented. This cool season grass is found in extensive colonies and can cause serious infestations. Control efforts include using a herbicide solution in water in the spring.

8.0 Performance Criteria

To demonstrate mitigative success, baseline conditions will be established in the form of as-built drawings. The as-built drawings will include profile and plan views of the completed stream project. At the conclusion of the construction activities, the channel modifications and planted vegetation based on a bankfull return period will be monitored annually for a minimum of five years. Monitoring reports will be prepared at the end each year and made available to the resource agencies.

8.1 Streams

The proposed success criteria for stream mitigation will be based on the stability of the stream. The geomorphology of the stream will be monitored as follows:

- Dimension: Permanent cross sections (surveyed or GPS'd) will be established in the frequency of one for every 20 bankfull widths along the length of the reach. Cross section sites will be selected such that approximately half are placed in riffles and half placed in pools. Measurements of W/D ratio, entrenchment ratio, and low bank height ratio will be monitored yearly.
- Pattern: Pattern measurements will include sinuosity and meander width ratio and will be performed yearly. Measurements of radius of curvature will be monitored on newly constructed meanders for the first year only.
- Profile: Longitudinal profile will be surveyed and measurements collected on slope (average, pool, riffle) and pool-to-pool spacing.
- Materials: Pebble counts in pools and riffles will be measured. The D50 and D84 particle size diameter percentiles will be monitored to assure an increase in coarseness in riffles and an increase in fineness in pools.
- Photo Reference Points: Photo reference points will be established at all cross sections showing banks and channel. Additional photos will be taken at selected structures on the project to monitor their structural stability.
- Vegetation: Vegetation plots will be established to monitor the plant survival in the planted areas of the conservation easement and stream bank. The vegetation plots will be 10 meters by 10 meters and will be established based on site conditions. Vegetative sampling will be undertaken on a yearly basis. The survival rate will be based on 320 stems/acre for trees after five years of planting.

During the annual review the entire stream reach will be evaluated for any potential problem areas and photographs taken to document the degree and severity. Potential problem areas may include bank instability, in-stream structure failure or unsuccessful vegetation establishment. If a failure area is noted, corrective actions will be evaluated to resolve the problem. Remedial actions will be undertaken considering any seasonal limitations. Any remedial actions will be documented on the as-built plans.

8.2 Wetlands

The project is expected to help to restore the hydrology to the non-jurisdictional wetland through a combination of stream re-routing, soil removal, and native plantings. The restored wetland is riparian and anticipated to have wetland hydrology for at least 12.5% of the growing season.

Wetlands 1, 3, and 5 are expected to be enhanced through the planting of tree and shrub species typical of a montane alluvial forest while Wetland 2 will be preserved and enhanced indirectly by completion of this project.

8.3 Vegetation

The vegetation monitoring will be conducted according to the Carolina Vegetation Survey (CVS) – EEP protocol Version 4.0 (Lee et al 2006). Vegetation monitoring plots will be 100 square meters in size and will be conducted according to the Level I protocol which has a focus on planted stems only. The purpose of this level of monitoring is to determine the pattern of installation of plant material with respect to species, spacing, density, and to monitor the survival and growth of those installed species. The success criteria for the preferred species in the restoration areas will be based on annual and cumulative survival and growth over five (5) years. Survival on preferred species must be at a minimum 320 stems/acre at the end of the three years of monitoring and 260 stems/acre after five years. The number of required plots is based on the mitigation category: stream enhancement, stream restoration, and wetland restoration. A spreadsheet is provided by EEP to calculate to necessary numbers of plots for streams (Lee et al 2006). The number of required wetland plots is determined on a case-by-case basis. According to the spreadsheet calculation, four plots will be required for the restored reach of Glade Creek. The restored reach of the UT to Glade Creek will require two plots.

8.4 Schedule/Reporting

The Glade Creek Stream Restoration Project will be determined to be successful once vegetation success criteria have been met within the restoration and enhancement areas. During vegetation monitoring, planted and volunteer stem densities will be measured in addition to the relative abundance and diversity of herbaceous vegetation within the monitoring plots. Species will be listed and identified by wetland indicator status. Planting locations and methods will be completed in the first year Annual Report. Survival, numbers per acre by species, and tree height will be measured at the end of each growing season just prior to leaf fall.

Monitoring data will be collected for a period of five years or until all success criteria are achieved, whichever is longer. Annual Reports will be submitted to the EEP prior to the end of each calendar year, documenting plant community conditions within the restoration areas and documenting hydrologic data within these areas and reference plots. The project areas will be photographed from permanent photo stations and changes in any of the above variables will be recorded and included in each annual report. The Annual Report will also include a proposed plan of action for the following year including maintenance activities.

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10.0 Tables

Table 1: Glade Creek Restoration Structure and Objectives

Restoration Segment ID	Station Range	Restoration Type	Priority Approach	Existing Linear Footage	Designed Linear Footage	Comment
Main Channel	1+00 to 16+80	Restoration	1	2345	1580	
Tributary	0+00 to 4+49	Restoration	1	150	441	
Tributary	Ex 0+00 to 1+50	Preservation		150	150	
Wetland	NA	Restoration		NA	0.16 Ac	
Wetland 1,3,5	NA	Enhancement		NA	0.16 Ac	
Wetland 2,4	NA	Preservation		NA	0.76 Ac	

Table 2: Drainage Areas

Stream	Drainage Area (Sq. Miles)
Glade Creek	8.00
UT to Glade Creek	0.016

Table 3: Land Use of the Glade Creek Watershed

Land Use	Square Miles	Percentage
Pavement	0.03	0.4 %
Commercial	0.09	1.1 %
Residential (1/2 Ac lots)	0.05	0.6 %
Residential (1 Ac lots)	0.08	1.0 %
Lawn (fair)	2.87	35.5 %
Woods (good)	4.97	61.4 %

Table 4: Morphological Table for Glade Creek

Variables	Existing Channel: Glade Creek	Upper Proposed Reach: Glade Creek	Lower Proposed Reach: Glade Creek	Reference Reach: Basin Creek
Stream type	Degraded C4/E4	C4	C4	C4
Drainage Area (Sq. Mile)	8.00	8.0	8.0	6.8
Bankfull width (Wbkf) feet	33.98 (17.51-42.38)	36	30	30.7
Bankfull mean depth (dbkf) feet	2.47 (2.02-3.27)	2.19	1.88	1.9
Width/depth ratio (Wbkf/dbkf)	14.13 (7.45-19.60)	16.4	16	16.4
Bankfull Cross Sectional Area (Abkf) (sq ft)	83.42 (41.15-108.90)	79	56.6	57.4
Bankfull Mean Velocity (Vbkf) feet/second	5.53 (4.89-7.05)	5.75	8.0	NA
Bankfull Discharge, cfs (Qbkf) cfs	455	455	455	NA
Bankfull Maximum depth (dmax) feet	4.18 (3.61-4.85)	3.0	3.0	2.5
Max driff/dbkf ratio	1.47 (1.30-1.80)	1.37	1.59	1.32*
Low Bank Height feet	4.03 (2.66-5.37)	3.0	3.0	2.5
Ratio of Low bank Height to max dbkf	0.97 (0.71-1.36)	1.0	1.0	1.0
Width of flood prone area (Wfpa) feet	273.14 (79.83-472.39)	354 (295-430)	243 (90-340)	70
Entrenchment ratio (Wfpa/Wbkf)	7.94 (3.10-13.71)	9.83 (8.19-11.94)	6.74 (2.5-9.44)	2.3
Meander length (Lm) feet	213.75 (100-275)	367 (360-370)	345 (330-360)	350
Ratio of meander length to bankfull width (Lm/Wbkf)	6.29 (2.94-8.09)	10.19 (10-10.28)	9.58 (9.17-10)	11.40*
Radius of Curvature (Rc) feet	63.25 (21-114)	103.5 (96-116)	120 (107-141)	105.2 (76.7-133.8)
Ratio of radius of curvature to bankfull width (Rc/Wbkf)	1.86 (0.62-3.35)	2.88 (2.67-3.22)	3.32 (2.97-3.92)	3.43 (2.5-4.36)

Belt width (Wblt) feet	75.31 (20-135)	140 (132-150)	91.5 (78-105)	105
Meander width ratio (Wblt/Wbkf)	2.22 (0.59-3.97)	3.89 (3.67-4.17)	2.54 (2.17-2.92)	3.2
Sinuosity (stream length /valley distance) (k)	1.60	1.38	1.2	1.1
Valley slope (ft/ft)	0.0072	0.0056	0.012	0.017
Average slope Savg= (Svalley / k)	0.0042	0.004	0.010	0.0141
Pool Slope (Spool) (ft/ft)	0.0020 (0.0000-0.0048)	0.002	0.002	0.0055 (0.0049-0.0061)
Ratio of pool slope to average slope (Spool/Sbkf)	0.47 (0.00-1.10)	0.49	0.20	0.388 (0.346-0.430)
Maximum pool depth (dpool) feet	4.54 (4.20-4.95)	4.25	4.0	3.1
Ratio of pool depth to average bankfull depth (dpool/dbkf)	1.84 (1.70-2.01)	1.94	2.13	1.66
Pool width (Wpool) Feet	31.75 (24.77-36.31)	33-36	28-30	40.6
Ratio of pool width to bankfull width (Wpool/Wbkf)	0.93 (0.73-1.07)	0.93-1.0	0.93-1.0	1.32
Pool Cross Sectional Area (sq ft)	93.01 (79.13-107.48)	95	68	64.4
Ratio of pool area to bankfull area	1.11 (0.95-1.29)	1.2	1.2	1.12
Pool to pool spacing (p-p) feet	99.26 (44.45-215.18)	227 (220-240)	190 (180-210)	224 (120-240)
Ratio of p-p spacing to bankfull width (p-p/Wbkf)	2.92 (1.31-6.33)	6.32 (6.11-6.67)	5.28 (5-5.83)	7.30*

Table 5: Morphological Table for UT to Glade Creek – "B" Type Channel

Variables	Existing Channel: Glade Creek Tributary	Proposed Reach: Glade Creek Tributary	Reference Reach: UT to Little Pine Creek Trib 1
Stream type	B4/C4	B4	B4a/C4a
Drainage Area (Sq. Mile)	0.01637	0.01637	0.051
Bankfull width (Wbkf) ft	3.80 (3.14-4.45)	3.5	7.55 (6.17-11.11)
Bankfull mean depth (dbkf) ft	0.22 (0.20-0.24)	0.23	0.60 (0.046-0.69)
Width/depth ratio (Wbkf/dbkf)	17.61 (12.97-22.25)	15.21	13.46 (9.11-24.30)
Bankfull Cross Sectional Area sq.ft. (Abkf)	0.83 (0.76-0.89)	0.80	4.35 (3.79-5.08)
Bankfull Mean Velocity (Vbkf) ft/sec	1.60 (1.40-1.80)	4.08	5.26 (4.18-5.86)
Bankfull Discharge, cfs (Qbkf)	3	3	23
Bankfull Maximum depth (dmax) ft	0.40 (0.40-0.40)	0.30	1.59 (0.82-1.03)
Max driff/dbkf ratio	1.83 (1.65-2.00)	1.3	1.54 (0.92-1.84)
Low Bank Height ft	1.78 (1.67-1.88)	0.30	1.19 (0.96-1.74)
Low bank Height to max dbkf	4.44 (4.18-4.70)	1.0	1.30 (1.01-2.12)
Width of flood prone area (Wfpa) ft	7.56 (5.28-9.84)	50	28.90 (14.31-46.33)
Entrenchment ratio (Wfpa/Wbkf)	1.95 (1.68-2.21)	14.29	4.36 (1.29-7.49)
Meander length (Lm) ft	38.09 (12-65)	46 (25-18.6)	101 (55-140)
Ratio of meander length to bankfull width (Lm/Wbkf)	10.04 (3.16-17.13)	13.39 (7.2-18.6)	13.39 (7.29-18.56)
Radius of Curvature (Rc) ft	21.82 (5-61)	18 (9.3-30.6)	38.8 (20-66)
Ratio of radius of curvature to bankfull width (Rc/Wbkf)	5.75 (1.32-16.07)	5.14 (2.65-8.75)	5.14 (2.65-8.75)
Belt width (Wblt) ft	16.27 (13-21)	9.9 (8.7-12.3)	21.4 (19-26)

Meander width ratio (Wblt/Wbkf)	4.29 (3.43-5.53)	2.84 (2.5-3.5)	2.84 (2.52-3.45)
Sinuosity (stream length /valley distance) (k)	1.04	1.25	1.09
Valley slope (ft/ft)	0.05	0.053	0.0516
Average slope Savg= (Svalley /k) ft/ft	0.048	0.049	0.04733
Pool Slope (Spool)	0.0414 (0.0185-0.0914)	0.01	0.0152 (0.0029-0.0351)
Ratio of pool slope to average slope (spool/Sbkf)	1.23 (0.55-2.72)	0.46 (0.09-1.05)	0.46 (0.09-1.05)
Maximum pool depth (dpool) ft	0.48 (0.35-0.70)	1.0	1.23 (0.7-1.5)
Ratio of pool depth to average bankfull depth (dpool/dbkf)	2.19 (1.58-3.17)	3.3	2.05 (1.17-2.50)
Pool width (Wpool) Ft.	5.63 (4.99-6.27)	3.0 (2.1-3.2)	5.83 (4.15-7.40)
Ratio of pool width to bankfull width (Wpool/Wbkf)	1.48 (1.31-1.65)	0.86 (0.6-0.9)	0.77 (0.55-0.98)
Pool Cross Sectional Area sq.ft.	0.82 (0.78-0.86)	1.0	3.70 (1.26-6.93)
Ratio of pool area to bankfull area	0.99 (0.95-1.04)	1.25 (0.29-1.6)	0.85 (0.29-1.59)
Pool to pool spacing (p-p) ft	26.14 (4.69-68.61)	35-38	40.88 (15.77-90.45)
Ratio of p-p spacing to bankfull width (p-p/Wbkf)	6.89 (1.24-18.08)	10-10.85	5.42 (2.09-11.99)

Table 6: Morphological Table for UT to Glade Creek – "C" Type Channel

Variables	Existing Channel: Glade Creek Tributary	Proposed Reach: Glade Creek Tributary	Reference Reach: UT South Fork Cane Creek
Stream type	B/C	C4	C4
Drainage Area (Sq. Mile)	0.01637	0.01637	0.41
Bankfull width (Wbkf) ft	3.80 (3.14-4.45)	5	(12.7 – 13.9) 13.3
Bankfull mean depth (dbkf) ft	0.22 (0.20-0.24)	0.28	(0.85 – 0.91) 0.88
Width/depth ratio (Wbkf/dbkf)	17.61 (12.97-22.25)	17.8	(14.5 – 16.35) 15.15
Bankfull Cross Sectional Area sq.ft. (Abkf)	0.83 (0.76-0.89)	1.4	(11.03 – 11.95) 11.59
Bankfull Mean Velocity (Vbkf) ft/sec	1.60 (1.40-1.80)	2.2	(2.86 – 2.98) 2.9
Bankfull Discharge, cfs (Qbkf)	3	3	(32.2 – 35.7) 33.9
Bankfull Maximum depth (dmax) ft	0.40 (0.40-0.40)	0.43	(1.26 – 1.44) 1.34
Max driff/dbkf ratio	1.83 (1.65-2.00)	1.53 (1.44-1.64)	(1.44 - 1.64) 1.53
Low Bank Height ft	1.78 (1.67-1.88)	0.43	(1.06 – 2.4) 1.59
Low bank Height to max dbkf	4.44 (4.18-4.70)	1.0 (0.9-1.1)	(0.84 – 1.8) 1.19
Width of flood prone area (Wfpa) ft	7.56 (5.28-9.84)	100	(27 – 45) 35.3
Entrenchment ratio (Wfpa/Wbkf)	1.95 (1.68-2.21)	28.57	(2.13 – 3.24) 2.65
Meander length (Lm) ft	38.09 (12-65)	45 (40-58)	(35 – 57.5) 45.8
Ratio of meander length to bankfull width (Lm/Wbkf)	10.04 (3.16-17.13)	9 (8-11)	(2.64 – 4.33) 3.49
Radius of Curvature (Rc) ft	21.82 (5-61)	8.1 (4.4-14.9)	(11.7 – 35.9) 21.5
Ratio of radius of curvature to bankfull width (Rc/Wbkf)	5.75 (1.32-16.07)	1.62 (0.9-2.9)	(0.88 – 2.71) 1.62
Belt width (Wblt) ft	16.27 (13-21)	30 (25-42)	(15 – 32) 21.7

Meander width ratio (Wblt/Wbkf)	4.29 (3.43-5.53)	6 (5-8.4)	(1.13 – 2.41) 1.63
Sinuosity (stream length /valley distance) (k)	1.13	1.27	1.27
Valley slope (ft/ft)	0.05	0.014	0.010
Average slope Savg= (Svalley /k) ft/ft	0.044	0.011	0.0079
Pool Slope (Spool)	0.0414 (0.0185-0.0914)	0.001	(0.00 – 0.0013) 0.0003
Ratio of pool slope to average slope (spool/Sbkf)	1.23 (0.55-2.72)	.030	(0.00 – 0.16) 0.04
Maximum pool depth (dpool) ft	0.48 (0.35-0.70)	0.8	(1.63 – 2.2) 1.99
Ratio of pool depth to average bankfull depth (dpool/dbkf)	2.19 (1.58-3.17)	2.8	(1.86 – 2.51) 2.27
Pool width (Wpool) Ft.	5.63 (4.99-6.27)	5 (4-5)	12.3
Ratio of pool width to bankfull width (Wpool/Wbkf)	1.48 (1.31-1.65)	0.8 (0.8-1.0)	0.93
Pool Cross Sectional Area sq.ft.	0.82 (0.78-0.86)	1.9	(15.4 – 16.7) 16
Ratio of pool area to bankfull area	0.99 (0.95-1.04)	1.3 (1.3-1.4)	(1.33 – 1.44) 1.38
Pool to pool spacing (p-p) ft	26.14 (4.69-68.61)	20 (23-30)	(22.8 - 64) 40.3
Ratio of p-p spacing to bankfull width (p-p/Wbkf)	6.89 (1.24-18.08)	4 (4.6-6)	(1.72 – 4.82) 3.04

Table 7: BEHI/NBS and Sediment Export Estimate for Glade Creek

Time Point	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
Pre-Construction		Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ton/y
	2286	64	3	355	16	568	25	840	37	461	20	0	0	399

Table 8: BEHI/NBS and Sediment Export Estimate for UT to Glade Creek

Time Point	Linear Footage	Extreme		Very High		High		Moderate		Low		Very Low		Sediment Export
Pre-Construction		Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ft.	%	Ton/y
	288	0	0	0	0	61	21	157	54	71	24	0	0	8.4

Table 9. Planting Plan Species List

Planting Zone 1 (Streambank)

Trees and Shrubs	
Alnus serrulata	Tag alder
Physocarpus opulifolius	Eastern ninebark
Cornus amomum	Silky dogwood
Hamamelis viginiana	Witch-hazel
Salix sericea	Silky willow
Carpinus caroliniana	Ironwood
Spiraea latifolia	Meadowsweet
Vibrurnum cassinoides	Northern Wild Raisin
Xanthorhiza simplicissima	Yellow-root

Planting Zone 2 (Stream buffer-Montane Alluvial Forest)

Trees and Shrubs	
Platanus occidentalis	Sycamore
Liriodendron tulipifera	Tulip poplar
Carya cordiformis	Bitternut hickory
Celtis laevigata	Hackberry
Asimina triloba	Common pawpaw
Corylus americana	Hazelnut
Alnus serrulata	Tag alder
Physocarpus opulifolius	Ninebark
Corylus americana	Hazelnut
Hamamelis viginiana	Witch-hazel
Carpinus caroliniana	Ironwood
Vaccinium corymbosum	Highbush blueberry
Ilex verticillata	Blue Huckleberry
Lindera benzoin	Spicebush

Planting Zone 3 (Wetland Enhancement/Restoration)

Trees and Shrubs	
Carya ovata	Shagbark hickory
Fraxinus pennsylvanica	Green ash
Alnus serrulata	Tag alder
Rosa palustris	Swamp rose
Physocarpus opulifolius	Eastern ninebark
Salix sericea	Silky willow
Sambucus canadensis	Common elderberry
Lindera benzoin	Spicebush

Planting Zone 4 (Chestnut Oak Forest)

Trees and Shrubs	
Quercus montana	Chestnut oak
Quercus coccinea	Scarlet oak
Quercus alba	White oak
Nyssa sylvatica	Blackgum
Carya alba	Mockernut hickory
Liriodendron tulipifera	Tulip tree
Sassafras albidum	Sassafras
Kalmia latifolia	Mountain laurel
Rhododendrom maximum	Great Rhododendron

Planting Zone 5 - (Power Line Easement-Montane Alluvial Forest Shrubs Only)

Shrubs	
Corylus americana	Hazelnut
Alnus serrulata	Tag alder
Physocarpus opulifolius	Ninebark
Euonymus americana	Strawberry bush
Hamamelis viginiana	Witch-hazel
Vaccinium corymbosum	Highbush blueberry
Ilex verticillata	Blue Huckleberry
Cornus amomum	Silky Dogwood
Lindera benzoin	Spicebush

Table 10. Particle Size Distribution – Glade Creek

Materials:	Existing	Proposed	Reference
Particle Size distribution of channel material (mm)			
D16	12	12	0.17
D35	20	20	29
D50	31	30	58
D84	80	80	180
D95	105	105	300
Particle Size distribution of bar material (mm)			
D16	1.1	1.1	N/A
D35	2.4	2.5	N/A
D50	3.9	4	N/A
D84	12	12	N/A
D95	19	19	N/A
Largest size particle at the toe (lower third) of bar (mm)	4.5-6	4.5-6	N/A

Table 11. Particle Size Distribution – UT to Glade Creek Type “B”

Materials:	Existing	Proposed	Reference
Particle Size distribution of channel material (mm)			
D16	0.5	0.5	0.38
D35	4	4	0.9
D50	7.1	7.1	7
D84	42	42	31
D95	95	95	62
Particle Size distribution of bar material (mm)			
D16	0.24	0.24	0.62
D35	0.38	0.38	3.3
D50	0.48	0.48	8.1
D84	1.3	1.3	37.4
D95	4.7	4.7	68
Largest size particle at the toe (lower third) of bar (mm)	1.3”-2”	1.3”-2”	3.0”-3.5”

Table 12. Particle Size Distribution – UT to Glade Creek Type “C”

Materials:	Existing	Proposed	Reference
Particle Size distribution of channel material (mm)			
D16	0.5	0.5	N/A
D35	4	4	N/A
D50	7.1	7.1	N/A
D84	42	42	N/A
D95	95	95	N/A
Particle Size distribution of bar material (mm)			
D16	0.24	0.24	N/A
D35	0.38	0.38	N/A
D50	0.48	0.48	N/A
D84	1.3	1.3	N/A
D95	4.7	4.7	N/A
Largest size particle at the toe (lower third) of bar (mm)	1.3”-2”	1.3”-2”	N/A

Table 13. Sediment Transport Validation Glade Creek

Sediment Transport Validation (Based on Bankfull shear Stress)	Existing	Proposed
Calculated value (lb/sq.ft.)	0.65	0.68-0.71
Value from Shield Diagram (lb/sq.ft.)	0.65	0.65
Critical dimensionless shear stress	0.0137	0.0137
Miminum mean dbkf calculated using critical dimensionless shear stress equations (ft)	2.69	1.88-2.19

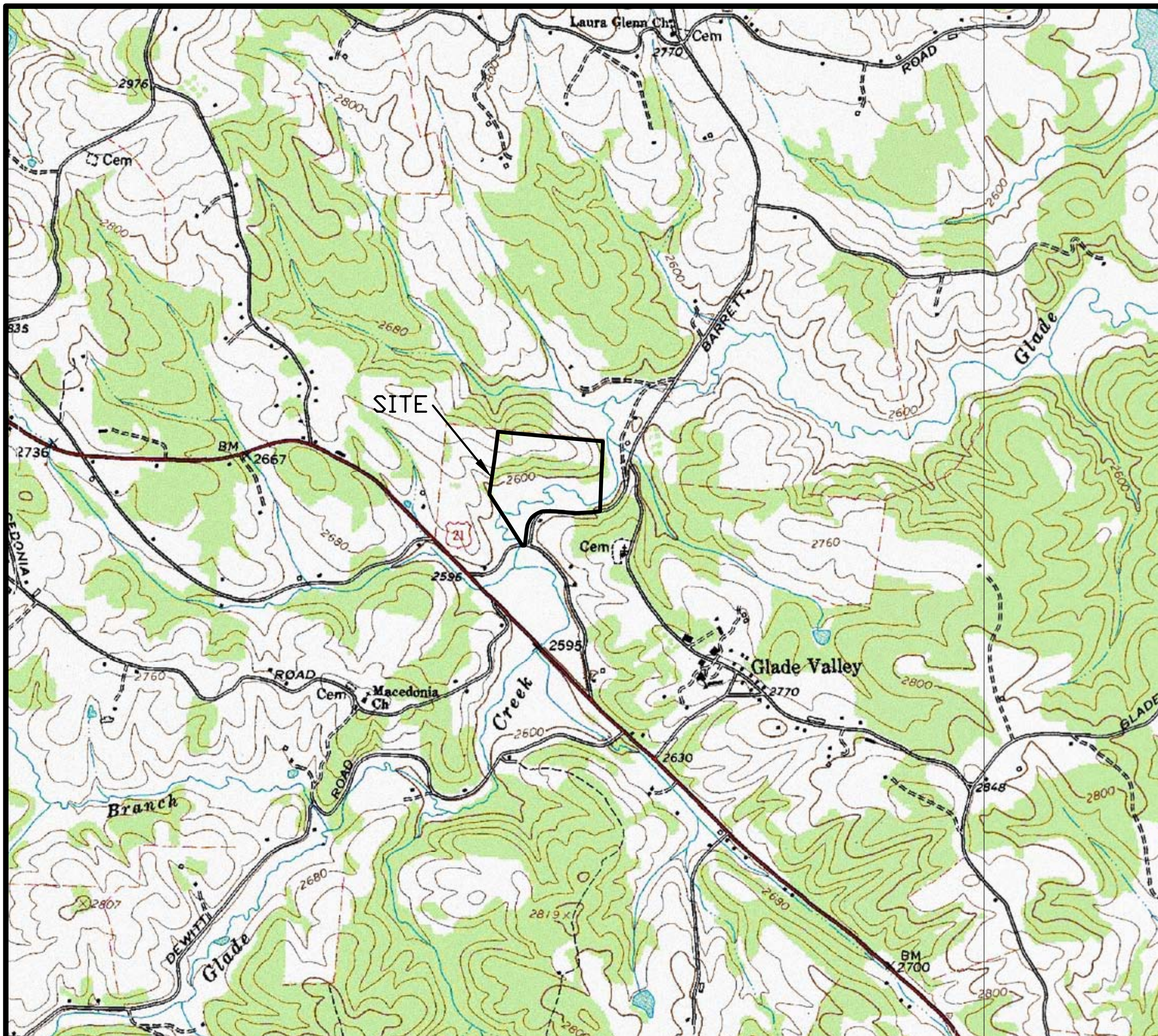
Table 14. Sediment Transport Validation UT to Glade Creek Type “B”

Sediment Transport Validation (Based on Bankfull shear Stress)	Existing	Proposed
Calculated value (lb/sq.ft.)	0.66	0.60
Value from Shield Diagram (lb/sq.ft.)	0.33	0.33
Critical dimensionless shear stress	0.008	0.008
Miminum mean dbkf calculated using critical dimensionless shear stress equations (ft)	0.049	0.23

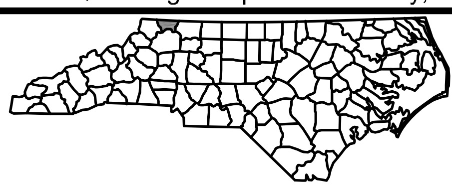
*Note this is a step pool system.

Table 15. Sediment Transport Validation UT to Glade Creek Type “C”

Sediment Transport Validation (Based on Bankfull shear Stress)	Existing	Proposed
Calculated value (lb/sq.ft.)	0.64	0.23
Value from Shield Diagram (lb/sq.ft.)	0.3	0.3
Critical dimensionless shear stress	0.008	0.008
Miminum mean dbkf calculated using critical dimensionless shear stress equations (ft)	0.2	0.28



USGS Quadrangle Map Glade Valley, 1968



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

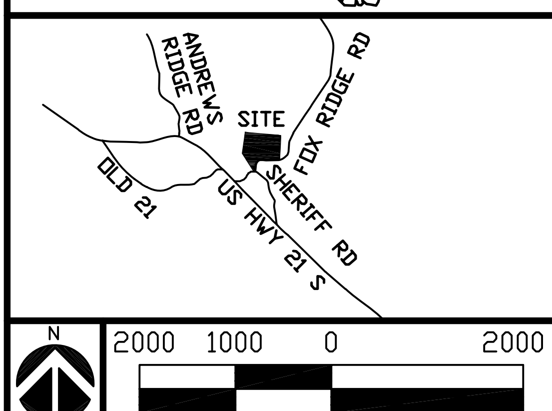
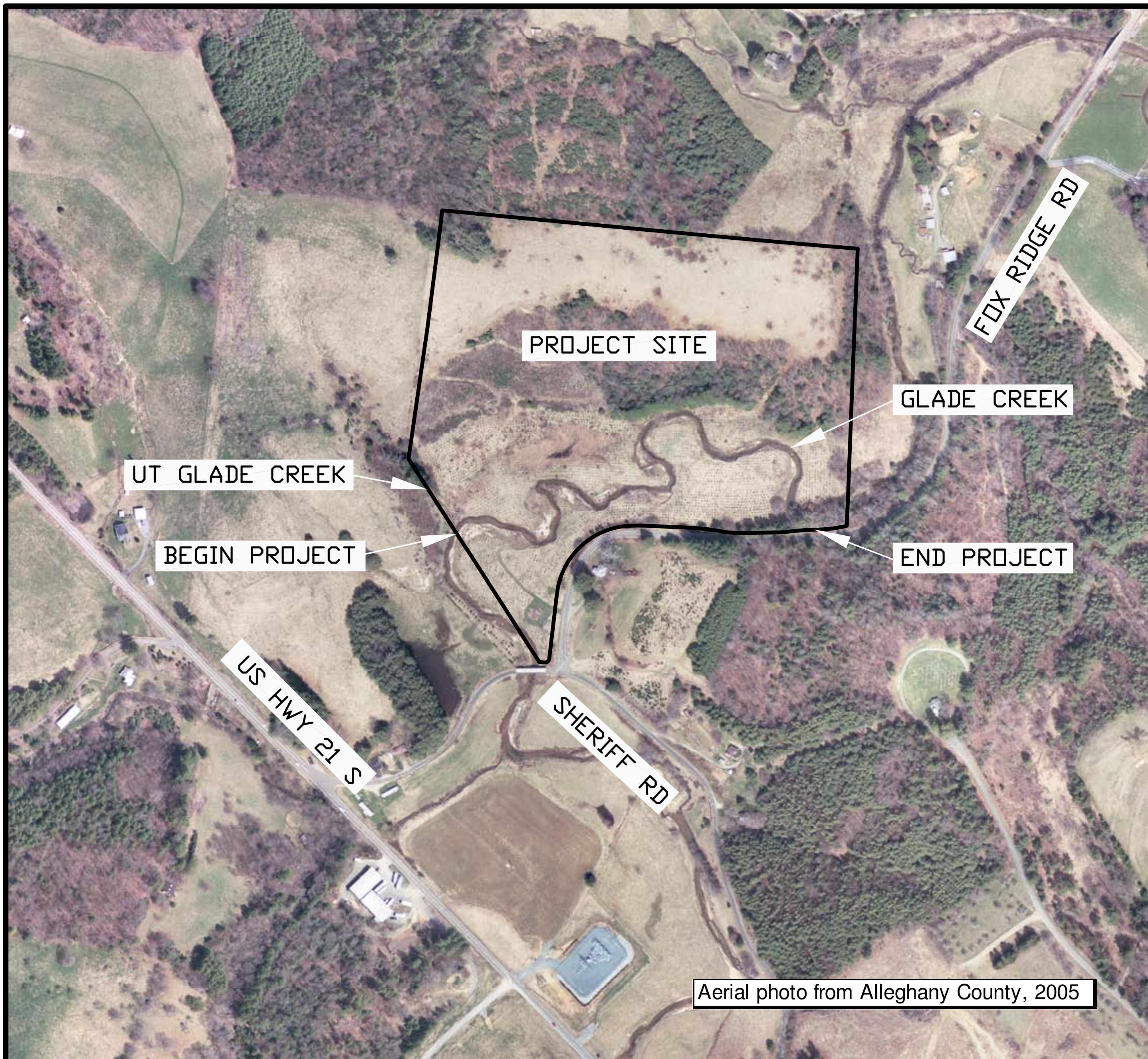


FIGURE 1
GLADE CREEK VICINITY MAP

DATE: JULY 21, 2008

WARD CONSULTING ENGINEERS, PC

8386 Six Forks Rd. Suite 101 (919) 870-0526
Raleigh, NC 27615-5088 FAX (919) 870-5359



North Carolina - Ecosystem Enhancement Program

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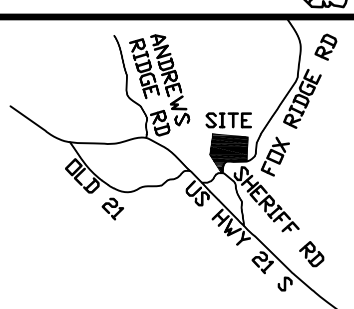
Alleghany County, North Carolina
SCO #070708801



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500 250 0 500

FIGURE 2
GLADE CREEK
AERIAL VICINITY MAP

DATE: JULY 21, 2008

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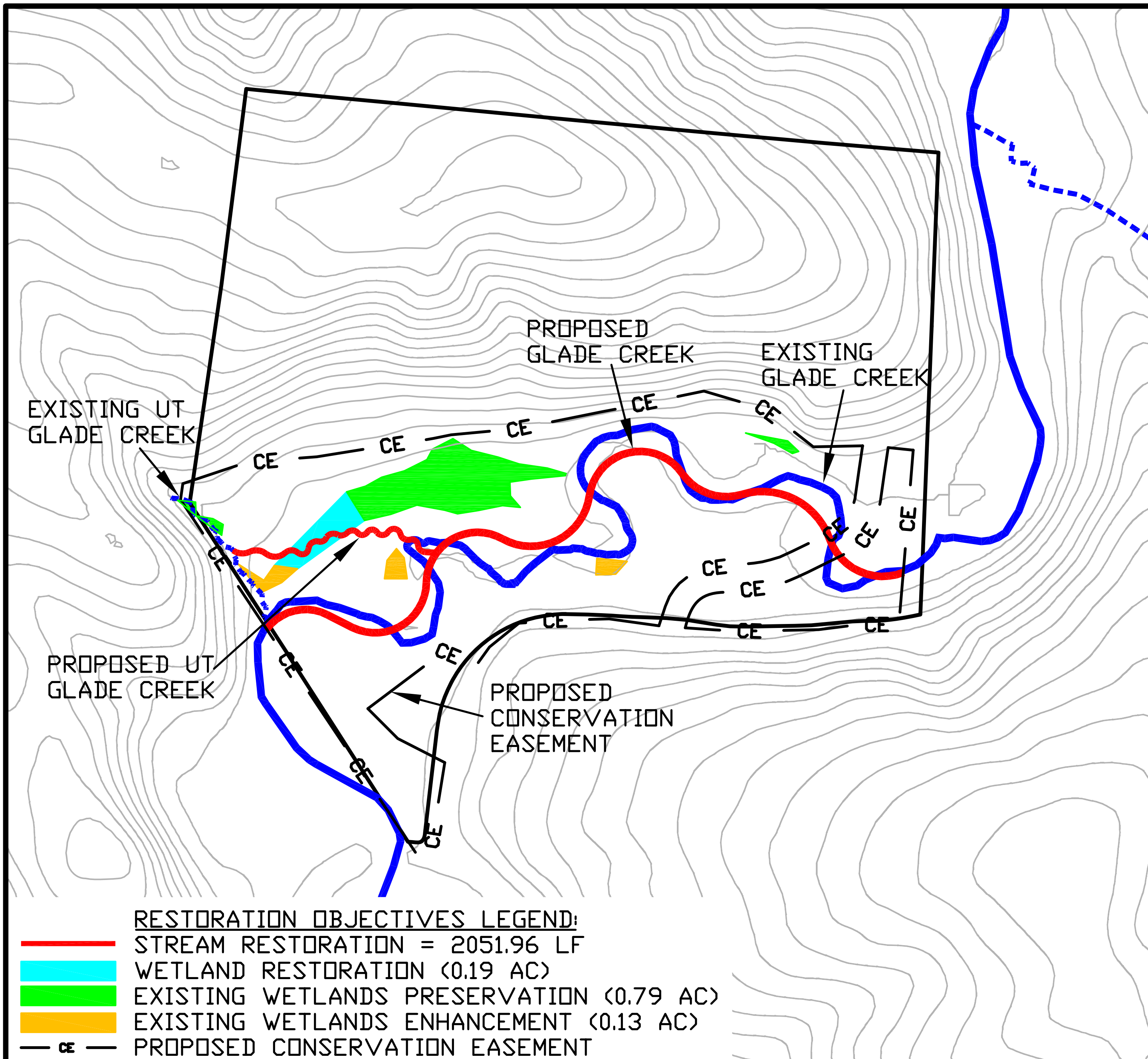
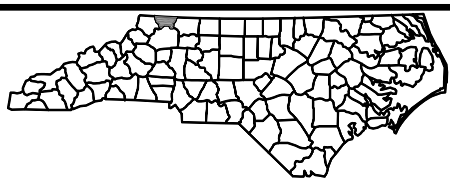
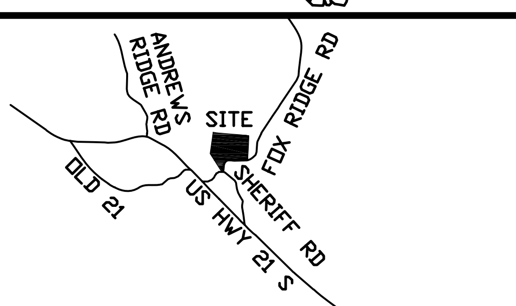
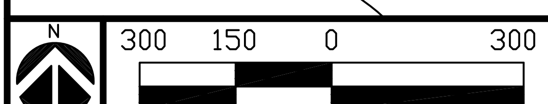
C:\Autocad Drawings\Glade-Little Pine\Glade Creek\Glade Creek Exhibits.dwg, 8/8/2008 4:59:23 PM, 1:1









Ecosystem Enhancement PROGRAM

North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

FIGURE 3
GLADE CREEK
RESTORATION OBJECTIVES

DATE: JULY 21, 2008

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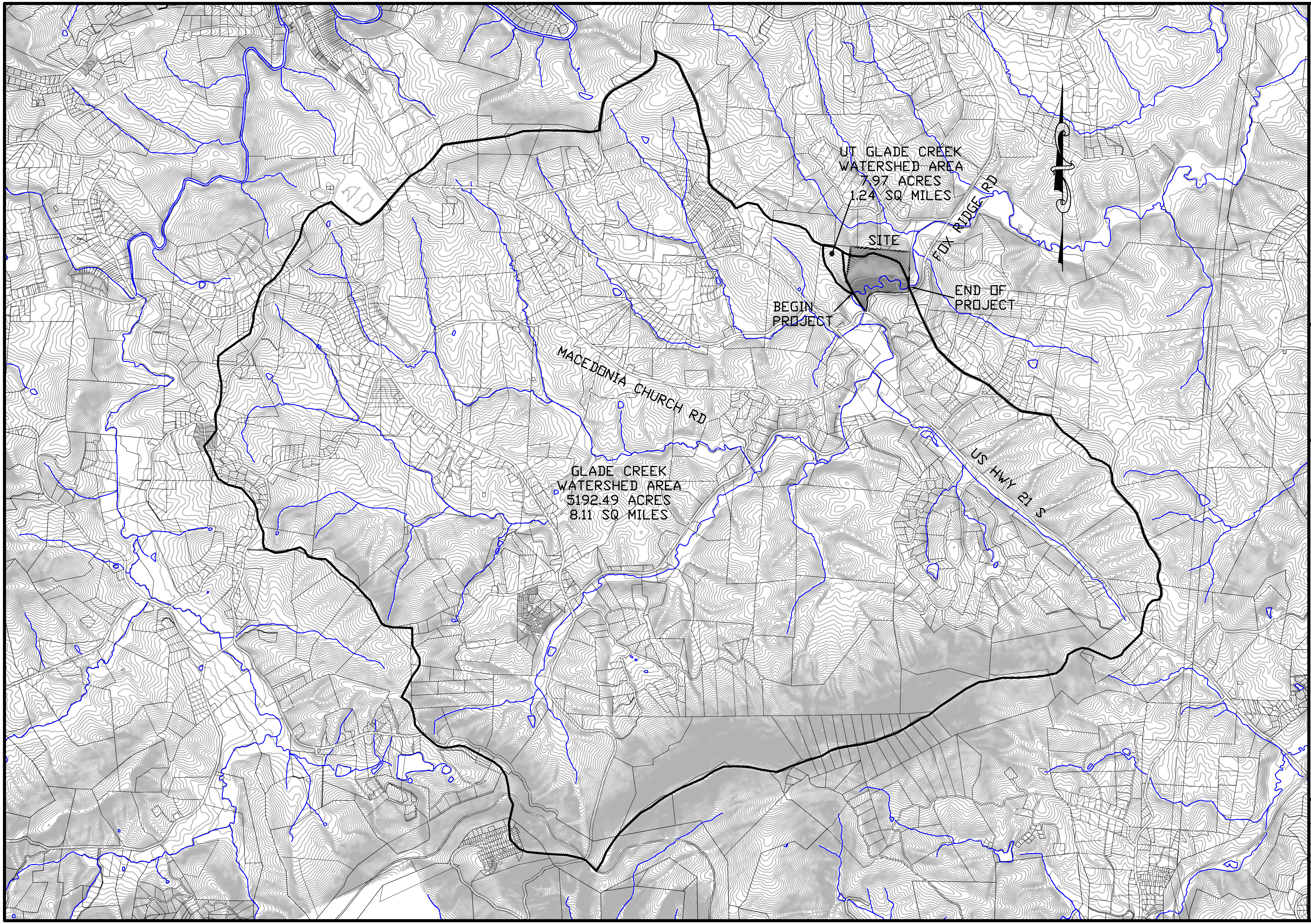

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Ecosystem Enhancement PROGRAM

GLADE CREEK WATERSHED MAP
ALLEGHANY COUNTY, NORTH CAROLINA

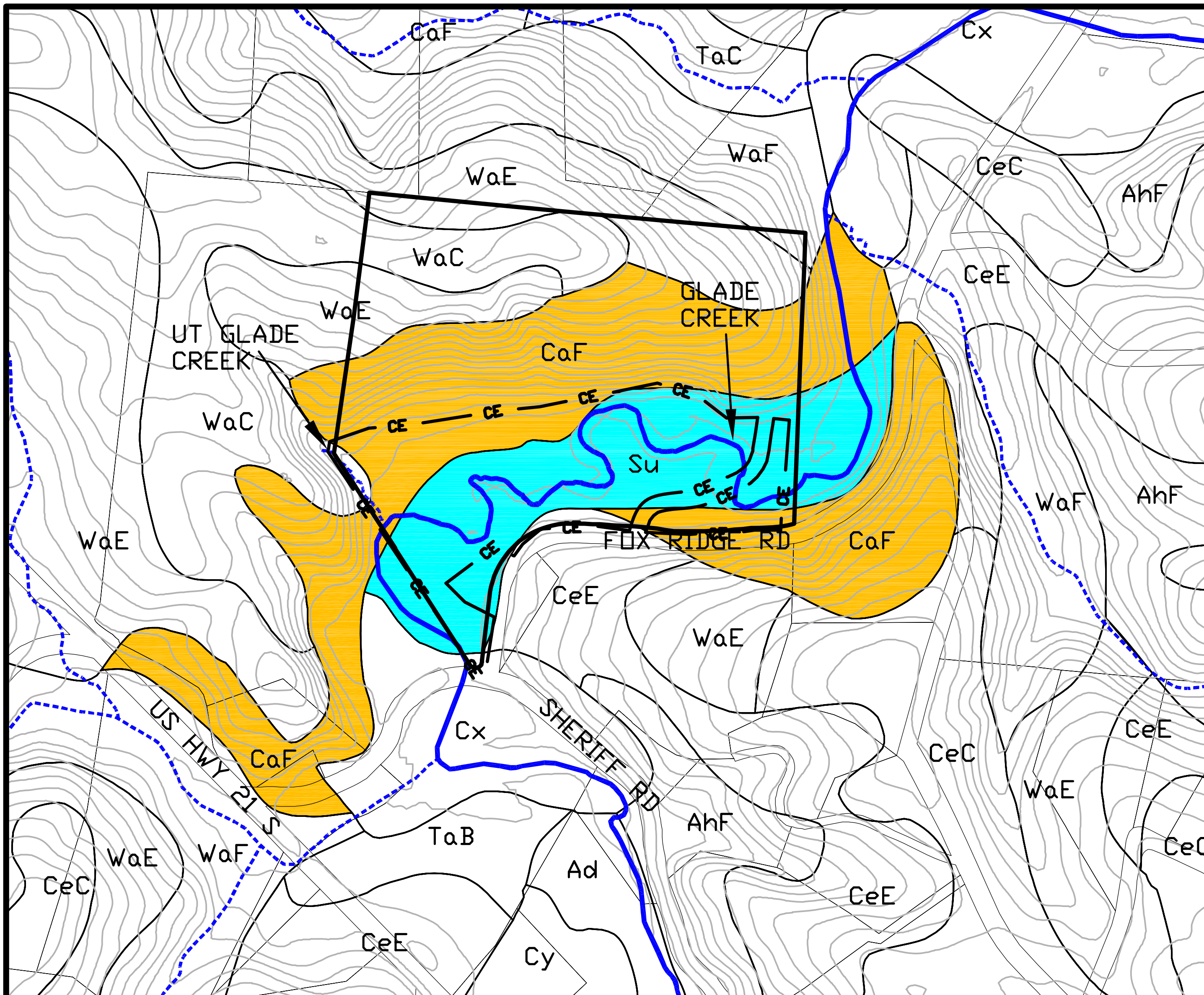
DATE: JULY 21, 2008

PROJ./DWG. NAME: Glade-Little Pine Glade Watershed

SCALE: 1"=2000'

FIGURE 4

C:\Autocad Drawings\Glade-Little Pine\Glade Creek\Glade Watershed Exhibit.dwg, 8/11/2008 10:20:46 AM, 1:1

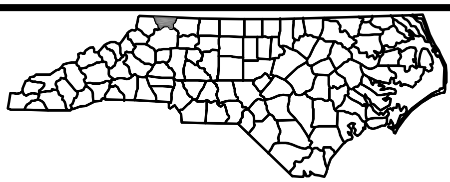


SOILS LEGEND

Su – SUNCOOK, 0 – 2% SLOPES

CaF – CHANDLER, 25 – 45% SLOPES

CE — CONSERVATION EASEMENT



Ecosystem Enhancement PROGRAM

North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

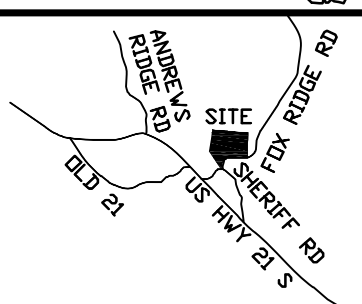


FIGURE 6
GLADE CREEK
NRCS SOIL SURVEY

DATE: JULY 21, 2008

N

500 250 0 500

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Raleigh, NC 27615-5088 FAX (919) 870-5359

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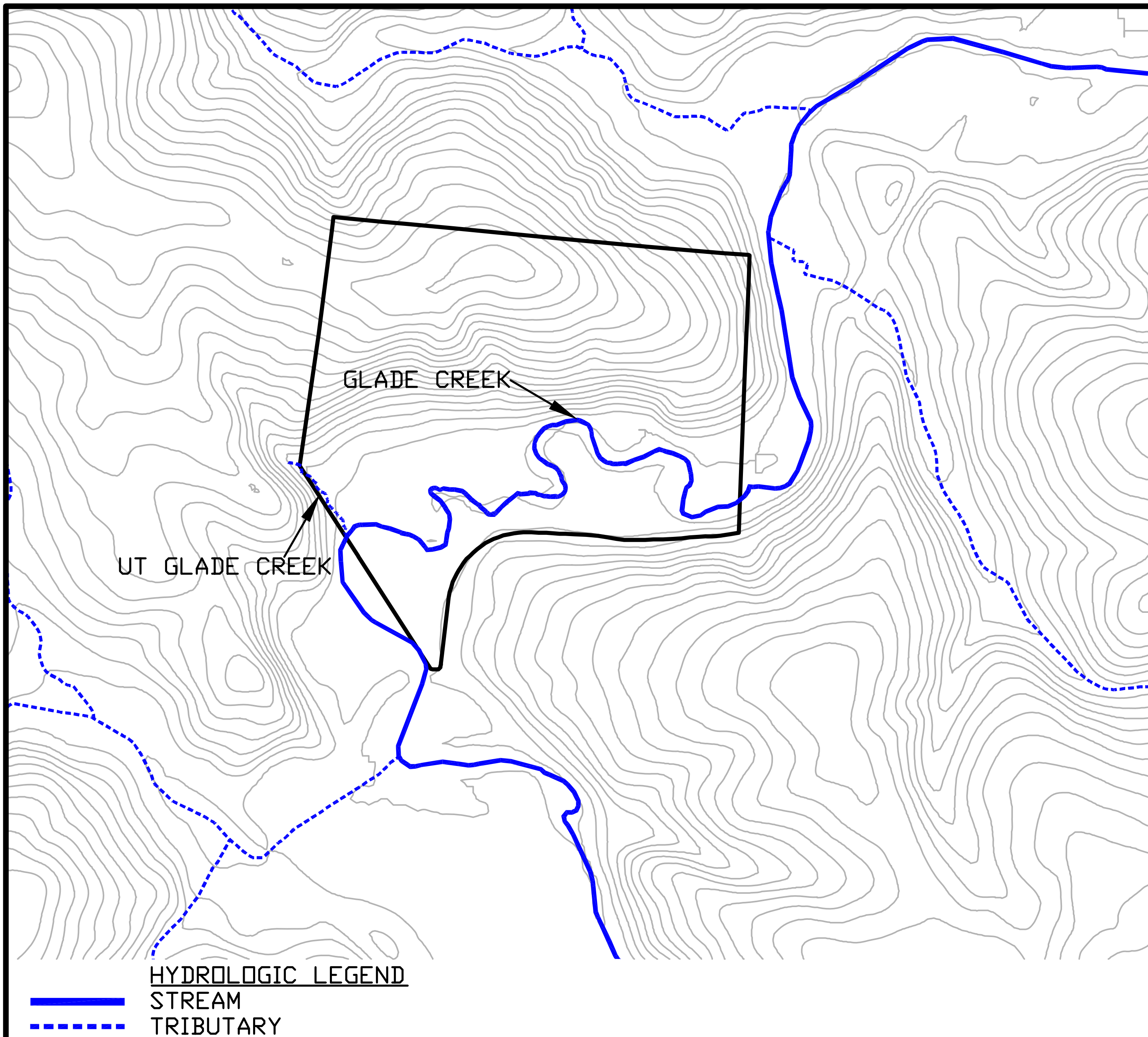
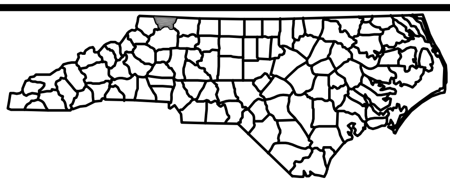




North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

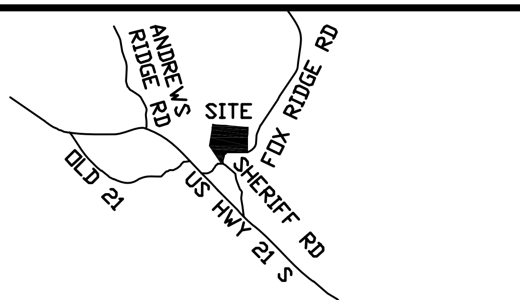
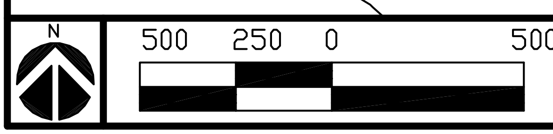


FIGURE 7
GLADE CREEK
HYDROLOGIC FEATURES

DATE: JULY 21, 2008



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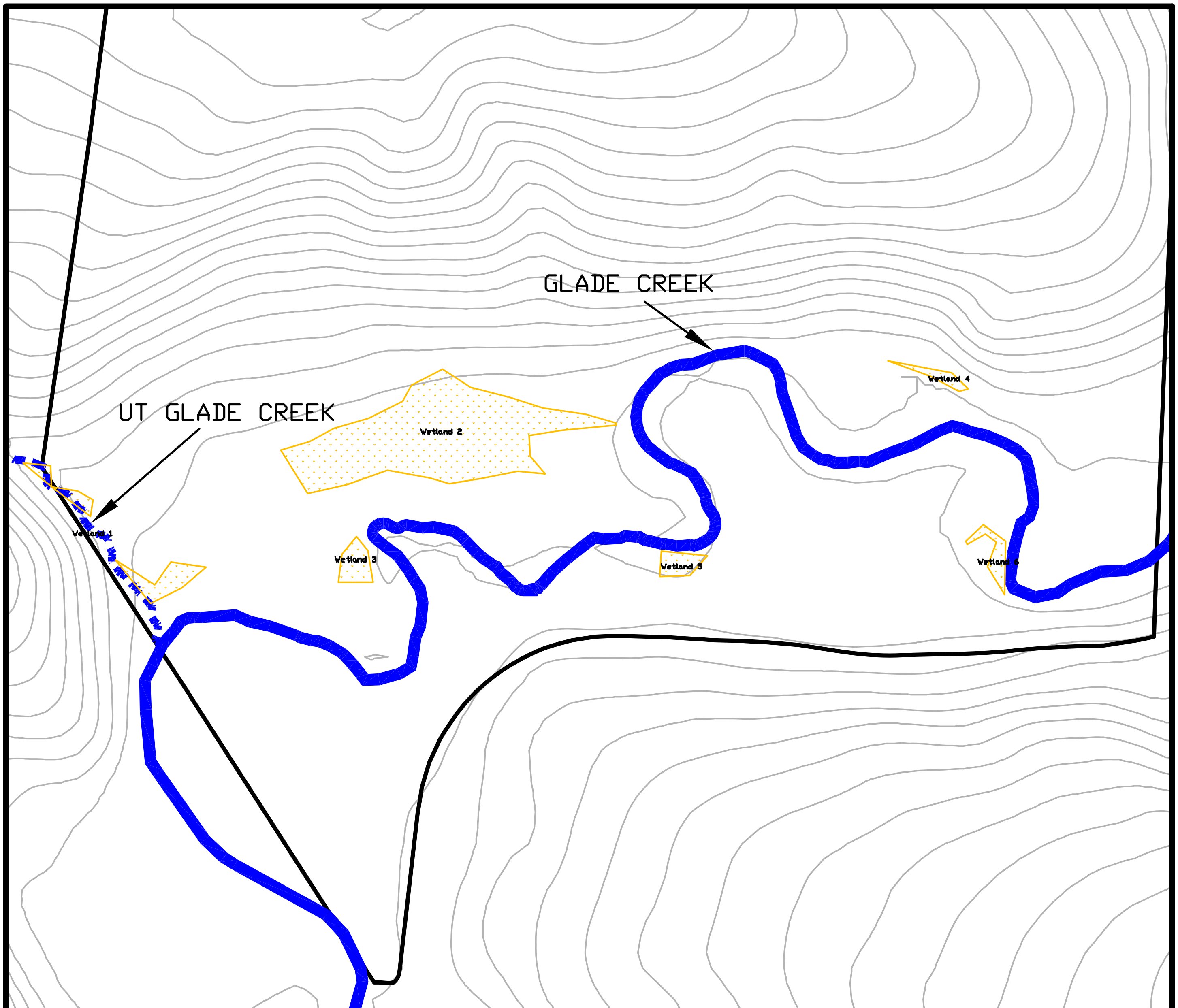
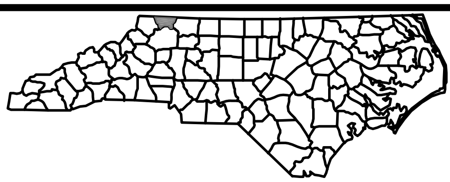


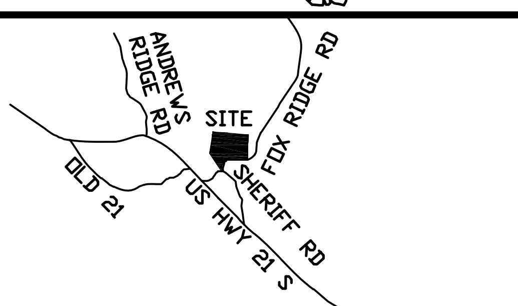
WETLAND DELINEATION LEGEND

EXISTING WETLANDS



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801



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200 100 0 200

FIGURE 8
GLADE CREEK
WETLAND DELINEATION

DATE: JULY 21, 2008

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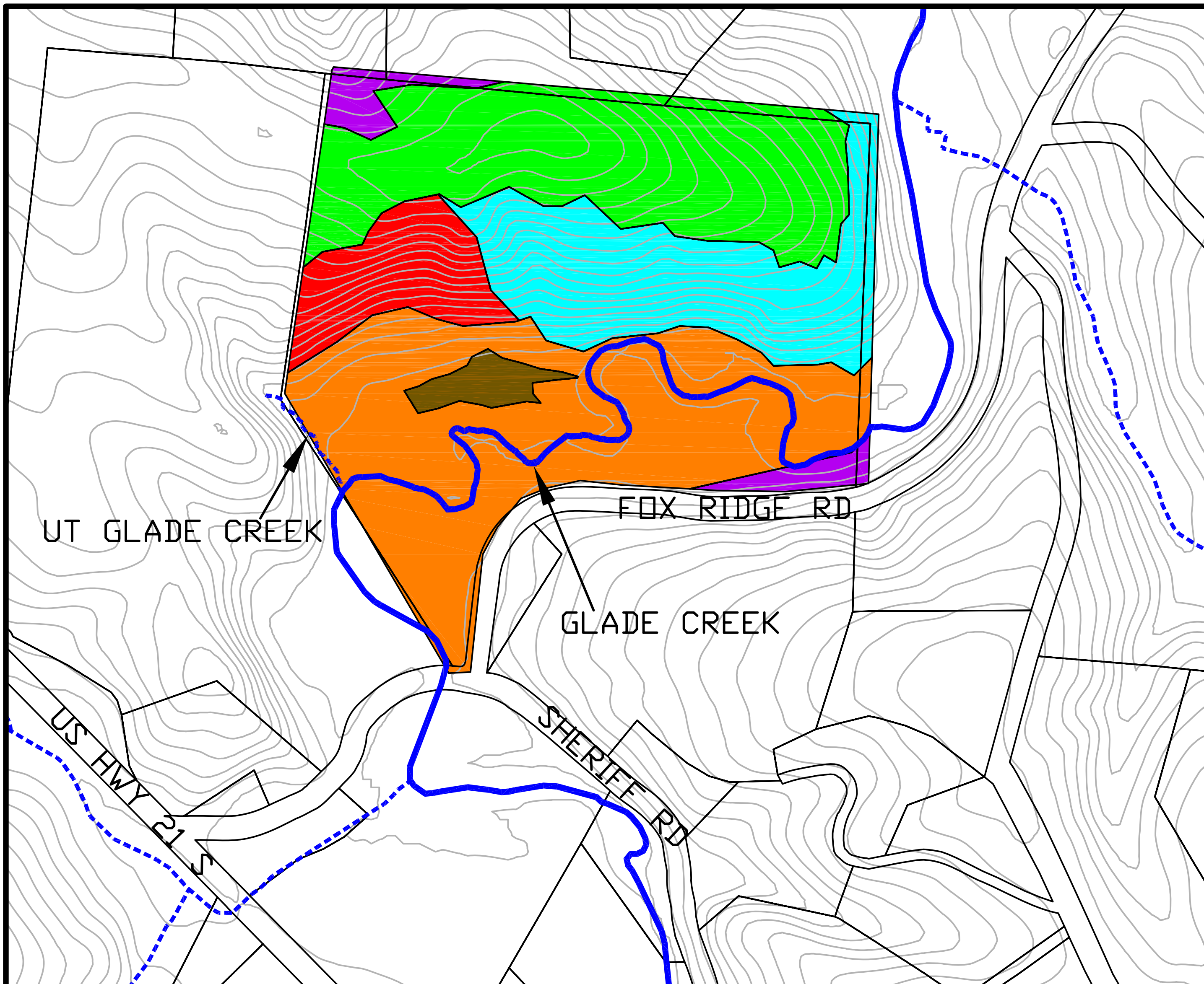
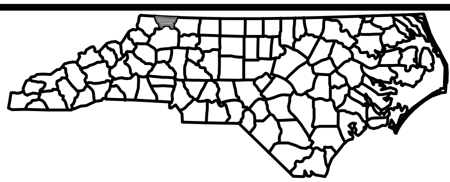


VEGETATIVE COMMUNITIES LEGEND

- WHITE PINE PLANTATION
- FLOODPLAIN POOL
- CHESTNUT OAK FOREST
- FALLOW FIELD
- DISTURBED/CUTOVER COMMUNITY
- MONTANE ALLUVIAL FOREST



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

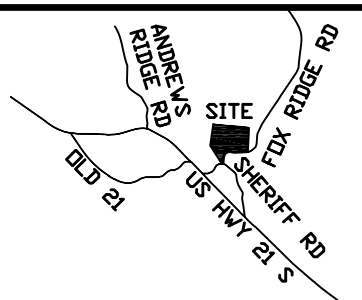


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FIGURE 9
GLADE CREEK
VEGETATIVE COMMUNITIES MAP

DATE: JULY 21, 2008

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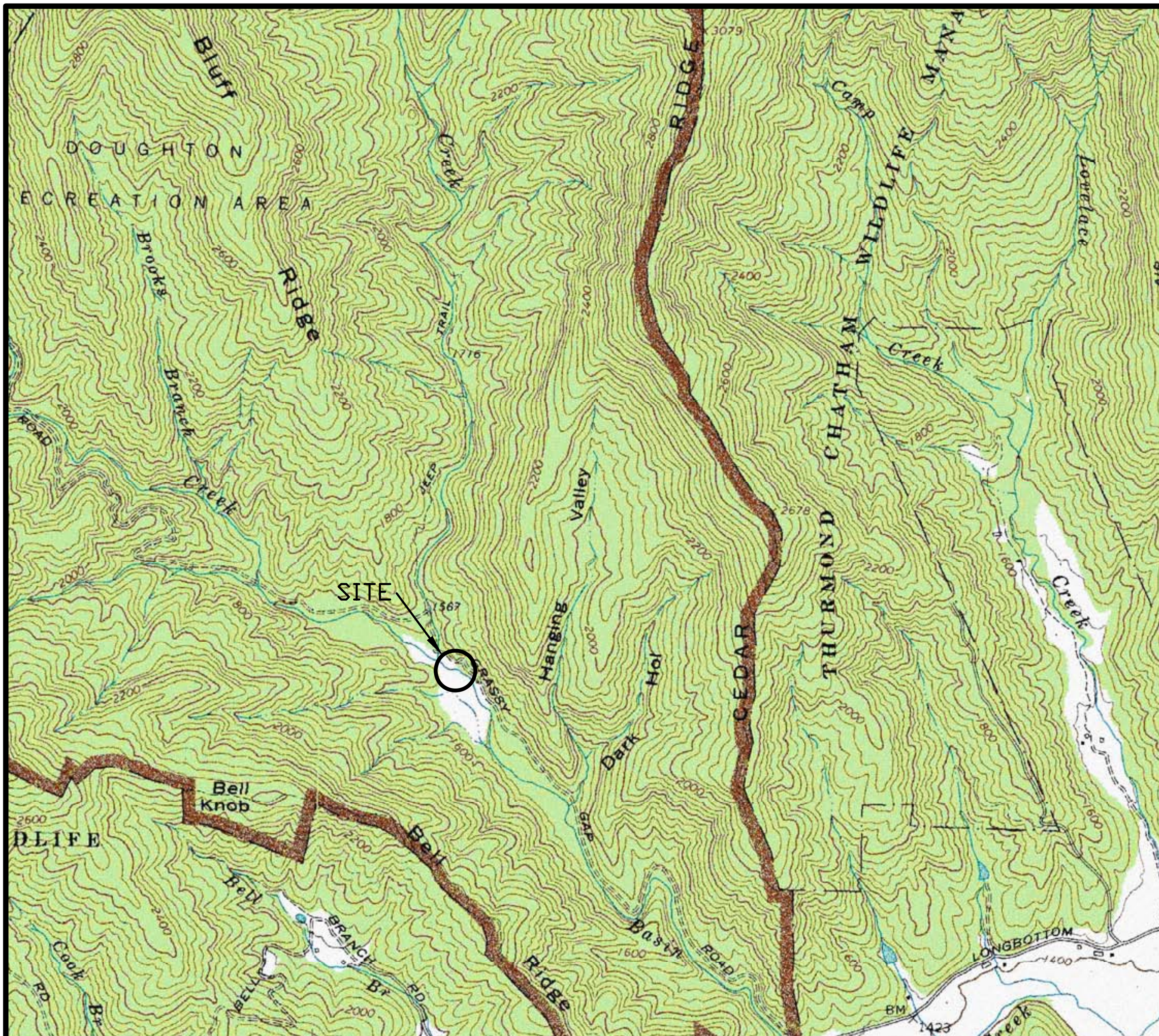
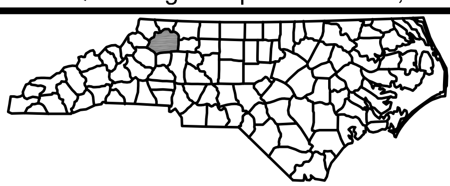


USGS Quadrangle Map Whitehead, 1998



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

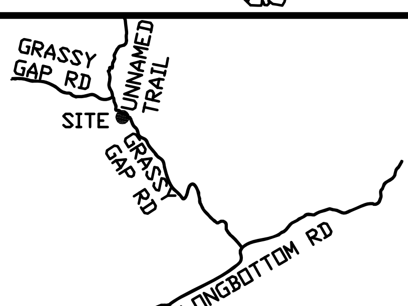
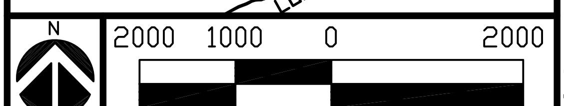


FIGURE 10
REFERENCE SITE
BASIN CREEK
VICINITY MAP

DATE: JULY 28, 2008



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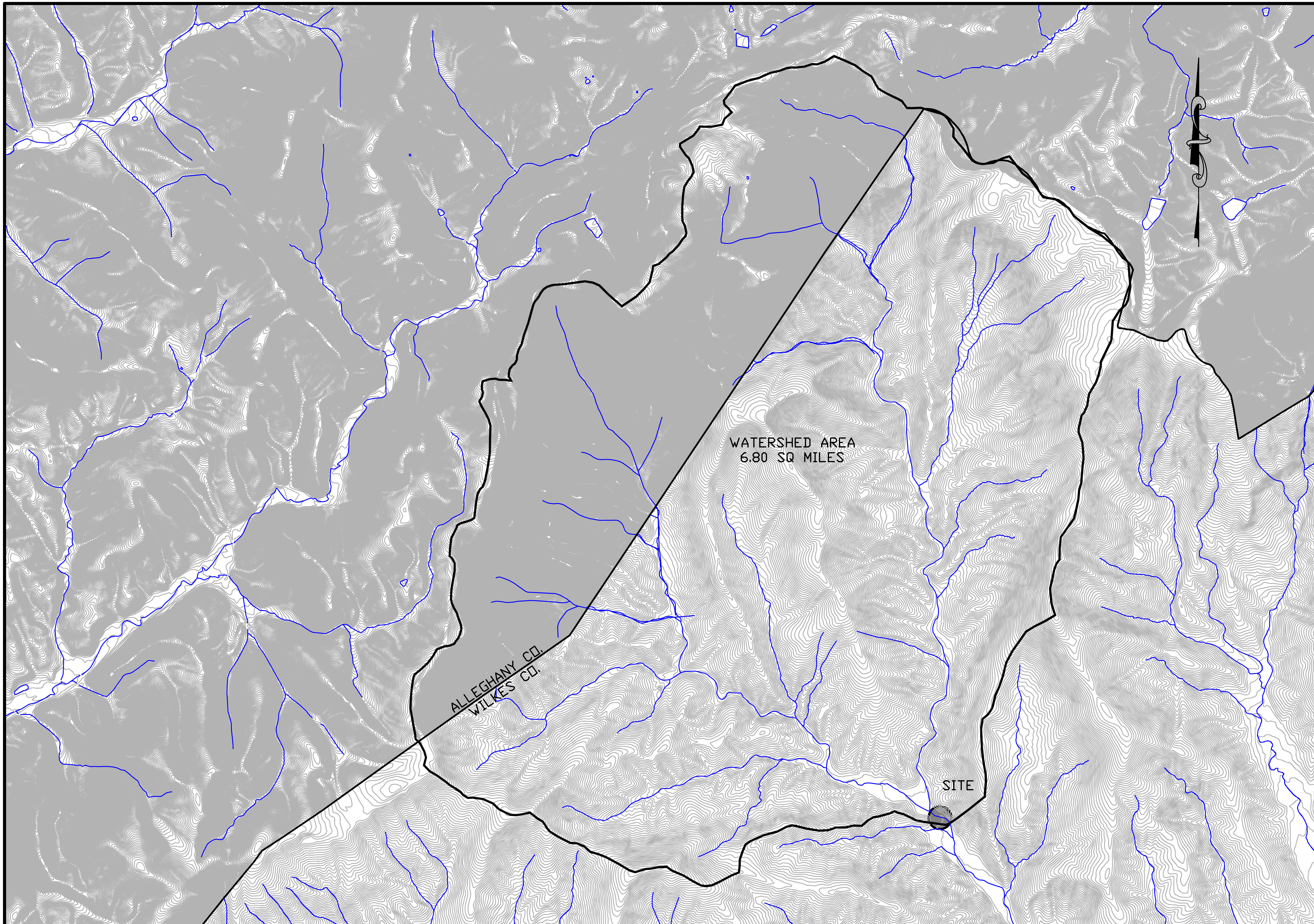

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Ecosystem Enhancement PROGRAM

BASIN CREEK
WATERSHED MAP

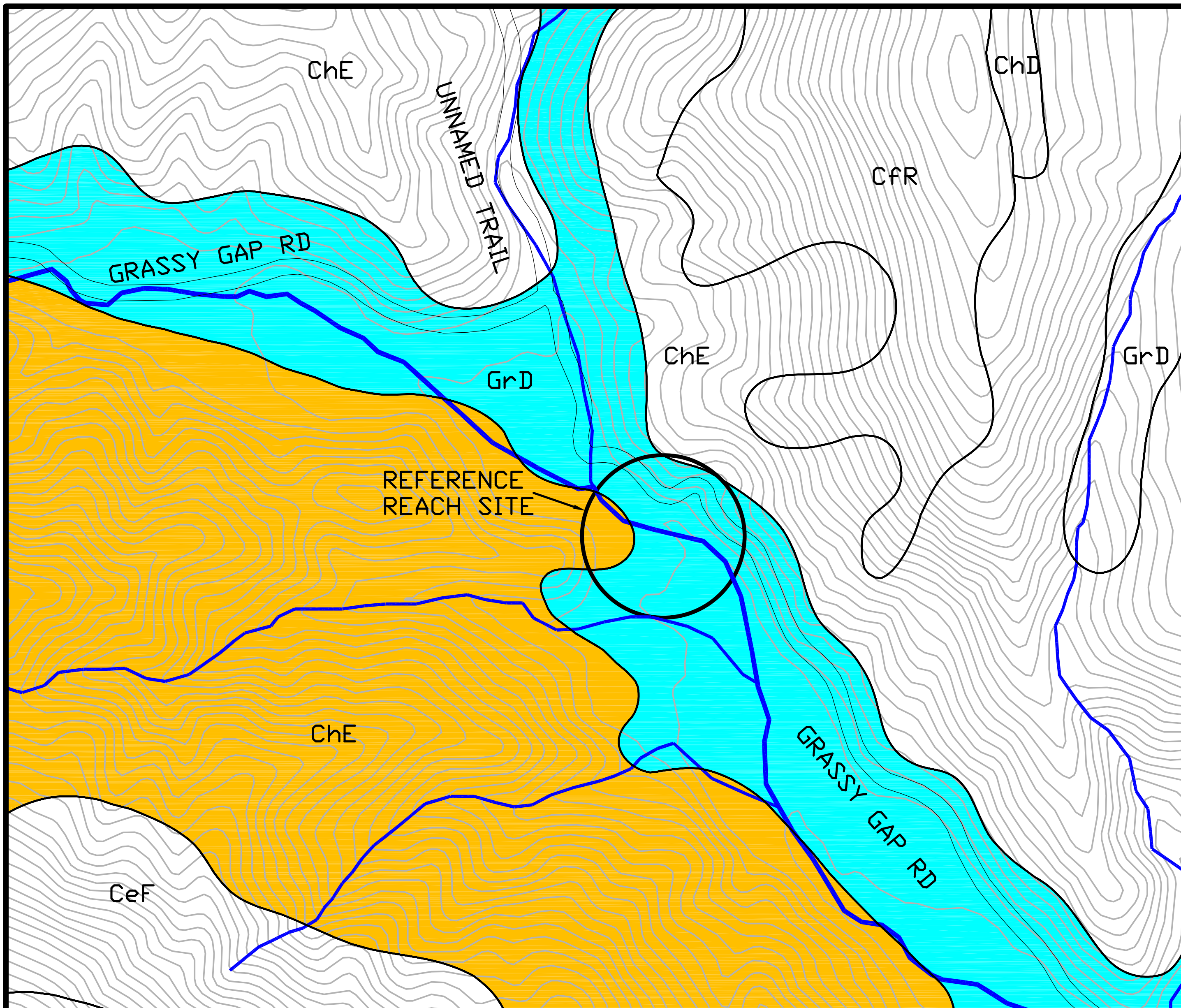
WILKES COUNTY, NORTH CAROLINA

DATE:
JULY 21, 2008

PROJ./DWG. NAME:
Glade–Little Pine
Basin Creek Watershed

SCALE:
1"=2000'

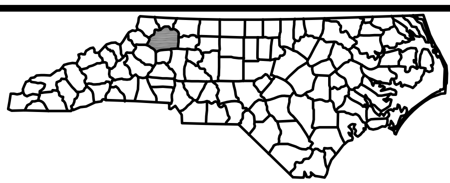
FIGURE 11



SOILS LEGEND

ChE - Chestnut-Edneyville complex, 25 to 60 percent slopes, stony

GrD - Greenlee-Ostin complex, 3 to 40 percent slopes, very stony



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

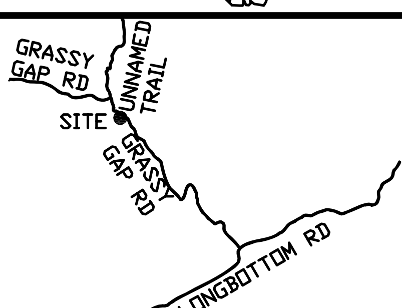


FIGURE 12
REFERENCE SITE
BASIN CREEK
NRCS SOIL SURVEY

DATE: JULY 28, 2008

N

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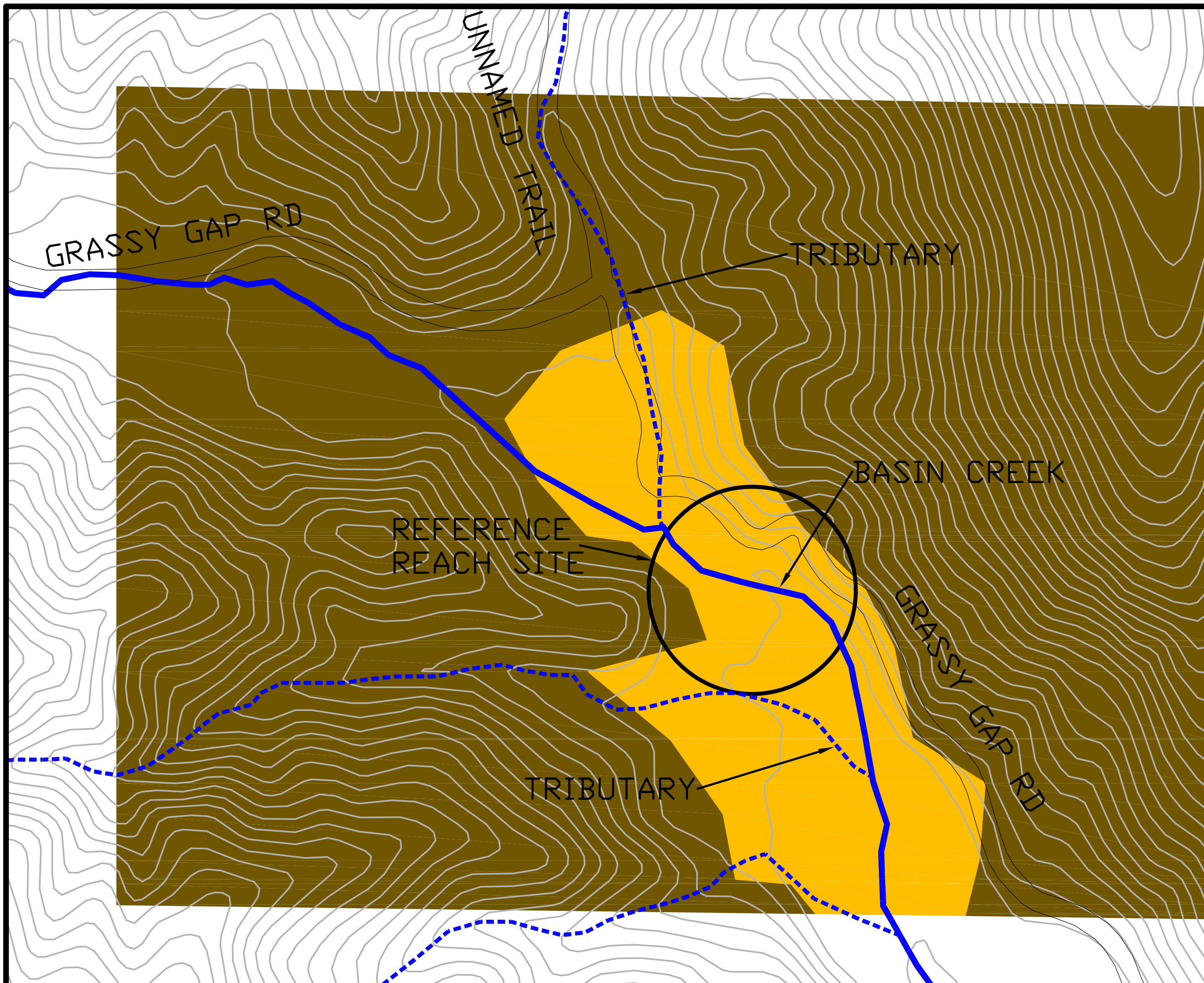
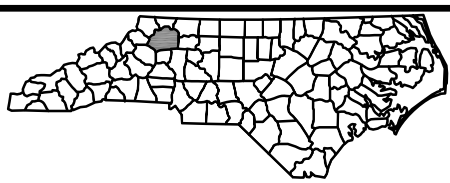


VEGETATIVE COMMUNITIES LEGEND

MONTANE ALLUVIAL FOREST

ACIDIC COVE FOREST



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

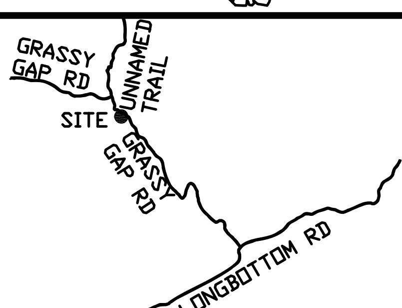


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FIGURE 13
REFERENCE SITE
BASIN CREEK
VEGETATIVE COMMUNITIES MAP

DATE: JULY 28, 2008

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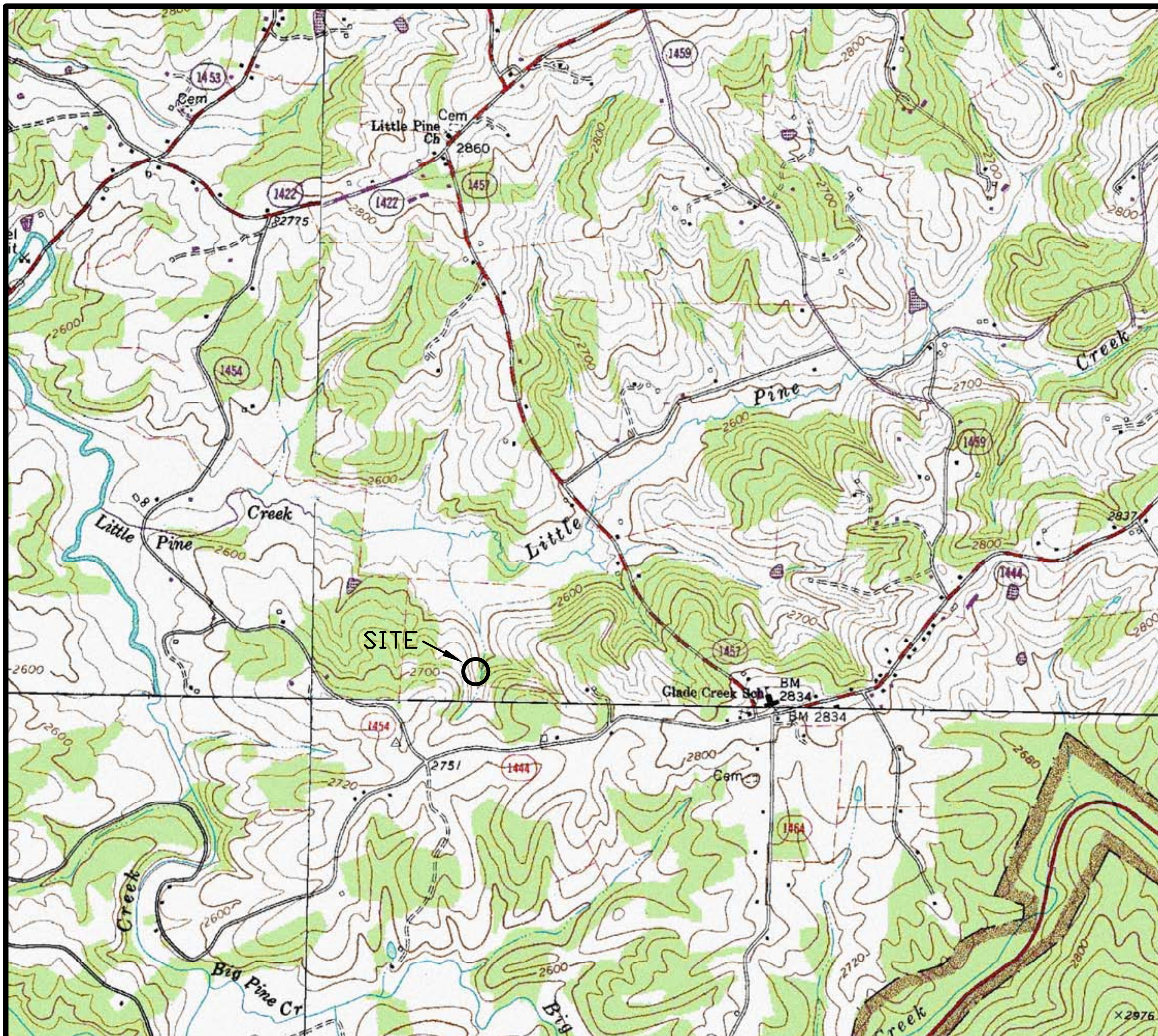
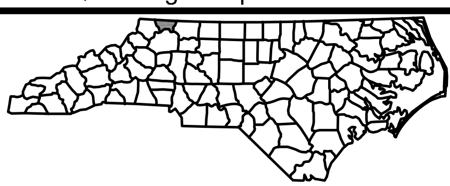


USGS Quadrangle Map Cumberland Know, 1981



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

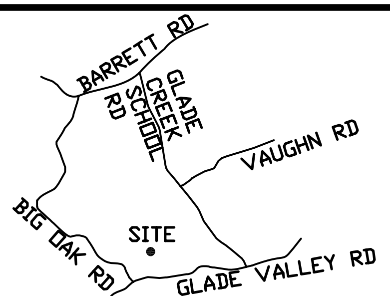


FIGURE 14
REFERENCE SITE
UT TO LITTLE PINE CREEK
VICINITY MAP

DATE: JULY 21, 2008

N

2000 1000 0 2000

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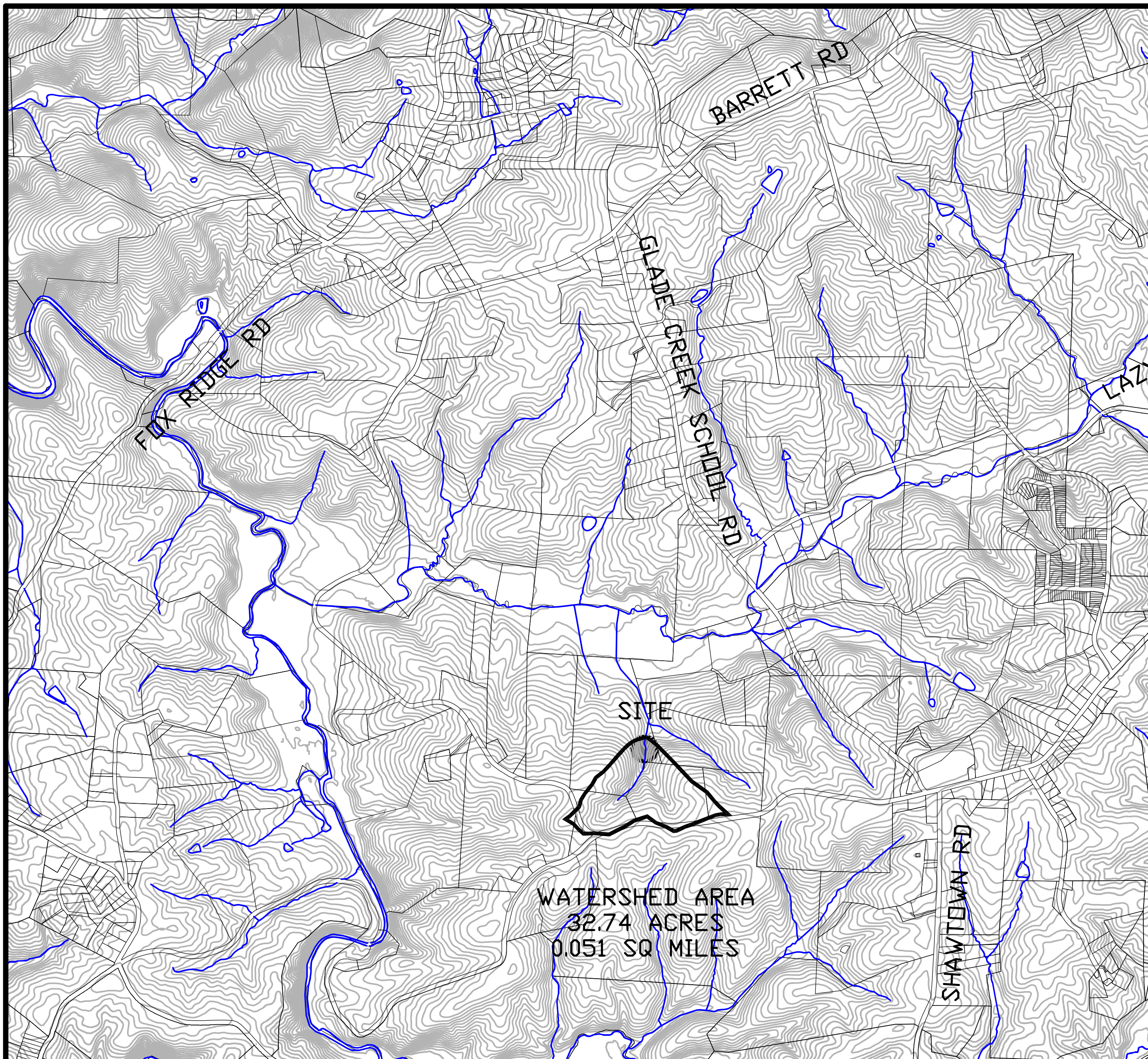

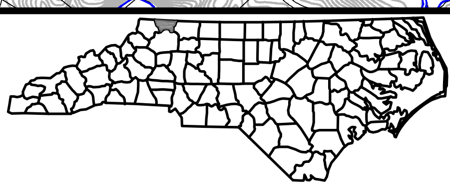

North Carolina - Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

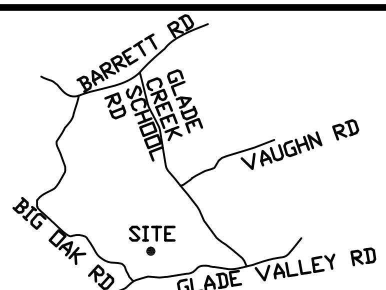

FIGURE 15
REFERENCE SITE
UT TO LITTLE PINE CREEK
WATERSHED MAP

DATE: JULY 21, 2008

N

500 250 0 500

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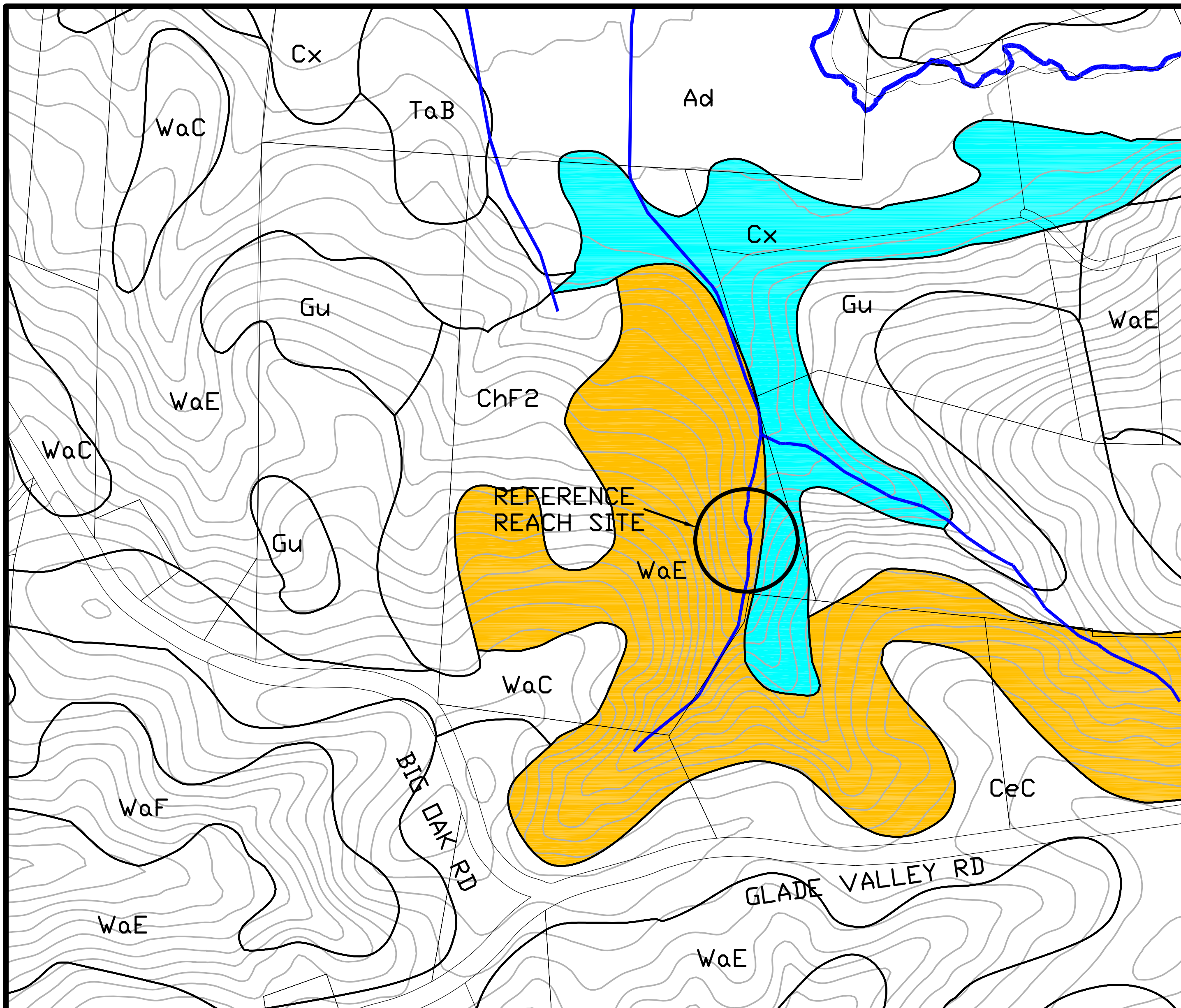
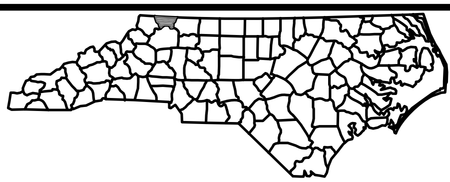


SOILS LEGEND

WaE - WATAUGA, 10 - 25% SLOPES
Cx - CODORUS, 0 - 2% SLOPES
WaC - WATAUGA, 6 - 10% SLOPES
CeC - CHESTER, 6 - 10% SLOPES



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

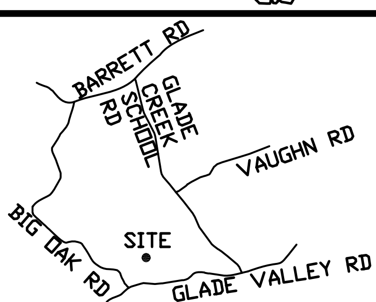


FIGURE 16
REFERENCE SITE
UT TO LITTLE PINE CREEK
NRCS SOIL SURVEY

DATE: JULY 21, 2008

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500 250 0 500

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Raleigh, NC 27615-5088 FAX (919) 870-5359

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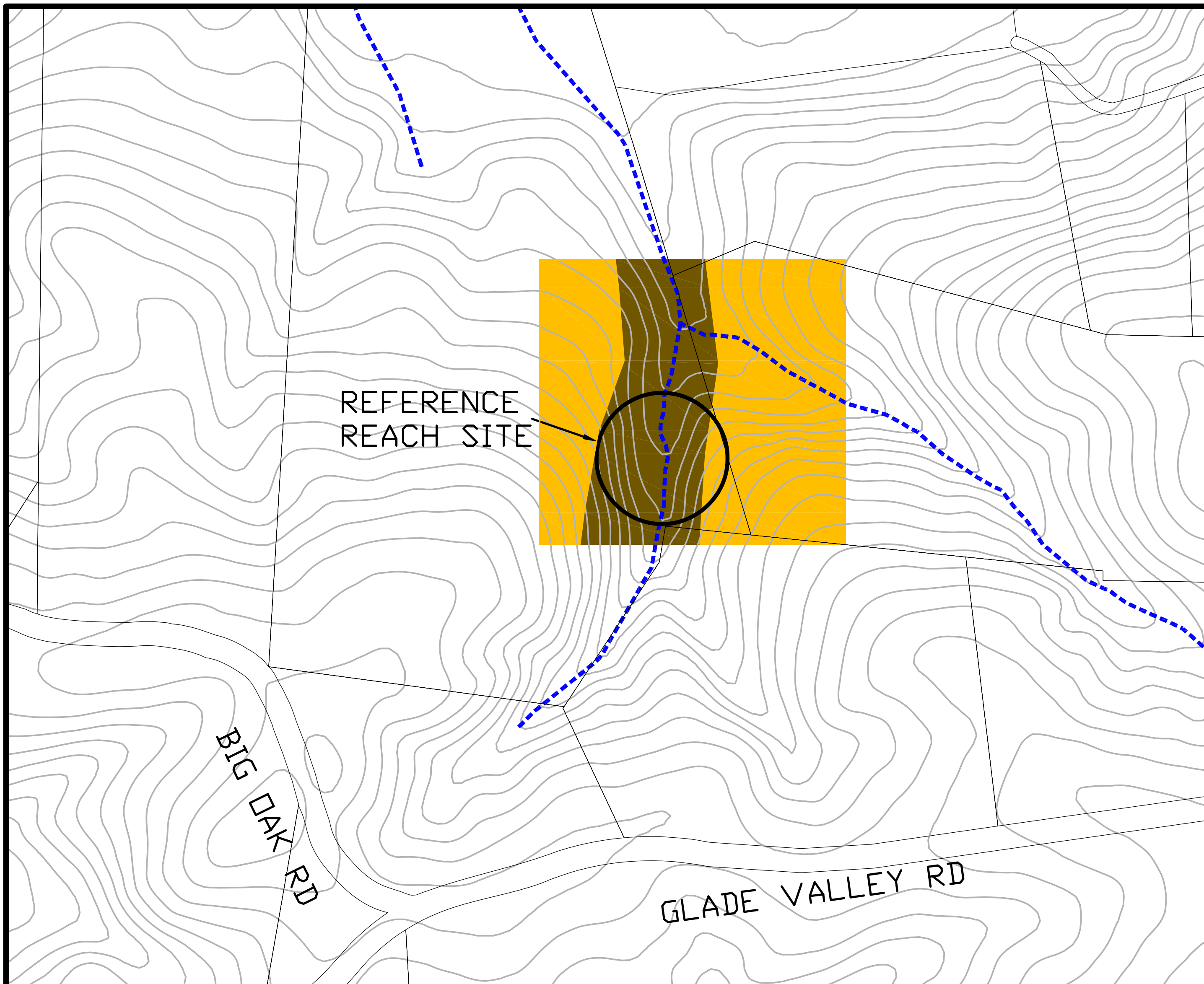
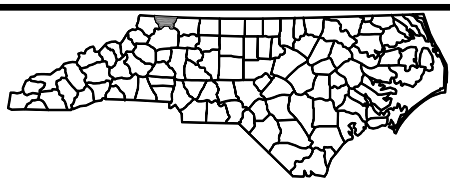


VEGETATIVE COMMUNITIES LEGEND

MESIC MIXED HARDWOOD FOREST

ACIDIC COVE FOREST



North Carolina - Ecosystem Enhancement Program

Ecosystem Enhancement PROGRAM

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

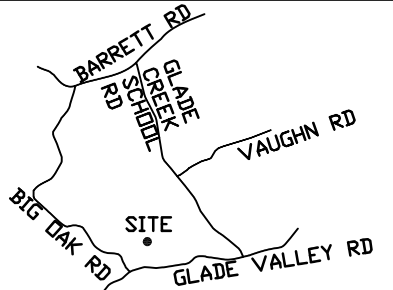


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FIGURE 17
REFERENCE SITE
UT TO LITTLE PINE CREEK
VEGETATIVE COMMUNITIES MAP

DATE: JULY 21, 2008

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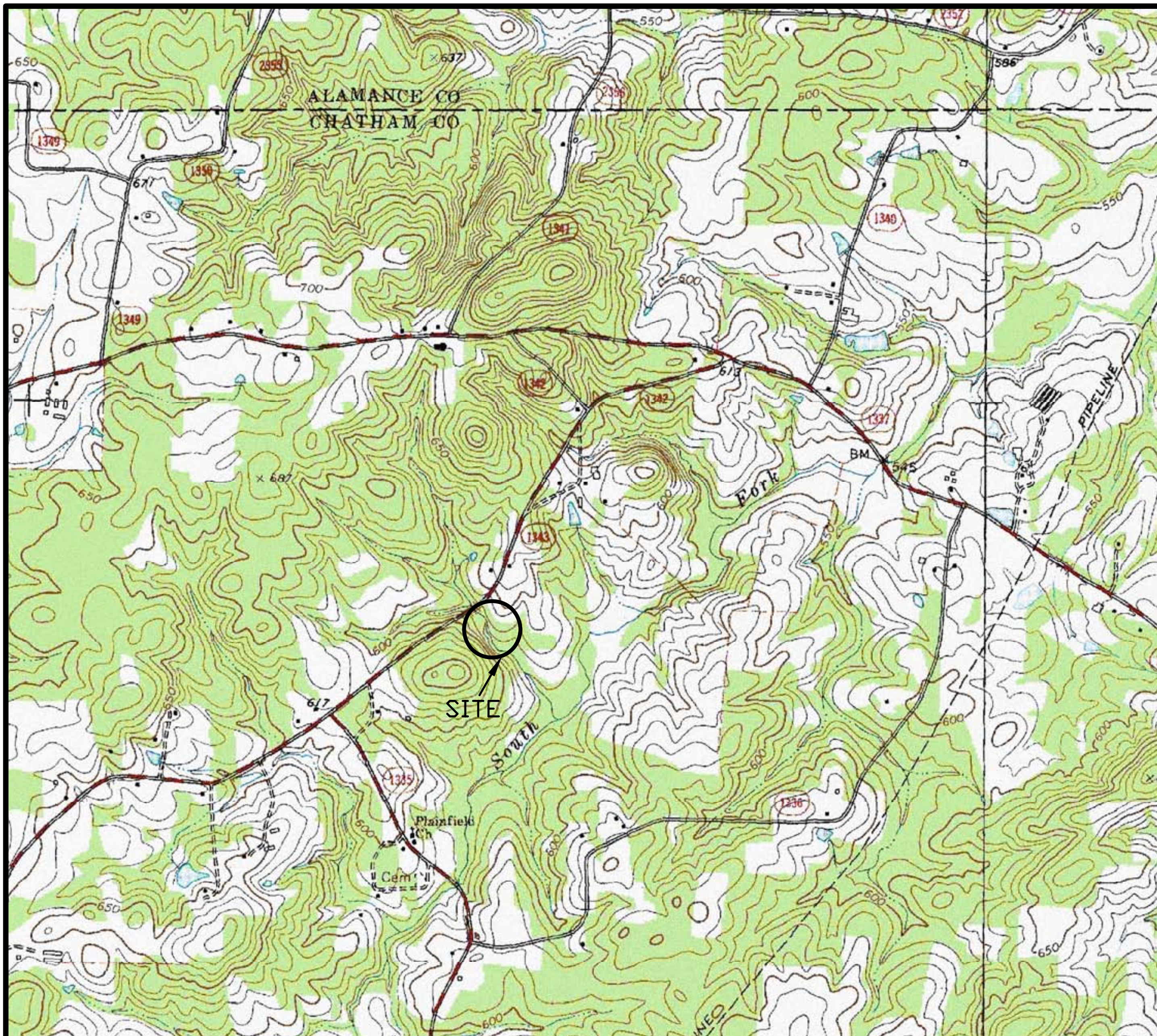
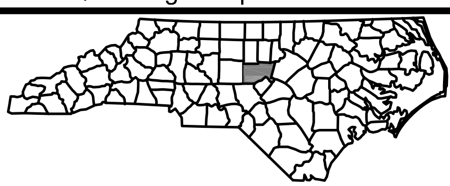
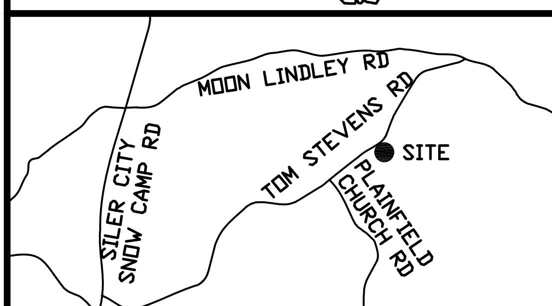


USGS Quadrangle Map   Crutchfield Crossroads, 1974



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801



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2000 1000 0 2000

FIGURE 18
REFERENCE SITE
UT SOUTH FORK CANE CREEK
VICINITY MAP

DATE: JULY 21, 2008

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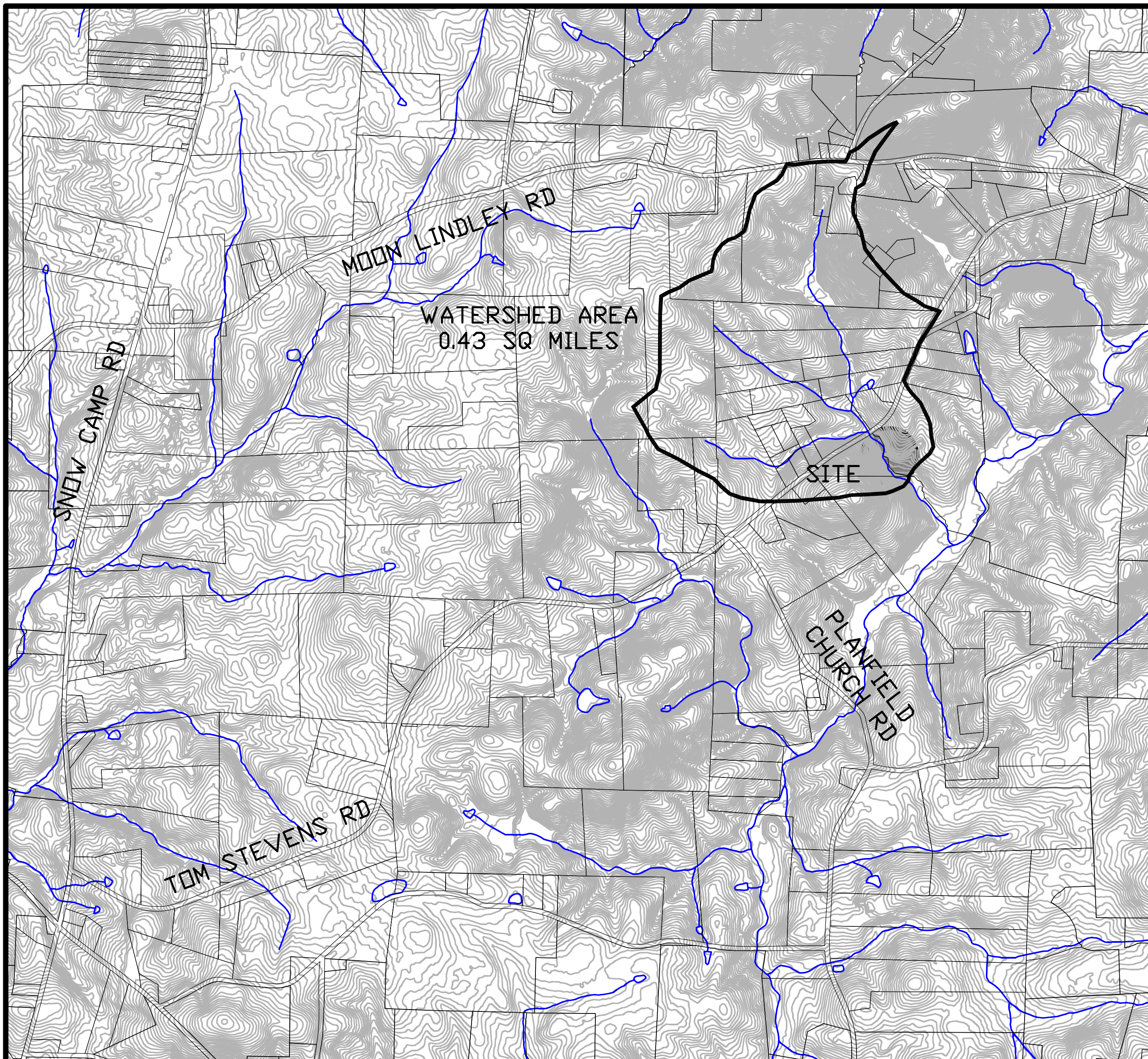
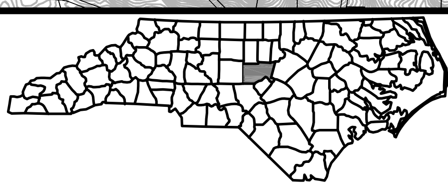
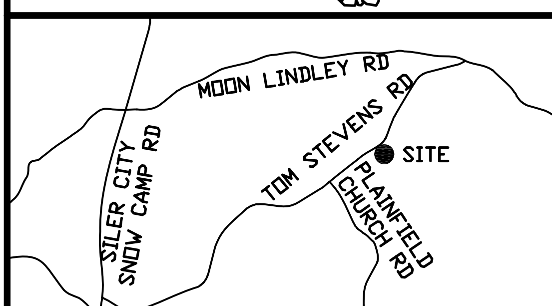
Raleigh, NC 27615-5088   FAX (919) 870-5359





North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801



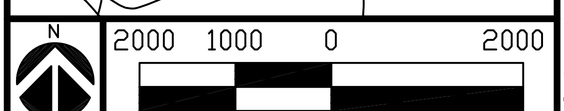


FIGURE 19
REFERENCE SITE
UT SOUTH FORK CANE CREEK
WATERSHED MAP

DATE: JULY 21, 2008

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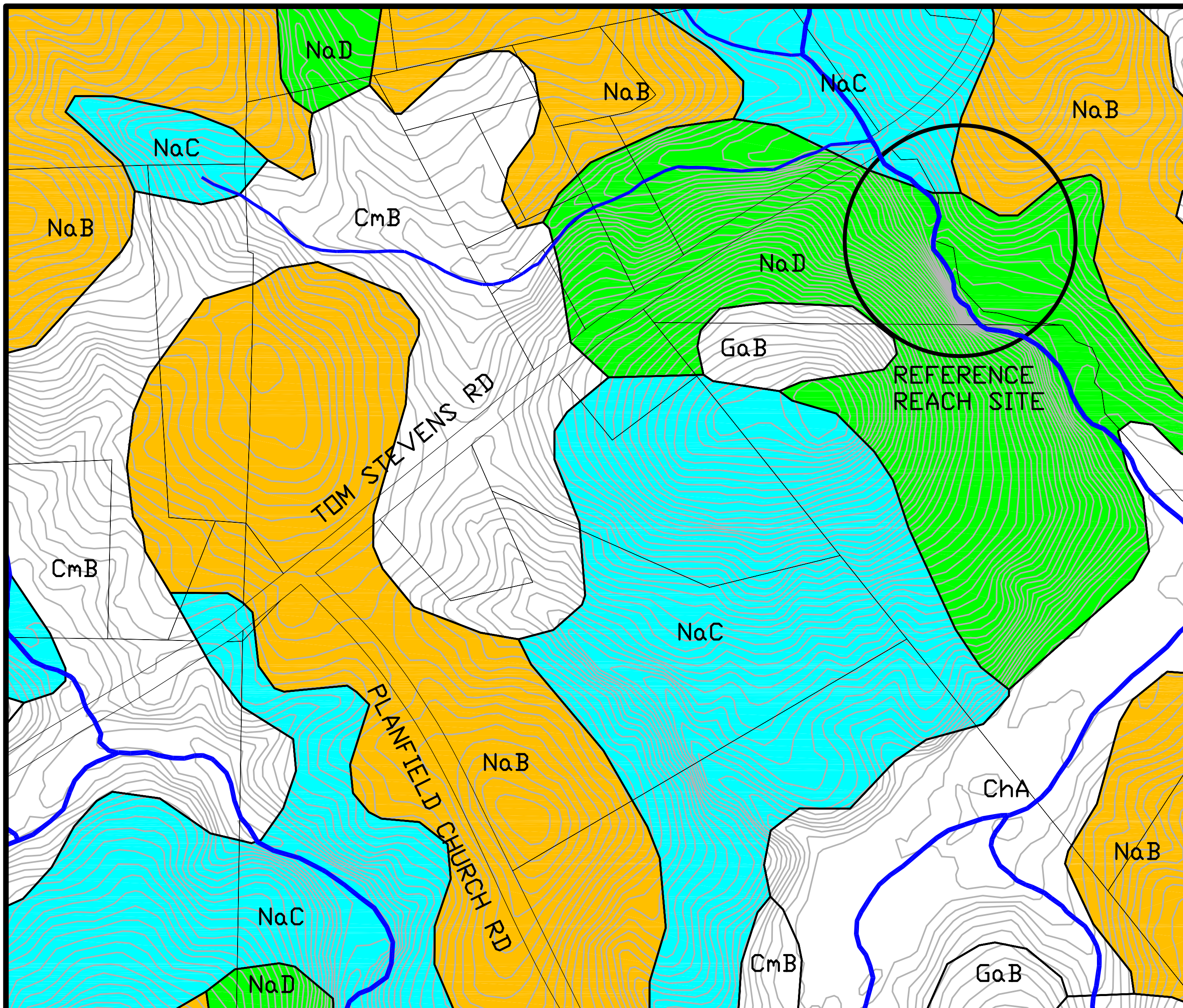
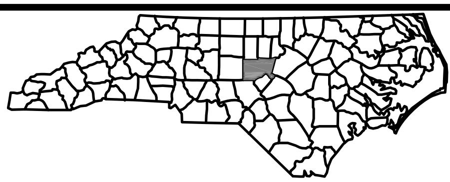


SOILS LEGEND

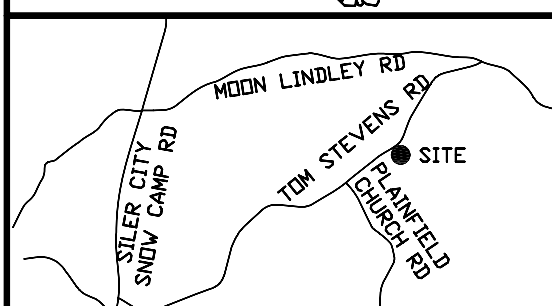
NaB - NADFORD-BADIN COMPLEX, 2 - 6% SLOPES

NaC - NADFORD-BADIN COMPLEX, 6 - 10% SLOPES



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801



N

500 250 0 500

FIGURE 20
REFERENCE SITE
UT SOUTH FORK CANE CREEK
NRCS SOIL SURVEY

DATE: JULY 21, 2008

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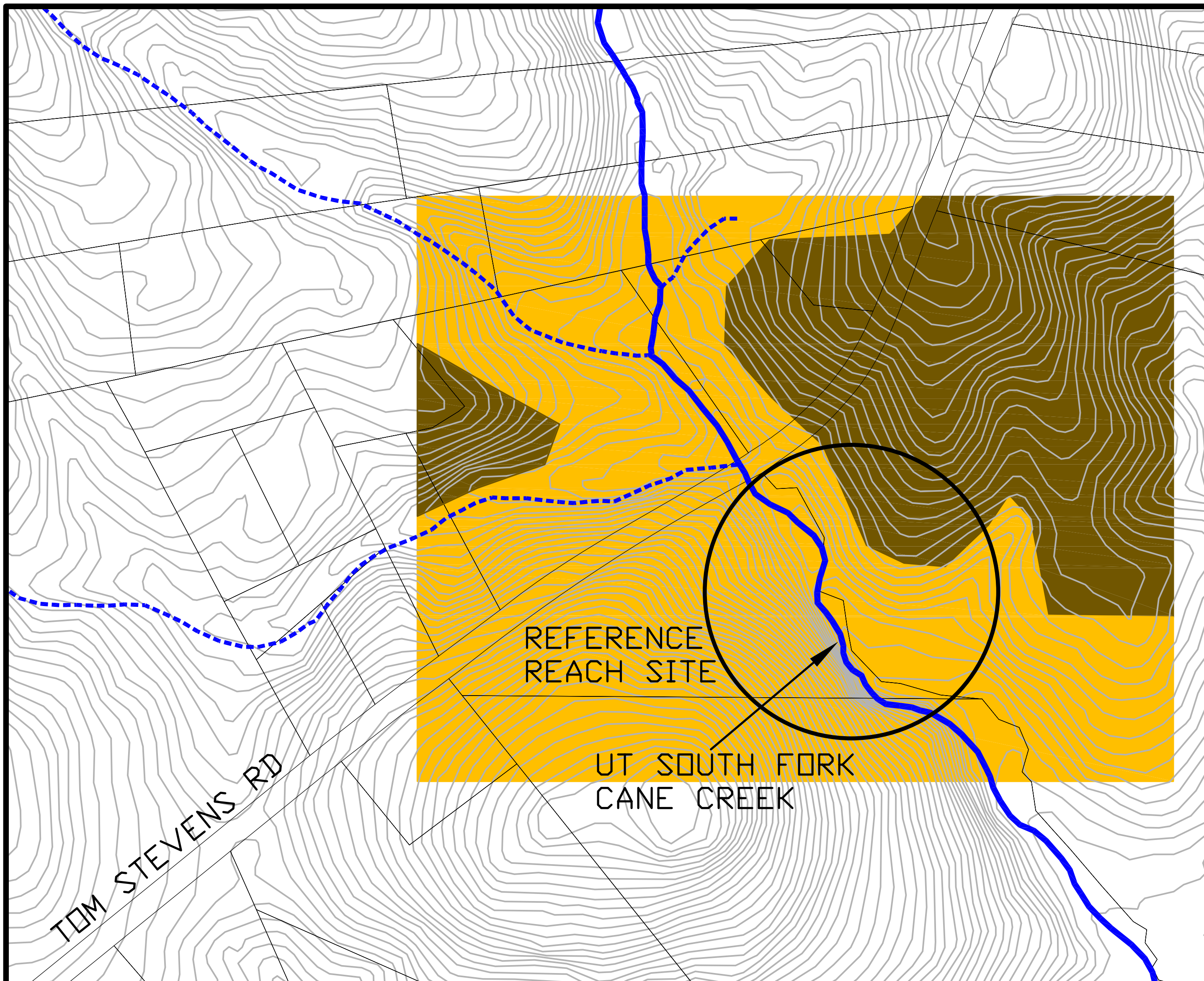
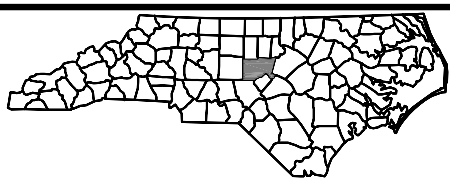


VEGETATIVE COMMUNITIES LEGEND

MEXIC MIXED HARDWOOD FOREST

FALLOW FIELD



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SCO #070708801

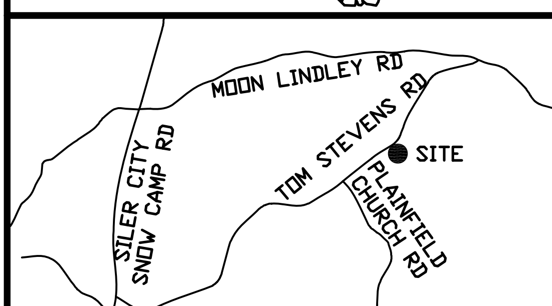
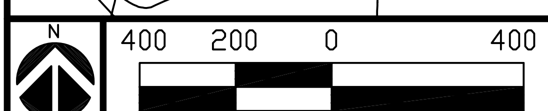


FIGURE 21
REFERENCE SITE
UT SOUTH FORK CANE CREEK
VEGETATIVE COMMUNITIES MAP

DATE: JULY 21, 2008



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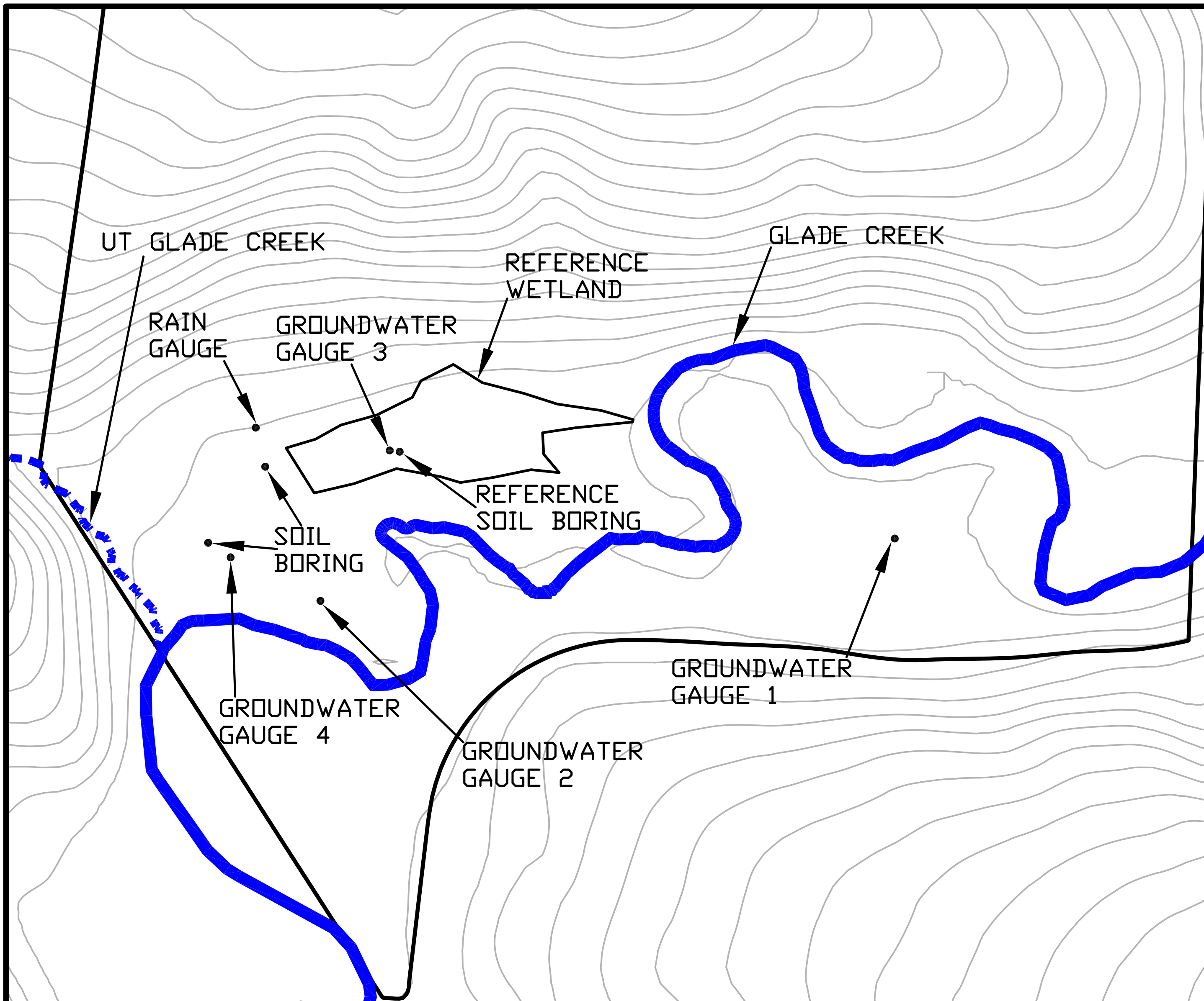
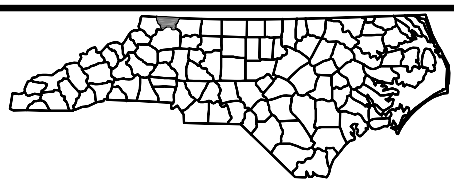


LEGEND
STREAM
TRIBUTARY
EXISTING WETLANDS



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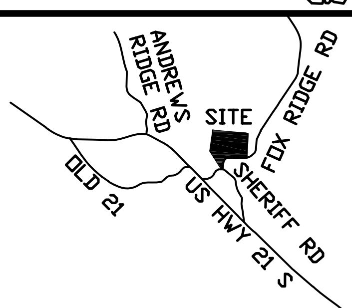
SCO #070708801



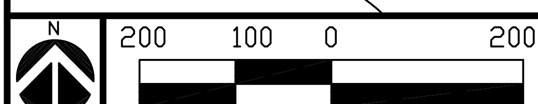


FIGURE 22
GLADE CREEK
WETLAND DETERMINATION SAMPLE LOCATIONS WITH GAUGE LOCATIONS

DATE: JULY 21, 2008

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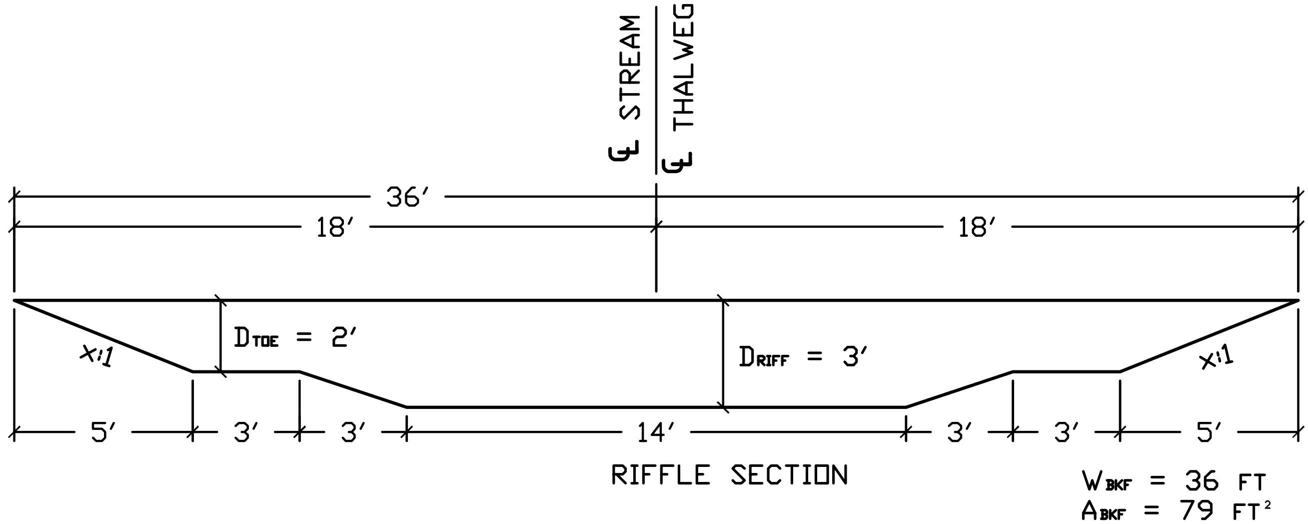
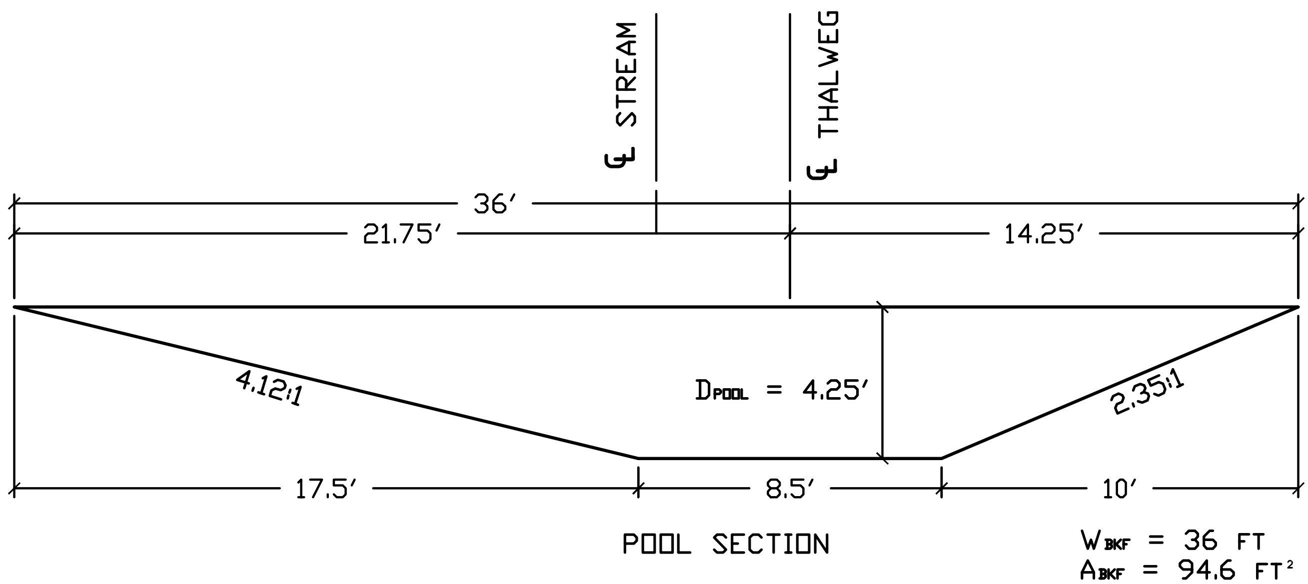
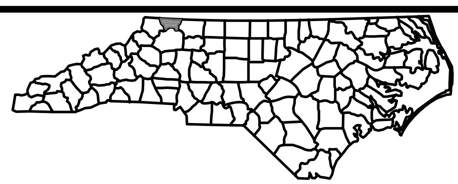


RIFFLE SECTION



POOL SECTION



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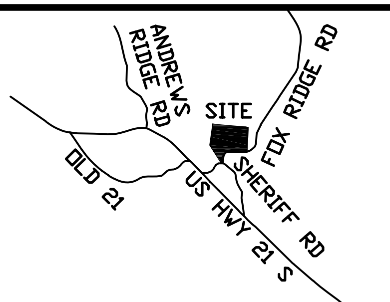
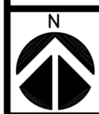
SCO #070708801





NOT TO SCALE

FIGURE 23
GLADE CREEK - UPPER
TYPICAL DESIGN CROSS SECTIONS

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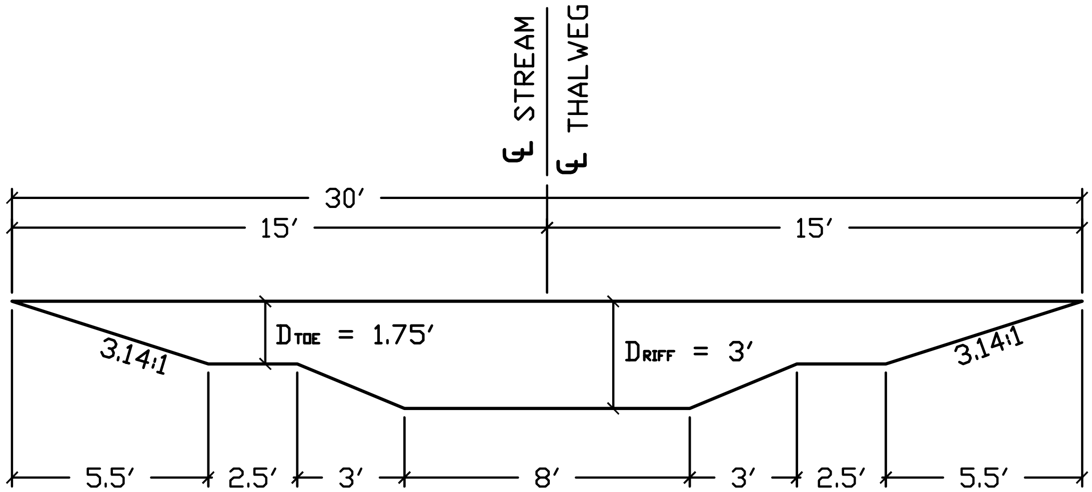
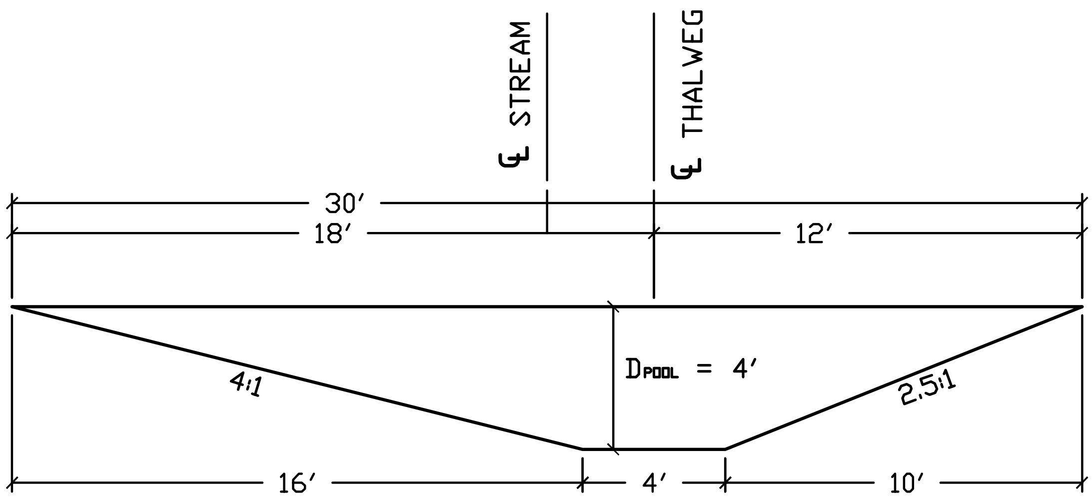


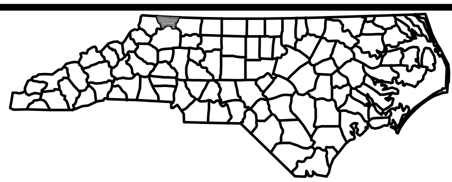
RIFFLE SECTION

W_{BKF} = 30 FT
A_{BKF} = 56.6 FT^2



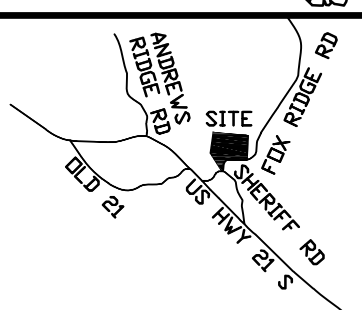
POOL SECTION

W_{BKF} = 30 FT
A_{BKF} = 68 FT^2



North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801



NOT TO SCALE

FIGURE 24
GLADE CREEK - LOWER
TYPICAL DESIGN CROSS SECTIONS

DATE: JULY 21, 2008

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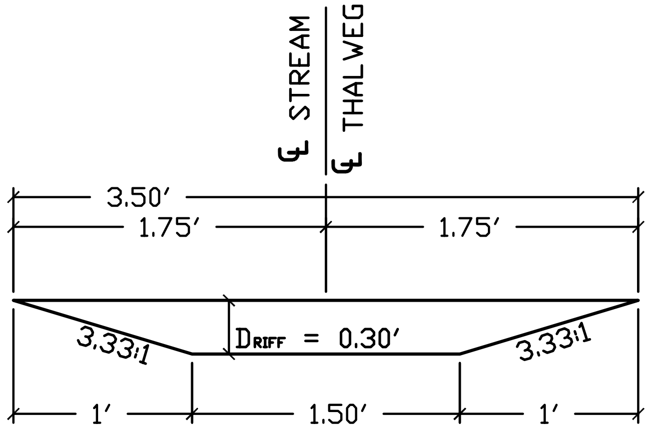
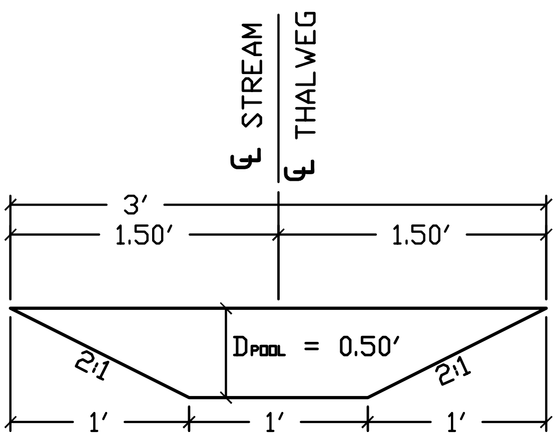


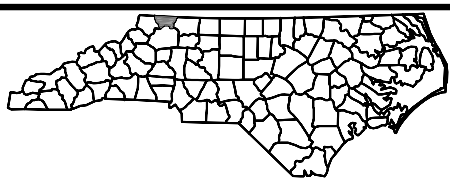
RIFFLE SECTION

W_{BKF} = 3.50 FT
A_{BKF} = 0.8 FT^2



POOL SECTION

W_{BKF} = 3.0 FT
A_{BKF} = 1.0 FT^2



Ecosystem Enhancement PROGRAM

North Carolina - Ecosystem Enhancement Program

Glade Creek Restoration Site
Alleghany County, North Carolina
SCO #070708801

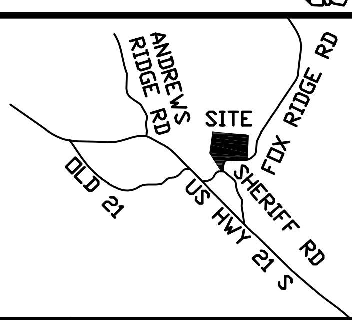


FIGURE 25

UT GLADE CREEK - "B" TYPE CHANNEL TYPICAL DESIGN CROSS SECTIONS

DATE: JULY 21, 2008

N

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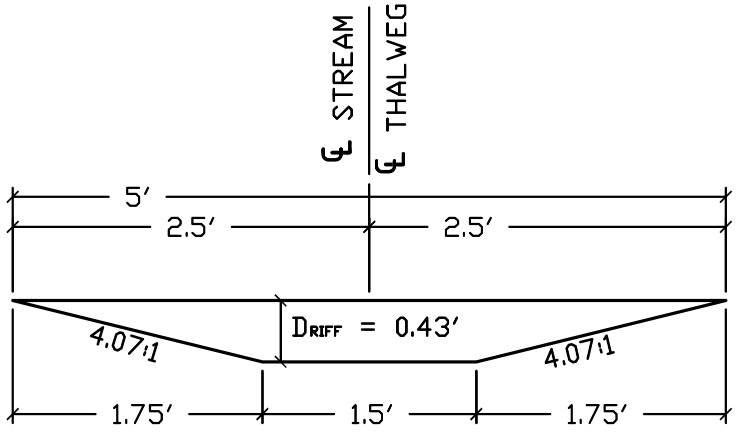
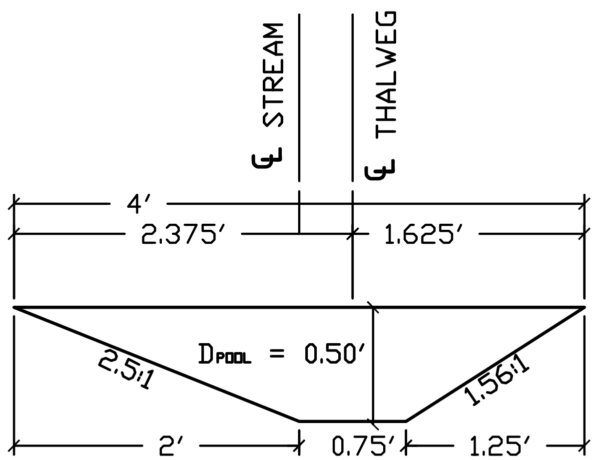


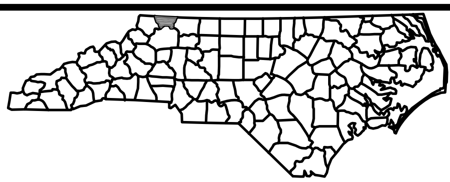
RIFFLE SECTION

W_{BKF} = 5 FT
A_{BKF} = 1.4 FT^2



POOL SECTION

W_{BKF} = 4.0 FT
A_{BKF} = 1.9 FT^2



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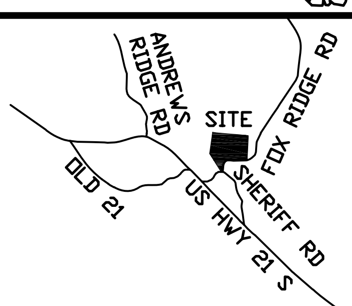

N

NOT TO SCALE

FIGURE 26

UT GLADE CREEK - "C" TYPE CHANNEL TYPICAL DESIGN CROSS SECTIONS

DATE: JULY 21, 2008

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12.0 Restoration Plans

Sheet 1. Glade Creek Existing Conditions Station 0+35 to 9+80

Sheet 2. Glade Creek Existing Conditions Station 9+80 to 23+08

Sheet 3. Glade Creek Restoration Plan Station 1+00 to 8+12

Sheet 4. Glade Creek Restoration Plan Station 8+12 to 16+80

Sheet 5. Glade Creek and UT to Glade Creek Planting Plan

Sheet 6. Longitudinal Profile Glade Creek

Sheet 7. Longitudinal Profile UT to Glade Creek

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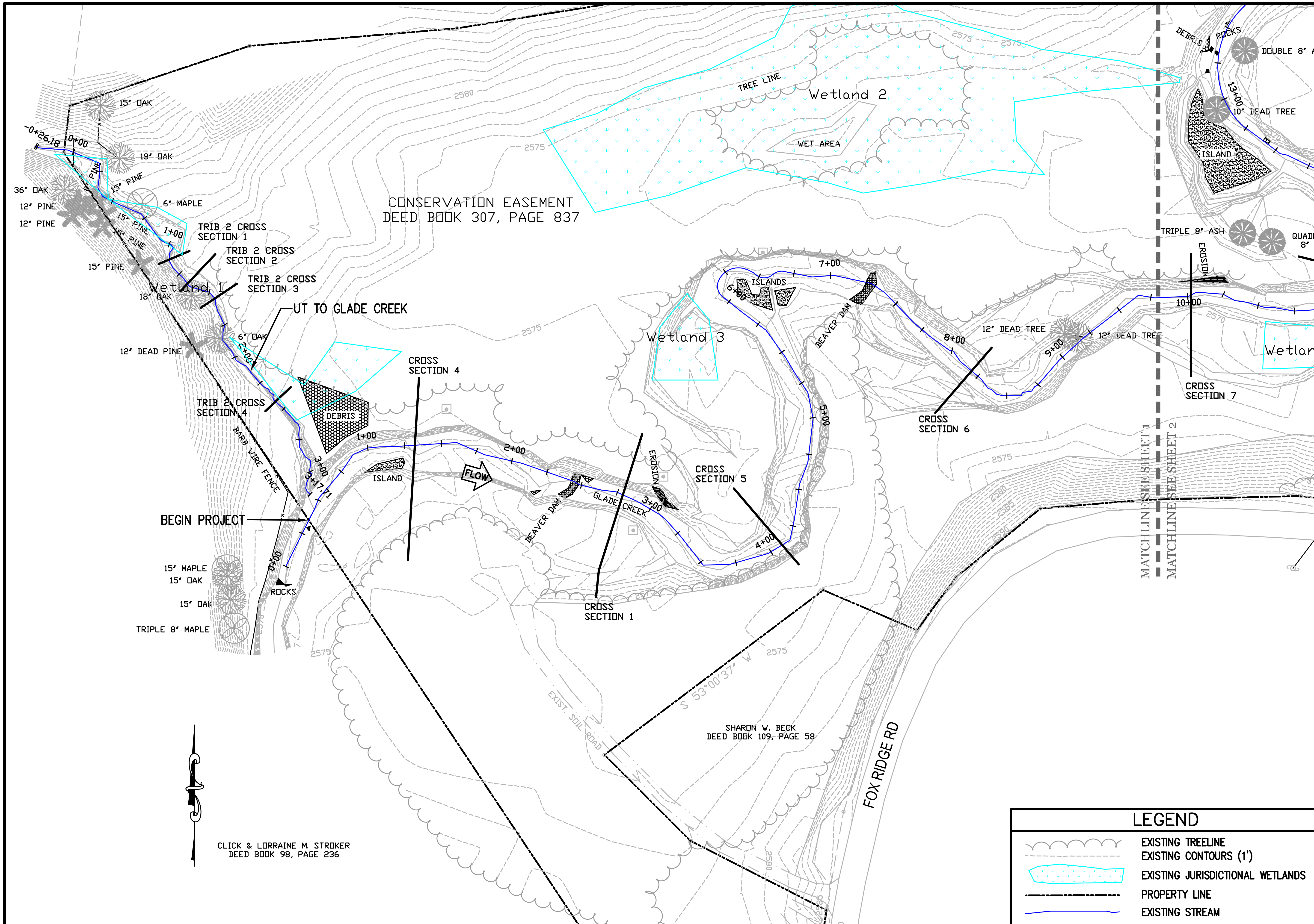

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Ecosystem Enhancement PROGRAM

GLADE CREEK EXISTING CONDITIONS

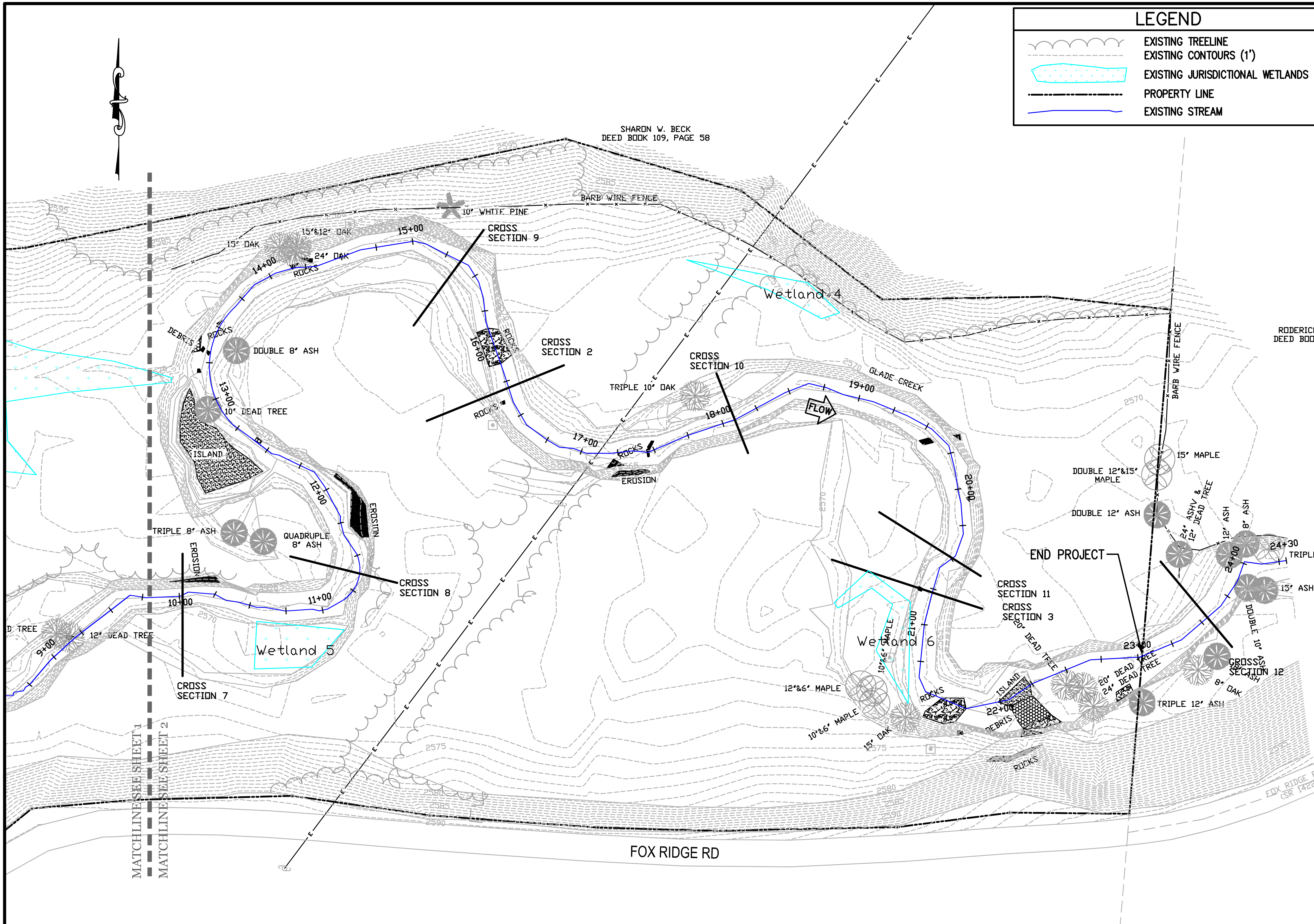
ALLEGHANY COUNTY, NORTH CAROLINA

DATE: 06-03-2008

PROJ./DWG. NAME: Glade Creek Rest. Plan Ex Cond

SCALE: 1"=60'

SHEET 1



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Ecosystem Enhancement PROGRAM

GLADE CREEK
EXISTING CONDITIONS

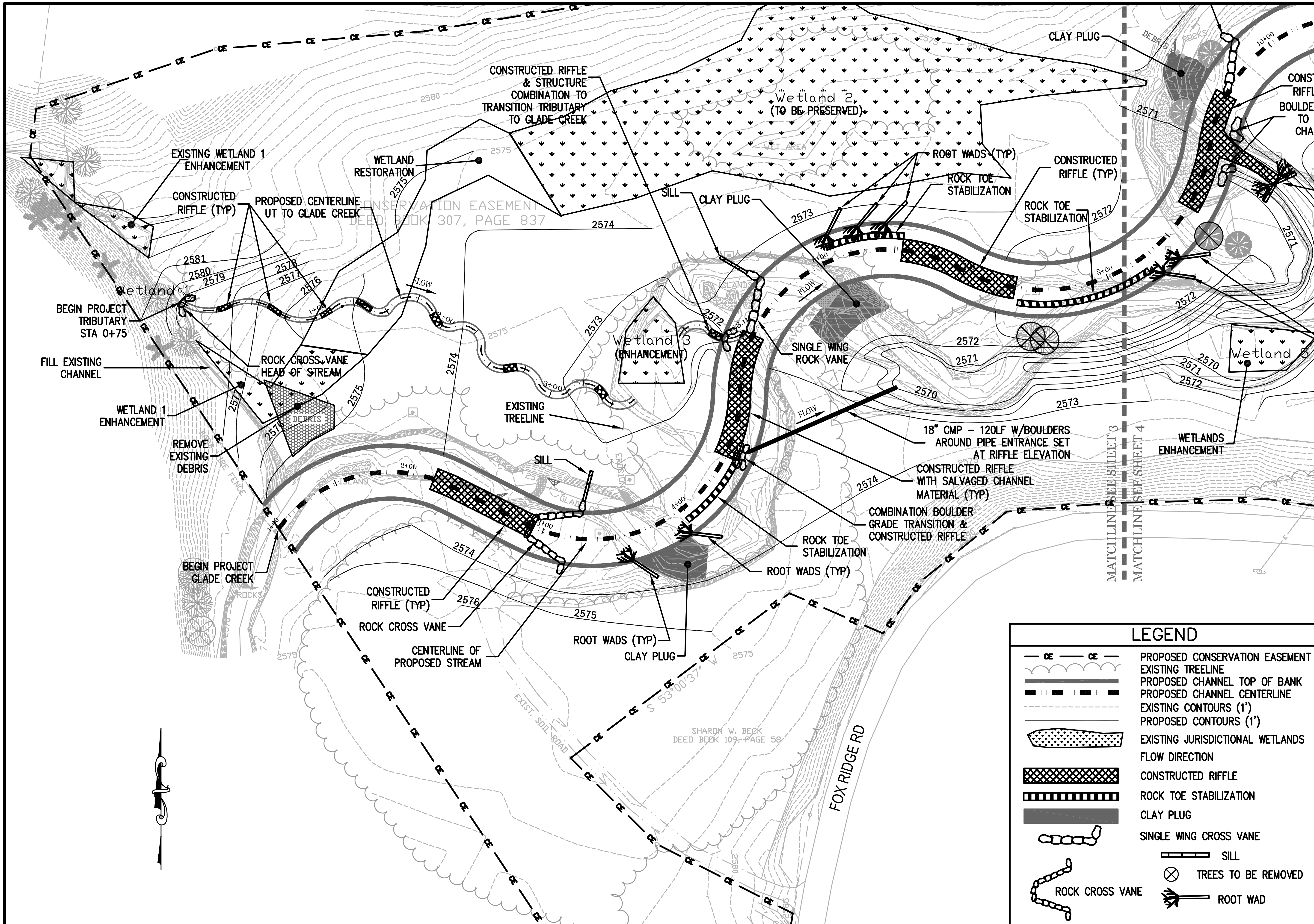
ALLEGHANY COUNTY, NORTH CAROLINA

DATE: 06-03-2008

PROJ./DWG. NAME: Glade Creek Rest. Plan Ex Cond

SCALE: 1"=60'

SHEET 2



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Ecosystem Enhancement PROGRAM

GLADE CREEK RESTORATION PLAN

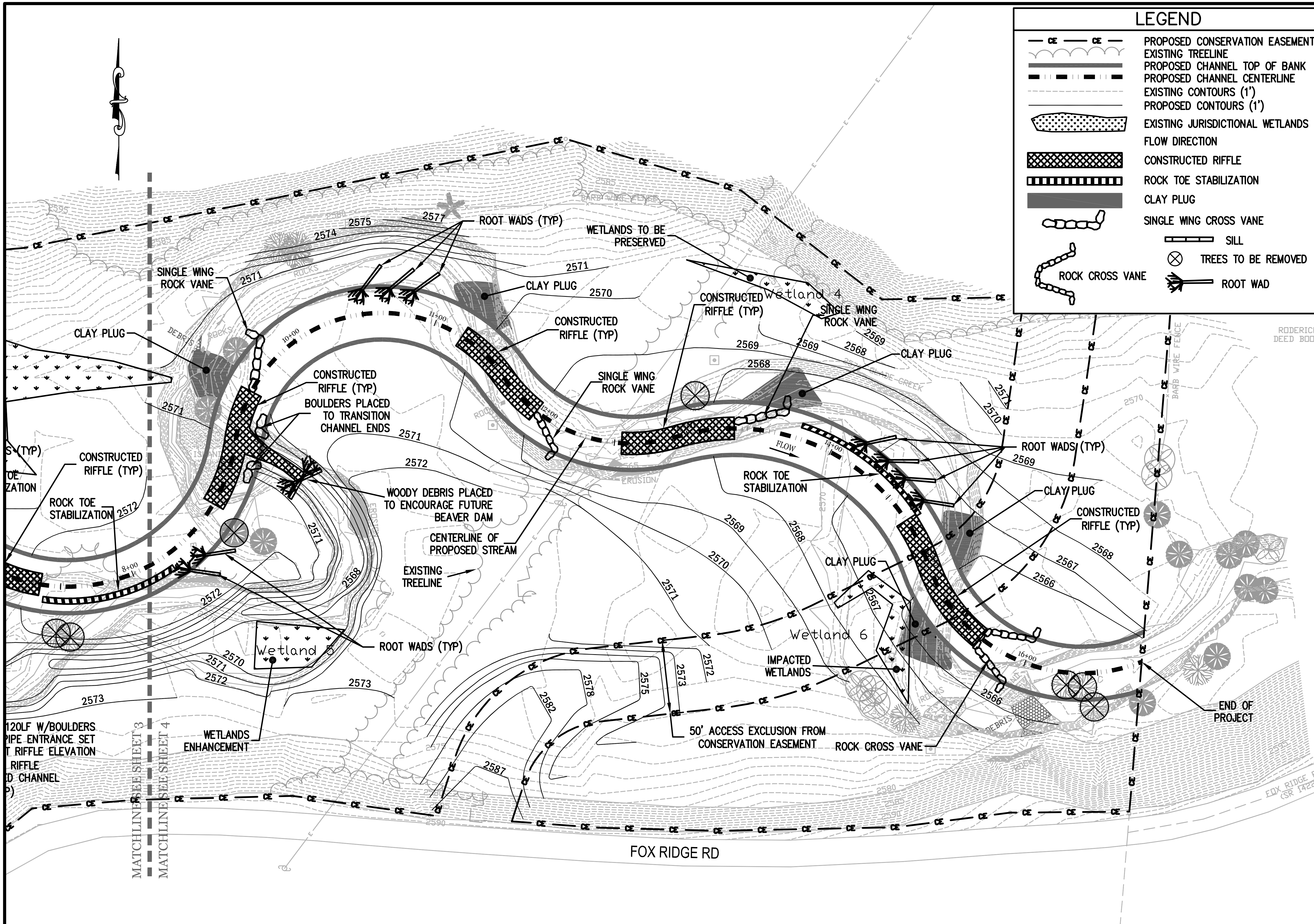
ALLEGHANY COUNTY, NORTH CAROLINA

DATE: 06-03-2008

PROJ./DWG. NAME: Glade Creek Restoration Plan

SCALE: 1"=60'

SHEET 3



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Ecosystem Enhancement PROGRAM

GLADE CREEK RESTORATION PLAN

ALLEGHANY COUNTY, NORTH CAROLINA

DATE: 06-03-2008

PROJ./DWG. NAME: Glade Creek Restoration Plan

SCALE: 1"=60'

SHEET 4

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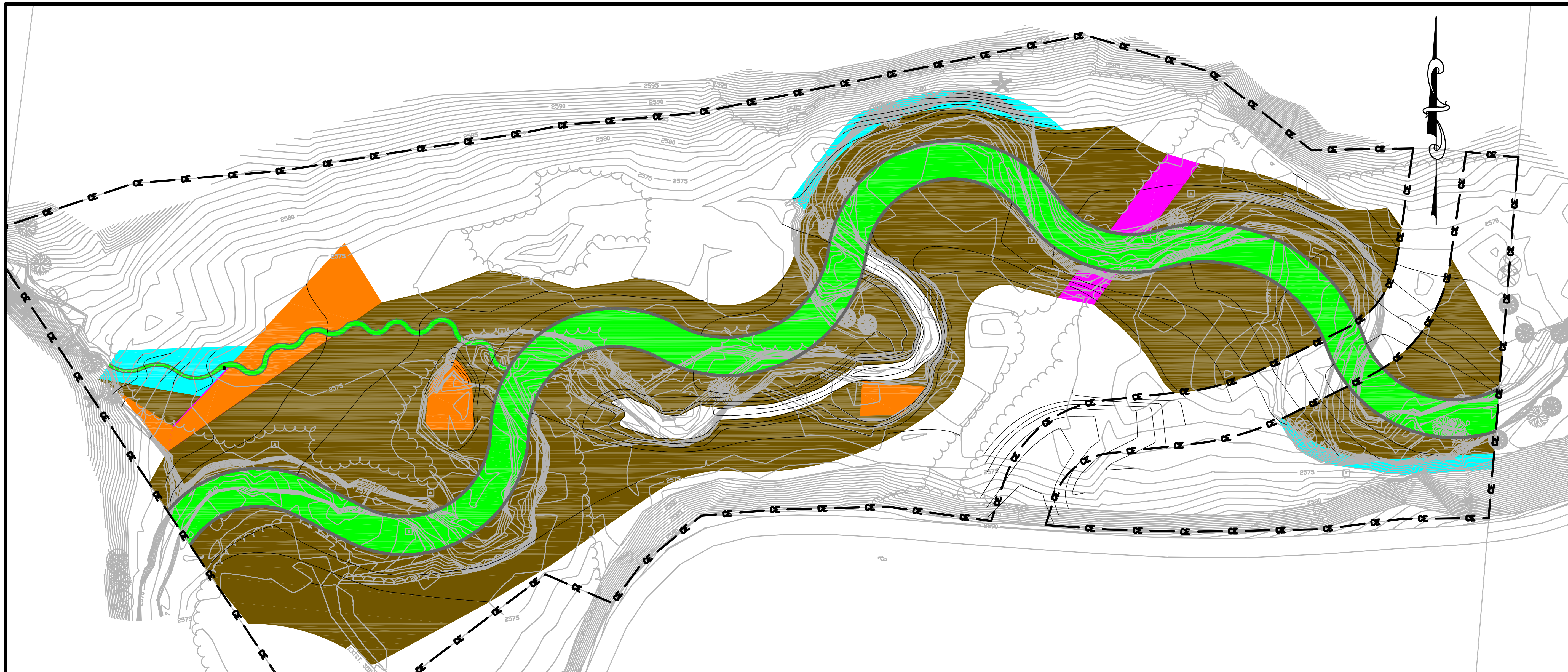

Planting Zone 1 - (Streambank)	
Taxonomic Name	Common Name
Trees and Shrubs	
Alnus serrulata	Tag alder
Cephalanthus occidentalis	Buttonbush
Cornus amomum	Silky dogwood
Hamamelis viginiana	Witch-hazel
Salix sericea	Silky willow
Carpinus caroliniana	Ironwood
Spiraea latifolia	Meadowsweet
Vibrurnum cassinoides	Northern Wild Raisin
Xanthorhiza simplicissima	Yellow-root

Planting Zone 2 - (Stream buffer- Low Mountain Alluvial Forest)	
Taxonomic Name	Common Name
Trees and Shrubs	
Platanus occidentalis	Sycamore
Liriodendron tulipifera	Tulip poplar
Carya cordiformis	Bitternut hickory
Celtis laevigata	Hackberry
Asimina triloba	Common pawpaw
Corylus americana	Hazelnut
Alnus serrulata	Tag alder
Physocarpus opulifolius	Ninebark
Corylus americana	Hazelnut
Hamamelis viginiana	Witch-hazel
Carpinus caroliniana	Ironwood
Vaccinium corymbosum	Highbush blueberry
Ilex verticillata	Blue Huckleberry
Lindera benzoin	Spicebush

Planting Zone 3 - (Wetland Enhancement/Restoration)	
Taxonomic Name	Common Name
Trees and Shrubs	
Populus deltoides	Eastern cottonwood
Fraxinus pennsylvanica	Green ash
Alnus serrulata	Tag alder
Rosa palustris	Swamp rose
Cephalanthus occidentalis	Buttonbush
Salix sericea	Silky willow
Sambucus canadensis	Common elderberry
Lindera benzoin	Spicebush
Physocarpus opulifolius	Ninebark

Planting Zone 4 - (Chestnut Oak Forest)	
Taxonomic Name	Common Name
Trees and Shrubs	
Quercus montana	Chestnut oak
Quercus coccinea	Scarlet oak
Quercus alba	White oak
Nyssa sylvatica	Blackgum
Carya alba	Mockernut hickory
Liriodendron tulipifera	Tulip tree
Sassafras albidum	Sassafras
Kalmia latifolia	Mountain laurel
Rhododendron maximum	Great Rhododendron

Planting Zone 5 - (Power Line Easement- Low Mountain Alluvial Forest Shrubs Only)	
Taxonomic Name	Common Name
Shrubs	
Corylus americana	Hazelnut
Alnus serrulata	Tag alder
Physocarpus opulifolius	Ninebark
Euonymus americana	Strawberry bush
Hamamelis viginiana	Witch-hazel
Vaccinium corymbosum	Highbush blueberry
Ilex verticillata	Blue Huckleberry
Cornus amomum	Silky Dogwood
Lindera benzoin	Spicebush

LEGEND:
- ZONE 1 - STREAM BANK
- ZONE 2 - STREAM BUFFER (LOW MOUNTAIN ALLUVIAL FOREST SPECIES)
- ZONE 3 - WETLAND ENHANCEMENT/RESTORATION
- ZONE 4 - STREAM BUFFER (CHESTNUT OAK FOREST SPECIES)
- ZONE 5 - POWER EASEMENT PLANTING

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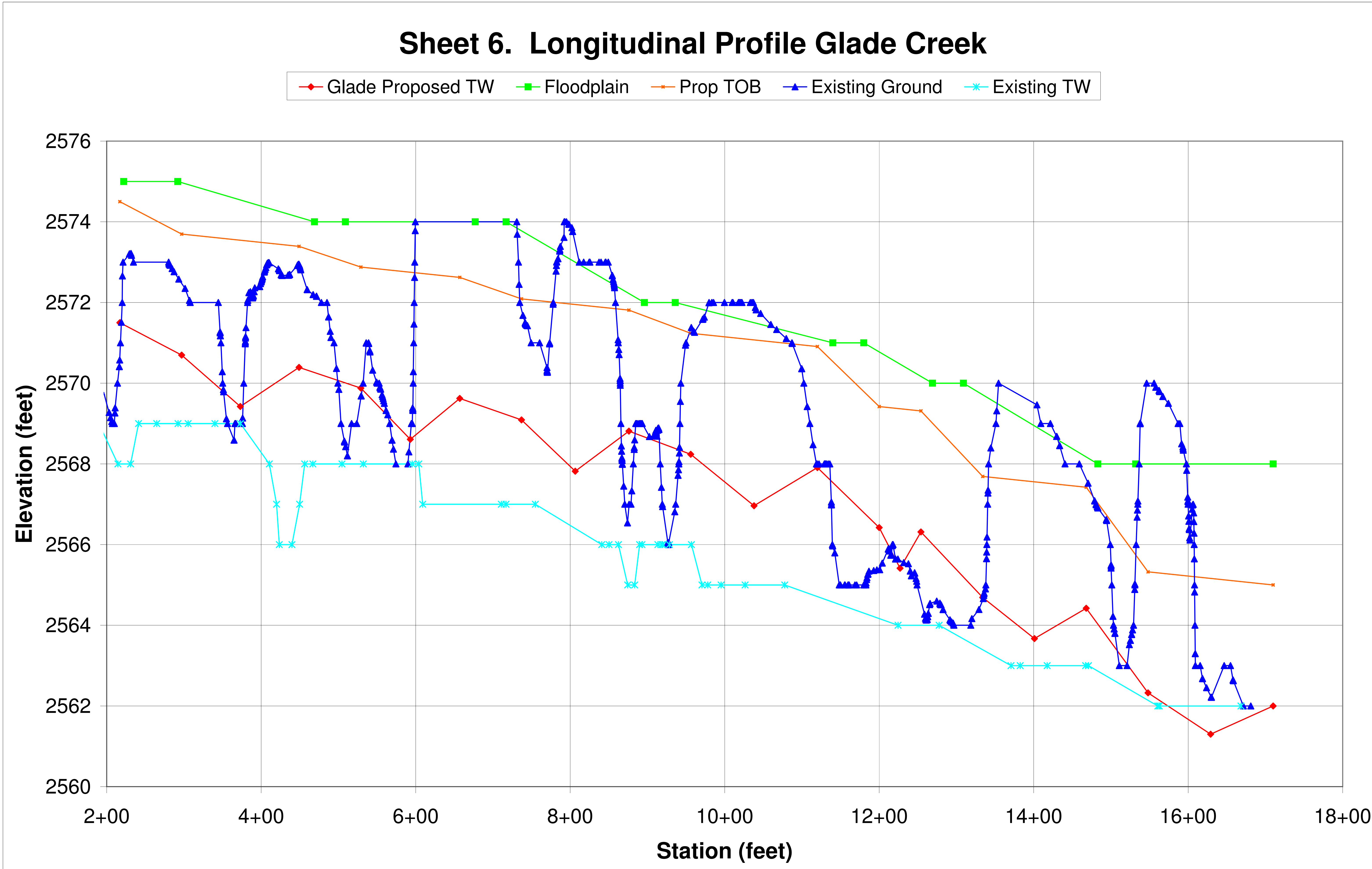
Ecosystem Enhancement PROGRAM

GLADE CREEK
PLANTING PLAN

ALLEGHANY COUNTY, NORTH CAROLINA

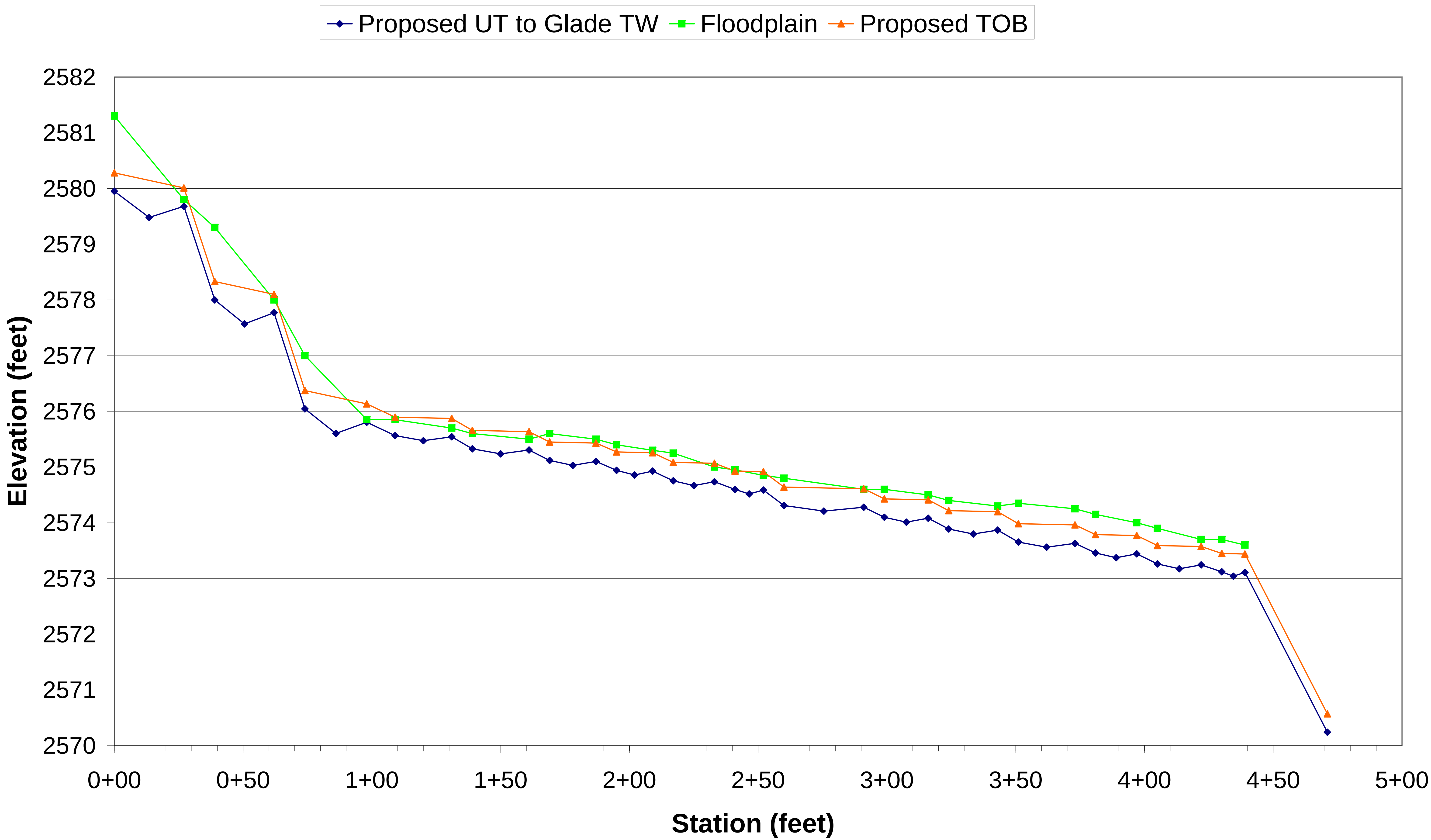
DATE: 06-03-2008
PROJ./DWG. NAME: Glade Creek Rest. Plan Ex Cond
SCALE: 1"=100'

SHEET 5



Sheet 6. Longitudinal Profile Glade Creek
Glade Proposed TW
Floodplain
Prop TOB
Existing Ground
Existing TW
Elevation (feet)
2576
2574
2572
2570
2568
2566
2564
2562
2560
Station (feet)
2+00
4+00
6+00
8+00
10+00
12+00
14+00
16+00
18+00

Sheet 7. Longitudinal Profile UT to Glade Creek



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Appendices