Little Alamance Creek Stream Restoration, Alamance County
State Construction Office Project Number: D07050S

Final Restoration Plan
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Prepared For:

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Executive Summary

1. Project Goals and Objectives

The primary goals of this stream restoration project focus on improving water quality, enhancing flood attenuation, and restoring aquatic habitat and will be accomplished by:

- Reducing non-point sources of pollution associated with historic lawn maintenance in the park area by providing a vegetative buffer adjacent to Little Alamance Creek and its unnamed tributary and the installation of stormwater best management practices to treat surface runoff. The riparian buffer will remain in a State-owned conservation easement in perpetuity.

- Reducing sedimentation on-site and in downstream receiving waters through a reduction of bank erosion associated with current vegetation maintenance practices and through providing a forested vegetative buffer adjacent to Little Alamance Creek and its tributary.

- Reestablishing stream stability and the capacity to transport watershed flows and sediment loads by restoring stable dimension, pattern, and profile.

- Promoting floodwater attenuation through increased flood storage capacity by construction of bankfull benches along Little Alamance Creek and its tributary.

- Improving aquatic habitat by enhancing stream bed variability.

The EEP is currently in Phase II of developing a Local Watershed Plan (LWP) in the Little Alamance, Travis, and Tickle Creek watersheds with interested stakeholders. The LWP goals include both short- and long-term strategies to restore, manage, and protect vital functions in the watershed. The Little Alamance stream project was identified through the LWP process and the projects meet three of the six planning goals, which include:

a) Increase local government awareness of the impacts of urban growth on water resources;

b) Improve water quality through stormwater management;

c) Identify and rank parcels for retrofits, stream repair, preservation, and/or conservation.

2. Existing Amount of Streams and Wetlands

The existing length of Little Alamance Creek within City Park is approximately 2,636 linear feet. The existing length of the Unnamed Tributary is approximately 422 linear feet. These distances were measured along the streams' thalwegs within the project limits. There are no wetlands located on the project site.

Bare root seedlings of tree and shrub species will be planted within the buffer at a density up to 555 stems per acre (10-foot centers). Appropriate species on live stakes will be installed within the bankfull channel. Planting will be performed between December and March to allow plants to stabilize during the dormant period and set roots during the spring.

Existing non-native exotics within the proposed buffer will be removed during construction. Exotic shrubs will be removed with construction equipment or cut and the stumps treated with an appropriate herbicide.

Little Alamance Creek and its unnamed tributary are located in City Park and are easily accessible by the public. This setting can provide an excellent opportunity for environmental education promoting the importance of water quality, riparian buffers, terrestrial and aquatic habitats, and reduction of point and non-point source pollution. There is also the opportunity to have students from Walter M. Williams High School involved in future project monitoring. The school is located just northeast of City Park.

3. Amount of Streams and Wetlands Designed

The stream restoration will reduce the total stream length of Little Alamance Creek by approximately 3 feet, to a length of 2,633 linear feet. The reduction is the result of increasing the radius of curvature of one tight bend near the ball field. The length of the unnamed tributary will not change. Jurisdictional wetlands are not proposed as part of this mitigation design.

1.0 Project Site Identification and Location

The project is located in City Park in the City of Burlington, Alamance County, North Carolina (Figure 1).

Directions to Project Site

From Interstate 40/85, take North Carolina Highway 62 (NC 62)/Alamance Road north (exit 143). Go approximately 1 mile to the intersection with US Highway 70 (S. Church Street) and make a right (east). City Park is located approximately 0.25 mile on the right.

1.1 USGS Hydrologic Unit Codes (8 and 14-digit)

Little Alamance Creek and its unnamed tributary are located in the 8-digit Hydrologic Unit Code (HUC) 03030002 and the 14-digit Local Watershed Unit HUC 03030002040010. Both streams are located in the North Carolina Division of Water Quality (NCDWQ) Subbasin 03-06-03 (NCDWQ 2005). The NCEEP identifies this HUC as a targeted Local Watershed in their Watershed Restoration Plan for the Cape Fear River Basin (NCDENR 2001). Watersheds in this plan exhibit the need and opportunity for stream and riparian buffer restoration.

1.2 NCDWQ River Basin Designations

Little Alamance Creek and its unnamed tributary are located in the Cape Fear River Basin. The information presented in the following section is derived from the Cape Fear Basinwide Assessment Report (NCDWQ 2005a). The Cape Fear River Basin drains the middle portion of North Carolina and includes portions of 26 counties and 115 municipalities. It is one of four river basins completely contained within North Carolina state boundaries. It is the state’s largest river basin (9,322 square miles) and flows southeast from the north-central Piedmont region near Greensboro to the Atlantic Ocean near Wilmington (NCDWQ 2005a).

2.0 Watershed Characterization

2.1 Drainage Area

The drainage area of Little Alamance Creek is approximately 4.2 square miles. Approximately 40 to 50 percent of the drainage area is impervious. The majority of the drainage area (approximately 80 percent) is urban residential consisting of single family homes. The remaining 20 percent of the watershed is comprised of city streets, businesses, light industrial and natural/undeveloped areas. There are several impoundments located in the watershed; the two largest are Mays Lake and Gant Lake (Figure 2).

The drainage area of the unnamed tributary is approximately 0.1 square mile. Nearly 100 percent of the drainage area is urban residential and city streets. Approximately 50 to 60 percent of the drainage area is impervious. Table 1 outlines the drainage area of both streams, and Table 2 describes the land uses.

Major point sources of contaminants that contribute to the degradation of water quality in the drainage area are stormwater culverts draining city streets. These culverts carry all contaminants deposited by vehicles and residents on city streets to the stream system. Non-point sources included runoff from residential yards. Runoff from residential yards includes fertilizers, herbicides, and pesticides.

2.2 Surface Water Classification

Best usage classification for surface waters is determined by NCDWQ. Both Little Alamance Creek and its unnamed tributary are classified as Class C, nutrient sensitive waters (NSW). Class C denotes waters that are suitable for aquatic life propagation, wildlife, secondary recreation, and agriculture.

Section 303(d) of the Clean Water Act (CWA) requires states to develop a comprehensive public accounting of all impaired waters. The list includes waters impaired by pollutants, such as nitrogen, phosphorus and fecal coliform bacteria, and by pollution, such as hydromodification and habitat degradation. The source of impairment might be from point sources, nonpoint sources, or atmospheric deposition. Little Alamance Creek is listed on the North Carolina 303(d) List as impaired due to impaired biological integrity (NCDWQ 2006). The impairment is due to fair and poor benthic community ratings at benthic monitoring sites BB388, BB193, BB131, and BB78. An NCDWQ total maximum daily load (TMDL) stressor study found that urban runoff from large impervious surface areas in the watershed has caused stream channelization with associated habitat degradation. Pollutants associated with urban runoff as well as riparian area removals are also noted stressors to the benthic community. The report noted that streambank erosion exists and many storm sewers discharge into Little Alamance Creek (NCDWQ 2005).

2.3 Physiography, Geology and Soils

The Little Alamance Creek restoration site is located in the Piedmont Physiography Province of North Carolina. The Piedmont Province occupies about 45 percent of the area of the state and consists of generally rolling, well-rounded hills and ridges with a few hundred feet of elevation difference between the hills and valleys. Elevations in the Piedmont range from 300 to 600 feet above mean sea level (ft msl) near its border with the Coastal Plain to 1,500 feet at the foot of the Blue Ridge (NCGS 2004). The Piedmont includes some relatively low mountains, including the South Mountains and the Uwharrie Mountains. Elevations within the restoration site range from approximately 575 to 610 ft msl.

According to the Natural Resources Conservation Service (NRCS) Official Soil Series Descriptions (OSD) webpage, four soil series are located on the project site (Cecil, Enon, Lloyd, and Urban). No hydric soils are located within the restoration site (Figure 3). Table 3 discusses these soil series.

2.4 Historical Land Uses and Development Trends

As far back as could be researched, the site has been in its current condition. A city directory search of the area conducted by Environmental Data Resources, Inc. (EDR 2007) shows that the city pool, city recreational center, and the City Department of Recreation and Parks were located at their current site in 1964. Currently, the watershed is nearly fully developed by a light industrial residential mosaic. The characteristics of the watershed are not expected to change in the near future.

2.5 Endangered and Threatened Species

Some populations of fauna and flora have declined, or are in the process of declining due to either natural forces or their inability to coexist with humans. Federal law (under the provisions of Section 7 of the Endangered Species Act of 1973, as amended [ESA]) requires that any action likely to adversely affect a species classified as federally protected is subject to review by the United States Fish and Wildlife Service (USFWS). Other species may receive additional protection under state laws.

ARCADIS conducted a file review at the North Carolina Natural Heritage Program's (NHP) records to help identify the presence of federally protected species. Protected species lists for Alamance County were also obtained from the USFWS and NHP internet sites.

As of May 10, 2007, the USFWS lists no federally threatened or endangered species as potentially occurring in Alamance County. The USFWS lists six federal species of concern (FSC) for Alamance County (USFWS 2007). Federal species of concern are not protected under the provisions of the ESA. FSC species are defined as species that are under consideration for listing, but for which there is insufficient information to support listing as threatened or endangered (formerly C2 candidate species). The status of these species may be upgraded at any time, thus they are included here for consideration.

Table 4 describes FSC species for Alamance County, their habitat requirements, and if suitable habitat is available.

2.5.1 Biological Conclusion

The proposed restoration project will have no effect on federally listed threatened or endangered species.

2.5.2 Federal Designated Critical Habitat

The USFWS designates critical habitats that are deemed necessary for the survival of federally listed threatened or endanger species. Activities within these designated areas are subject to federal review and approval.

2.5.3 Habitat Description

There are no designated critical habitats within the project area (USFWS 2007).

2.5.4 Biological Conclusion

The proposed restoration project will have no effect on federally designated critical habitats.

A formal letter was sent to the USFWS on April 10, 2007, requesting a site review. ARCADIS has not received a response to date from USFWS. A formal letter was sent to North Carolina Wildlife Resources Commission (NCWRC) on April 10, 2007, requesting a site review. The NCWRC recommend preserving as many mature trees as possible (ARCADIS 2007).

2.6 Cultural Resources

A review of North Carolina Historic Preservation Office (NCHPO) files was conducted, and no resources were identified within the project area. Several historic structures were identified outside the project area.

2.6.1 Potential for Historic Architectural Resources

A known historic carousel is located within the City Park site. This carousel is located near the northern portion of the site, approximately 100 feet from Little Alamance Creek.

2.6.2 Potential for Archaeological Resources

No potential archaeological resources were identified at the City Park site.

2.6.3 SHPO/THPO Concurrence

A formal letter was sent to NCHPO on April 10, 2007, for a project site review. A response was received on May 10, 2007. NCHPO had no comment on the City Park site.

2.6.4 Other Compliance Issues

There are no other compliance issues associated with this site.

2.7 Constraint Analysis

Constraints affecting stream restoration options include: five pedestrian crossings, two train crossings, train tracks (and other park facilities, including the historic carousel), sanitary sewer lines, stormwater culverts, water lines, construction window related to park operations, and existing mature trees.

2.7.1 Property Ownership and Site Access

The site is located on property owned and operated by the City of Burlington. The City has agreed to the stream restoration project. The site is easily accessed from City streets or parking lots. City Park is heavily used by the public. A carousel and an amusement train railway are located within the park. The carousel is outside of the potential area of disturbance. However, the train tracks cross the stream in two locations. There are also five pedestrian crossings, one of which is also used for City vehicle access.

2.7.2 Environmental Screening

An EDR report was obtained for the site. The EDR report summarizes a search of available environmental records for the evaluation of environmental risks associated with a parcel or real estate. The EDR report for the Little Alamance Creek site identified 7 underground storage tanks (UST) and 12 leaking underground storage tanks (LUST) with 1/4 mile of the site. Six of the USTs have been permanently closed, and one is currently in use (Fairway One Stop gas station, 1382 South Church Street). Of the 12 LUSTs, 8 have been closed out and 4 were in the response phase (ARCADIS 2007).

2.7.3 Utilities and Easements

There are several sanitary sewer lines within City Park. In most cases the sewer lines are located an adequate distance from the streams so that they will not affect restoration practices. There are locations where the sewer line is located within 15 feet of the top of stream bank. The design will be adjusted to avoid damaging the sewer lines. Portions of the sewer lines are located within the proposed 50-foot buffer. Based on conversation with City of Burlington staff, planting can occur over the sewer lines. However, access to the manholes within the buffer needs to be maintained. Access could consist of a 10- to 12-foot wide path from edge of the buffer to the manhole.

Two exposed sewer lines cross Little Alamance Creek, both near the carousel. The sewer line crossings are ductile iron pipe, which is very durable and can tolerate high stream flows. These crossings will have little effect on the stream restoration design. At most, the stream banks may require some riprap armoring in these areas.

2.7.4 FEMA / Hydrological Trespass

Restoration activities will involve stabilizing the stream in its current location. Stream banks will be regraded to a more gradual slope and a riparian buffer established. The stream bed elevation will not be raised. Stormwater BMPs will likely consist of dry detention ponds or wet gardens that dry quickly after storm events. Hydrological trespass is not a concern due to the fact that wetland mitigation will not take place at the site.

A No Impact Study will be conducted to determine any impacts to the floodplain from restoration. If negative impacts to the floodplain are discovered, a Conditional Letter of Map Revision may need to be prepared and submitted to FEMA in order to obtain a work permit for the project.

3.0 Project Site Streams (Existing Conditions)

Little Alamance Creek is located in City Park in the City of Burlington. The project begins at a culvert beneath South Church Street and continues approximately 2,640 feet through City Park and ends at a bridge at Overbrook Road. An unnamed tributary enters Little Alamance Creek approximately 500 feet downstream of South Church Street. The approximately 500-foot-long unnamed tributary begins at a culvert under Overbrook Road. Little Alamance Creek is approximately 30 to 60 feet wide at the top of bank with banks ranging between 4 and 8 feet high and bank heights ratios between 1.0 and 1.4. The unnamed tributary is approximately 5 to 10 feet wide at the top of bank with bank heights of 2 to 4 feet and bank heights ratios between 1.0 and 1.3.

Little Alamance Creek flows through a maintained park setting, with several large mature trees outside the stream banks. A paved walking trail winds among the trees and crosses Little Alamance Creek in five locations. The majority of the park is regularly mowed. However, the City recently implemented a no mow policy on the stream banks and 10 to 20 feet beyond the top of the stream bank. The intent of the no mow area is to allow a buffer to reestablish naturally along the stream. An amusement train railway crosses the stream in two locations in this area. Downstream of the amusement train railway, the stream flows south of a historic carousel and then north of a baseball/softball field. Little Alamance Creek then exits the site under Overbrook Road. A beaver dam was identified near the downstream end of the project after the detailed stream survey. The design sheets do not show the beaver dam and associated backwater.

Several areas along Little Alamance Creek are experiencing severe bank erosion. The most severe areas include the left bank, just downstream of the first pedestrian crosswalk, the left bank in the tight radius downstream of the first trestle, and the right bank adjacent to the baseball field and upstream of the last pedestrian crosswalk. These areas are experiencing high to extreme Near Bank Stress (NBS) resulting from high, vertical banks and/or tight radii. The Bank Erosion Hazard Index (BEHI) rating for these areas ranged from very high to extreme due to a lack of woody vegetation and high, vertical banks. Bank erosion has caused the stream to become overly wide in these sections and transverse and/or central bars have developed because the stream lacks the capacity to transport sediment through these reaches. Herbaceous vegetation has become well established throughout the entire restoration reach; however, the rooting depth is very shallow.

There are also several sections of Little Alamance Creek that are fairly stable due to the presence of woody vegetation along the banks and/or lower bank angles. The left bank along the last 500 feet of the proposed restoration reach is stabilized by a fairly dense stand of woody vegetation. Mature hardwoods along with several shrubby species such as tag alder (*Alnus serrulata*) also serve to stabilize the banks in the tight meander just upstream of the third pedestrian crosswalk. Riprap is also providing bank protection in this tight meander. The right bank, downstream of the third pedestrian crosswalk, is also vegetated and fairly stable.

The unnamed tributary is slightly incised and exhibits bank erosion along the majority of this reach. There is very little woody vegetation to support the stream banks aside from a few scattered black willow (*Salix nigra*) trees at the upstream end. Herbaceous vegetation dominates the stream banks along this reach of the unnamed tributary; however, the shallow rooting depth has led to bank erosion along the lower portions of the banks and created several undercut banks. Photographs of the site are included in Appendix 1.

3.1 Channel Classification

Little Alamance Creek is classified as a C/E5/1 stream type. The C5 stream type is a slightly entrenched, meandering, sand dominated, riffle/pool channel with a well developed floodplain (Rosgen 1996). The E5 stream type is characterized by low to moderate sinuosity, gentle to moderately steep gradients with very low channel width to depth ratios (Rosgen 1996). The substrate of an E5/1 or C5/1 stream type is comprised mainly of sand, with the occurrence of bedrock. The hybrid classification given to Little Alamance Creek reflects the range of channel dimensions found throughout the site.

The unnamed tributary to Little Alamance Creek is classified as an E4/1 stream type; however, it is slightly incised throughout most of the reach with bank height ratios ranging between 1.0 and 1.3. The E4 stream type is characterized by low to moderate sinuosity, gentle to moderately steep gradients with very low channel width to depth ratios (Rosgen 1996). The substrate of an E4/1 stream type is comprised mainly of gravel with the occurrence of bedrock. NCDWQ Stream Classification Forms were prepared for both streams. Little Alamance Creek scored 47.5. The unnamed tributary scored 33. Stream classification forms are presented in Appendix 2.

3.2 Discharge (bankfull, trends)

The bankfull discharge was determined by first calculated the streams average velocity. Using the Manning's equation with a calculated Manning's "n" value of 0.054 ft $^{1/6}$, the average velocity for the channel is 2.5 feet per second. Applying this velocity over the average cross sectional area of the channel (95.0 square feet [ft^2]), a discharge of 237.5 cubic feet per second (cfs) is calculated. This discharge was then compared to the revised North Carolina Rural Curves developed by Haywood County Natural Resources Conservation Service. Based on the curve the bankfull discharge for a 4.2 square mile drainage area is approximately 188.0 cfs. This value is less than calculated discharge. However, as with the bankfull cross sectional area discussion above, the bankfull discharge taken from the regional curve is expected to be lower than the actual stream discharge because of the urban setting. The calculated discharge is likely to be more accurate than the discharge determined by the regional curves since it reflects actual on site conditions.

3.3 Channel Morphology (Pattern, Dimension, Profile)

The channel dimension was measured by taking cross section surveys of the channel at representative locations. Six riffle cross sections were measured on Little Alamance Creek; two on the unnamed tributary. The upstream-most cross section on Little Alamance Creek was not used in the channel morphology assessment. This cross section is located just downstream of the box culvert under South Church Street. This proximity to the culvert has resulted in an excessively wide channel which is not representative of the entire reach. Stream dimension information was obtained from the remaining cross sections. Little Alamance Creek's cross sectional area ranged between 79.3 $ft^2$and 125.0 s ft^2 with an average of 95.0 ft^2. Channel width ranged from 31.8 feet to 42.5 feet with an average of 36.2 feet, and mean depth ranged between 2.2 feet and 2.9 feet, with an average of 2.6 feet. The width to depth ratio ranged between 11.6 and 17.0 with an average of 14.0. The unnamed tributary's cross sectional area ranged between 14.8 ft^2 and 16.7 ft^2 with an average of 15.8 ft^2. Channel width ranged from 10.9 feet to 13.0 feet with an average of 12.0 feet, and mean depth ranged between 1.1 feet and 1.5 feet with an average of 1.3 feet. The width to depth ratio ranged between 7.1 and 11.5 with an average of 9.3.

Sinuosity is the measure of the pattern or the curviness of a stream channel. Sinuosity is calculated by dividing the stream length by the valley length or dividing the valley slope by the stream slope. The sinuosity of Little Alamance Creek calculated to be 1.2. The sinuosity of the unnamed tributary calculated to be 1.1.

The average water surface slope of Little Alamance Creek is 0.0024 ft/ft (0.24 percent). Little Alamance Creek is a pool-dominated system with approximately 65 percent of the stream length being comprised of pools. In the middle section of the project reach, the pools are separated by fairly short and steep bed rock steps.

The average water surface slope of the unnamed tributary is 0.0095 ft/ft (0.95 percent). The upper reach immediately downstream of Overbrook Road is steeper than the lower reach at the confluence with Little Alamance Creek. The lower reach is located in the relatively flat floodplain of Little Alamance Creek.

The particle size distribution of Little Alamance Creek's substrate is:
D_{16} = 0.2 mm D_{35} = 0.7 mm D_{50} = 2.4 mm D_{84} = 138.0 mmD_{95} = 216.0 mm

The particle size distribution of the Unnamed Tributary's substrate is:
D_{16} = 0.2 mm D_{35} = 0.5 mm D_{50} = 3.4 mm D_{84} = 19.0 mm D_{95} = 53.0 mm

Tables 3 and 4 and sheets 3 and 3A of the design sheets show the channel morphology measurements.

3.4 Channel Stability Assessment

A BEHI analysis was performed on Little Alamance Creek and its unnamed tributary. The ratings ranged from low to extreme on Little Alamance Creek and from low to very high on the unnamed tributary. Contributing to the high, very high and extreme ratings were high bank heights, shallow rooting depths, and low rooting densities (a function of the lack of woody vegetation). Near bank stress (NBS) ranged from low to extreme on both Little Alamance Creek and the unnamed tributary. Extreme NBS ratings were due to high banks, central bars, and tight meander bends. Based on these ratings, an estimated 694 tons of sediment per year are being contributed by this reach of Little Alamance Creek, and the unnamed tributary is contributing an additional 55 tons of sediment per year. The BEHI and NBS data sheets are included in Appendix 3.

The modified channel stability rating for both streams was determined to be poor (unstable) according to the Pfankuch channel stability rating.

3.5 Bankfull Verification

The riffle cross sectional areas were compared to the revised North Carolina Rural Curves developed by Haywood County Natural Resources Conservation Service. The revised curve predicts the cross sectional area for Little Alamance creek and the unnamed tributary to be 46.1 ft^2 and 3.2 ft^2, respectively. The actual average cross sectional area was measured to be 95.0 ft^2 on Little Alamance Creek and 15.8 ft^2 on the unnamed tributary. This is exactly what was expected to occur because of the streams urban setting. In order to validate the bankfull determination, cross section measurement was taken on Brown Branch (the adjacent watershed to the east) and several other urban streams. These areas were plotted against the North Carolina Rural Curves to see where they would fall in relation to the curve and each other. They were all consistently 2 to 3 times greater than the curve. Based on this relationship, it is expected that the correct bankfull indicator was selected on all streams surveyed.

3.6 Vegetation

Dominant woody vegetation observed on site includes: willow oak (*Quercus phellos*), sweet gum (*Liquidambar styraciflua*), tulip popular (*Liriodendron tulipifera*), red maple (*Acer rubrum*), white mulberry (*Morus alba*), tag alder (*Alnus serrulata*), Chinese privet (*Ligustrum sinense*), American elm (*Ulmus Americana)*, black willow (*Salix nigra)*, weeping willow (*Salix babylonica)*, eastern red cedar (*Juniperus virginiana)*, green ash (*Fraxinus pennsylvanica)*, box elder (*Acer nugundo)*, redbud (*Cercis canadensis)*, trumpet creeper (*Campsis radicans*), mimosa (*Albizia julibrissin*), persimmons (*Diospyros virginiana*), winged elm (*Ulmus alata*), Virginia creeper (*Parthenocissus quinquefolia*), tree of heaven (*Ailanthus altissima*), Flowering dogwood (*Cornus florida*), river birch (*Betula nigra*), Virginia pine (*Pinus virginiana*), and poison ivy (*Toxicodendron radicans*).

Herbaceous vegetation on site includes various jewel weed (*Impatiens capensis*), poke weed (*Phytolacca americana*), Japanese stiltgrass (*Microstegium vimineum*), tear-thumb (*Polygonum saggitafolia*), false nettle (*Boehmeria cylindrica*), dodder vine (*Cuscuta gronovii*), and fescue grasses (*Festuca* sp.).

4.0 Reference Streams

Due to the confined nature of Little Alamance Creek and the unnamed tributary, in combination with the urban setting, data used to develop the restoration plan were derived from several reference reaches and several restored streams in Greensboro, North Carolina. These streams were chosen because they exhibited valley types and watersheds similar to those at the restoration site. Data from a reach of Brown Branch in the City of Burlington were also used. The majority of the proposed work on site will consist of Enhancement I. Only one short section of the channel thalweg will be realigned. Therefore, several geomorphic measurements were not taken on the reference streams. These include stream pattern, stream profile, and several stream feature cross sections. Figure 4 shows the location of the reference streams used. Morphological measurements of the reference streams are shown in Table 4 and 5 and design sheets 3 and 3A.

4.1 Watershed Characterization

The Greensboro reference streams are located in urban watersheds. The watersheds ranged from urban residential to urban industrial. Watershed sizes ranged from 0.18 square mile to 0.77 square mile.

4.2 Channel Classification

The reference streams used in the design are classified as C4, E4, and C/E4 streams. Characteristics of C4 and E4 streams are discussed in section 3.1.

4.3 Discharge (bankfull, trends)

Bankfull discharges were obtained from the revised North Carolina Rural Curves. These discharges ranged from 14.1 cfs to 45.5 cfs. As with the reach of Little Alamance Creek and the unnamed tributary to be restored, the discharges of the reference streams taken from the regional curves are expected to be lower than the true discharge because of the urban setting.

4.4 Channel Morphology (pattern, dimension, profile)

Channel pattern and profile measurements were not collected on the reference streams. Due to the restoration site constraints, significant channel realignment is not proposed. Therefore, pattern and profile measurements were not required. Bankfull cross sectional areas ranged from 13.0 ft^2 to 35.3 ft^2, bankfull width ranged from 9.5 feet to 20.9 feet, mean depth ranged from 1.4 feet to 1.7 feet and width to depth ratios ranged between 6.9 and 12.4.

4.5 Channel Stability Assessment

Visual assessments of channel stability were made during the site visit to each reference stream. In general, the banks of all the reaches assessed appeared to be stable. However, areas of bank erosion were observed at all the sites, including the newly restored sites. The cross section measurements were taken at stable sections well outside the influence of the bank erosion areas.

4.6 Bankfull Verification

A cross section was taken at a typical riffle on each stream. The bankfull cross sectional areas were compared to the revised North Carolina rural curves. The cross sectional area of each stream was consistently above the regression line. The cross sectional areas were two to three times higher than the value predicted by the regression equation.

4.7 Vegetation

Woody vegetation at the reference sites varied. Vegetation at the recently restored site consisted of young, newly planted hardwood species. The bare root plantings were too young to identify. Vegetation at the reference sites was typical of urban areas consisting of red maple, black walnut and Chinese privet. Vegetation at the segment of Brown Branch was dominated by bamboo.

5.0 Project Site Wetlands

There are no wetlands present on the site.

6.0 Project Site Restoration Plan

6.1 Restoration Project Goals and Objectives

The goals of the restoration project are to improve water quality and improve aquatic habitat diversity. Water quality will be improved by stabilizing eroding stream banks, thereby reducing sedimentation in the streams and incorporating stormwater BMPs to treat stormwater prior to discharging into the streams. A continuous riparian buffer will be established to provide shading of the streams, slow sheet flow, and reduce erosion and sedimentation. Aquatic habitat will be improved by creating a riffle/pool complex and providing in-stream woody debris. Rock structures will be installed to provide bank protection, establish grade control, and promote pool formation. In-stream woody debris will be provided by utilizing root wads, brush mattresses, and/or log vanes throughout the reach. Table 5 outlines the project restoration structure and objectives.

6.1.1 Designed Channel Classification

A C 4/1 channel is proposed at the restoration site. Sections of Little Alamance Creek currently classify as a C4/1 stream; however, it is slightly incised with bank height ratios ranging from 1.0 to 1.4. In the sections where the bank height ratio is greater than 1.0, a bankfull bench will be excavated to the extent possible to obtain a bank height ratio of 1.0. Due to the constraints on site, the channel sinuosity will not be altered. One short section of the channel thalweg will be realigned and a center bar removed. The realignment was not based on reference reach data. The channel pattern for this short section was based on values that fit within the existing design constraints and still provide a stable channel. Reference reach data could not be used because the reference reach area did not contain the same site constraints as the project site. Instream structures will be installed to increase habitat diversity and provide grade control and bank protection.

The unnamed tributary will be restored to a low sinuosity C 4/1 channel. The site constraints prohibit changing the channel alignment. The unnamed tributary is slightly incised with bank height ratios between 1.0 and 1.3. In the sections where the bank height ratio is greater than 1.0, a bankfull bench will be excavated to the extent possible to obtain a bank height ratio of 1.0. Instream structures will be installed to increase habitat diversity, provide grade control and bank protection. Design sheets are included in Appendix 4.

The vegetation community established on site will closely resemble a Piedmont/Low Mountain Alluvial Forest (Schafale and Weakley 1990). Alluvial Forests are located on smaller streams and, therefore, smaller floodplains than Piedmont/Mountain Bottomland Forests and lack the development of the depositional fluvial landforms (levees, sloughs and ridges) (Schafale and Weakley 1990). Woody species planted within the floodplain will include river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), American elm, green ash, hackberry (*Celtis laevigata*), American holly (*Ilex opaca*), and ironwood (*Carpinus caroliniana*). Woody species on the stream banks will be comprised of the above and also include black willow, tag alder, buttonbush (*Cephalanthus occidentalis*), and elderberry (*Sambucus canadensis*). The width of the buffer will depend on the results of discussions with the City of Burlington.

Bare root seedlings of tree and shrub species will be planted within the buffer at a density up to 555 stems per acre (10-foot centers). Appropriate species on live stakes will be installed within the bankfull channel. Planting will be performed between December and March to allow plants to stabilize during the dormant period and set roots during the spring. Existing non-native exotics within the proposed buffer will be removed during construction. Exotic trees and shrubs will be removed with construction equipment or cut and the stumps treated with an appropriate herbicide.

6.2 Sediment Transport Analysis

Sediment transport analysis is used to predict if the designed channel will be able to move the bedload that is supplied to the channel. It compares the proposed channel morphological parameters to the bed load material in the channel and determines if the proposed channel is capable of moving the material.

6.2.1 Methodology

Sediment transport analysis was conducted by calculating the proposed channel shear stress then comparing it to the Shields curve (Leopold, Wolman and Miller 1964). The Shields curve estimates the largest size particle capable of moving at a given shear stress. This size particle is then compared to the particle size within the stream bed. If the Shields curve particle size estimated is significantly higher than the actual particle size in the stream, then the stream is degrading. If the Shields particle size estimate is significantly smaller than the particle size in the stream, then the stream is aggrading. If the Shields particle size is near the same size as the particle in the channel, then the stream is stable.

In order to validate the above calculations, the critical dimensionless shear stress was calculated. The critical dimensionless shear stress estimates the mean bankfull depth and bankfull water surface slope required to transport the bed material. This depth and slope are compared to the proposed depth and slope to determine channel stability.

6.2.2 Calculations and Discussion

The calculated shear stress for the proposed Little Alamance Creek is 0.37 lb/ft^2 (see calculations below). The particle size moveable at this shear stress according to the Shields curve is 80 mm. The largest particle from the pavement sample is 80 mm. These particles are identical in size.

• = •RS Where • = bankfull shear stress (lb/ft^2)
• = specific weight of water (lbs/ft^3)
R = hydraulic radius of bankfull channel (ft)
S = average water surface slope (ft/ft)

• = 62.4 lbs/ft^3 x 2.5 ft x 0.0024 ft/ft
= 0.37 lb/ft^2

The calculated shear stress for the proposed unnamed tributary is 0.71 lb/ft^2 (see calculations below). The particle size moveable at this shear stress according to the Shields curve is 55 mm. The largest particle from the pavement sample is 48 mm. These particles are very near the same size.

• = •RS Where • = bankfull shear stress (lb/ft^2)
• = specific weight of water (lbs/ft^3)
R = hydraulic radius of bankfull channel (ft)
S = average water surface slope (ft/ft)

• = 62.4 lbs/ft^3 x 1.2 x 0.0095t/ft
= 0.71b/ft^2

Based on the shear stress calculations and the Shields curve predictions of the moveable particle size, both designed channels will be able to transport the existing bedload.

6.3 HEC-RAS Analysis

A “No-Impact” Study will be performed on Little Alamance Creek in order to obtain a floodplain development permit for the project. The currently effective model will be duplicated, and subsequent model(s) will be created with the US Army Corps of Engineers hydraulic modeling software, HEC-RAS.

6.3.1 No-rise, LOMR, CLOMR

Little Alamance Creek is located in Federal Emergency Management Agency (FEMA) regulated floodways where base flood elevations have been determined. The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1 percent annual chance flood (100 year) can be carried without an increase in 100-year water surface elevation. Work within the floodway requires the preparation of a No Impact Study during the design phase and a Letter of Map Revision (LOMR) at the completion of work if the work results in a change in the base flood elevations.

6.4 Stormwater Best Management Practices

6.4.1 Narrative of Site-Specific Stormwater Concerns

The main stormwater concern at the Little Alamance Creek site is stormwater discharging directly into the stream channels. Stormwater culverts are located on the channel banks and discharge directly into the channel in several locations. These discharges deliver pollutants carried from lawns and city streets to Little Alamance Creek and its unnamed tributary. This untreated urban runoff contributes to the water quality degradation of the watershed.

6.4.2 Device Description and Application

BMP devices expected to be used on site are grassed swales, level spreaders, wet gardens, and filter strips. Stormwater culverts that discharge directly into Little Alamance Creek and the unnamed tributary will be removed and replaced with grassed swales. Grassed swales are trapezoidal or parabolic earthen channels covered with a dense growth of a hardy grass. Grassed swales take up some pollutants and help filter sediment and other solid particles out of runoff. They convey stormwater and provide some stormwater management for small storms by retarding peak flow rates, lowering velocities of runoff and by infiltrating runoff water into the soil. Because of their limited pollutant removal ability, grass swales are assumed to have a total suspended solid removal of 35 percent (NCDWQ 2007). The estimate removal rate is 29 percent for total phosphorous and 38 percent for nitrate nitrogen (USEPA 2007).

Level spreaders will be installed at stormwater culvert outlets or where runoff from adjacent streets enters the site in a concentrated area. Level spreaders convert concentrated flow to sheet flow and release it uniformly over a stabilized area, namely a filter strip. For this project, the level spreaders were designed to accommodate the 10-year storm event, thereby eliminating the necessity of a high flow by-pass system (NCDWQ 2007). Filter strips are sections of vegetation designed to reduce pollutants in stormwater runoff before the runoff enters a steam. They remove pollutants from runoff by the filtering action of the vegetation, infiltration of pollutant-carrying water and sediment deposition. Properly constructed forested and grassed filter strips can be expected to remove a minimum of 25 to 40 percent of total suspended solids. The estimated removal rate is 30 to 42 percent for total phosphorous and 85 percent for total nitrogen though studies have shown their effectiveness to vary widely (USEPA 2007). In this application, the stabilized area will be the restored riparian buffer.

7.0 Performance Criteria

7.1 Streams

Success criteria need to be established to determine if the restoration project is meeting the designed goals and objectives. These will include changes in the dimension, pattern, profile, bed material, and vegetation over the 5-year monitoring period. Stream performance monitoring will be conducted following protocols outlined in the US Army Corps of Engineers Stream Mitigation Guidelines (April 2003).

7.1.1 Dimension

The stream cross section measurements should not significantly change from the baseline cross section. Minor adjustment in the cross section within specified tolerances of the construction documents is expected. The adjustment is due to the lack of precision of large heavy machinery. The lack of permanent vegetation can also contribute to adjustments in the channel dimension.

7.1.2 Pattern

The stability of stream pattern will be measured using stream sinuosity (the ratio of stream length divided by valley length or approximated by the ratio of valley slope divided by stream slope). If there is a significant change in sinuosity, then belt width, radius of curvature, and meander length will be evaluated to determine where the adjustment occurred that affected the sinuosity.

7.1.3 Profile

The channel profile is not expected to significantly change over the monitoring period. The baseline average water surface slope will be used as a measure of profile stability. The average water surface slope will be determined by taking water surface elevation readings at the beginning and the end of the monitored reach, at the same feature (head of riffle, head of pool, etc.), determining the elevation difference between the two and dividing the difference by the stream length between the two features.

Another measure of channel profile stability is pool-to-pool spacing. This is the stream distance between the same features on sequential pools. The measurements are usually taken between heads of pools. Baseline pool-to-pool spacing will be measured and recorded.

7.1.4 Material

Usually the particle size distribution of the bed material becomes coarser as a result of stream restoration. This is a result of adjusting the shear stress and stabilizing the existing stream banks. The change in the substrate material will be measured over the 5-year monitoring period.

7.1.5 Photo Points

Permanent photo points will be established on the site. The photographs should show the succession of vegetation growth and no significant changes in the stream configuration or structure stability.

7.2 Stormwater Management Devices

Stormwater management devices will be visually evaluated during the monitoring site visits. They will be inspected and any evidence of erosion, sediment build up, lack of vegetation establishment, vandalism will be noted. Water quality monitoring will not be performed.

7.3 Wetlands

Wetlands are not proposed on the site. Therefore, wetland monitoring is not required.

7.4 Vegetation

Vegetation monitoring protocol will follow the CVS-EEP Protocol for Recording Vegetation; Level 1-2 Plot Sampling Only, Version 4.0 (Lee et al., 2006). This protocol establishes monitoring plots based on the size of the buffer area planted and documents the development of the buffer.

Vegetation success criteria are based on the US Army Corps of Engineers Stream Mitigation Guidelines April 2003, which is the survival of at least 320 stems per acre through year 3; 288 stems per acre in year 4; and 260 stems per acre in year 5. Stems tallied on site will include all "Character Tree Species." Character Tree Species include all planted species and those listed by Schafale and Weakley (1990) as likely to occur in this forest type community.

As with most urban restoration projects, the presence of non-native, exotic vegetation is a concern. This vegetation typically responds well to disturbance and may affect planted vegetation success. To reduce the potential of non-native vegetation out-competing the desired species, existing non-native exotics within the proposed buffer will be removed during construction. Exotic trees and shrubs will be removed with construction equipment or cut and the stumps treated with an appropriate herbicide. The establishment of non-native vegetation during the monitoring period will also be monitored and remedial actions will be taken if deemed necessary to meet establish success criteria.

7.5 Schedule/Reporting

The baseline and all subsequent annual monitoring reports will be submitted to the NCEEP prior to November 1 of all monitoring years.

8.0 References

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Tables

**Table 1. Drainage Areas,
Project Number 060685501 (Little Alamance Creek)**

Reach	Drainage Area (Square Mile)
Little Alamance Creek	4.2
Unnamed Tributary	0.12
Total	4.2*

*Total drainage area for Little Alamance Creek measured at down stream end of project.

**Table 2. Land Use of Watershed,
Project Number 060685501 (Little Alamance Creek)**

Land Use	Acreage	Percentage
Urban Residential	2,150	80%
City streets, businesses, light industrial and natural/undeveloped areas	538	20%

TABLE 3: MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Adapted from Rosgen, 1996)

Restoration Site:	Little Alamance Creek, Burlington, NC									
Reference Reach:	Benbow Park, Park @ Friendly, Brown Branch u/s									
Variables	Existing Channel		Proposed Reach		Benbow Park Reference Reach		Park @ Friendly Reference Reach		Brown Branch u/s Reference Reach	
1. Stream Type		C/E5/1		C 4/1		C4		E4		C/E4
2. Drainage Area (sq. mi)		4.2		4.2		0.7		0.2		0.77
3. Bankfull Width (Wbkf) ft	Mean:	36.2	Mean:	36.2	Mean:	20.9	Mean:	9.5	Mean:	15.1
	Range:	31.8 - 42.5	Range:		Range:		Range:		Range:	
4. Bankfull Mean Depth (dbkf) ft	Mean:	2.6	Mean:	2.6	Mean:	1.7	Mean:	1.4	Mean:	1.6
	Range:	2.2 - 2.9	Range:		Range:		Range:		Range:	
5. Width/Depth Ratio (Wbkf/dbkf)	Mean:	14.0	Mean:	13.8	Mean:	12.4	Mean:	6.9	Mean:	9.3
	Range:	11.6 - 17.0	Range:		Range:		Range:		Range:	
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean:	95.0	Mean:	95.0	Mean:	35.3	Mean:	13.0	Mean:	24.3
	Range:	79.3 - 125.0	Range:		Range:		Range:		Range:	
7. Bankfull Mean Velocity (Vbkf) fps	Mean:	2.5	Mean:	2.5	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
8. Bankfull Discharge, cfs (Qbkf)	Mean:	237.5	Mean:	237.5	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
9. Maximum Bankfull Depth (dmax) ft	Mean:	4.0	Mean:	4.0	Mean:	3.1	Mean:	2.0	Mean:	2.6
	Range:	3.9 - 4.1	Range:	3.9 - 4.1	Range:		Range:		Range:	
10. Ratio of Low Bank Height to Max. Bankfull Depth (Bhlow/dmax)	Mean:	1.2	Mean:	1.0	Mean:	1.0	Mean:	1.4	Mean:	1.0
	Range:	1.0 - 1.4	Range:		Range:		Range:		Range:	
11. Width of Flood Prone Area (Wfpa) ft	Mean:	94.0	Mean:	> 80.0	Mean:	40.0	Mean:	30.0	Mean:	30.0
	Range:	70.0 - 120.0	Range:		Range:		Range:		Range:	
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean:	2.6	Mean:	> 2.2	Mean:	1.9	Mean:	3.2	Mean:	2.0
	Range:	2.1 - 3.8	Range:		Range:		Range:		Range:	
13. Meander Length (Lm) ft	Mean:	361.0	Mean:	361.0	Mean:	*	Mean:	*	Mean:	*
	Range:	227.0 - 559.0	Range:	227.0 - 559.0	Range:		Range:		Range:	
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean:	10.0	Mean:	10.0	Mean:	*	Mean:	*	Mean:	*
	Range:	6.3 - 15.4	Range:	6.3 - 15.4	Range:		Range:		Range:	
15. Raduis of Curvature (Rc) ft	Mean:	115.0	Mean:	115.0	Mean:	*	Mean:	*	Mean:	*
	Range:	45.0 - 220.0	Range:	45.0 - 220.0	Range:		Range:		Range:	
16. Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf)	Mean:	3.2	Mean:	3.2	Mean:	*	Mean:	*	Mean:	*
	Range:	1.2-6.1	Range:	1.2-6.1	Range:		Range:		Range:	
17. Belt Width (Wblt) ft	Mean:	70.0	Mean:	70	Mean:	*	Mean:	*	Mean:	*
	Range:	33.0 - 255.0	Range:	33.0 - 255.0	Range:		Range:		Range:	
18. Meander Width Ratio (Wblt/Wbkf)	Mean:	1.9	Mean:	1.9	Mean:	*	Mean:	*	Mean:	*
	Range:	0.9 - 7.0	Range:	0.9 - 7.0	Range:		Range:		Range:	

19. Sinuosity (Stream length/valley distance) (k)	Mean:	1.2	Mean:	1.2	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
20. Valley Slope (ft/ft)	Mean:	0.0028	Mean:	0.0028	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
21. Average Water Surface Slope or Bankful Slope for Reach (Sbkf or Savg)=(Svalley/k) ft / ft	Mean:	0.0024	Mean:	0.0024	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
22. Pool Slope (Spool) ft / ft	Mean:	0.0005	Mean:	0.0	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 0.0015	Range:		Range:		Range:		Range:	
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean:	0.2	Mean:	0.0	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 0.6	Range:		Range:		Range:		Range:	
24. Maximum Pool Depth (dpool) ft	Mean:	6.1	Mean:	6.1	Mean:	*	Mean:	*	Mean:	*
	Range:	5.5 - 6.9	Range:	5.5 - 6.9	Range:		Range:		Range:	
25. Ratio of Maximum Pool Depth to Bankfull Mean Depth (dpool/dbkf)	Mean:	2.3	Mean:	2.3	Mean:	*	Mean:	*	Mean:	*
	Range:	2.1 - 2.7	Range:	2.1 - 2.7	Range:		Range:		Range:	
26. Pool Width (Wpool) ft	Mean:	37.6	Mean:	37.6	Mean:	*	Mean:	*	Mean:	*
	Range:	32.3 - 42.3	Range:	32.3 - 42.3	Range:		Range:		Range:	
27. Ratio of Pool Width to Bankfull Width (Wpool/Wbkf)	Mean:	1.0	Mean:	1.0	Mean:	*	Mean:	*	Mean:	*
	Range:	0.9 - 1.2	Range:	0.9 - 1.2	Range:		Range:		Range:	
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean:	140.2	Mean:	140.2	Mean:	*	Mean:	*	Mean:	*
	Range:	121.0 - 156.6	Range:	121.0 - 156.6	Range:		Range:		Range:	
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean:	1.0	Mean:	1.0	Mean:	*	Mean:	*	Mean:	*
	Range:	1.3 - 1.7	Range:	1.3 - 1.7	Range:		Range:		Range:	
30. Pool to Pool Spacing (p-p) ft	Mean:	473.1	Mean:	473.1	Mean:	*	Mean:	*	Mean:	*
	Range:	313.7 - 749.5	Range:	313.7 - 749.5	Range:		Range:		Range:	
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/Wbkf)	Mean:	13.1	Mean:	13.1	Mean:	*	Mean:	*	Mean:	*
	Range:	8.7 - 20.7	Range:	8.7 - 20.7	Range:		Range:		Range:	
32. Pool Length (Lp) ft	Mean:	293.7	Mean:	293.7	Mean:	*	Mean:	*	Mean:	*
	Range:	107.9 - 505.4	Range:	107.9 - 505.4	Range:		Range:		Range:	
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean:	8.1	Mean:	8.1	Mean:	*	Mean:	*	Mean:	*
	Range:	3.0 - 14.0	Range:	3.0 - 14.0	Range:		Range:		Range:	
34. Riffle Slope (Sriff) ft / ft	Mean:	0.0126	Mean:	0.0126	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0028 - 0.0254	Range:	0.0028 - 0.0254	Range:		Range:		Range:	
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean:	5.2	Mean:	5.2	Mean:	*	Mean:	*	Mean:	*
	Range:	1.2 - 10.6	Range:	1.2 - 10.6	Range:		Range:		Range:	
36. Maximum Riffle Depth (driff) ft	Mean:	4.0	Mean:	4.0	Mean:	*	Mean:	*	Mean:	*
	Range:	3.9 - 4.1	Range:	3.9 - 4.1	Range:		Range:		Range:	
37. Ratio of Riffle Depth to Bankfull Mean Depth (driff/dbkf)	Mean:	1.5	Mean:	1.5	Mean:	*	Mean:	*	Mean:	*
	Range:	1.5 - 1.6	Range:	1.5 - 1.6	Range:		Range:		Range:	
38. Run Slope (Srun) ft / ft	Mean:	0.0032	Mean:	0.0032	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 0.0090	Range:	0.0 - 0.0090	Range:		Range:		Range:	

39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean:	1.3	Mean:	1.3	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 3.7	Range:	0.0 - 3.7	Range:		Range:		Range:	
40. Maximum Run Depth (drun) ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
41. Ratio of Run Depth to Bankfull Mean Depth (drun/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
42. Slope of Glide (Sgl) ft / ft	Mean:	0.0039	Mean:	0.0039	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 0.0107	Range:	0.0 - 0.0107	Range:		Range:		Range:	
43. Ratio of Glide Slope to Average Water Surface Slope (Sgl/Sws)	Mean:	1.6	Mean:	1.6	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 4.5	Range:	0.0 - 4.5	Range:		Range:		Range:	
44. Maximum Glide Depth (dgl) ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
45. Ratio of Glide Depth to Bankfull Mean Depth (dgl/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
46. Step Slope (Sst)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
47. Ratio of Step Slope to Average Water Surface Slope (Sst/Savg)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
48. Maximum Step Depth (dst)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
49. Ratio of Step Depth to Bankfull Mean Depth (dst/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

Materials:					
Particle Size Distribution of Channel Material (mm)					
D16		0.2	*	*	*
D35		0.7	*	*	*
D50		2.4	*	*	*
D84		138.0	*	*	*
D95		216.0	*	*	*
Particle Size Distribution of Bar Material	P	SP			
D16	15.0	<2	*	*	*
D35	22.4	<2	*	*	*
D50	29.8	<2	*	*	*
D84	99.6	17.9	*	*	*
D95	118.4	81.9	*	*	*
Largest Size Particle on Bar	80.0		*	*	*

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

Sediment Transport:

Sediment Transport Validation (Based on Bankfull Shear Stress)	**Existing**	**Proposed**
Calculated value (mm) from curve	30	30
Value from Shields Curve (lb/ft2)	0.43	0.43
Critical dimensionless shear stress	0.021	0.021
Minimal mean dbkf (ft) calculated using critical dimensionless shear stress equations	1.6	1.6

TABLE 4: MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH GAGE STATION AND REFERENCE REACH DATA (Adapted from Rosgen, 1996)

Restoration Site: UT to Little Alamance Creek, Burlington, NC

Reference Reach: Benbow Park, Park @ Friendly, Brown Branch u/s

Variables	Existing Channel		Proposed Reach		Benbow Park Reference Reach		Park @ Friendly Reference Reach		Brown Branch u/s Reference Reach	
1. Stream Type	E4/1		C 4/1		C4		E4		C/E4	
2. Drainage Area (sq. mi)	0.12		0.12		0.7		0.2		0.77	
3. Bankfull Width (Wbkf) ft	Mean:	12.0	Mean:	12.0	Mean:	20.9	Mean:	9.5	Mean:	15.1
	Range:	10.9 - 13.0	Range:	10.9 - 13.0	Range:		Range:		Range:	
4. Bankfull Mean Depth (dbkf) ft	Mean:	1.3	Mean:	1.3	Mean:	1.7	Mean:	1.4	Mean:	1.6
	Range:	1.1 - 1.5	Range:	1.1 - 1.5	Range:		Range:		Range:	
5. Width/Depth Ratio (Wbkf/dbkf)	Mean:	9.3	Mean:	9.3	Mean:	12.4	Mean:	6.9	Mean:	9.3
	Range:	7.1 - 11.5	Range:	7.1 - 11.5	Range:		Range:		Range:	
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean:	15.8	Mean:	15.8	Mean:	35.3	Mean:	13.0	Mean:	24.3
	Range:	14.8 - 16.7	Range:	14.8 - 16.7	Range:		Range:		Range:	
7. Bankfull Mean Velocity (Vbkf) fps	Mean:	4.4	Mean:	4.4	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
8. Bankfull Discharge, cfs (Qbkf)	Mean:	68.7	Mean:	68.7	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
9. Maximum Bankfull Depth (dmax) ft	Mean:	2.0	Mean:	2.0	Mean:	3.1	Mean:	2.0	Mean:	2.6
	Range:	2.0 - 2.1	Range:	2.0 - 2.1	Range:		Range:		Range:	
10. Ratio of Low Bank Height to Max. Bankfull Depth (Bhlow/dmax)	Mean:	1.2	Mean:	1.0	Mean:	1.0	Mean:	1.4	Mean:	1.0
	Range:	1.0 - 1.3	Range:		Range:		Range:		Range:	
11. Width of Flood Prone Area (Wfpa) ft	Mean:	33.5	Mean:	33.5	Mean:	40.0	Mean:	30.0	Mean:	30.0
	Range:	27.0 - 40.0	Range:	27.0 - 40.0	Range:		Range:		Range:	
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean:	2.9	Mean:	2.9	Mean:	1.9	Mean:	3.2	Mean:	2.0
	Range:	2.1 - 3.7	Range:	2.1 - 3.7	Range:		Range:		Range:	
13. Meander Length (Lm) ft	Mean:	83.9	Mean:	83.9	Mean:	*	Mean:	*	Mean:	*
	Range:	55.8 - 111.9	Range:	55.8 - 111.9	Range:		Range:		Range:	
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean:	7.0	Mean:	7.0	Mean:	*	Mean:	*	Mean:	*
	Range:	4.7 - 9.3	Range:	4.7 - 9.3	Range:		Range:		Range:	
15. Raduis of Curvature (Rc) ft	Mean:	29.0	Mean:	29.0	Mean:	*	Mean:	*	Mean:	*
	Range:	15.0 - 55.0	Range:	15.0 - 55.0	Range:		Range:		Range:	
16. Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf)	Mean:	2.4	Mean:	2.4	Mean:	*	Mean:	*	Mean:	*
	Range:	1.2 - 4.6	Range:	1.2 - 4.6	Range:		Range:		Range:	
17. Belt Width (Wblt) ft	Mean:	24.6	Mean:	24.6	Mean:	*	Mean:	*	Mean:	*
	Range:	13.5 - 33.7	Range:	13.5 - 33.7	Range:		Range:		Range:	
18. Meander Width Ratio (Wblt/Wbkf)	Mean:	2.0	Mean:	2.0	Mean:	*	Mean:	*	Mean:	*
	Range:	1.1 - 2.8	Range:	1.1 - 2.8	Range:		Range:		Range:	

19. Sinuosity (Stream length/valley distance) (k)	Mean:	1.1	Mean:	1.1	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
20. Valley Slope (ft/ft)	Mean:	0.0106	Mean:	0.0106	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
21. Average Water Surface Slope or Bankful Slope for Reach (Sbkf or Savg)=(Svalley/k) ft / ft	Mean:	0.0095	Mean:	0.0095	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
22. Pool Slope (Spool) ft / ft	Mean:	0.0077	Mean:	0.0077	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 0.0174	Range:	0.0 - 0.0174	Range:		Range:		Range:	
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean:	0.8	Mean:	0.8	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0 - 1.8	Range:	0.0 - 1.8	Range:		Range:		Range:	
24. Maximum Pool Depth (dpool) ft	Mean:	2.4	Mean:	2.4	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
25. Ratio of Maximum Pool Depth to Bankfull Mean Depth (dpool/dbkf)	Mean:	1.8	Mean:	1.8	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
26. Pool Width (Wpool) ft	Mean:	6.1	Mean:	6.1	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
27. Ratio of Pool Width to Bankfull Width (Wpool/Wbkf)	Mean:	0.5	Mean:	0.5	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean:	9.5	Mean:	9.5	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean:	0.6	Mean:	0.6	Mean:	*	Mean:	*	Mean:	*
	Range:		Range:		Range:		Range:		Range:	
30. Pool to Pool Spacing (p-p) ft	Mean:	34.1	Mean:	34.1	Mean:	*	Mean:	*	Mean:	*
	Range:	23.4 - 54.8	Range:	23.4 - 54.8	Range:		Range:		Range:	
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/Wbkf)	Mean:	2.8	Mean:	2.8	Mean:	*	Mean:	*	Mean:	*
	Range:	2.0 - 4.6	Range:	2.0 - 4.6	Range:		Range:		Range:	
32. Pool Length (Lp) ft	Mean:	18.2	Mean:	18.2	Mean:	*	Mean:	*	Mean:	*
	Range:	4.0 - 163.0	Range:	4.0 - 163.0	Range:		Range:		Range:	
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean:	1.5	Mean:	1.5	Mean:	*	Mean:	*	Mean:	*
	Range:	0.3 - 13.6	Range:	0.3 - 13.6	Range:		Range:		Range:	
34. Riffle Slope (Sriff) ft / ft	Mean:	0.0252	Mean:	0.0252	Mean:	*	Mean:	*	Mean:	*
	Range:	0.0145 - 0.0498	Range:	0.0145 - 0.0498	Range:		Range:		Range:	
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean:	2.6	Mean:	2.6	Mean:	*	Mean:	*	Mean:	*
	Range:	1.5 - 5.2	Range:	1.5 - 5.2	Range:		Range:		Range:	
36. Maximum Riffle Depth (driff) ft	Mean:	2.0	Mean:	2.0	Mean:	*	Mean:	*	Mean:	*
	Range:	2.0-2.1	Range:	2.0-2.1	Range:		Range:		Range:	
37. Ratio of Riffle Depth to Bankfull Mean Depth (driff/dbkf)	Mean:	1.6	Mean:	1.6	Mean:	*	Mean:	*	Mean:	*
	Range:	1.5 - 1.6	Range:	1.5 - 1.6	Range:		Range:		Range:	
38. Run Slope (Srun) ft / ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	

39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
40. Maximum Run Depth (drun) ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
41. Ratio of Run Depth to Bankfull Mean Depth (drun/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
42. Slope of Glide (Sgl) ft / ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
43. Ratio of Glide Slope to Average Water Surface Slope (Sgl/Sws)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
44. Maximum Glide Depth (dgl) ft	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
45. Ratio of Glide Depth to Bankfull Mean Depth (dgl/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
46. Step Slope (Sst)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
47. Ratio of Step Slope to Average Water Surface Slope (Sst/Savg)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
48. Maximum Step Depth (dst)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	
49. Ratio of Step Depth to Bankfull Mean Depth (dst/dbkf)	Mean:	N/A	Mean:	N/A	Mean:	*	Mean:	*	Mean:	*
	Range:	N/A	Range:	N/A	Range:		Range:		Range:	

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

Materials:

Particle Size Distribution of Channel Material (mm)					
D16		0.2	*	*	*
D35		0.5	*	*	*
D50		3.4	*	*	*
D84		19.0	*	*	*
D95		53.0	*	*	*
Particle Size Distribution of Bar Material	P	SP			
D16	7.6	<2	*	*	*
D35	12.4	4.5	*	*	*
D50	17.8	10.0	*	*	*
D84	40.7	54.4	*	*	*
D95	55.6	96.7	*	*	*
Largest Size Particle on Bar	48.0		*	*	*

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

Sediment Transport: Sediment Transport Validation (Based on Bankfull Shear Stress)	**Existing**	**Proposed**
Calculated value (mm) from curve	55	55
Value from Shields Curve (lb/ft2)	0.71	0.71
Critical dimensionless shear stress	0.016	0.016
Minimal mean dbkf (ft) calculated using critical dimensionless shear stress equations	0.4	0.4

Table 5a. Substrate Particle Size Distribution of Little Alamance Creek

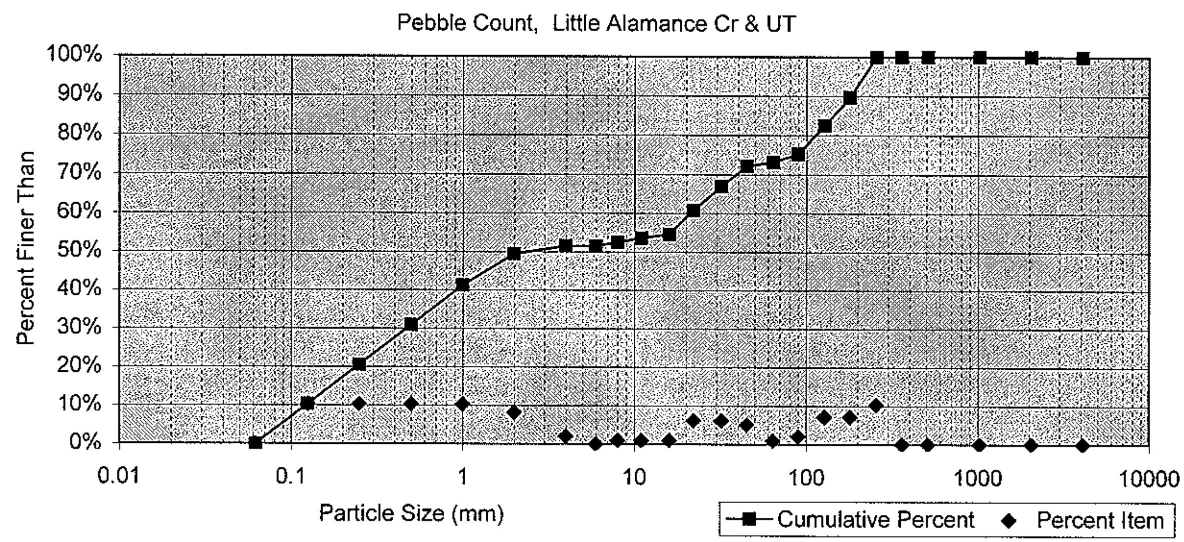
Pebble Count

Material	Size Range (mm)		Count	
silt/clay	0	0.062		# #
very fine sand	0.062	0.13	**10**	# #
fine sand	0.13	0.25	**10**	# #
medium sand	0.25	0.5	**10**	# #
coarse sand	0.5	1	**10**	# #
very coarse sand	1	2	**8**	# #
very fine gravel	2	4	**2**	# #
fine gravel	4	6		# #
fine gravel	6	8	**1**	# #
medium gravel	8	11	**1**	# #
medium gravel	11	16	**1**	# #
coarse gravel	16	22	**6**	# #
coarse gravel	22	32	**6**	# #
very coarse gravel	32	45	**5**	# #
very coarse gravel	45	64	**1**	# #
small cobble	64	90	**2**	# #
medium cobble	90	128	**7**	# #
large cobble	128	180	**7**	# #
very large cobble	180	256	**10**	# #
small boulder	256	362		# #
small boulder	362	512		# #
medium boulder	512	1024		# #
large boulder	1024	2048		# #
very large boulder	2048	4096		# #
bedrock			**1**	#
	Total Particle Count:		98	

Pebble Count,

	Little Alamance Cr & UT

	Burlington
Note:	**Main Channel 85% pool 15% riffle**



Size percent less than (mm)				
D16	D35	D50	D84	D95
0.183	0.66	2.4	138	216

Percent by substrate type					
silt/clay	sand	gravel	cobble	boulder	bedrock
0%	49%	23%	27%	0%	1%

Table 5b. Substrate Particle-Size Distribution of UT to Little Alamance Creek

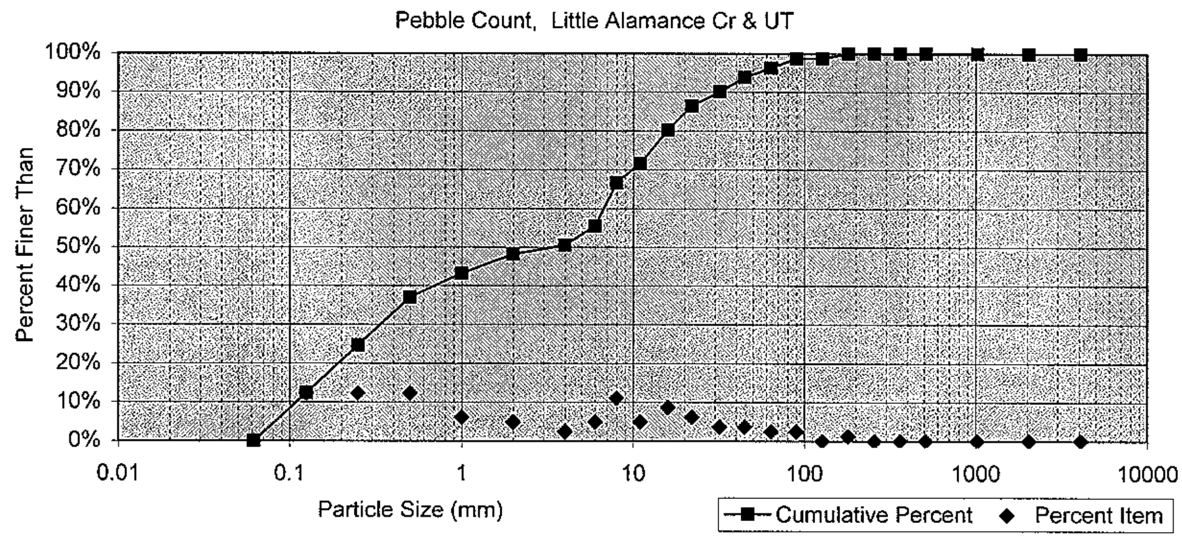
Pebble Count

Material	Size Range (mm)		Count	
silt/clay	0	0.062		# #
very fine sand	0.062	0.13	**10**	# #
fine sand	0.13	0.25	**10**	# #
medium sand	0.25	0.5	**10**	# #
coarse sand	0.5	1	**5**	# #
very coarse sand	1	2	**4**	# #
very fine gravel	2	4	**2**	# #
fine gravel	4	6	**4**	# #
fine gravel	6	8	**9**	# #
medium gravel	8	11	**4**	# #
medium gravel	11	16	**7**	# #
coarse gravel	16	22	**5**	# #
coarse gravel	22	32	**3**	# #
very coarse gravel	32	45	**3**	# #
very coarse gravel	45	64	**2**	# #
small cobble	64	90	**2**	# #
medium cobble	90	128		# #
large cobble	128	180	**1**	# #
very large cobble	180	256		# #
small boulder	256	362		# #
small boulder	362	512		# #
medium boulder	512	1024		# #
large boulder	1024	2048		# #
very large boulder	2048	4096		# #
bedrock			**19**	#
Total Particle Count:			100	

Pebble Count,

	Little Alamance Cr & UT

	Burlington
Note:	**Pebble Count for UT 85% Pool, 15% Riffle**



Size percent less than (mm)					Percent by substrate type					
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder	bedrock
0.153	0.45	3.4	19	53	0%	39%	39%	3%	0%	19%

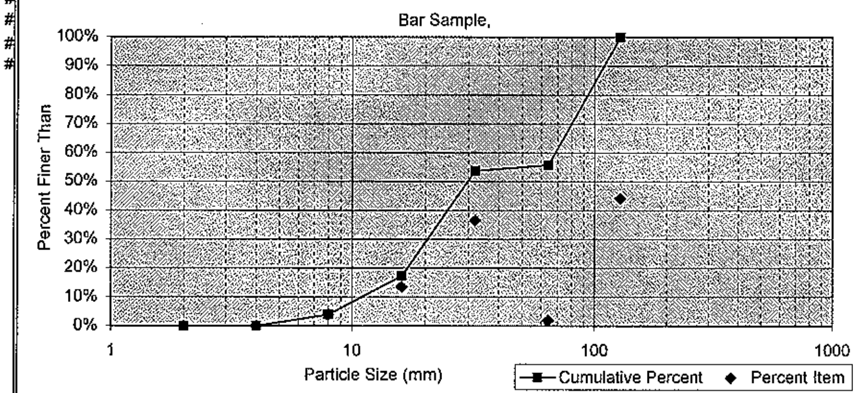
Table 6a. Pavement and Sub-pavement Particle Size Distribution of Little Alamance Creek

Bar Sample

Material	Size Range (mm)		Count
sand	<	2	0
very fine gravel	2	4	0
fine gravel	4	8	2
medium gravel	8	16	7
coarse gravel	16	32	19
very coarse gravel	32	64	1
small cobble	64	128	23
		Total Particle Count:	52

Bar Sample,
Little Alamance Cr & UT

Burlington
Note: **Pavement - Little Alamance Cr @ cross section 11-RF**



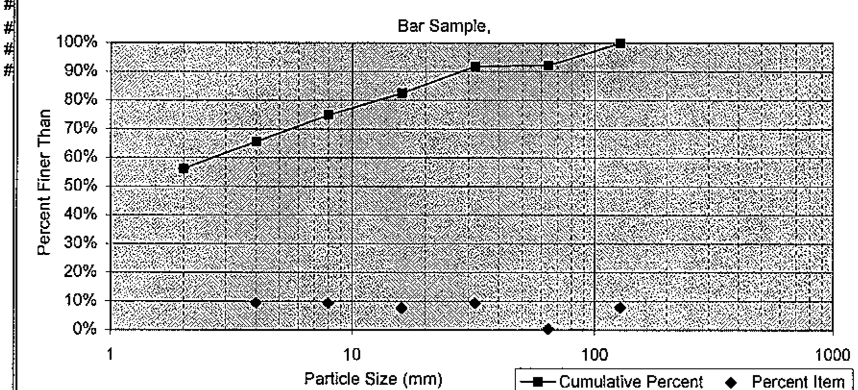
Size percent less than (mm)					Percent by substrate type				
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder
14.958	22.38	29.75	99.61	118.35	NA	0%	56%	44%	NA

Bar Sample

Material	Size Range (mm)		Count
sand	<	2	282
very fine gravel	2	4	47
fine gravel	4	8	47
medium gravel	8	16	38
coarse gravel	16	32	47
very coarse gravel	32	64	2
small cobble	64	128	39
		Total Particle Count:	502

Bar Sample,
Little Alamance Cr & UT

Burlington
Note: **Subpavement - Little Alamance Cr. @ x-sect 11-RF hit clay at 145mm**



Size percent less than (mm)					Percent by substrate type				
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder
#N/A	#N/A	#N/A	17.92	81.94	NA	56%	36%	8%	NA

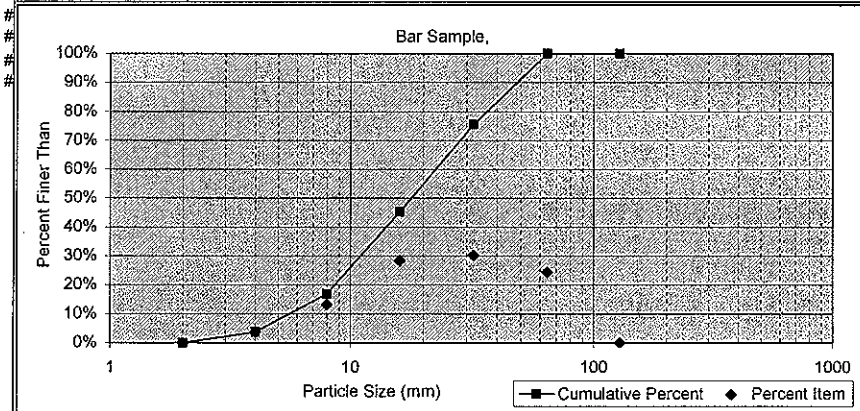
Table 6b. Pavement and Sub-pavement Particle Size Distribution of UT to Little Alamance Creek

Bar Sample

Bar Sample,
Little Alamance Cr & UT

Burlington
Note: **Pavement - UT to Little Alamance b/w x-sect 3 & 4**

Material	Size Range (mm)		Count
sand	<	2	0
very fine gravel	2	4	2
fine gravel	4	8	7
medium gravel	8	16	15
coarse gravel	16	32	16
very coarse gravel	32	64	13
small cobble	64	128	0
		Total Particle Count:	53



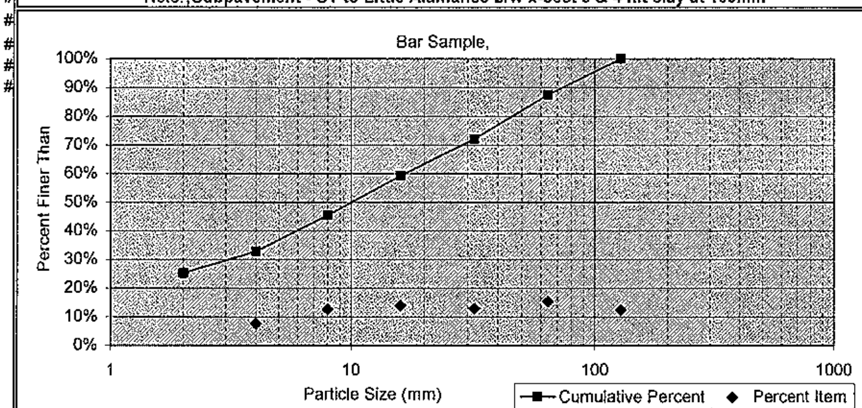
Size percent less than (mm)					Percent by substrate type				
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder
7.598	12.44	17.83	40.72	55.57	NA	0%	100%	0%	NA

Bar Sample

Bar Sample,
Little Alamance Cr & UT

Burlington
Note: **Subpavement - UT to Little Alamance b/w x-sect 3 & 4 hit clay at 100mm**

Material	Size Range (mm)		Count
sand	<	2	100
very fine gravel	2	4	30
fine gravel	4	8	50
medium gravel	8	16	55
coarse gravel	16	32	51
very coarse gravel	32	64	61
small cobble	64	128	49
		Total Particle Count:	396



Size percent less than (mm)					Percent by substrate type				
D16	D35	D50	D84	D95	silt/clay	sand	gravel	cobble	boulder
#N/A	4.51	10.04	54.36	96.73	NA	25%	62%	12%	NA

Table 7. Soils Summary of the Little Alamance Creek Stream Restoration Project, Alamance County

Map Unit	Soil Series	Slope	Drainage	General Characteristics
CbC2	Cecil fine sandy loam	2-6%	Well drained	Cecil series consists of very deep, moderately permeable soils on ridges and side slopes of the Piedmont uplands. They are deep to saprolite and very deep to bedrock.
EdB2	Enon fine sandy loam	2-6%	Well drained	Enon Series consists of very deep, slowly permeable soils on ridge tops and side slopes in the Piedmont.
LbB2	Lloyd loam	2-6%	Well drained	Lloyd series consists of very deep, moderately permeable soils on uplands in the Southern Piedmont.
Ur	Urban land			Consists of areas more than 85 percent of which are covered with street, buildings of all types, parking lots, railroad yards, and airports. The natural soils were greatly altered by cutting, filling, grading and shaping during the processes of urbanization. The original landscape, topography, and commonly the drainage pattern have been changed.

Source: NRCS Official Soil Series Descriptions (OSD) webpage

Table 8. Federal Species of Concern Known from Alamance County, North Carolina

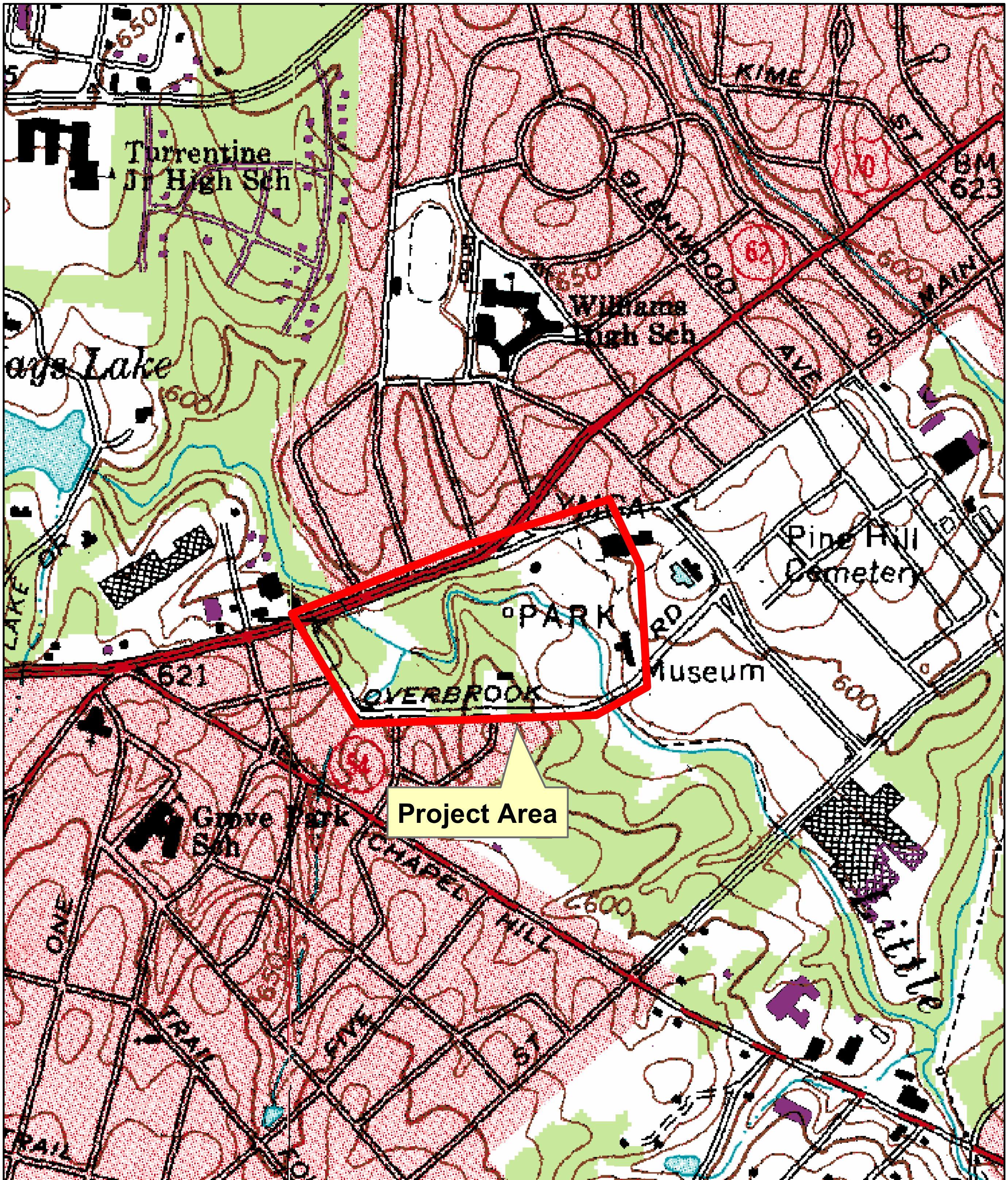
Common Name	Scientific Name	Federal Status	State Status	Habitat Requirements	Habitat Available
Vertebrates					
American Eel	*Anguilla rostrata*	FSC	None	Catadramous species, adults live in large rivers or lakes	No
Carolina darter	*Etheostoma collis lepidinion*	FSC	None	Small upland creeks with slow to moderate current and substrate of sand, gravel, or bedrock	Yes
Invertebrates					
Carolina creekshell	*Villosa vaughaniana*	FSC	E	Muddy or silty gravel in shallow waters	Yes
Yellow lampmussel	*Lampsilis cariosa*	FSC	E	Large rivers and streams found in sand and gravel	No
Vascular Plants					
Buttercup phacelia	*Phacelia covillei*	FSC	SR-T	Floodplains and adjacent forests	Yes
Sweet pinesap	*Monotropsis odorata*	FSC	SR-T	Pine woods	No

Status: E – Endangered
FSC – Federal species of concern
PE – Proposed endangered
SR – Significantly rare
-T – Throughout their range

Table 9. Project Restoration Structure and Objectives,
Project Number 060685501 (Little Alamance Creek)

Restoration Segment / Reach ID	Station Range	Restoration Type	Priority Approach	Existing Linear Footage or Acreage	Designed Linear Footage or Acreage	Comment
Reach I	10+00 – 27+83	Enhancement I	P2	1,783 lf	1,783 lf	Modifying channel dimension and profile with structure placement.
Reach II	27+83 – 29+45	Restoration	P2	160 lf	162 lf	Reach II consists of realigning the stream and removing a center bar.
Reach II	29+45– 36+32	Enhancement I	P2	687	687 lf	Modifying channel dimension and profile with structure placement.
Reach I - Trib	10+00 – 14+22	Enhancement I	P2	422	422 lf	Modifying channel dimension and profile with structure placement.

Figures



Prepared For:

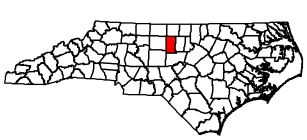
Ecosystem Enhancement PROGRAM

0 0.05 0.1 0.2 0.3 0.4 Miles

0 410 820 1,640 2,460 3,280 Feet

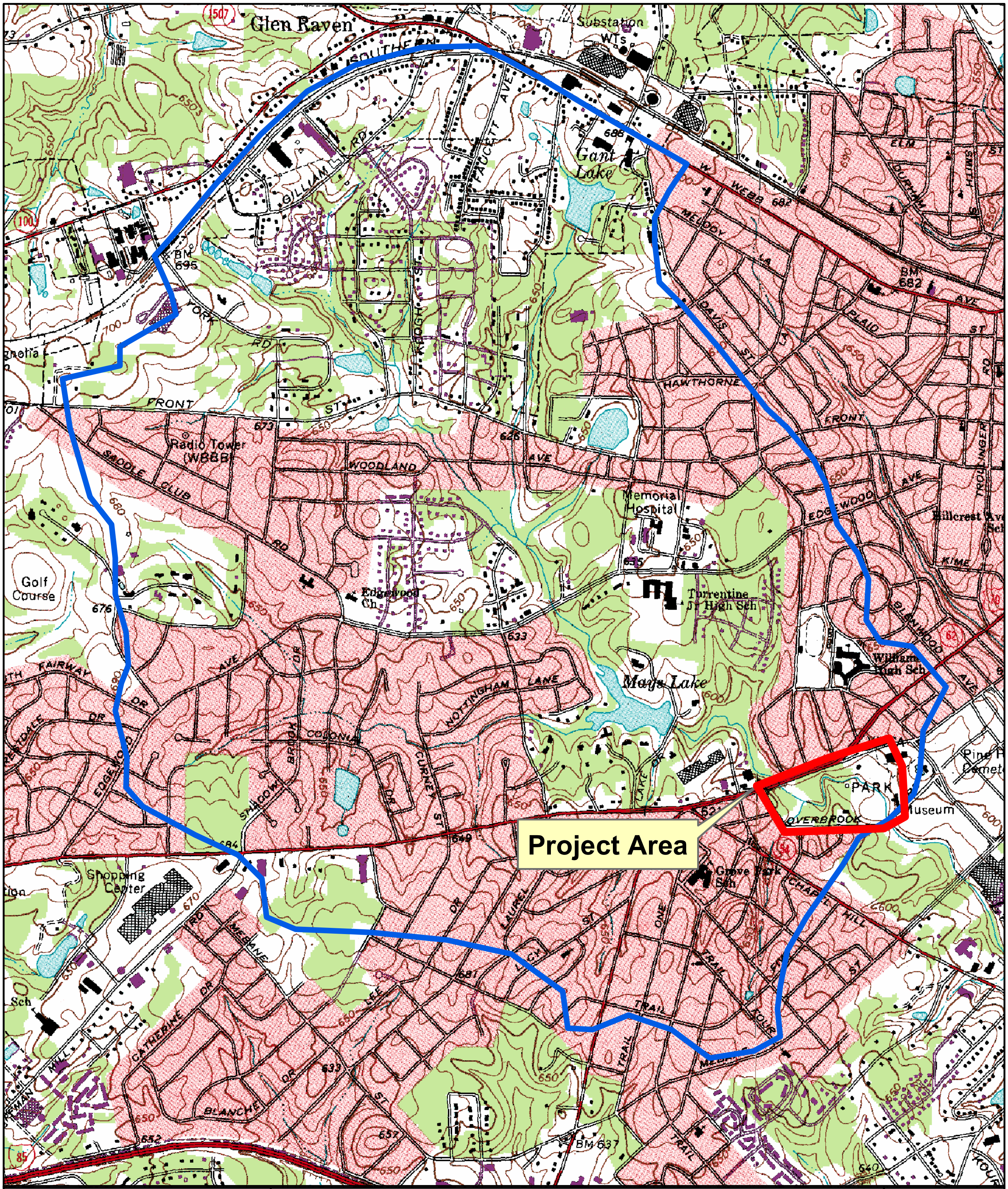
SCALE: 1:10,000

N W E S



PROJECT SITE VICINITY MAP
Little Alamance Creek Stream Restoration
ALAMANCE COUNTY, NORTH CAROLINA

Figure No.
1



Prepared For:

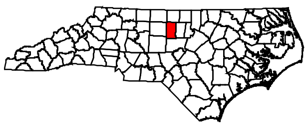
Ecosystem Enhancement PROGRAM

0 0.125 0.25 0.5 0.75 1 Miles

0 950 1,900 3,800 5,700 7,600 Feet

SCALE: 1:24,000

N W E S



DRAINAGE AREA MAP
Little Alamance Creek Stream Restoration
ALAMANCE COUNTY, NORTH CAROLINA

Figure No.
2

Prepared For:

Ecosystem Enhancement Program

0 105 210 420 630 840 Feet

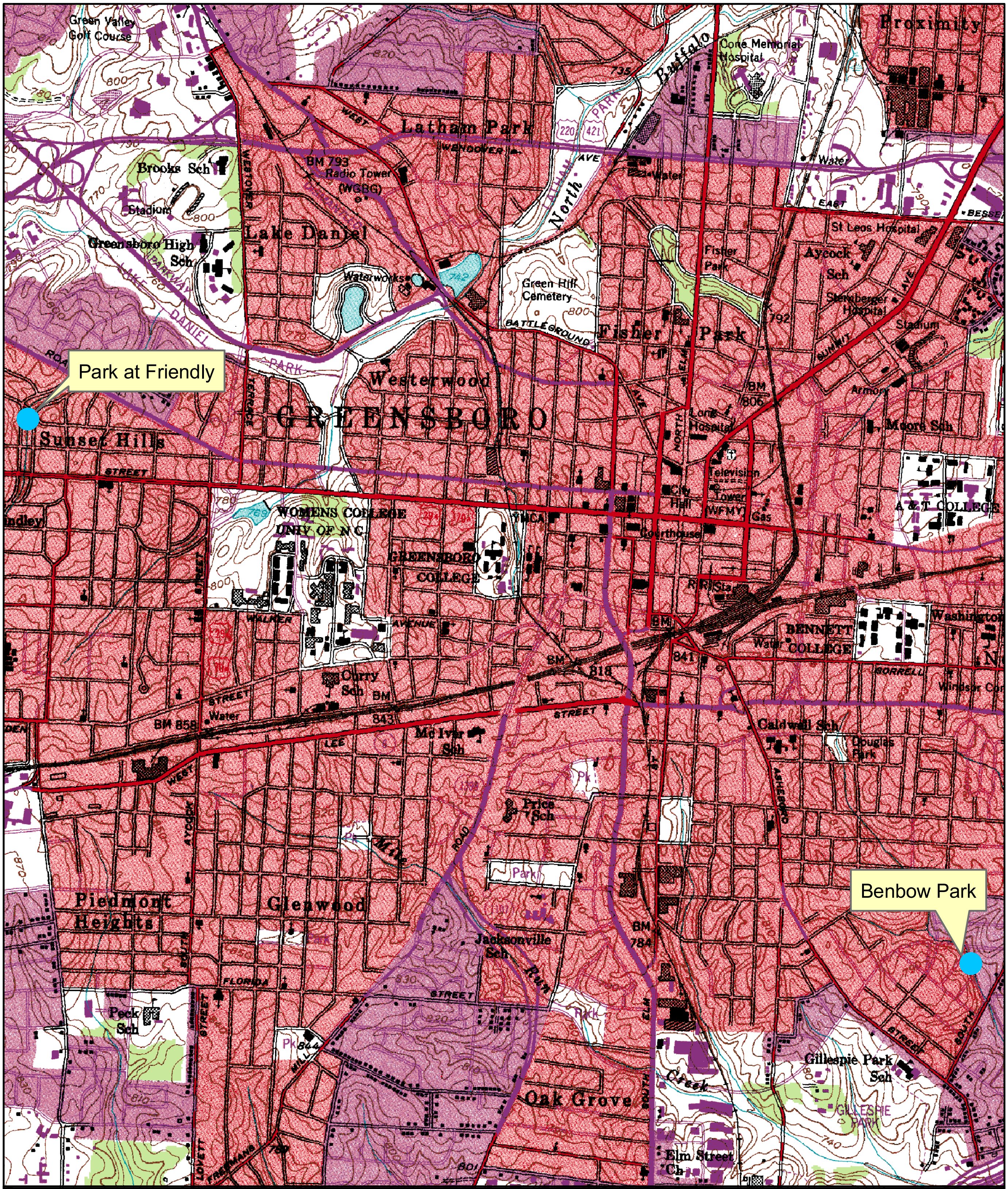
SCALE: 1:2,400

Source: Soil Survey Alamance County (1901)

SOILS MAP
Little Alamance Creek Stream Restoration
ALAMANCE COUNTY, NORTH CAROLINA

N W E S

Figure No. 3



Prepared For:

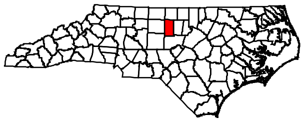
Ecosystem Enhancement Program

0 0.125 0.25 0.5 0.75 1 Miles

0 1,050 2,100 4,200 6,300 8,400 Feet

SCALE: 1:26,000

N W E S



REFERENCE REACH

Little Alamance Creek Stream Restoration

ALAMANCE COUNTY, NORTH CAROLINA

Figure No.

4

Appendix A

Project Site Photographs


Little Alamance Creek looking downstream from S Church Street. Note pedestrian bridge.

Little Alamance Creek at the confluence with the Unnamed Tributary


One of several culverts entering Little Alamance Creek. Note Rip rap banks.


One of two train trestles crossing Little Alamance Creek.

Second train trestle crossing Little Alamance Creek. Pedestrian/vehicle bridge can be seen in the background.

Sewer line and pedestrian/vehicle bridge crossing Little Alamance Creek


Little Alamance Creek with center bar.


Second sewer line crossing Little Alamance Creek.


Typical section of Little Alamance Creek.


Little Alamance Creek downstream end of project at Overbrook Road.


Unnamed tributary to Little Alamance Creek.

Appendix B

Project Site NCDWQ Stream Classification Forms

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 4/2/07	**Project:** Little Alamance Cr	**Latitude:**
Evaluator: RSC, BNF	**Site:** City Park	**Longitude:**
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 47.5	**County:** Alamance	**Other** *e.g. Quad Name:* Burlington

A. Geomorphology (Subtotal = 26.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	**3**
2. Sinuosity	0	1	2	**3**
3. In-channel structure: riffle-pool sequence	0	1	**2**	3
4. Soil texture or stream substrate sorting	0	1	**2**	3
5. Active/relic floodplain	0	1	2	**3**
6. Depositional bars or benches	0	1	2	**3**
7. Braided channel	0	**1**	2	3
8. Recent alluvial deposits	0	1	2	**3**
9[a] Natural levees	0	**1**	2	3
10. Headcuts	**0**	1	2	3
11. Grade controls	0	0.5	**1**	1.5
12. Natural valley or drainageway	0	0.5	1	**1.5**
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	No = 0		**Yes = 3**	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 10)	Absent	Weak	Moderate	Strong
14. Groundwater flow/discharge	0	1	2	**3**
15. Water in channel and > 48 hrs since rain, **or** Water in channel – dry or growing season	0	1	2	**3**
16. Leaflitter	**1.5**	1	0.5	0
17. Sediment on plants or debris	0	0.5	**1**	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	1	**1.5**
19. Hydric soils (redoximorphic features) present?	**No = 0**		Yes = 1.5	

C. Biology (Subtotal = 11)	Absent	Weak	Moderate	Strong
20[b]. Fibrous roots in channel	**3**	2	1	0
21[b]. Rooted plants in channel	**3**	2	1	0
22. Crayfish	0	**0.5**	1	1.5
23. Bivalves	**0**	1	2	3
24. Fish	0	0.5	1	**1.5**
25. Amphibians	0	0.5	[illegible]	**1.5**
26. Macrobenthos (note diversity and abundance)	0	0.5	**1**	1.5
27. Filamentous algae; periphyton	**0**	1	2	3
28. Iron oxidizing bacteria/fungus.	**0**	0.5	1	1.5
29[b]. Wetland plants in streambed	**FAC = 0.5**; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Fish + turtles observed in channel.
Few macrobenthos.
Rip rap in several locations.

Sketch:

North Carolina Division of Water Quality – Stream Identification Form; Version 3.1

Date: 4/2/07	Project: UT to Little Alamance	Latitude:
Evaluator: RSL, BNF	Site: City Park	Longitude:
Total Points: *Stream is at least intermittent if ≥ 19 or perennial if ≥ 30* 33	County: Alamance	Other *e.g. Quad Name*: Burlington

A. Geomorphology (Subtotal = 19.5)	Absent	Weak	Moderate	Strong
1[a]. Continuous bed and bank	0	1	2	**3**
2. Sinuosity	0	1	**2**	3
3. In-channel structure: riffle-pool sequence	0	1	**2**	3
4. Soil texture or stream substrate sorting	0	1	**2**	3
5. Active/relic floodplain	0	1	**2**	3
6. Depositional bars or benches	0	1	**2**	3
7. Braided channel	**0**	1	2	3
8. Recent alluvial deposits	0	1	**2**	3
9[a] Natural levees	0	**1**	2	3
10. Headcuts	0	**1**	2	3
11. Grade controls	0	0.5	**1**	1.5
12. Natural valley or drainageway	0	0.5	1	**1.5**
13. Second or greater order channel on existing USGS or NRCS map or other documented evidence.	**No = 0**		Yes = 3	

[a] Man-made ditches are not rated; see discussions in manual

B. Hydrology (Subtotal = 7.5)				
14. Groundwater flow/discharge	0	**1**	2	3
15. Water in channel and > 48 hrs since rain, **or** Water in channel – dry or growing season	0	1	2	**3**
16. Leaflitter	**1.5**	1	0.5	0
17. Sediment on plants or debris	0	0.5	**1**	1.5
18. Organic debris lines or piles (Wrack lines)	0	0.5	**1**	1.5
19. Hydric soils (redoximorphic features) present?	**No = 0**		Yes = 1.5	

C. Biology (Subtotal = 6)				
20[b]. Fibrous roots in channel	3	**2**	1	0
21[b]. Rooted plants in channel	3	**2**	1	0
22. Crayfish	**0**	0.5	1	1.5
23. Bivalves	**0**	1	2	3
24. Fish	0	**0.5**	1	1.5
25. Amphibians	0	**0.5**	1	1.5
26. Macrobenthos (note diversity and abundance)	0	**0.5**	1	1.5
27. Filamentous algae; periphyton	**0**	1	2	3
28. Iron oxidizing bacteria/fungus.	**0**	0.5	1	1.5
29[b]. Wetland plants in streambed	**FAC = 0.5**; FACW = 0.75; OBL = 1.5 SAV = 2.0; Other = 0			

[b] Items 20 and 21 focus on the presence of upland plants, Item 29 focuses on the presence of aquatic or wetland plants.

Notes: (use back side of this form for additional notes.)

Stream begins @ culvert. Lack of Fish + benthos could be water quality.

Sketch:

Appendix C

BEHI and Sediment Export Estimates

Right Bank

Summary Form - ANNUAL STREAMBANK EROSION - Estimates / Calculations

Stream: Little Alamance Cr. **Observers:** BNF **Date:** 7/18/07

Stream Type: C/E5/1 **Graph Used:** NC **Total BANK Length:** 1,760 Ft.

Item	(1) Station Ft.	(2) BEHI (adjective)	(3) NEAR-BANK STRESS (adjective)	(4) BANK EROSION RATE (Ft / yr)	(5) LENGTH of Bank (Ft)	(6) Bank HEIGHT (Ft)	(7) EROSION SubTotal (4)x(5)x(6) (Ft^3 / yr)
1	10+75 11+40	VH	L	.6	65	4.5	175.5
2	11+40 12+00	H	L	.11	60	4.0	26.4
3	12+00 13+85	M	L	.017	185	3.5	11.0
4	13+85 14+20	M	H	.1	35	4.0	14.0
5	14+35 14+60	L	M	.01	25	4.0	1.0
6	14+60 15+15	H	M	.16	55	4.0	35.2
7	15+15 16+75	H	L	.11	160	3.5	61.6
8	16+75 17+75	H	Ext.	.38	100	6.0	228 ←
9	17+75 19+00	H	H	.2	125	6.0	150
10	19+00 21+00	M	L	.017	200	4.0	13.6
11	21+00 22+15	H	L	.11	115	5.0	63.25
12	22+15 23+00	VH	Ext	1.6	85	6.0	816 ←
13	23+00 23+50	M	L	.017	50	4.0	3.4
14	23+50 24+00	VH	M	.75	50	4.5	168.8
15	24+00 24+45	H	L	.11	45	4.0	19.8
16	24+45 25+80	VH	M	.75	135	4.5	455.6 ←
17	25+80 27+10	M	L	.017	130	3.5	7.7
18	27+10 28+50	VH	M	.75	140	5.0	525 ←

confluence w/UT → (between items 4 and 5)

Sum (Feet^3/Year) EROSION *Sub-Totals* for each BEHI / NBS Combination	Total **Erosion** = 2,775.9 Feet^3/ Year
Convert EROSION (Feet^3 / Year) to (Yards^3 / Year) { divide Total EROSION (Feet^3/Year) by 27 }	Total **Erosion** = 102.8 Yards^3/ Year
Convert EROSION (Yards^3 / Year) to (Tons / Year) { multiply Total EROSION (Yards^3 / Year) by 1.3 }	Total **Erosion** = 133.7 Tons / Year
Calculate EROSION per unit LENGTH of Channel. {Divide Total EROSION (Tons/Year) by Total Length of CHANNEL (ft) surveyed.}	Total **Erosion** = 0.076 Tons / Yr / Ft

Right Bank

Summary Form - ANNUAL STREAMBANK EROSION - Estimates / Calculations

Stream: Little Alamance Cr. Observers: BNF Date: 7/18/07

Stream Type: C/E5/1 Graph Used: NC Total BANK Length: 785 Ft.

Item	(1) Station Ft.	(2) BEHI (adjective)	(3) NEAR-BANK STRESS (adjective)	(4) BANK EROSION RATE (Ft / yr)	(5) LENGTH of Bank (Ft)	(6) Bank HEIGHT (Ft)	(7) EROSION SubTotal (4)x(5)x(6) (Ft^3 / yr)
1	28+50 29+15	Ext	Ext	8	65	5.0	2,600 ←
2	29+15 29+75	VH	H	.95	60	5.0	285
3	29+75 31+00	Ext	H	3.8	125	5.0	2,375 ←
4	31+00 31+35	H	H	.2	35	5.0	35
5	31+35 31+70	M	L	.017	35	3.5	2.1
6	31+70 32+75	Ext	H	3.8	105	5.0	1,995 ←
7	32+75 34+00	VH	M	.75	125	4.0	375
8	34+00 36+35	H	L	.11	235	3.5	90.5
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							

Sum ($Feet^3$/Year) EROSION *Sub-Totals* for each BEHI / NBS Combination	Total **Erosion** = 7,757.6 $Feet^3$/ Year
Convert EROSION ($Feet^3$ / Year) to ($Yards^3$ / Year) { divide Total EROSION ($Feet^3$/Year) by 27 }	Total **Erosion** = 287.3 $Yards^3$/ Year
Convert EROSION ($Yards^3$ / Year) to (Tons / Year) { multiply Total EROSION ($Yards^3$ / Year) by 1.3 }	Total **Erosion** = 373.5 Tons / Year
Calculate EROSION per unit LENGTH of Channel. {Divide Total EROSION (Tons/Year) by Total Length of CHANNEL (ft) surveyed.}	Total **Erosion** = 0.476 Tons / Yr / Ft

Left Bank

Summary Form - ANNUAL STREAMBANK EROSION - Estimates / Calculations

Stream: Little Alamance Cr. Observers: BNF Date: 7/18/07

Stream Type: C/E5/1 Graph Used: NC Total BANK Length: 1,580 Ft.

Item	(1) Station Ft.	(2) BEHI (adjective)	(3) NEAR-BANK STRESS (adjective)	(4) BANK EROSION RATE (Ft / yr)	(5) LENGTH of Bank (Ft)	(6) Bank HEIGHT (Ft)	(7) EROSION SubTotal (4)x(5)x(6) (Ft^3 / yr)	
1	10+20 12+40	H	L	.11	220	4.0	96.8	
2	12+40 12+60	Ext	H	3.8	20	5.0	380	←
3	12+60 13+75	VH	M	.75	115	4.5	388.1	←
4	13+75 14+00	H	M	.16	25	4.5	18	
5	14+00 15+15	M	L	.017	115	4.0	7.8	
6	15+15 16+80	H	L	.11	165	4.0	72.6	
7	16+80 17+75	H	Ext.	.38	95	5.5	198.6	
8	17+75 18+85	H	H	.2	110	5.5	121	
9	18+85 19+30	VH	H	.95	45	5.0	213.8	
10	19+30 20+80	H	L	.11	150	4.0	66	
11	20+80 21+23	H	H	.2	43	5.0	43	
12	21+23 21+70	M	L	.017	47	4.0	3.2	
13	21+70 22+35	H	Ext.	.38	65	5.0	123.5	
14	22+35 23+30	VH	Ext.	1.6	95	6.0	912	←
15	23+30 24+00	H	M	.16	70	5.0	56	
16	24+00 24+40	VH	H	.95	40	5.0	190	
17	24+40 25+00	M	L	.017	60	4.0	4.1	
18	25+00 26+00	M	L	.017	100	4.0	6.8	

Sum ($Feet^3$/Year) EROSION *Sub-Totals* for each BEHI / NBS Combination	Total **Erosion** = 2,901.3 $Feet^3$/ Year
Convert EROSION ($Feet^3$ / Year) to ($Yards^3$ / Year) { divide Total EROSION ($Feet^3$/Year) by 27 }	Total **Erosion** = 107.5 $Yards^3$/ Year
Convert EROSION ($Yards^3$ / Year) to (Tons / Year) { multiply Total EROSION ($Yards^3$ / Year) by 1.3 }	Total **Erosion** = 139.7 Tons / Year
Calculate EROSION per unit LENGTH of Channel. {Divide Total EROSION (Tons/Year) by Total Length of CHANNEL (ft) surveyed.}	Total **Erosion** = 0.088 Tons / Yr / Ft

Left Bank

Summary Form - ANNUAL STREAMBANK EROSION - Estimates / Calculations

Stream: Little Alamance Cr. Observers: BNF Date: 7/18/07

Stream Type: C/E5/1 Graph Used: NC Total BANK Length: 1,135 Ft.

Item	(1) Station Ft.	(2) BEHI (adjective)	(3) NEAR-BANK STRESS (adjective)	(4) BANK EROSION RATE (Ft / yr)	(5) LENGTH of Bank (Ft)	(6) Bank HEIGHT (Ft)	(7) EROSION SubTotal (4)x(5)x(6) (Ft^3 / yr)	
1	26+00 27+20	H	H	.2	120	4.5	108	
2	27+20 27+57	M	H	.1	37	5.0	18.5	
3	27+57 28+35	VH	H	.95	78	5.0	370.5	←
4	28+35 29+30	M	H	.1	95	5.0	47.5	
5	29+30 31+00	M	L	.017	170	4.0	11.6	
6	31+00 31+45	H	H	.2	145	4.0	116	
7	31+45 33+25	L	L	.001	230	3.5	0.8	
8	33+75 34+80	H	VH	.28	105	10.0	294	←
9	34+80 36+35	M	L	.017	155	4.0	10.5	
10								
11								
12								
13								
14								
15								
16								
17								
18								

Sum ($Feet^3$/Year) EROSION *Sub-Totals* for each BEHI / NBS Combination	Total Erosion = 977.4 $Feet^3$/ Year
Convert EROSION ($Feet^3$ / Year) to ($Yards^3$ / Year) { divide Total EROSION ($Feet^3$/Year) by 27 }	Total Erosion = 36.2 $Yards^3$/ Year
Convert EROSION ($Yards^3$ / Year) to (Tons / Year) { multiply Total EROSION ($Yards^3$ / Year) by 1.3 }	Total Erosion = 47.1 Tons / Year
Calculate EROSION per unit LENGTH of Channel. {Divide Total EROSION (Tons/Year) by Total Length of CHANNEL (ft) surveyed.}	Total Erosion = 0.041 Tons / Yr / Ft

Stream: Little Alan. Reach: ~~[illegible]~~ -11+80 10+20 Cross Section: L-Bank

Observers: BNF, JET Date: 5-21-07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) same as BKF	Bankfull Height (ft) =	(B) 3.25	(A) / (B) =	1 (C)	BEHI Score (Fig. V-15): 0

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 0.5'	Study Bank Height (ft) =	(A) 3.25 BKF	(D) / (A) =	.1 (E)	8

Weighted Root Density (G)

Root Density as % =	(F) 10	(F) x (E) =	1 (G)	10

Bank Angle (H)

Bank Angle as Degrees =	80 (H)	6

High

(* see note about root depth & density)

Surface Protection (I)

Surface Protection as % =	55 (I)	4

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

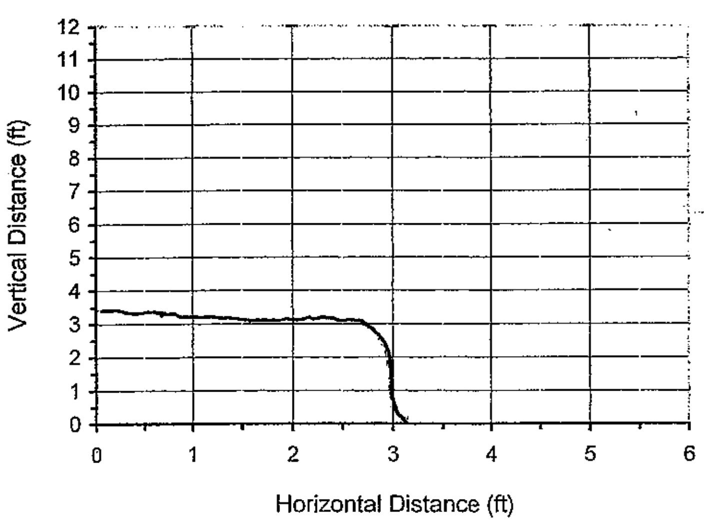
Bank Materials Adjustment: 10 (sand)

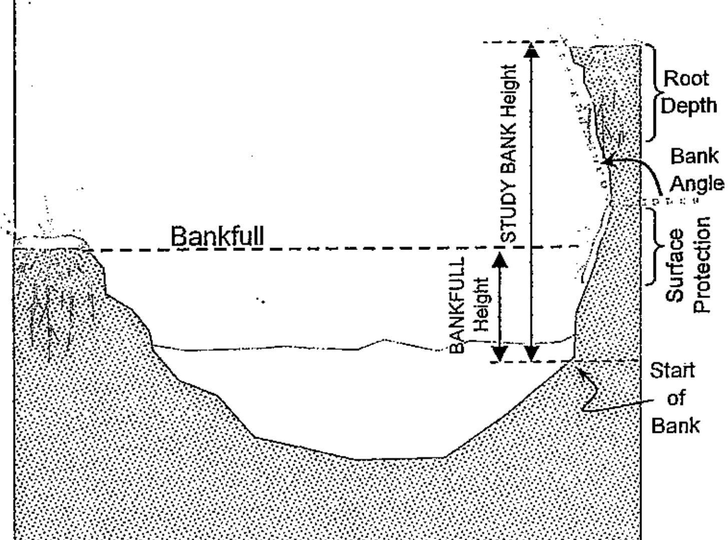
Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5 (circled)	40 - 45	46 - 50

ADJECTIVE RATING and **TOTAL SCORE**: 38

Bank Sketch





BEHI Variable Worksheet

Stream: Little Alam Reach: 10775-11440 Cross Section: R-Bank

Observers: BNF, JET Date: 5-21-07

BEHI Score (Fig. V-15)

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 4.5	**Bankfull** Height (ft) =	(B) 3.5	(A) / (B) =	1.29 (C)	5

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 0.5	**Study Bank** Height (ft) =	(A) 4.5	(D) / (A) =	.11 (E)	8

Weighted Root Density (G)

Root Density as % =	(F) 15%	(F) x (E) =	1.5 (G)	9

Very High

(*see note about root depth to density)

Bank Angle (H)

Bank **Angle** as *Degrees* =	~~[illegible]~~ 80-130 (H)	~~8~~ 9

Surface Protection (I)

Surface **Protection** as % =	80 (I)	2

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

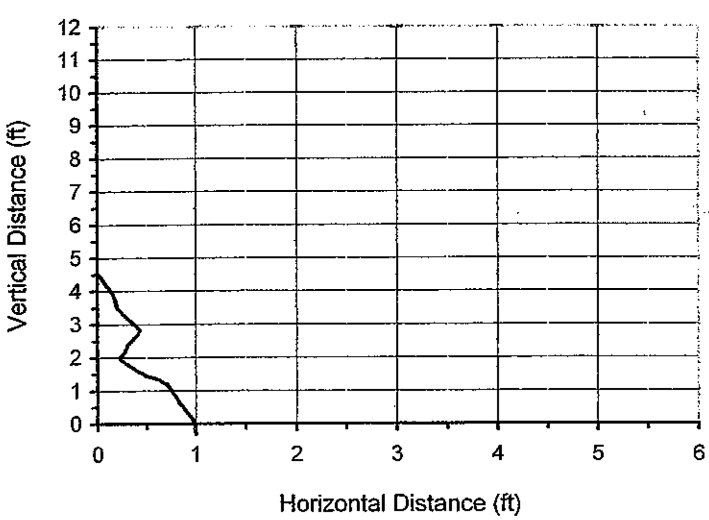
Bank Materials Adjustment: 10

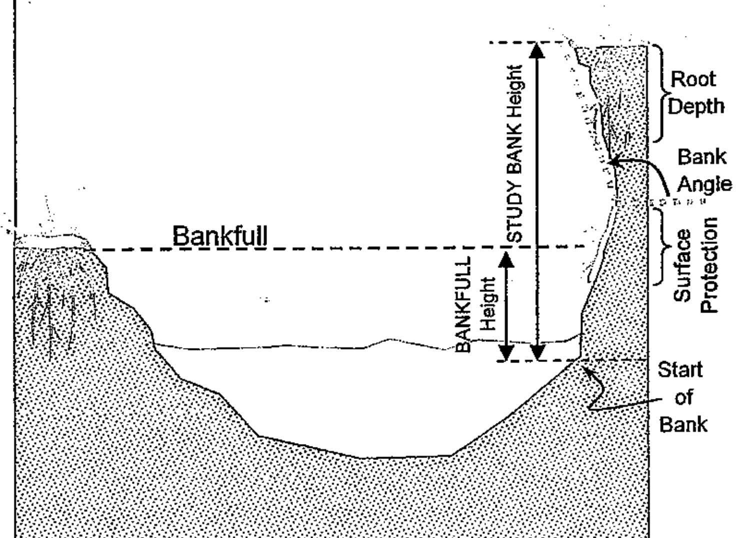
Stratification Adjustment

Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH (circled)	EXTREME	*ADJECTIVE RATING* and **TOTAL SCORE**
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50	43

Bank Sketch





BEHI Variable Worksheet

Stream: Little Alam, Reach: 11+40-12+00 Cross Section: R-Bank

Observers: BNF, JET Date: 5-21-07

BEHI Score (Fig. V-15)

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 4	***Bankfull*** Height (ft) =	(B) 3,5	(A) / (B) =	1,14 (C)	2

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 0,5	***Study Bank*** Height (ft) =	(A) 4	(D) / (A) =	,13 (E)	8

Weighted Root Density (G)

Root Density as **%** =	(F) 30%	(F) x (E) =	3,90 (G)	9

Bank Angle (H)

Bank **Angle** as *Degrees* =	70-80 (H)	5

Surface Protection (I)

Surface **Protection** as **%** =	80 (I)	2

High

(but root depth & density seem to be making it high, we have herbaceous species dominating bank from top to toe but root depth of herbs is only about 0,5')

Bank Material Adjustment:

- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points) **Silt Clay** (no adjustment)

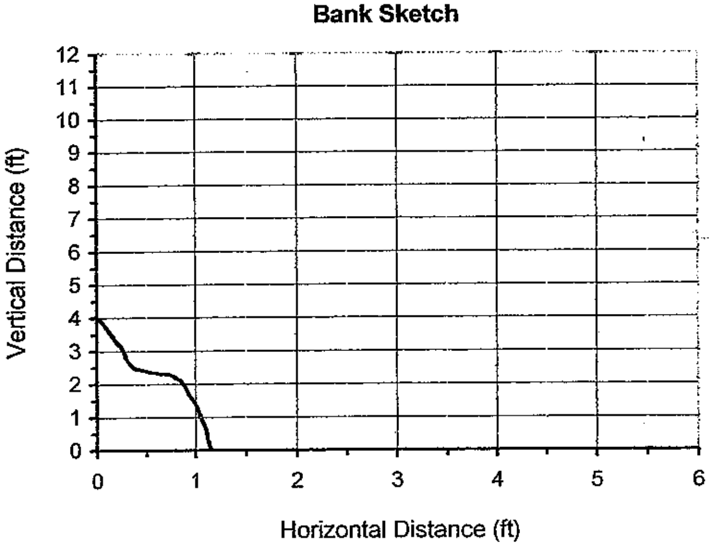
Bank Materials Adjustment: 10

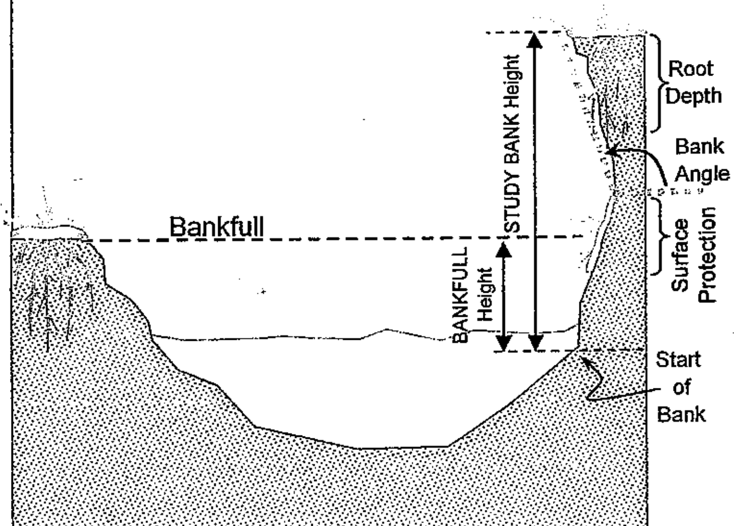
Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5 (circled)	40 - 45	46 - 50

ADJECTIVE RATING and **TOTAL SCORE**: 36

Bank Sketch





Stream: Little Alam Reach: 11+80—12+40 LT Cross Section:

Observers: BNF, JET Date: 5-21-07

Bank Height / Max Depth Bankfull (C)

						BEHI Score (Fig. V-15)
Study Bank Height (ft) =	(A) 4.75	***Bankfull*** Height (ft) =	(B) 3.5	(A) / (B) =	1.36 (C)	5

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 0.5'	***Study Bank*** Height (ft) =	(A) 4.75	(D) / (A) =	0.11 (E)	8

Weighted Root Density (G)

Root Density as % =	(F) 20	(F) x (E) =	2.11 (G)	9

HIGH

☆ (see note about root depth + density)

Bank Angle (H)

Bank **Angle** as *Degrees* =	60 (H)	4

Surface Protection (I)

Surface **Protection** as % =	75 (I)	2

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

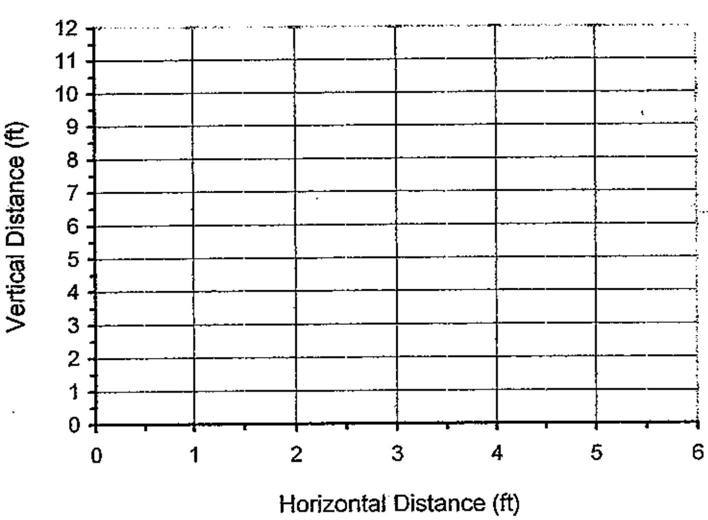
Bank Materials Adjustment: 5

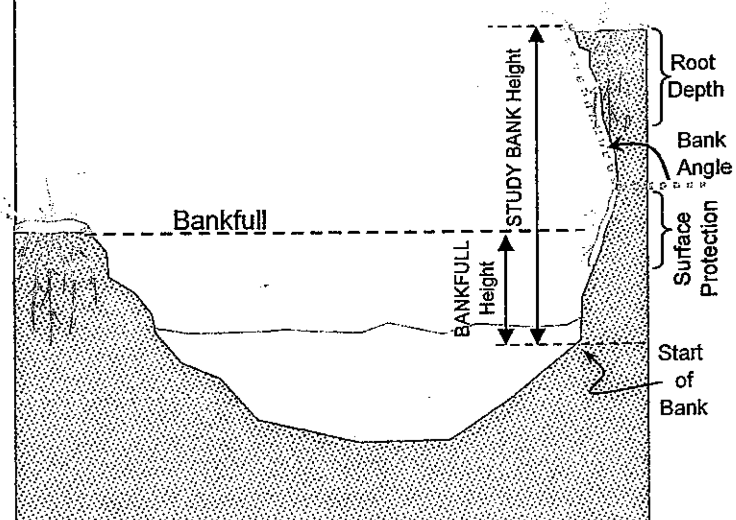
Stratification Adjustment

Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME	*ADJECTIVE RATING* and **TOTAL SCORE**
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5 (circled)	40 - 45	46 - 50	33

Bank Sketch





BEHI Variable Worksheet

Stream: L. Alamance Reach: 12+40 – 12+60 LT Cross Section:

Observers: BNF, JET Date: 5/21/07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 5	**Bankfull** Height (ft) =	(B) 3.5	(A) / (B) =	1.43 (C)	BEHI Score (Fig. V-15): 6

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) ~~0.5~~ 1.0	**Study Bank** Height (ft) =	(A) 5	(D) / (A) =	0.2 (E)	8

Weighted Root Density (G)

Root Density as % =	(F) 10	(F) x (E) =	2 (G)	9

EXTREME

*(Bare bank dwnstrm of 1st footbridge)

Bank Angle (H)

Bank **Angle** as *Degrees* =	80 (H)	6

Surface Protection (I)

Surface **Protection** as % =	5 (I)	10

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

Bank Materials Adjustment: 8

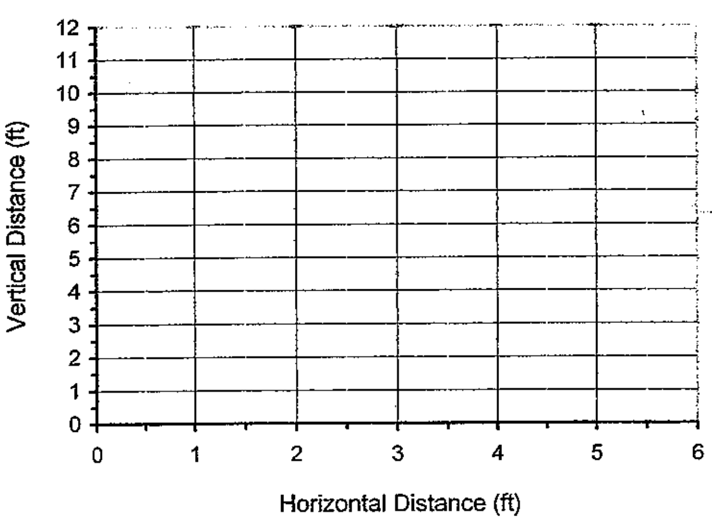
Stratification Adjustment

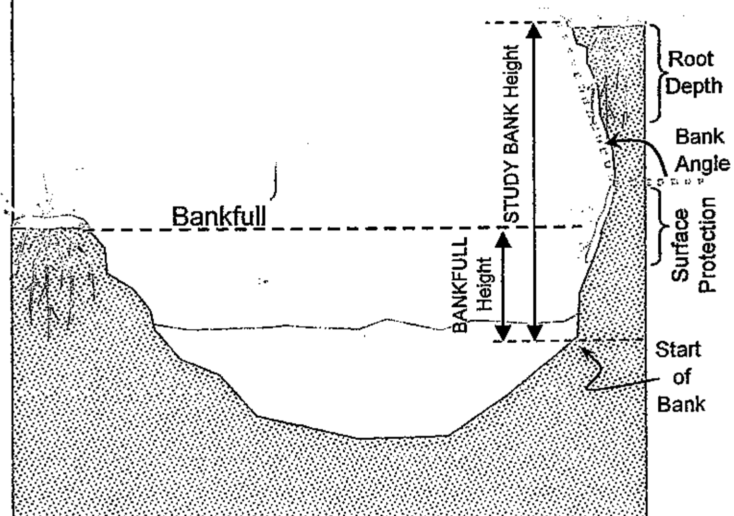
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50

ADJECTIVE RATING and **TOTAL SCORE**: 47 (EXTREME circled)

Bank Sketch





Stream: L. Alamance Reach: 12+00 – 14+20 RT Cross Section:

Observers: BNF, JET Date: 5/21/07

BEHI Score (Fig. V-15)

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 3.5	***Bankfull*** Height (ft) =	(B) 3.5	(A) / (B) =	1 (C)	0

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 1.0	***Study Bank*** Height (ft) =	(A) 3.5	(D) / (A) =	0.29 (E)	6

Weighted Root Density (G)

Root Density as % =	(F) 10	(F) x (E) =	2.9 (G)	9

MODERATE

* – lower slope on bank
– good herbaceous cover

Bank Angle (H)

Bank **Angle** as *Degrees* =	30 (H)	2.5

Surface Protection (I)

Surface **Protection** as % =	75 (I)	2

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

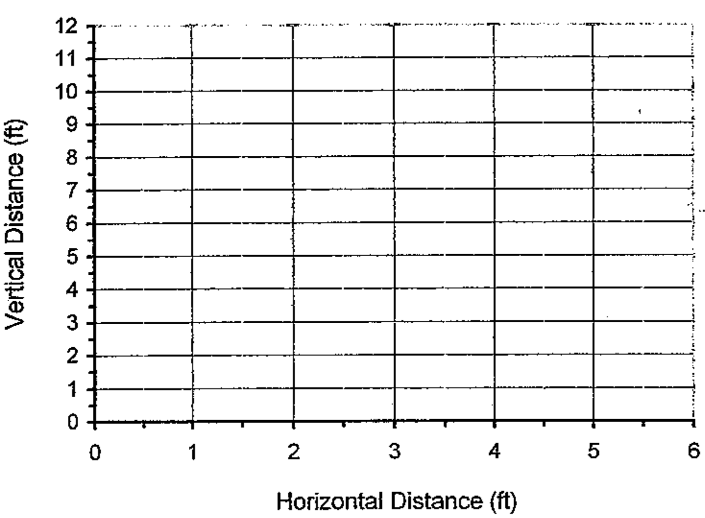
Sand (Add 10 points) **Silt Clay** (no adjustment)

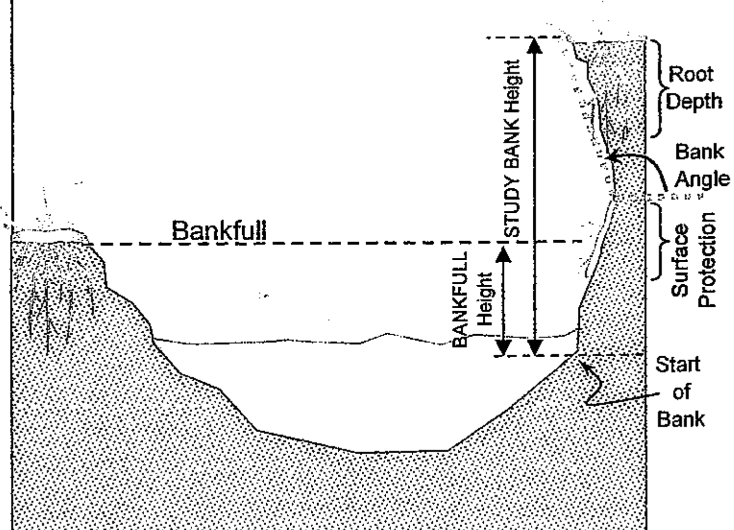
Bank Materials Adjustment: 10

Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME	*ADJECTIVE RATING* and **TOTAL SCORE**
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50	29.5

Bank Sketch





Stream: Little Alamance Reach: Sta. 16+80-18+85 Cross Section:

Observers: BNF, JT Date: 5/21/07

BEHI Score (Fig. V-15)

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 4.9	**Bankfull** Height (ft) =	(B) 3.9	(A) / (B) =	1.26 (C)	4

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 4.9	**Study Bank** Height (ft) =	(A) 4.9	(D) / (A) =	1 (E)	1

Weighted Root Density (G)

Root Density as **%** =	(F) 15	(F) x (E) =	15 (G)	8

High

Bank Angle (H)

Bank **Angle** as *Degrees* =	70 (H)	5

Surface Protection (I)

Surface **Protection** as **%** =	75 (I)	~~90~~ 2.5

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is ~~composed of sand)~~

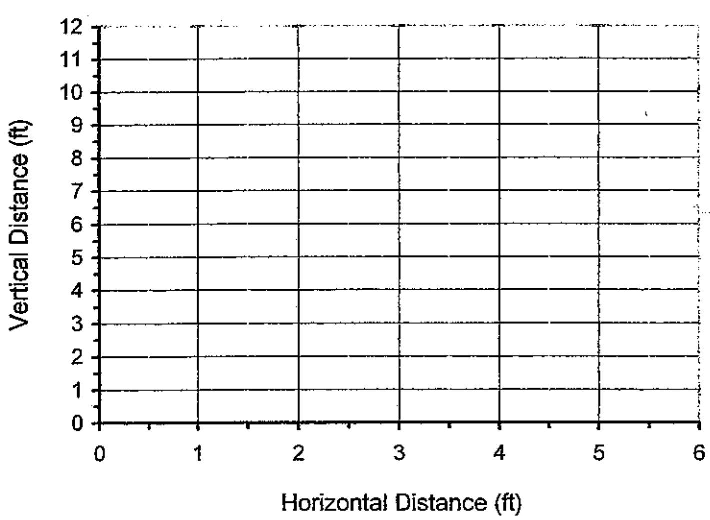
Sand (Add 10 points) **Silt Clay** (no adjustment)

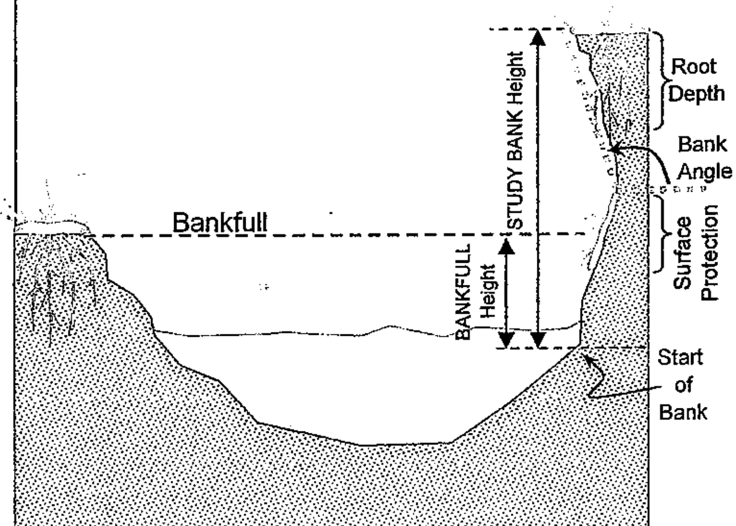
Bank Materials Adjustment: 10

Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME	*ADJECTIVE RATING* and TOTAL SCORE	High 30.5
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45	46 - 50		

Bank Sketch





Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Cr. Location:

Observers: BNF, JET Date: 5/21/07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I — (1)

- Transverse and/or central bars-short and/or discontinuous ... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) ... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) ... NBS = Extreme

Level II — (2)

Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

Level II — (3)

Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

Level II — (4)

Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant **Near-Bank Stress**
low

Level III — (5)

Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
3.5	2.6	1.3	low

Level III — (6)

Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV — (7)

Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low (circled)	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50 (circled)	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING	

Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Cr. Location:

Observers: BNF, JET Date: 5/21/07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1)	Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2)	Channel pattern (Rc / W)	Level II	General Prediction
(3)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)

- Transverse and/or central bars-short and/or discontinuous .... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) .... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) .... NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant **Near-Bank Stress**
low

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
	4.0	2.6	1.5	low

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)	Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low (circled)	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50 (circled)	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING	

Estimating Near-Bank Stress (NBS)

Stream: Little Alamo Location: 14700 - 14720
Observers: BNF, JET Date: 5-21-07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I — (1)

Transverse and/or central bars-short and/or discontinuous	NBS = High / Very High
Extensive deposition (continuous, cross-channel)	NBS = Extreme
Chute cutoffs, down-valley meander migration, converging flow (NBS #1)	NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**
(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**
(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
High

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)	Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Near-Bank Stress RATINGS	Converting Values to a *Near-Bank Stress* RATING — Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N/A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N/A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N/A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING:

Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Location: Sta. 20+80 - 21+23

Observers: BNF, JT Date: 5/21/07

Methods for Estimating Near-Bank Stress

(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)

- Transverse and/or central bars-short and/or discontinuous .... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) .... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) .... NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
~~Moderate~~

High

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
	6	[illegible] 2.6	[illegible] 2.3	[illegible]

High

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS
	[illegible]							

Level IV

(7)	Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
~~Moderate~~	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall ***N****ear-****B****ank* ***S****tress* RATING	

Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Cr. Location: Sta 12+40 - 13+75

Observers: BNF, JET Date: 5/21/07

METHODS FOR ESTIMATING NEAR-BANK STRESS

	Method	Level	Purpose
(1)	Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2)	Channel pattern (Rc / W)	Level II	General Prediction
(3)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)
- Transverse and/or central bars-short and/or discontinuous ... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) ... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) ... NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant **N**ear-**B**ank **S**tress
~~Low-Moderate~~ High

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
	5.5	~~[illegible]~~ 2.6	~~1.5~~ 2.1	~~Low-Mod.~~ High

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)	Velocity Gradient (ft / s / ft)	Near-Bank Stress **NBS**

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
~~Low~~	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	~~1.00 - 1.50~~	0.80 - 1.05	1.00 - 1.20
~~Moderate~~	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	~~1.51 - 1.80~~	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall ***N**ear-**B**ank **S**tress* RATING	

Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Location: Sta 16+80 - 18+85

Observers: BNF, JT Date: 5/21/07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)

Transverse and/or central bars-short and/or discontinuous.........NBS = High / Very High

Extensive deposition (continuous, cross-channel).........NBS = Extreme

Chute cutoffs, down-valley meander migration, converging flow (NBS #1).........NBS = Extreme

Level II (2)

Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**
45	32	1.4	extreme

Level II (3)

Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
extreme

Level II (4)

Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Level III (5)

Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**

Level III (6)

Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV (7)

Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING:

Estimating Near-Bank Stress (NBS)

Stream: Little Alamance Cr. Location: [redacted]

Observers: BNF, [redacted] JET Date: 5/21/07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1)	Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2)	Channel pattern (Rc / W)	Level II	General Prediction
(3)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I

(1)
- Transverse and/or central bars-short and/or discontinuous..........NBS = High / Very High
- Extensive deposition (continuous, cross-channel)..........NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1)..........NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
Moderate

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
	4.5	2.6	1.7	Mod

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)	Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Near-Bank Stress RATINGS	Converting Values to a *Near-Bank Stress* RATING — Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING:

Worksheet C-3. Summary form to estimate annuals streambank erosion for various study reaches.

Stream: UT to Little Alam. Cr.		Location: Burlington, NC	
Graph Used: Colorado	Total Bank Length (ft): 400 (Right Bank)		Date: 5-2-07
Observers: BNF, JET	Valley Type: 8		Stream Type: E4/1

(1) Station (ft)	(2) BEHI rating (Worksheet A-14) (adjective)	(3) NBS rating (Worksheet A-15) (adjective)	(4) Bank erosion rate (Figure A-24 or A-25) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft^3/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 10+00 – 10+40	v. high	ext.	1.5	40	4	240	
2. ~~[illegible]~~	~~[illegible]~~	~~[illegible]~~					
3. 10+40 – 10+80	Mod	high	.42	40	2	33.6	
4. 10+80 – 11+40	low	low	.036	60	2	4.3	
5. 11+40 – 11+70	v. high	ext.	1.5	30	3	135	
6. 11+70 – 12+40	high	high	.58	70	3	121.8	
7. 12+40 – 12+60	v. high	high	.58	20	3	34.8	
8. 12+60 – 14+00	high	high	.58	140	3	243.6	
9.							
10.							
11.							
12.							
13.							
14.							
15.							

Sum erosion subtotals in Column (7) for each BEHI/NBS combination	Total erosion (ft^3/yr)	813.1	
Convert erosion in ft^3/yr to yds^3/yr {divide Total erosion (ft^3/yr) by 27}	Total erosion (yds^3/yr)	30.1	
Convert erosion in yds^3/yr to tons/yr {multiply Total erosion (yds^3/yr) by 1.3}	Total erosion (tons/yr)	39.1	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}	Total erosion (tons/yr/ft)	0.1	

Worksheet C-3. Summary form to estimate annuals streambank erosion for various study reaches.

Stream: UT to Little Alan. Cr. Location: Burlington, NC

Graph Used: Colorado Total Bank Length (ft): 400 (Left Bank) Date: 5-2-07

Observers: BNF, JET Valley Type: 8 Stream Type: E4/1

(1) Station (ft)	(2) BEHI rating (Worksheet A-14) (adjective)	(3) NBS rating (Worksheet A-15) (adjective)	(4) Bank erosion rate (Figure A-24 or A-25) (ft/yr)	(5) Length of bank (ft)	(6) Study bank height (ft)	(7) Erosion subtotal [(4)×(5)×(6)] (ft³/yr)	(8) Erosion Rate (tons/yr/ft) {[(7)/27] × 1.3 / (5)}
1. 10+00 - 10+40	low	low	.036	40	2	2.88	
2. 10+40 - 10+80	Mod	low	.15	40	2	12	
3. 10+80 - 11+20	VH	high	.58	40	2.7	62.6	
4. 11+20 - 11+60	Mod	low	.15	40	2	12	
5. 11+60 - 12+45	Mod	low	.15	85	2	25.5	
6. 12+45 - 12+75	Mod	low	.15	30	2	9	
7. 12+75 - 14+00	high	high	.58	125	3	217.5	
8.							
9.							
10.							
11.							
12.							
13.							
14.							
15.							
Sum erosion subtotals in Column (7) for each BEHI/NBS combination					Total erosion (ft³/yr)	[illegible]	
Convert erosion in ft³/yr to yds³/yr {divide Total erosion (ft³/yr) by 27}					Total erosion (yds³/yr)	[illegible]	
Convert erosion in yds³/yr to tons/yr {multiply Total erosion (yds³/yr) by 1.3}					Total erosion (tons/yr)	16.41	
Calculate erosion per unit length of channel {divide Total erosion (tons/yr) by total length of stream (ft) surveyed}					Total erosion (tons/yr/ft)	.041	

Stream: UT to Little Alam Reach: Cross Section: X-Sect 3

Observers: BNF, JET Right Bank Date: 5-21-07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 4	Bankfull Height (ft) =	(B) 2.4	(A)/(B) =	1.7 (C)	BEHI Score (Fig. V-15) 7.5

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 1	Study Bank Height (ft) =	(A) 4	(D)/(A) =	.25 (E)	7

Weighted Root Density (G)

Root Density as % =	(F) 40	(F) x (E) =	10 (G)	8.5

Bank Angle (H)

Bank Angle as *Degrees* =	120 (H)	9

Very High

Surface Protection (I)

Surface Protection as % =	60 (I)	3.5

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

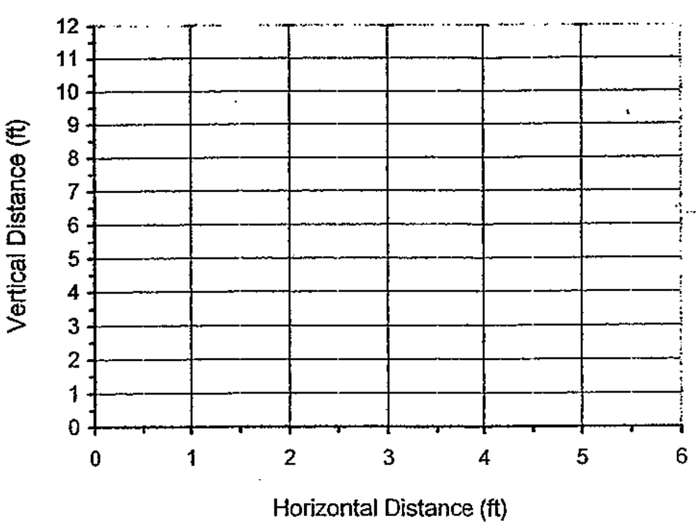
Sand (Add 10 points) **Silt Clay** (no adjustment)

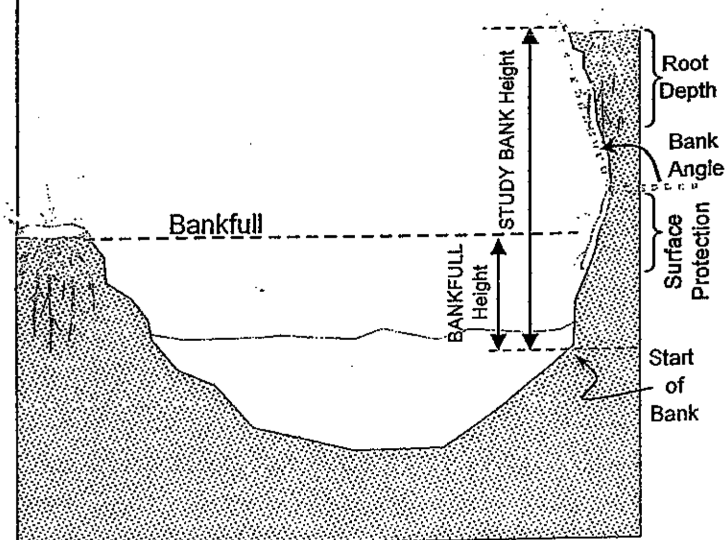
Bank Materials Adjustment 5

Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME	*ADJECTIVE RATING* and **TOTAL SCORE**
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5	40 - 45 (circled)	46 - 50	40.5

Bank Sketch





Stream: UT to Little Alam Reach: Cross Section: d/s of x-sect 3

Observers: BNF, JET Left + Right bank Date: 5-21-07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 3	Bankfull Height (ft) =	(B) 2.4	(A) / (B) =	1.25 (C)	BEHI Score (Fig. V-15): 4

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 1	Study Bank Height (ft) =	(A) 3	(D) / (A) =	.3 (E)	6

Weighted Root Density (G)

Root Density as % =	(F) 40	(F) x (E) =	12 (G)	8

Bank Angle (H)

Bank Angle as Degrees =	60 (H)	4

High

Surface Protection (I)

Surface Protection as % =	50 (I)	4

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

Bank Materials Adjustment: 5

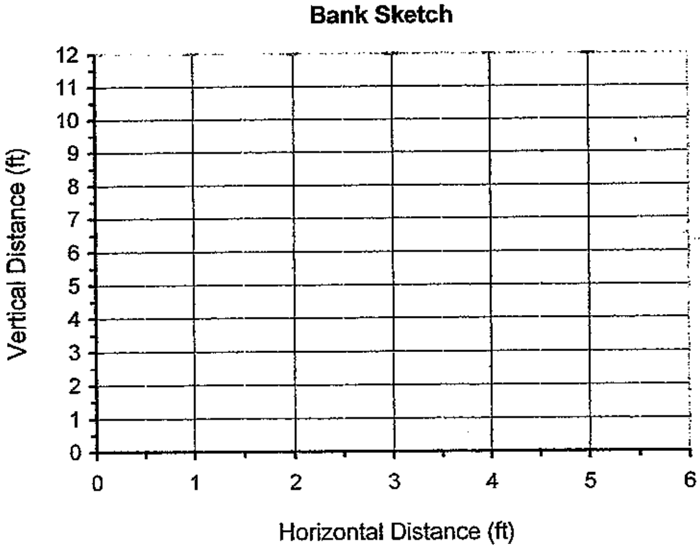
Stratification Adjustment

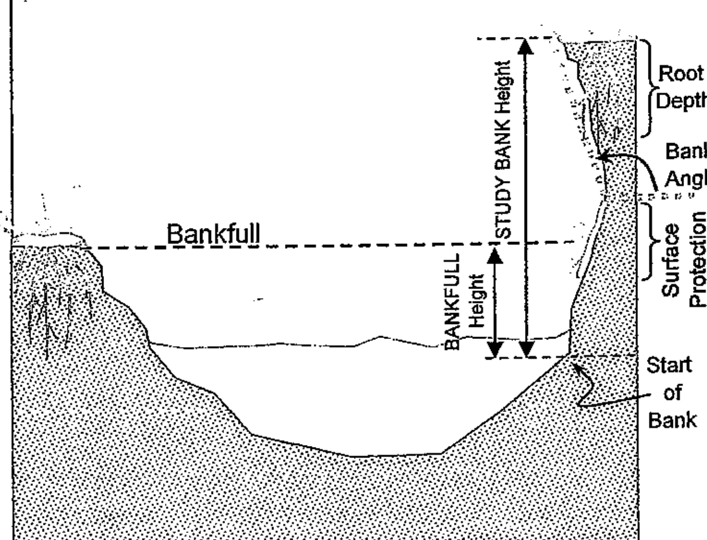
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5 - 9.5	10 - 19.5	20 - 29.5	30 - 39.5 (circled)	40 - 45	46 - 50

ADJECTIVE RATING **and TOTAL SCORE**: 31

Bank Sketch





Stream: UT to Little Alam Reach: Cross Section: x-sect 4

Observers: BNF, JET left & right bank Date: 5-2-07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A) 2.1	Bankfull Height (ft) =	(B) 2.1	(A) / (B) =	1 (C)	BEHI Score (Fig. V-15): 0

Root Depth / Bank Height (E)

Root Depth (ft) =	(D) 1	Study Bank Height (ft) =	(A) 2.1	(D) / (A) =	0.5 (E)	4

Weighted Root Density (G)

Root Density as % =	(F) 40	(F) x (E) =	20 (G)	7

Bank Angle (H)

Bank Angle as Degrees =	70 (H)	5

Moderate

Surface Protection (I)

Surface Protection as % =	50 (I)	4

Bank Material Adjustment:

Bedrock (Overall Very Low BEHI)

Boulders (Overall Low BEHI)

Cobble (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)

Gravel (Add 5-10 points depending percentage of bank material that is composed of sand)

Sand (Add 10 points) **Silt Clay** (no adjustment)

Bank Materials Adjustment: 5

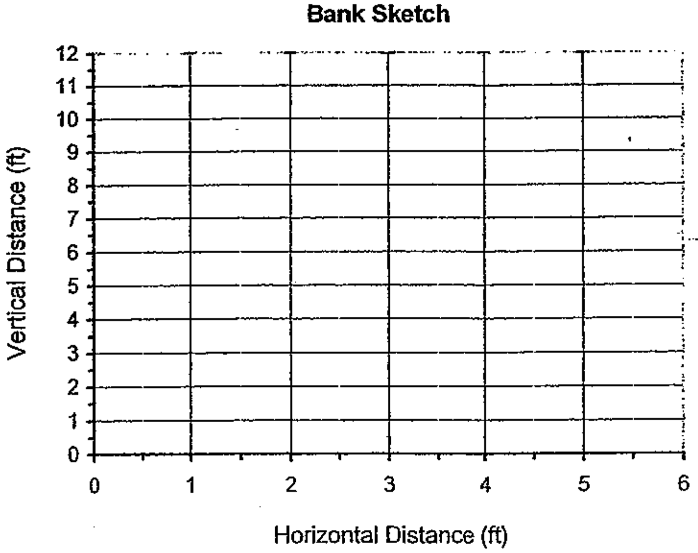
Stratification Adjustment

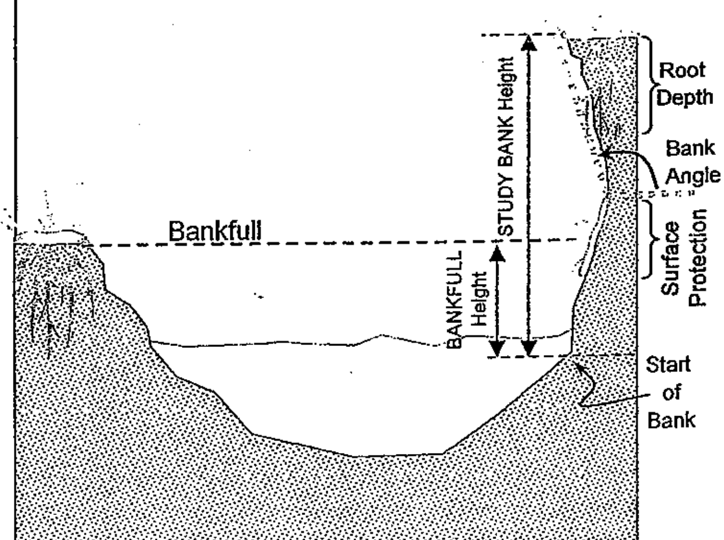
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME
5 - 9.5	10 - 19.5	20 - 29.5 (circled)	30 - 39.5	40 - 45	46 - 50

***ADJECTIVE RATING* and TOTAL SCORE**: 25

Bank Sketch





Stream: UT to Little Alam Reach: 10+80 - 11+20 Cross Section: X-Sect 6

Observers: BNF, JET Right Bank Date: 5-21-07

Bank Height / Max Depth Bankfull (C)

Study Bank Height (ft) =	(A)	Bankfull Height (ft) =	(B)	(A)/(B) =	(C)	BEHI Score (Fig. V-15)
	2		2		1	0

Root Depth / Bank Height (E)

Root Depth (ft) =	(D)	Study Bank Height (ft) =	(A)	(D)/(A) =	(E)	BEHI Score
	2		2		1	0

Weighted Root Density (G)

Root Density as % =	(F)	(F) x (E) =	(G)	BEHI Score
	50		50	4.5

Bank Angle (H)

Bank Angle as Degrees =	(H)	BEHI Score
	60	4

Surface Protection (I)

Surface Protection as % =	(I)	BEHI Score
	60	3.5

LOW

Bank Material Adjustment:

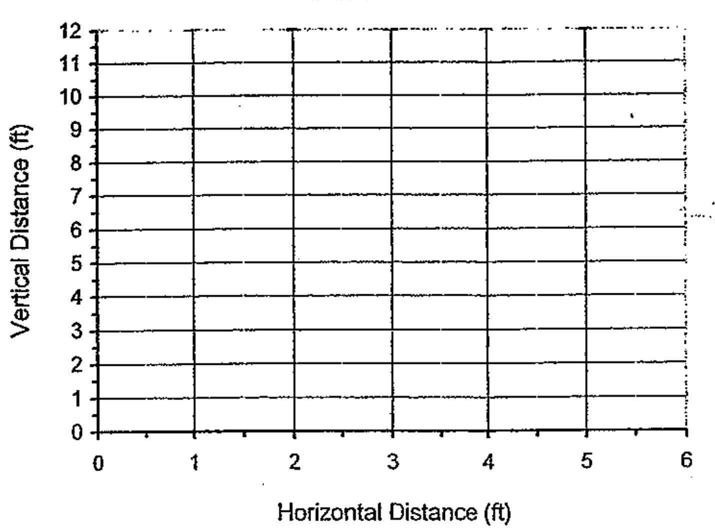
- **Bedrock** (Overall Very Low BEHI)
- **Boulders** (Overall Low BEHI)
- **Cobble** (Subtract 10 points. If sand/gravel matrix greater than 50% of bank material, then do not adjust)
- **Gravel** (Add 5-10 points depending percentage of bank material that is composed of sand)
- **Sand** (Add 10 points) **Silt Clay** (no adjustment)

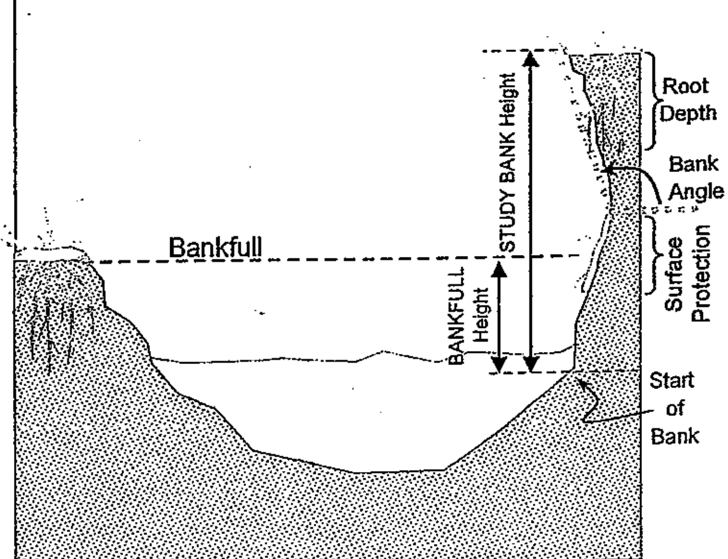
Bank Materials Adjustment 5

Stratification Adjustment
Add 5-10 points, depending on position of unstable layers in relation to bankfull stage

VERY LOW	LOW	MODERATE	HIGH	VERY HIGH	EXTREME	*ADJECTIVE RATING* and **TOTAL SCORE**
5 - 9.5	10 - 19.5 (circled)	20 - 29.5	30 - 39.5	40 - 45	46 - 50	17

Bank Sketch





Estimating Near-Bank Stress (NBS)

Stream: UT to Little Alam, Location: Burlington, NC 10+00 to 10+30

Observers: BNF, JET Right Bank Date: 5-21-07

METHODS FOR ESTIMATING NEAR-BANK STRESS		
(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)
- Transverse and/or central bars-short and/or discontinuous ... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) ... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) ... NBS = Extreme

Level II

(2)	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**

(3)	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
extreme

Level III

(5)	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
	4.0	1.0	4	ext.

(6)	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)	Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Near-Bank Stress RATINGS	Converting Values to a *Near-Bank Stress* RATING — Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING: extreme

Estimating Near-Bank Stress (NBS)

Stream: UT to Little Alam. Location: near x-sect 6 left bank

Observers: BNF, JET Date: 5-2-07

Methods for Estimating Near-Bank Stress

Method	Level	Purpose
(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2) Channel pattern (Rc / W)	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)

- Transverse and/or central bars-short and/or discontinuous ... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) ... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) ... NBS = Extreme

Level II

(2)

Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	Ratio Rc / W	Near-Bank Stress NBS

(3)

Pool Slope Sp	Average Slope S	Ratio Sp / S	Near-Bank Stress NBS

(4)

Pool Slope Sp	Riffle Slope Srif	Ratio Sp / Srif	Near-Bank Stress NBS

Dominant Near-Bank Stress
High

Level III

(5)

Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	Ratio d_{nb} / d	Near-Bank Stress NBS
2.7	1.1	2.45	high

(6)

Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)

Velocity Gradient (ft / s / ft)		Near-Bank Stress NBS

Converting Values to a *Near-Bank Stress* RATING

Near-Bank Stress RATINGS	Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50 (circled)	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *Near-Bank Stress* RATING: high

Estimating Near-Bank Stress (NBS)

Stream: UT to Little Alam. Location: 11+20 to 11+45

Observers: BNF, JET Right Bank Date: 5-21-07

Methods for Estimating Near-Bank Stress

Method	Level	Purpose
(1) Transverse bar or split channel/central bar creating NBS/high velocity gradient...........	Level I	Reconaissance
(2) Channel pattern (Rc / W)........	Level II	General Prediction
(3) Ratio of pool slope to average water surface slope (S_p / S)........	Level II	General Prediction
(4) Ratio of pool slope to riffle slope (S_p / S_{rif})........	Level II	General Prediction
(5) Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})........	Level III	Detailed Prediction
(6) Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})........	Level III	Detailed Prediction
(7) Velocity profiles / Isovels / Velocity gradient........	Level IV	Validation

Level I

(1)
- Transverse and/or central bars-short and/or discontinuous........NBS = High / Very High
- Extensive deposition (continuous, cross-channel)........NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1)........NBS = Extreme

Level II

(2)

Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**
15	12	1.25	ext.

(3)

Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**

(4)

Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**

Dominant Near-Bank Stress
extreme

Level III

(5)

Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**

(6)

Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS

Level IV

(7)

Velocity Gradient (ft / s / ft)		Near-Bank Stress **NBS**

Near-Bank Stress RATINGS	Converting Values to a *Near-Bank Stress* RATING — Method Number (1)	(2)	(3)	(4)	(5)	(6)	(7)
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	1.00 - 1.50	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50 (circled)	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING: extreme

Estimating Near-Bank Stress (NBS)

Stream: UT to Little Alam Location: near x-sect 4 11+75 to 12+40

Observers: BNF, JET left + right bank Date: 5-21-07

METHODS FOR ESTIMATING NEAR-BANK STRESS

(1)	Transverse bar or split channel/central bar creating NBS/high velocity gradient	Level I	Reconaissance
(2)	Channel pattern (Rc / W)	Level II	General Prediction
(3)	Ratio of pool slope to average water surface slope (S_p / S)	Level II	General Prediction
(4)	Ratio of pool slope to riffle slope (S_p / S_{rif})	Level II	General Prediction
(5)	Ratio of near-bank maximum depth to bankfull mean depth (d_{nb} / d_{bkf})	Level III	Detailed Prediction
(6)	Ratio of near-bank shear stress to bankfull shear stress (τ_{nb} / τ_{bkf})	Level III	Detailed Prediction
(7)	Velocity profiles / Isovels / Velocity gradient	Level IV	Validation

Level I (1)
- Transverse and/or central bars-short and/or discontinuous .... NBS = High / Very High
- Extensive deposition (continuous, cross-channel) .... NBS = Extreme
- Chute cutoffs, down-valley meander migration, converging flow (NBS #1) .... NBS = Extreme

Level II

	Radius of Curvature Rc (feet)	Bankfull Width W_{bkf} (feet)	*Ratio* Rc / W	Near-Bank Stress **NBS**
(2)				

	Pool Slope Sp	Average Slope S	*Ratio* Sp / S	Near-Bank Stress **NBS**
(3)				

	Pool Slope Sp	Riffle Slope Srif	*Ratio* Sp / Srif	Near-Bank Stress **NBS**
(4)				

Dominant Near-Bank Stress
Low

Level III

	Near Bank Max Depth d_{nb} (feet)	Mean Depth d (feet)	*Ratio* d_{nb} / d	Near-Bank Stress **NBS**
(5)	2.1	1.5	1.4	Low

	Near Bank Max Depth d_{nb} (feet)	Near Bank Slope S_{nb}	Near-Bank Shear Stress τ_{nb} (lb/ft^2)	Mean Depth d (feet)	Average Slope S	Bankfull Shear Stress τ (lb/ft^2)	Ratio τ_{nb} / τ	Near-Bank Stress NBS
(6)								

Level IV

	Velocity Gradient (ft / s / ft)	Near-Bank Stress **NBS**
(7)		

Near-Bank Stress RATINGS	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Converting Values to a *Near-Bank Stress* RATING — Method Number						
Very Low	N / A	> 3.00	< 0.20	< 0.40	< 1.00	< 0.80	< 1.00
Low	N / A	2.21 - 3.00	0.20 - 0.40	0.41 - 0.60	(1.00 - 1.50)	0.80 - 1.05	1.00 - 1.20
Moderate	N / A	2.01 - 2.20	0.41 - 0.60	0.61 - 0.80	1.51 - 1.80	1.06 - 1.14	1.21 - 1.60
High	See	1.81 - 2.00	0.61 - 0.80	0.81 - 1.00	1.81 - 2.50	1.15 - 1.19	1.61 - 2.00
Very High	(1)	1.50 - 1.80	0.81 - 1.00	1.01 - 1.20	2.51 - 3.00	1.20 - 1.60	2.01 - 2.30
Extreme	Above	< 1.50	> 1.00	> 1.20	> 3.00	> 1.60	> 2.30

Overall *N*ear-*B*ank *S*tress RATING: Low

Appendix D

BMP Design Calculations

30" HDPE @ station 17+00, sheet 2

Q_{10} = 5.8 cfs

D.A. to swale = 2 acres

▣ Swale length = 100' for every 1 acre draining to it.

Swale length = 100' x 2 acres = 200' Req'd → Impractical for site.
Make swale 10' – just enough to collect flow at same location.

Design Forebay Surface Area (SA)

Contributing impervious area = ϕ, so use

D.A. not going to inlet = 0.95 ac x 0.2% = 83 ft²

Design Level spreader Lip length

▣ Length is 13' for every 1 cfs of flow to grass or to thick ground cover filter strip.

Length = 13' x 5.8 cfs / 1 ft = 75' long

18" RCP @ sta 25+00

Q_{10} = 7 cfs (capacity)

D.A. to swale = 0.33 acres

swale length = 100' x 0.33 ac
= 33' min. req'd

Design Forebay SA

Contributing impervious area = ϕ, so use

D.A. to swale 0.33 ac x 0.2% = 29 ft²

Design Level Spreader Lip length

13' x 7 cfs / 1 ft = 91 feet long

- 10-yr. storm
- thick ground cover filter strip

Assume unknown pipe is 12" HDPE
Sta 26+00

D.A. to swale = 0.13 ac
swale length = 100' x 0.13 ac
= 13 ft.

Q_{10} = 3 cfs

Design Forebay Surface Area

Contributing impervious drainage area = (ϕ)

∴ use Contributing D.A. to DI and to ditch = 0.13 ac + 0.43 = 0.56 ac
x 0.2% = 49 ft²

Design Level spreader Lip

for 10-yr. storm and thick ground cover.

13' x 3 cfs/1 ft = 39 feet long

18" HDPE @ Sta 27+00

D.A. to swale = 0.20 ac
swale length = 100' x 0.20 ac
= 20 ft.

Q_{10} = 3 cfs

D.A. to inlet + swale = 0.32 ac
use 32 ft Reqd.

Design Forebay

Contributing Impervious D.A. = 3,380.15 ft² (0.078 ac)
x 0.2% = 7 ft²

but make 49 ft² like previous pipe.

Design level spreader lip

13' x 3 cfs/2 ft. = 39 feet long

12" RCP @ Sta 35+00

D.A. to swale ditch = 0.094 ac

swale length = 100' x 0.094 ac
= 9.5 ft.

Q_{10} = 3cfs

– Leave alone –
Grassy area to act as filter.

Design Forebay

Contributing impervious D.A. = ϕ, so use (0.094 ac)

0.094 x 0.2% = 8 ft²

Design Level spreader Lip

13' per 1 cfs of flow = 13' x 3 cfs = 39 feet long

for 10-yr., thick ground cover filter strip.

15" RCP @ sta 12+00 Trib

D.A. to swale = 0.68 ac

swale length = 100' x 0.68 ac
= 68 feet

Q_{10} = 4.5cfs

Design Forebay

Contributing impervious D.A. = 1/3 of 0.68 = 0.23 ac x 0.2%
= 20 ft²

Design Level Spreader Lip

13' x 4.5 cfs/1ft = 59 feet long

for 10-yr., thick ground cover

Appendix E

Design Sheets

NC DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

DIVISION OF WATER QUALITY

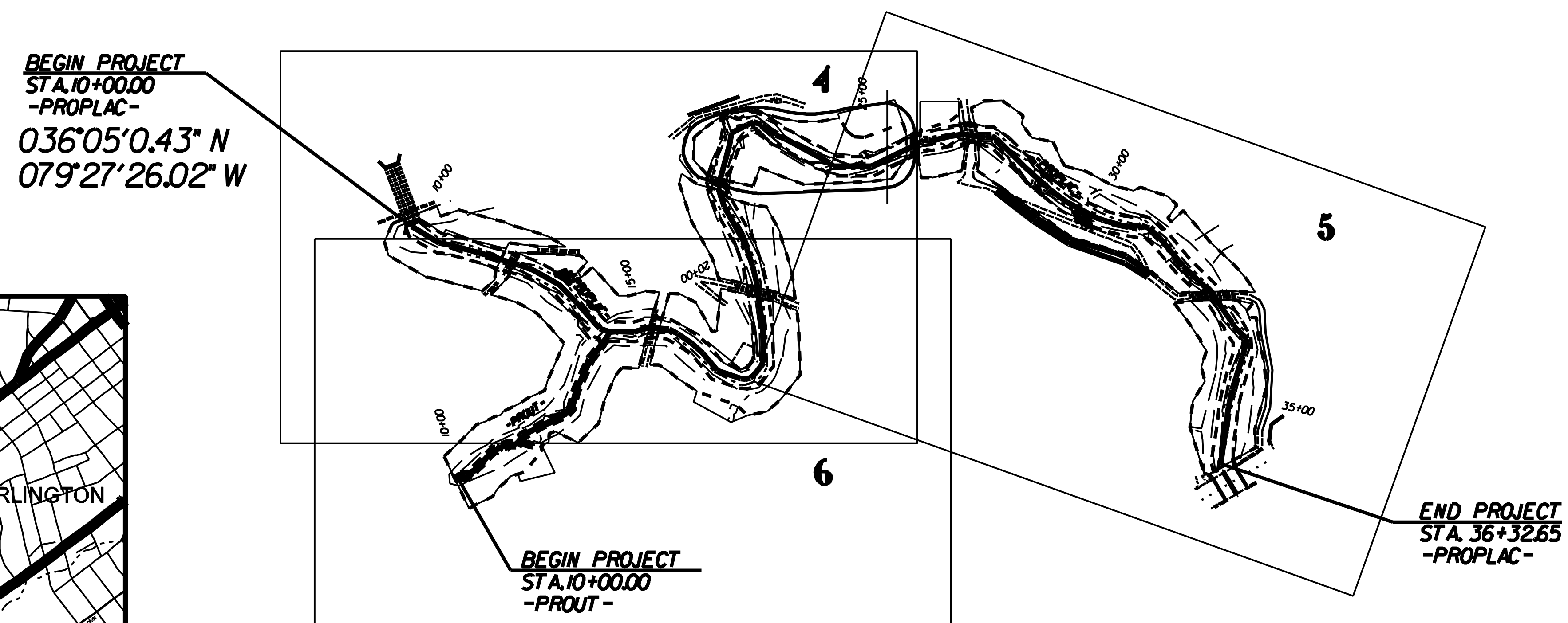
NORTH CAROLINA ECOSYSTEM ENHANCEMENT PROGRAM

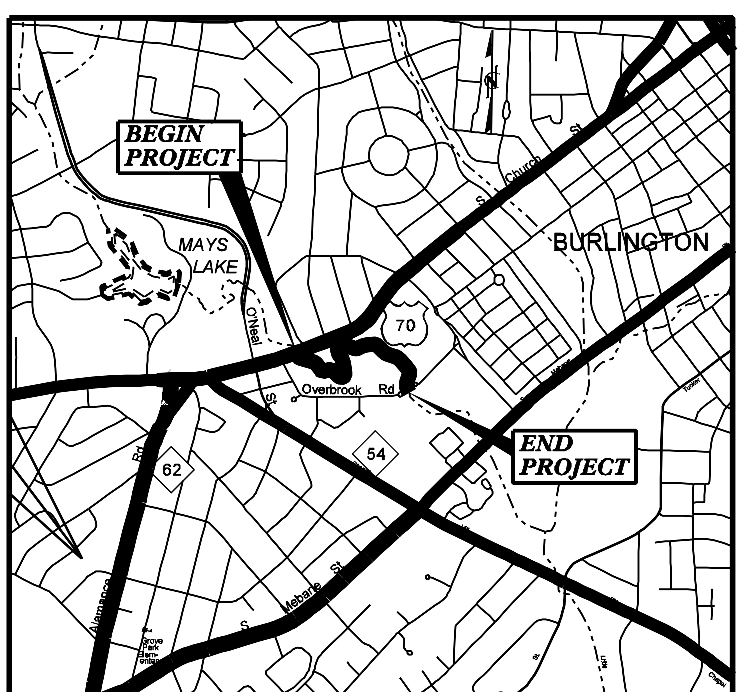
STREAM RESTORATION PROJECT

LITTLE ALAMANCE CREEK

ALAMANCE COUNTY, NORTH CAROLINA

SCO #060685501





VICINITY MAP

EEP Project Manager - Kristie Carson
EEP Review Coordinator - Salam Murtada
ARCADIS Project Manager - Robert Lepsic

PRELIMINARY PLANS

DO NOT USE FOR CONSTRUCTION

ARCADIS
G & M of North Carolina, Inc.
WWW.ARCADIS-US.COM
801 Corporate Center Drive, Suite 300
Raleigh, NC 27607-5073
Tel: 919/854-1282 Fax: 919/854-5448

DESIGN ENGINEER

INDEX OF SHEETS

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2/19/2008

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LEGEND

ROADS & RELATED ITEMS

- Prop. Woven Wire Fence
- Prop. Chain Link Fence
- Prop. Barbed Wire Fence
- Silt Fence (SF)
- Exist. Guardrail
- Prop. Guardrail
- Equality Symbol

RIGHT OF WAY

- Right of Way Marker
- Exist. Right of Way Line w/Marker
- Prop. Right of Way Line (by others)
- Prop. Right of Way Line (by contract)
- Exist. Control of Access Line
- Prop. Control of Access Line
- Exist. Easement Line
- Prop. Temp. Construction Easement Line
- Prop. Temp. Drainage Easement Line
- Prop. Perm. Drainage Easement Line

BOUNDARIES & PROPERTIES

- Property Line Surveyed
- Property Line Not Surveyed
- Exist. Iron Pin
- Property Corner
- Property Monument
- Property Number (123)
- Parcel Number (6)
- Fence Line
- Existing Wetland Boundaries (WLB)
- Proposed Wetland Boundaries (WLB)
- Buildings
- Foundations

HYDROLOGY

- Stream or Body of Water
- Flow Arrow
- Disappearing Stream
- Spring
- Shoreline
- Falls, Rapids

UTILITIES

- Exist. Pole
- Exist. Power Pole
- Exist. Telephone Pole
- Exist. Joint Use Pole
- Telephone Pedestal
- Cable TV Pedestal
- Hydrant
- Exist. Water Valve
- Sewer Clean Out
- Power Manhole
- Water Manhole
- Light Pole
- Power Line Tower
- Pole with Base
- Power Transformer
- Guy Wire Anchor
- Sanitary Sewer Manhole
- Storm Sewer Manhole
- Tank; Water, Gas, Oil
- Recorded Water Line
- Sanitary Sewer (SS)
- Recorded Gas Line (G)
- Storm Sewer (S)
- Recorded Power Line (P)
- Recorded Telephone Cable (T)
- Recorded U/G Telephone Conduit (TC)
- Exist. Water Meter
- Exist. Overhead Power Line
- Exist. Underground Utilities (UGU)

STRUCTURES

MAJOR

- Bridge, Tunnel, or Box Culvert (CONC)
- Bridge Wing Wall, Head Wall and End Wall (CONC WW)

MINOR

- Head & End Wall (CONC HW)
- Pipe Culvert
- Footbridge
- Drainage Boxes (CB)

TOPOGRAPHY

- Loose Surface
- Hard Surface
- Change in Road Surface
- Curb
- Right of Way Symbol (R/W)
- Guard Post (GP)
- Paved Walk
- Bridge
- Box Culvert or Tunnel
- Culvert
- Footbridge
- Trail, Footpath

STREAM IMPROVEMENTS

- Approx. Location of Proposed Boulder Vane (See Detail)
- Approx. Location of Proposed Boulder Cross Vane (See Detail)
- Approx. Location of Proposed Boulder Double Wing Deflector (See Detail)
- Approx. Location of Proposed Rootwad (See Detail)
- Approx. Location of Proposed Stream Plug w/ Root Wads (See Detail)
- Proposed Oxbox Pond/Wetland (See Detail)
- Approximate Limits of Buffer
- Existing Thalweg
- Existing Top of Bank
- Proposed Thalweg
- Proposed Bankfull
- Slope Stake Line — C(cut) F(fill)

VEGETATION

- Existing Woods Line
- Existing Tree

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

LEGEND SHEET NO. 2

Date:2/19/2008
Filename:g:\ira\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_Legend.dgn

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH REFERENCE REACH DATA

LITTLE ALAMANCE CREEK

Variables	Existing Channel	Proposed Reach	Benbow Park Reference Reach	Park @ Friendly Reference Reach	Brown Branch u/s Reference Reach
1. Stream Type	C/E5/1	C 4/1	C4	E4	C/E4
2. Drainage Area (sq.mi)	4.2	4.2	0.7	0.2	0.77
3. Bankfull Width (Wbkf) ft	Mean: 36.2 Range: 31.8-42.5	Mean: 36.2 Range:	Mean: 20.9 Range:	Mean: 9.5 Range:	Mean: 15.1 Range:
4. Bankfull Mean Depth (dbkf) ft	Mean: 2.6 Range: 2.2-2.9	Mean: 2.6 Range:	Mean: 1.7 Range:	Mean: 1.4 Range:	Mean: 1.6 Range:
5. Width/Depth Ratio (Wbkf/dbkf)	Mean: 14.0 Range: 11.6-17.0	Mean: 13.8 Range:	Mean: 12.4 Range:	Mean: 6.9 Range:	Mean: 9.3 Range:
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean: 95.0 Range: 79.3-125.0	Mean: 95.0 Range:	Mean: 35.3 Range:	Mean: 13.0 Range:	Mean: 24.3 Range:
7. Bankfull Mean Velocity (Vbkf) fps	Mean: 2.5 Range:	Mean: 2.5 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
8. Bankfull Discharge,cfs (Qbkf)	Mean: 237.5 Range:	Mean: 237.5 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
9. Maximum Bankfull Depth (dmax) ft	Mean: 4.0 Range: 3.9-4.1	Mean: 4.0 Range: 3.9-4.1	Mean: 3.1 Range:	Mean: 2.0 Range:	Mean: 2.6 Range:
10. Ratio of Low Bank Height to Max. Bankfull Depth (Bhlow/dmax)	Mean: 1.2 Range: 1.0-1.4	Mean: 1.0 Range:	Mean: 1.0 Range:	Mean: 1.4 Range:	Mean: 1.0 Range:
11. Width of Flood Prone Area (Wfpa) ft	Mean: 94.0 Range: 70.0-120.0	Mean: > 80.0 Range:	Mean: 40.0 Range:	Mean: 30.0 Range:	Mean: 30.0 Range:
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean: 2.6 Range: 2.1-3.8	Mean: > 2.2 Range:	Mean: 1.9 Range:	Mean: 3.2 Range:	Mean: 2.0 Range:
13. Meander Length (Lm) ft	Mean: 361.0 Range: 227.0-559.0	Mean: 361.0 Range: 227.0-559.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean: 10.0 Range: 6.3-15.4	Mean: 10.0 Range: 6.3-15.4	Mean: * Range:	Mean: * Range:	Mean: * Range:
15. Radius of Curvature (Rc) ft	Mean: 115.0 Range: 45.0-220.0	Mean: 115.0 Range: 45.0-220.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
16. Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf)	Mean: 3.2 Range: 1.2-6.1	Mean: 3.2 Range: 1.2-6.1	Mean: * Range:	Mean: * Range:	Mean: * Range:
17. Belt Width (Wblt) ft	Mean: 70.0 Range: 33.0-255.0	Mean: 70 Range: 33.0-255.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
18. Meander Width Ratio (Wblt/Wbkf)	Mean: 1.9 Range: 0.9-7.0	Mean: 1.9 Range: 0.9-7.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
19. Sinuosity (Stream length/valley distance) (k)	Mean: 1.2 Range:	Mean: 1.2 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
20. Valley Slope (ft/ft)	Mean: 0.0028 Range:	Mean: 0.0028 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
21. Average Water Surface Slope or Bankful Slope for Reach (Sbkf or Savg)=(Svalley/k) ft / ft	Mean: 0.0024 Range:	Mean: 0.0024 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
22. Pool Slope (Spool) ft / ft	Mean: 0.0005 Range: 0.0-0.0015	Mean: 0.0 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean: 0.2 Range: 0.0-0.6	Mean: 0.0 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
24. Maximum Pool Depth (dpool) ft	Mean: 6.1 Range: 5.5-6.9	Mean: 6.1 Range: 5.5-6.9	Mean: * Range:	Mean: * Range:	Mean: * Range:
25. Ratio of Maximum Pool Depth to Bankfull Mean Depth (dpool/dbkf)	Mean: 2.3 Range: 2.1-2.7	Mean: 2.3 Range: 2.1-2.7	Mean: * Range:	Mean: * Range:	Mean: * Range:
26. Pool Width (Wpool) ft	Mean: 37.6 Range: 32.3-42.3	Mean: 37.6 Range: 32.3-42.3	Mean: * Range:	Mean: * Range:	Mean: * Range:

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

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Raleigh, NC 27607-5073
Tel: 919/854-1282 Fax: 919/854-5448

DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

MORPHOLOGICAL TABLES -PROPLAC- SHEET NO. 3

Date:2/19/2008
Filename:g:\ra\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_Morph_Tables.dgn

Variables	Existing Channel	Proposed Reach	Benbow Park Reference Reach	Park @ Friendly Reference Reach	Brown Branch u/s Reference Reach
27. Ratio of Pool Width to Bankfull Width (Wpool/Wbkf)	Mean: 1.0 Range: 0.9-1.2	Mean: 1.0 Range: 0.9-1.2	Mean: * Range:	Mean: * Range:	Mean: * Range:
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean: 140.2 Range: 121.0-156.6	Mean: 140.2 Range: 121.0-156.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean: 1.0 Range: 1.3-1.7	Mean: 1.0 Range: 1.3-1.7	Mean: * Range:	Mean: * Range:	Mean: * Range:
30. Pool to Pool Spacing (p-p) ft	Mean: 473.1 Range: 313.7-749.5	Mean: 473.1 Range: 313.7-749.5	Mean: * Range:	Mean: * Range:	Mean: * Range:
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/Wbkf)	Mean: 13.1 Range: 8.7-20.7	Mean: 13.1 Range: 8.7-20.7	Mean: * Range:	Mean: * Range:	Mean: * Range:
32. Pool Length (Lp) ft	Mean: 293.7 Range: 107.9-505.4	Mean: 293.7 Range: 107.9-505.4	Mean: * Range:	Mean: * Range:	Mean: * Range:
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean: 8.1 Range: 3.0-14.0	Mean: 8.1 Range: 3.0-14.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
34. Riffle Slope (Sriff) ft / ft	Mean: 0.0126 Range: 0.0028-0.0254	Mean: 0.0126 Range: 0.0028-0.0254	Mean: * Range:	Mean: * Range:	Mean: * Range:
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean: 5.2 Range: 1.2-10.6	Mean: 5.2 Range: 1.2-10.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
36. Maximum Riffle Depth (driff) ft	Mean: 4.0 Range: 3.9-4.1	Mean: 4.0 Range: 3.9-4.1	Mean: * Range:	Mean: * Range:	Mean: * Range:
37. Ratio of Riffle Depth to Bankfull Mean Depth (driff/dbkf)	Mean: 1.5 Range: 1.5-1.6	Mean: 1.5 Range: 1.5-1.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
38. Run Slope (Srun) ft / ft	Mean: 0.0032 Range: 0.0-0.0090	Mean: 0.0032 Range: 0.0-0.0090	Mean: * Range:	Mean: * Range:	Mean: * Range:
39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean: 1.3 Range: 0.0-3.7	Mean: 1.3 Range: 0.0-3.7	Mean: * Range:	Mean: * Range:	Mean: * Range:
40. Maximum Run Depth (drun) ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
41. Ratio of Run Depth to Bankfull Mean Depth (drun/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
42. Slope of Glide (Sgl) ft / ft	Mean: 0.0039 Range: 0.0-0.0107	Mean: 0.0039 Range: 0.0-0.0107	Mean: * Range:	Mean: * Range:	Mean: * Range:
43. Ratio of Glide Slope to Average Water Surface Slope (Sgl/Sws)	Mean: 1.6 Range: 0.0-4.5	Mean: 1.6 Range: 0.0-4.5	Mean: * Range:	Mean: * Range:	Mean: * Range:
44. Maximum Glide Depth (dgl) ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
45. Ratio of Glide Depth to Bankfull Mean Depth (dgl/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
46. Step Slope (Sst)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
47. Ratio of Step Slope to Average Water Surface Slope (Sst/Savg)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
48. Maximum Step Depth (dst)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
49. Ratio of Step Depth to Bankfull Mean Depth (dst/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

MORPHOLOGICAL TABLES -PROPLAC- SHEET NO. 3A

Date:1/25/2008
Filename:g:\tra\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_Morph_Tables.dgn

MORPHOLOGICAL CHARACTERISTICS OF THE EXISTING AND PROPOSED CHANNEL WITH REFERENCE REACH DATA

UNNAMED TRIBUTARY TO LITTLE ALAMANCE CREEK

Variables	Existing Channel	Proposed Reach	Reference Reach	Reference Reach	Reference Reach
1. Stream Type	E4/1	C 4/1	C4	E4	C/E4
2. Drainage Area (sq.mi)	0.12	0.12	0.7	0.2	0.77
3. Bankfull Width (Wbkf) ft	Mean: 12.0 Range: 10.9-13.0	Mean: 12.0 Range: 10.9-13.0	Mean: 20.9 Range:	Mean: 9.5 Range:	Mean: 15.1 Range:
4. Bankfull Mean Depth (dbkf) ft	Mean: 1.3 Range: 1.1-1.5	Mean: 1.3 Range: 1.1-1.5	Mean: 1.7 Range:	Mean: 1.4 Range:	Mean: 1.6 Range:
5. Width/Depth Ratio (Wbkf/dbkf)	Mean: 9.3 Range: 7.1-11.5	Mean: 9.3 Range: 7.1-11.5	Mean: 12.4 Range:	Mean: 6.9 Range:	Mean: 9.3 Range:
6. Bankfull Cross-Sectional Area (Abkf) sq ft	Mean: 15.8 Range: 14.8-16.7	Mean: 15.8 Range: 14.8-16.7	Mean: 35.3 Range:	Mean: 13.0 Range:	Mean: 24.3 Range:
7. Bankfull Mean Velocity (Vbkf) fps	Mean: 4.4 Range:	Mean: 4.4 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
8. Bankfull Discharge, cfs (Qbkf)	Mean: 68.7 Range:	Mean: 68.7 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
9. Maximum Bankfull Depth (dmax) ft	Mean: 2.0 Range: 2.0-2.1	Mean: 2.0 Range: 2.0-2.1	Mean: 3.1 Range:	Mean: 2.0 Range:	Mean: 2.6 Range:
10. Ratio of Low Bank Height to Max. Bankfull Depth (Bhlow/dmax)	Mean: 1.2 Range: 1.0-1.3	Mean: 1.0 Range:	Mean: 1.0 Range:	Mean: 1.4 Range:	Mean: 1.0 Range:
11. Width of Flood Prone Area (Wfpa) ft	Mean: 33.5 Range: 27.0-40.0	Mean: 33.5 Range: 27.0-40.0	Mean: 40.0 Range:	Mean: 30.0 Range:	Mean: 30.0 Range:
12. Entrenchment Ratio (Wfpa/Wbkf)	Mean: 2.9 Range: 2.1-3.7	Mean: 2.9 Range: 2.1-3.7	Mean: 1.9 Range:	Mean: 3.2 Range:	Mean: 2.0 Range:
13. Meander Length (Lm) ft	Mean: 83.9 Range: 55.8-111.9	Mean: 83.9 Range: 55.8-111.9	Mean: * Range:	Mean: * Range:	Mean: * Range:
14. Ratio of Meander Length to Bankfull Width (Lm/Wbkf)	Mean: 7.0 Range: 4.7-9.3	Mean: 7.0 Range: 4.7-9.3	Mean: * Range:	Mean: * Range:	Mean: * Range:
15. Radius of Curvature (Rc) ft	Mean: 29.0 Range: 15.0-55.0	Mean: 29.0 Range: 15.0-55.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
16. Ratio of Radius of Curvature to Bankfull Width (Rc/Wbkf)	Mean: 2.4 Range: 1.2-4.6	Mean: 2.4 Range: 1.2-4.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
17. Belt Width (Wblt) ft	Mean: 24.6 Range: 13.5-33.7	Mean: 24.6 Range: 13.5-33.7	Mean: * Range:	Mean: * Range:	Mean: * Range:
18. Meander Width Ratio (Wblt/Wbkf)	Mean: 2.0 Range: 1.1-2.8	Mean: 2.0 Range: 1.1-2.8	Mean: * Range:	Mean: * Range:	Mean: * Range:
19. Sinuosity (Stream length/valley distance) (k)	Mean: 1.1 Range: N/A	Mean: 1.1 Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
20. Valley Slope (ft/ft)	Mean: 0.0106 Range: N/A	Mean: 0.0106 Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
21. Average Water Surface Slope or Bankful Slope for Reach (Sbkf or Savg)=(Svalley/k) ft / ft	Mean: 0.0095 Range: N/A	Mean: 0.0095 Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
22. Pool Slope (Spool) ft / ft	Mean: 0.0077 Range: 0.0-0.0174	Mean: 0.0077 Range: 0.0-0.0174	Mean: * Range:	Mean: * Range:	Mean: * Range:
23. Ratio of Pool Slope to Average Slope (Spool/Sbkf)	Mean: 0.8 Range: 0.0-1.8	Mean: 0.8 Range: 0.0-1.8	Mean: * Range:	Mean: * Range:	Mean: * Range:
24. Maximum Pool Depth (dpool) ft	Mean: 2.4 Range:	Mean: 2.4 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
25. Ratio of Maximum Pool Depth to Bankfull Mean Depth (dpool/dbkf)	Mean: 1.8 Range:	Mean: 1.8 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
26. Pool Width (Wpool) ft	Mean: 6.1 Range:	Mean: 6.1 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMO	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

MORPHOLOGICAL TABLE -PROUT- SHEET NO. 3B

Date: 1/25/2008
Filename: g:\tra\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_Morph_Tables.dgn

Variables	Existing Channel	Proposed Reach	Reference Reach	Reference Reach	Reference Reach
27. Ratio of Pool Width to Bankfull Width (Wpool/Wbkf)	Mean: 0.5 Range:	Mean: 0.5 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
28. Bankfull Cross-sectional Area at Pool (Apool) sq ft	Mean: 9.5 Range:	Mean: 9.5 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
29. Ratio of Pool Area to Bankfull Area (Apool/Abkf)	Mean: 0.6 Range:	Mean: 0.6 Range:	Mean: * Range:	Mean: * Range:	Mean: * Range:
30. Pool to Pool Spacing (p-p) ft	Mean: 34.1 Range: 23.4-54.8	Mean: 34.1 Range: 23.4-54.8	Mean: * Range:	Mean: * Range:	Mean: * Range:
31. Ratio of Pool-to-Pool Spacing to Bankfull Width (p-p/Wbkf)	Mean: 2.8 Range: 2.0-4.6	Mean: 2.8 Range: 2.0-4.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
32. Pool Length (Lp) ft	Mean: 18.2 Range: 4.0-163.0	Mean: 18.2 Range: 4.0-163.0	Mean: * Range:	Mean: * Range:	Mean: * Range:
33. Ratio of Pool Length to Bankfull Width (Lp/Wbkf)	Mean: 1.5 Range: 0.3-13.6	Mean: 1.5 Range: 0.3-13.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
34. Riffle Slope (Sriff) ft / ft	Mean: 0.0252 Range: 0.0145-0.0498	Mean: 0.0252 Range: 0.0145-0.0498	Mean: * Range:	Mean: * Range:	Mean: * Range:
35. Ratio of Riffle Slope to Average Slope (Sriff/Sbkf)	Mean: 2.6 Range: 1.5-5.2	Mean: 2.6 Range: 1.5-5.2	Mean: * Range:	Mean: * Range:	Mean: * Range:
36. Maximum Riffle Depth (driff) ft	Mean: 2.0 Range: 2.0-2.1	Mean: 2.0 Range: 2.0-2.1	Mean: * Range:	Mean: * Range:	Mean: * Range:
37. Ratio of Riffle Depth to Bankfull Mean Depth (driff/dbkf)	Mean: 1.6 Range: 1.5-1.6	Mean: 1.6 Range: 1.5-1.6	Mean: * Range:	Mean: * Range:	Mean: * Range:
38. Run Slope (Srun) ft / ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
39. Ratio of Run Slope to Average Slope (Srun/Sbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
40. Maximum Run Depth (drun) ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
41. Ratio of Run Depth to Bankfull Mean Depth (drun/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
42. Slope of Glide (Sgl) ft / ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
43. Ratio of Glide Slope to Average Water Surface Slope (Sgl/Sws)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
44. Maximum Glide Depth (dgl) ft	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
45. Ratio of Glide Depth to Bankfull Mean Depth (dgl/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
46. Step Slope (Sst)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
47. Ratio of Step Slope to Average Water Surface Slope (Sst/Savg)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
48. Maximum Step Depth (dst)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:
49. Ratio of Step Depth to Bankfull Mean Depth (dst/dbkf)	Mean: N/A Range: N/A	Mean: N/A Range: N/A	Mean: * Range:	Mean: * Range:	Mean: * Range:

* Geomorphic data not collected due to existing design constraints. The majority of the work on site will consist of Enhancement I. Ranges for restoration areas were developed around the existing site constraints.

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

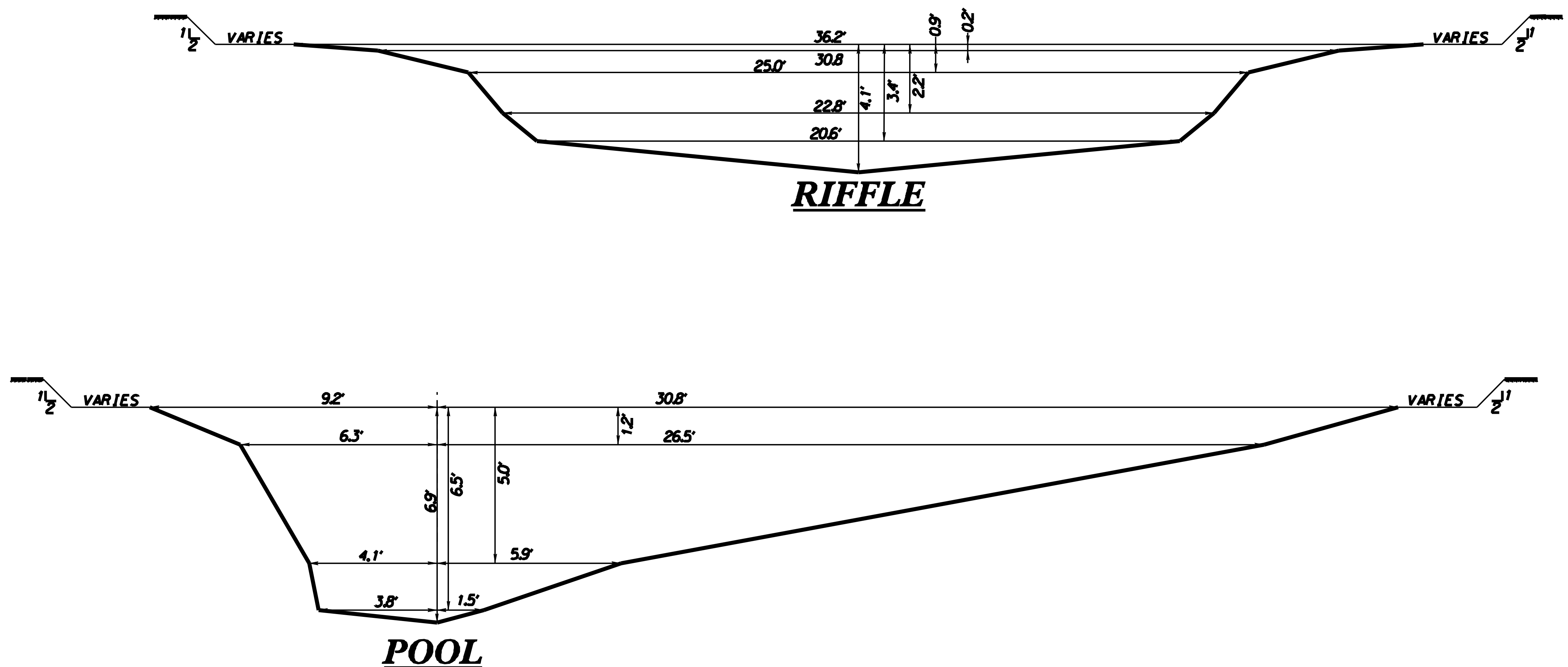
	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

MORPHOLOGICAL TABLE -PROUT- SHEET NO. 3C

Date:1/25/2008
Filename: g:\tro\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_Morph_Tables.dgn



Date:2/19/2008
Filename:g:\tra\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_typ.dgn

1' 0 2'
SCALE

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMO	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

TYPICALS
SHEET NO. 30

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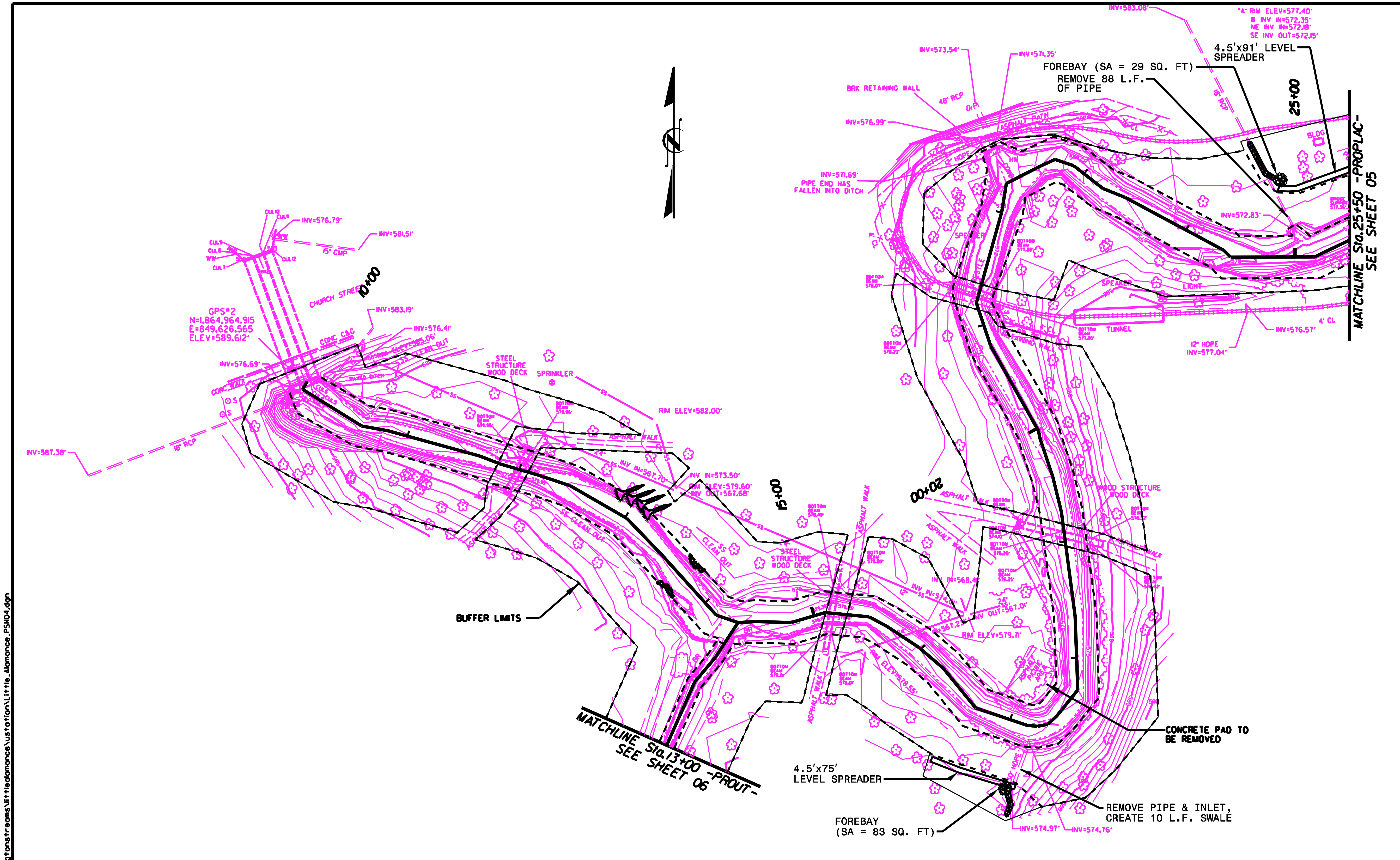

Date:2/19/2008
Filename:g:\ira\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_PSH04.dgn

20' 0 40'
SCALE

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DESIGN ENGINEER

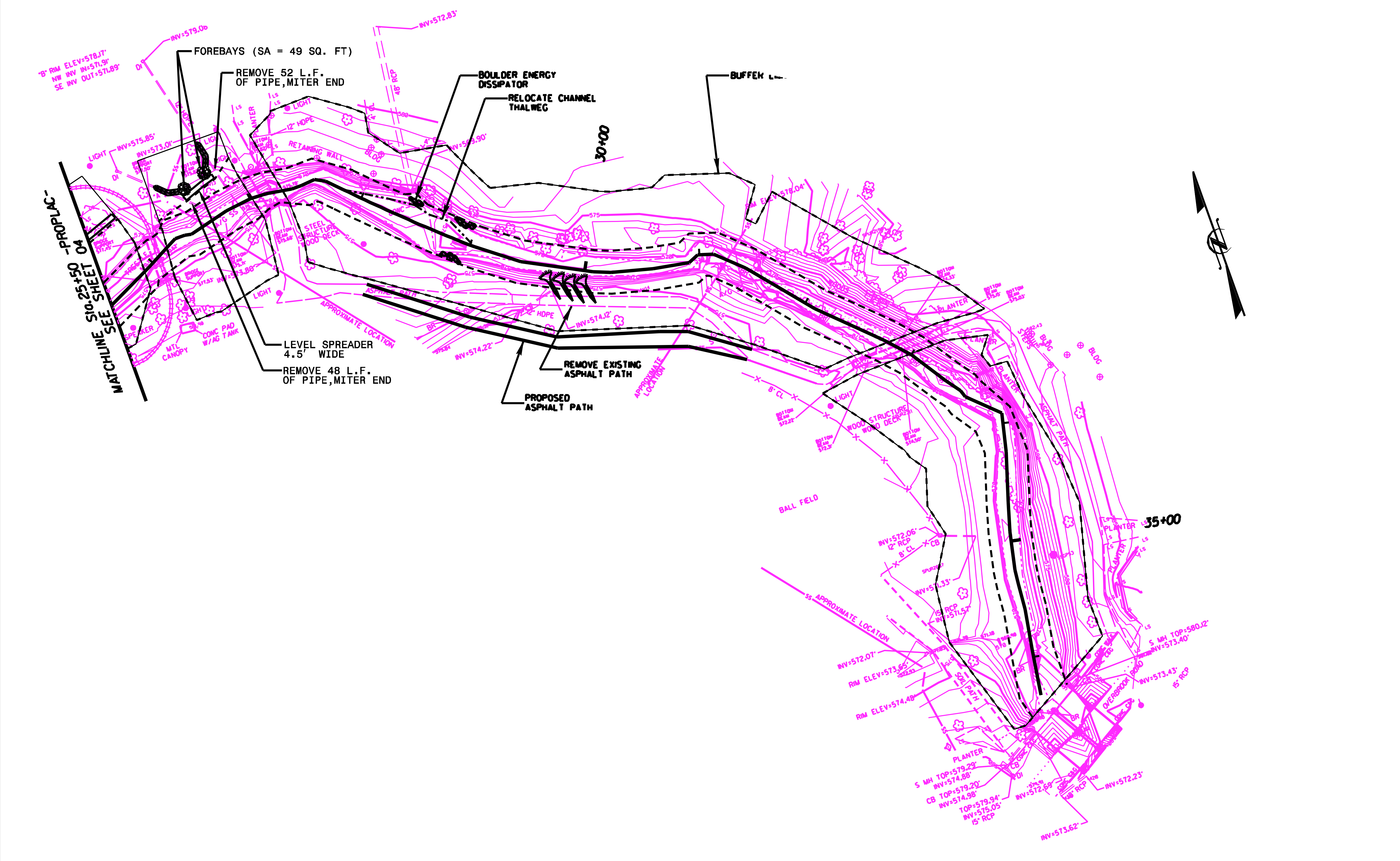
PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	RES	10/24/07	DRAFT RESTORATION PLAN
	BY	DATE	DESCRIPTION OF REVISION

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PLAN
SHEET NO. 4



20' 0 40'
SCALE

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DESIGN ENGINEER

PRELIMINARY PLANS

DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK

ALAMANCE COUNTY, NORTH CAROLINA

PLAN SHEET NO. 5

Date:2/19/2008
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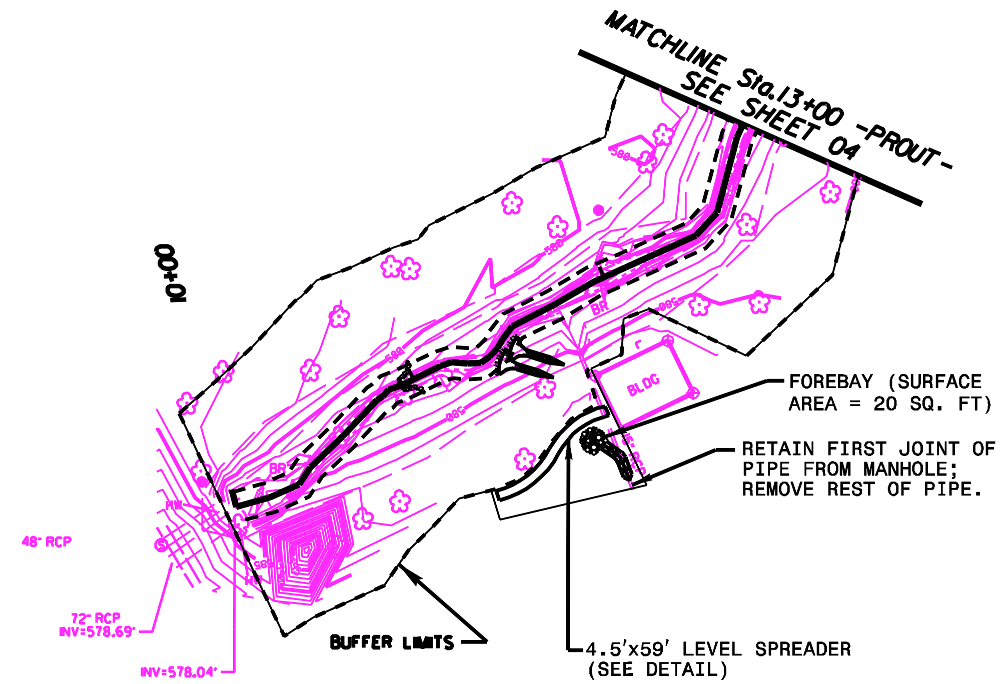

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20' 0 40'
SCALE

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PLAN — SHEET NO. 6

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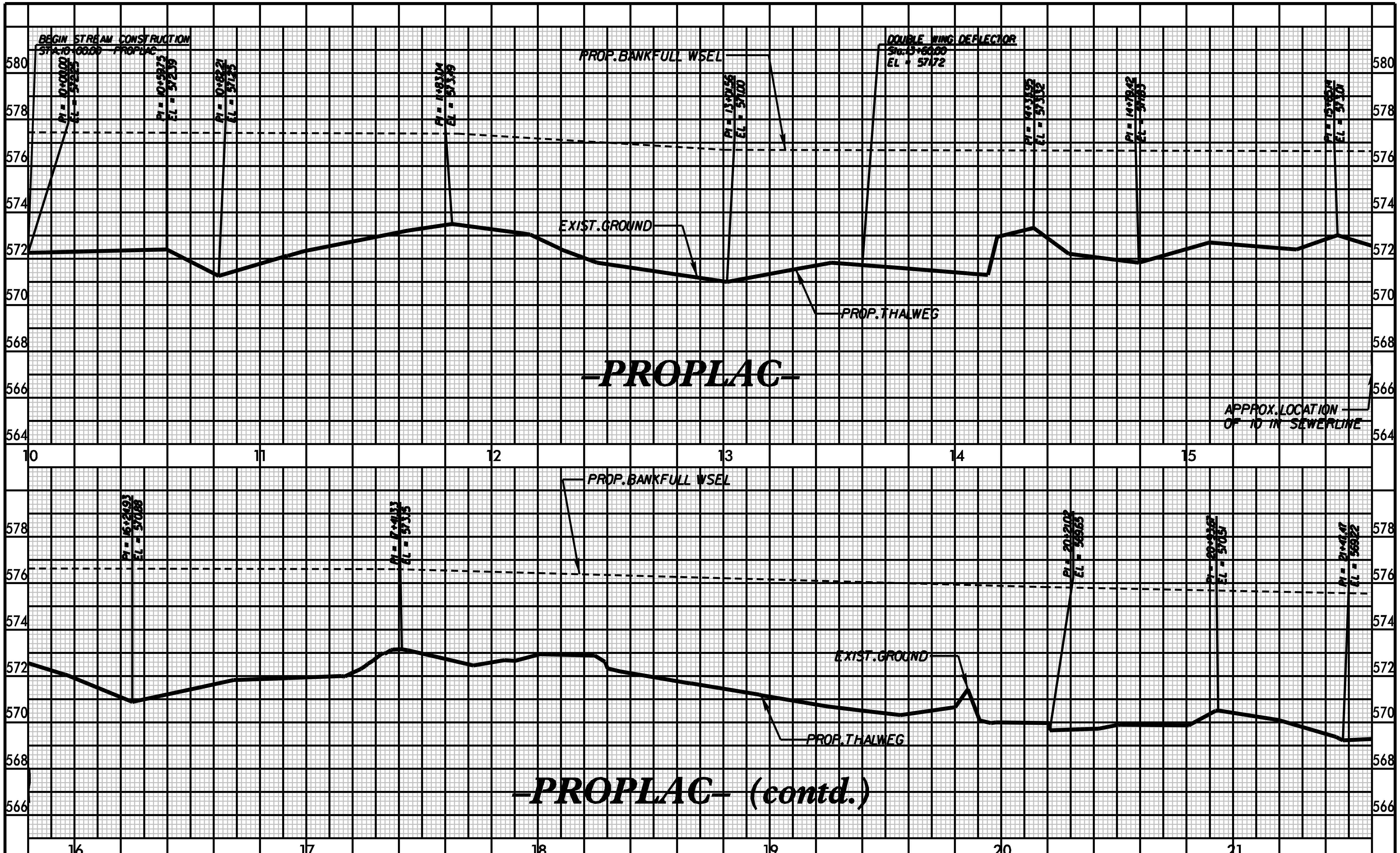

10' 0 20'
HORIZON. SCALE

1' 0 2'
VERTICAL SCALE

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2/19/2008

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DESIGN ENGINEER

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2			
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PROFILE
SHEET NO. 7

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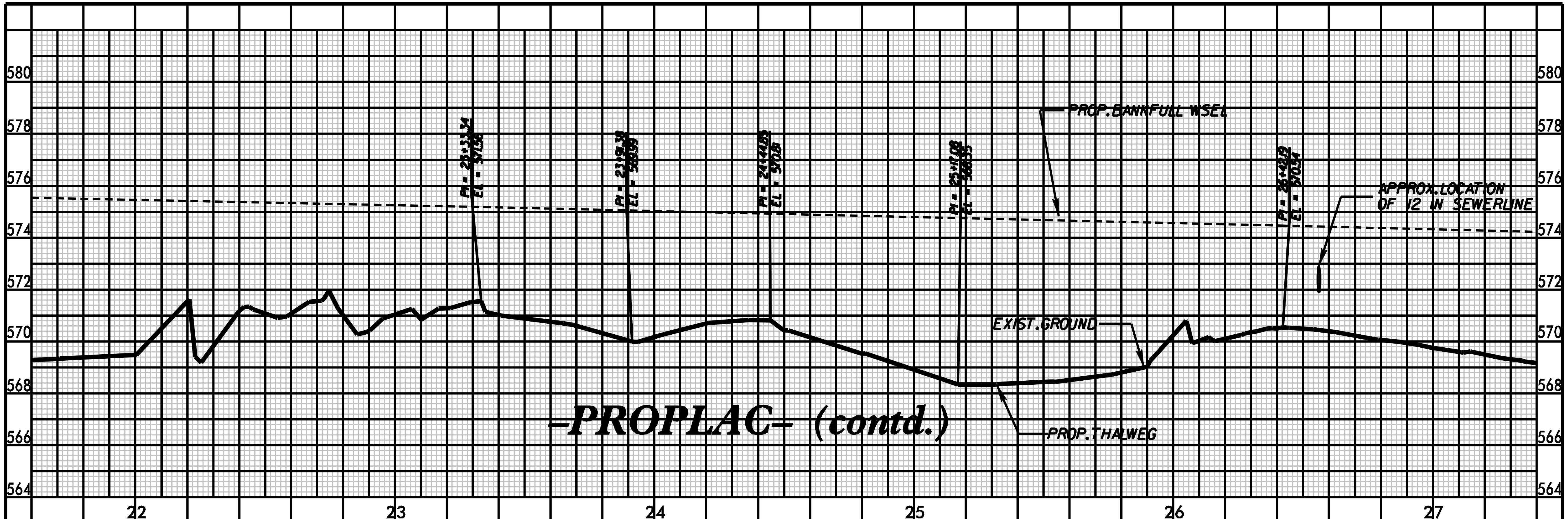

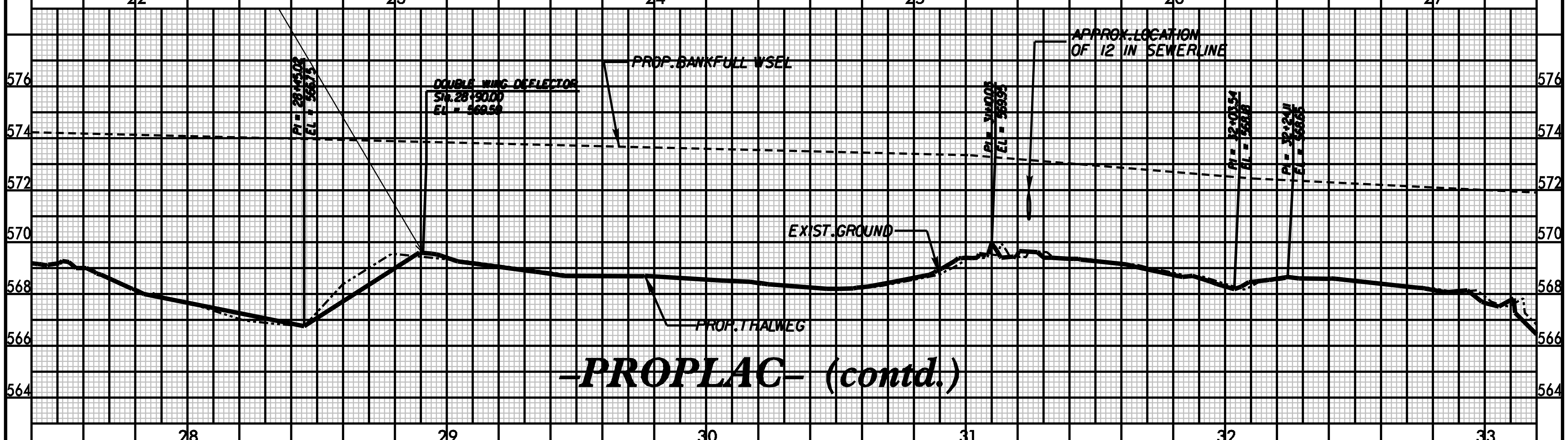

10' 0 20'
HORIZON. SCALE

1' 0 2'
VERTICAL SCALE

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2/19/2008

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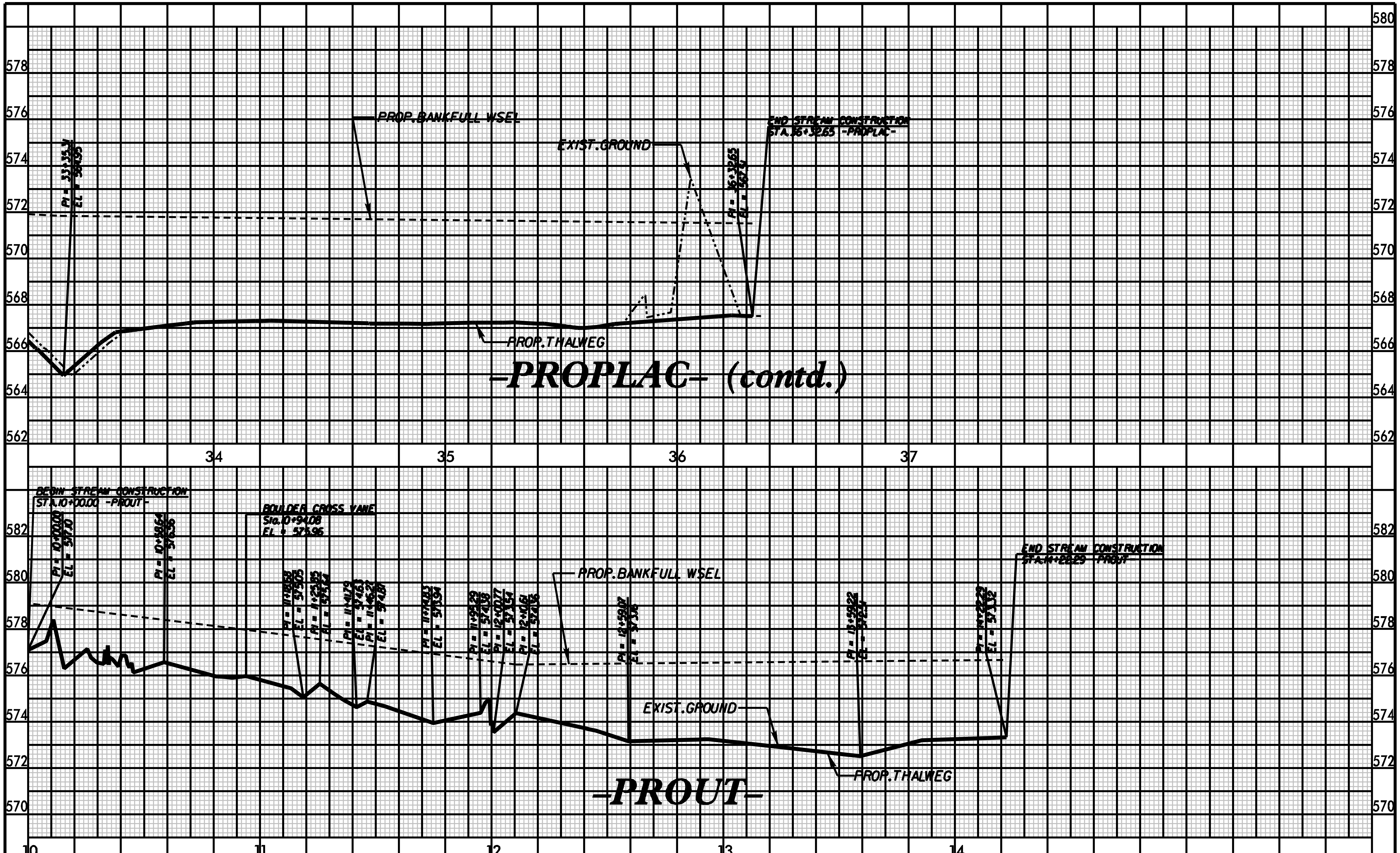
DESIGN ENGINEER

5			
4			
3			
2			
1	REB	10/24/07	DRAFT RESTORATION PLAN
	BY	DATE	DESCRIPTION OF REVISION

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PROFILE
SHEET NO. 8



g:\tra\607003.burlingtonstreams\littlealamance\ustation\Little_Alamance_PFL_09.dgn
2/19/2008

10' 0 20'
HORIZON. SCALE

1' 0 2'
VERTICAL SCALE

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DESIGN ENGINEER

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2			
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PROFILE
SHEET NO. 9

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Zone 1 - Bankfull to End of Buffer
Piedmont Alluvial Forest

Herbaceous (seed)

Solidago caesia	goldenrod
Impatiens capensis	jewelweed
Lobelia cardinalis	cardinal flower
Asclepias incarnata	swamp milkweed
Asclepias tuberosa	butterfly weed

Grass (seed)

Chasmanthium latifolium	river oats
Panicum virgatum	switchgrass
Hystrix patula	bottlebrush grass
Panicum clandestinum	deer tounge

Shrub

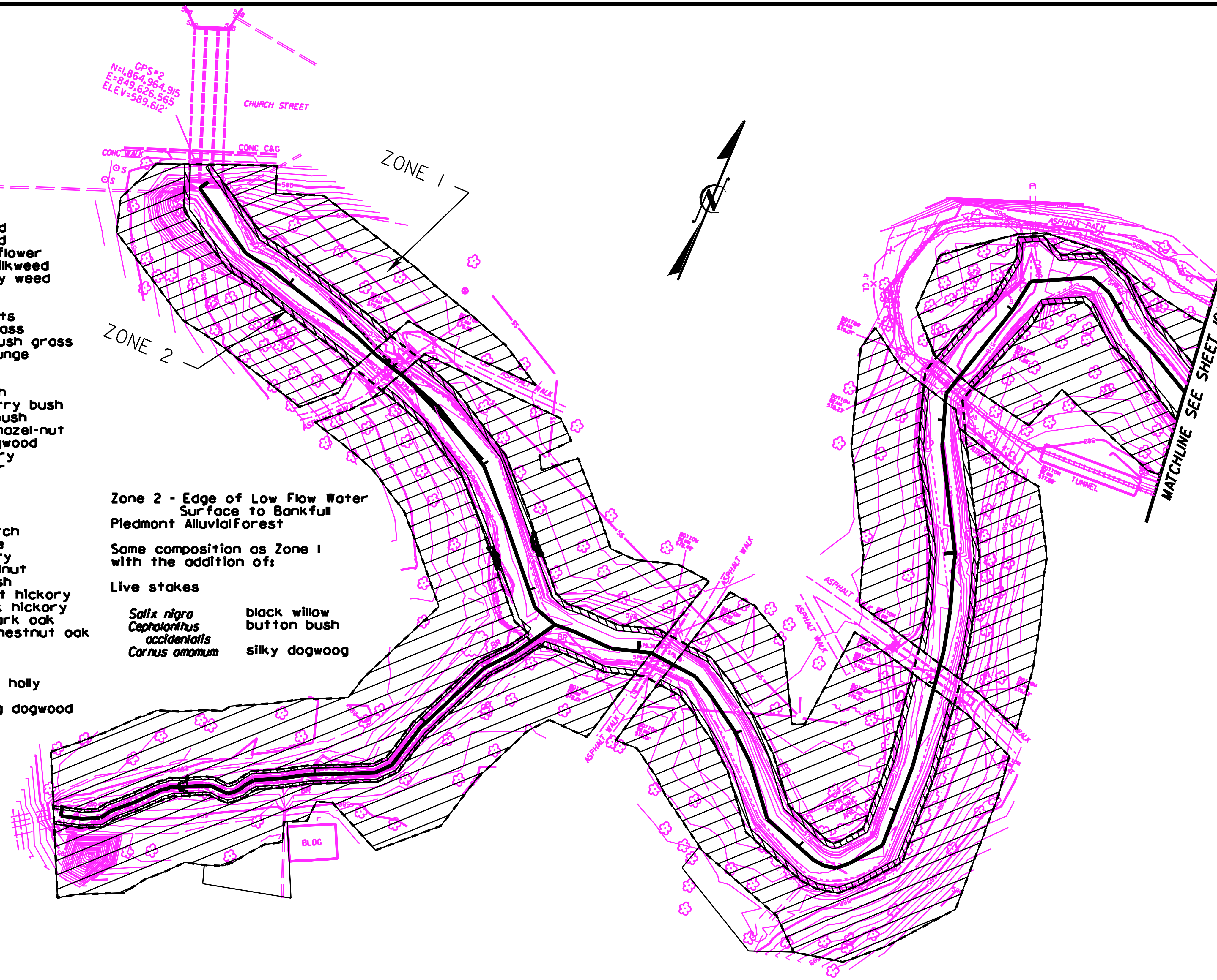
Lindera benzoin	spicebush
Euonymus americana	strawberry bush
Leucothoe recurva	fetter-bush
Corylus cornuta	beaked hazel-nut
Cornus amomum	silky dogwood
Sambucus canadensis	elderberry
Alnus serrulata	tag alder
Aesculus sylvatica	buckeye

Trees
Canopy

Betula nigra	river birch
Platanus occidentalis	sycamore
Celtis laevigata	hackberry
Juglans nigra	black walnut
Fraxinus pennsylvanica	green ash
Carya cordiformis	bitternut hickory
Carya ovata	shagbark hickory
Quercus pagoda	cherrybark oak
Quercus michauxii	swamp chestnut oak

Understory

Asimina triloba	paw paw
Ilex opaca	American holly
Carpinus caroliniana	ironwood
Cornus florida	flowering dogwood



Zone 2 - Edge of Low Flow Water Surface to Bankfull
Piedmont Alluvial Forest

Same composition as Zone 1 with the addition of:

Live stakes

Salix nigra	black willow
Cephalanthus occidentalis	button bush
Cornus amomum	silky dogwoog

20' 0 40'
SCALE

LEGEND

PIEDMONT ALLUVIAL FOREST (ZONE 1)

PIEDMONT ALLUVIAL FOREST (ZONE 2)

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

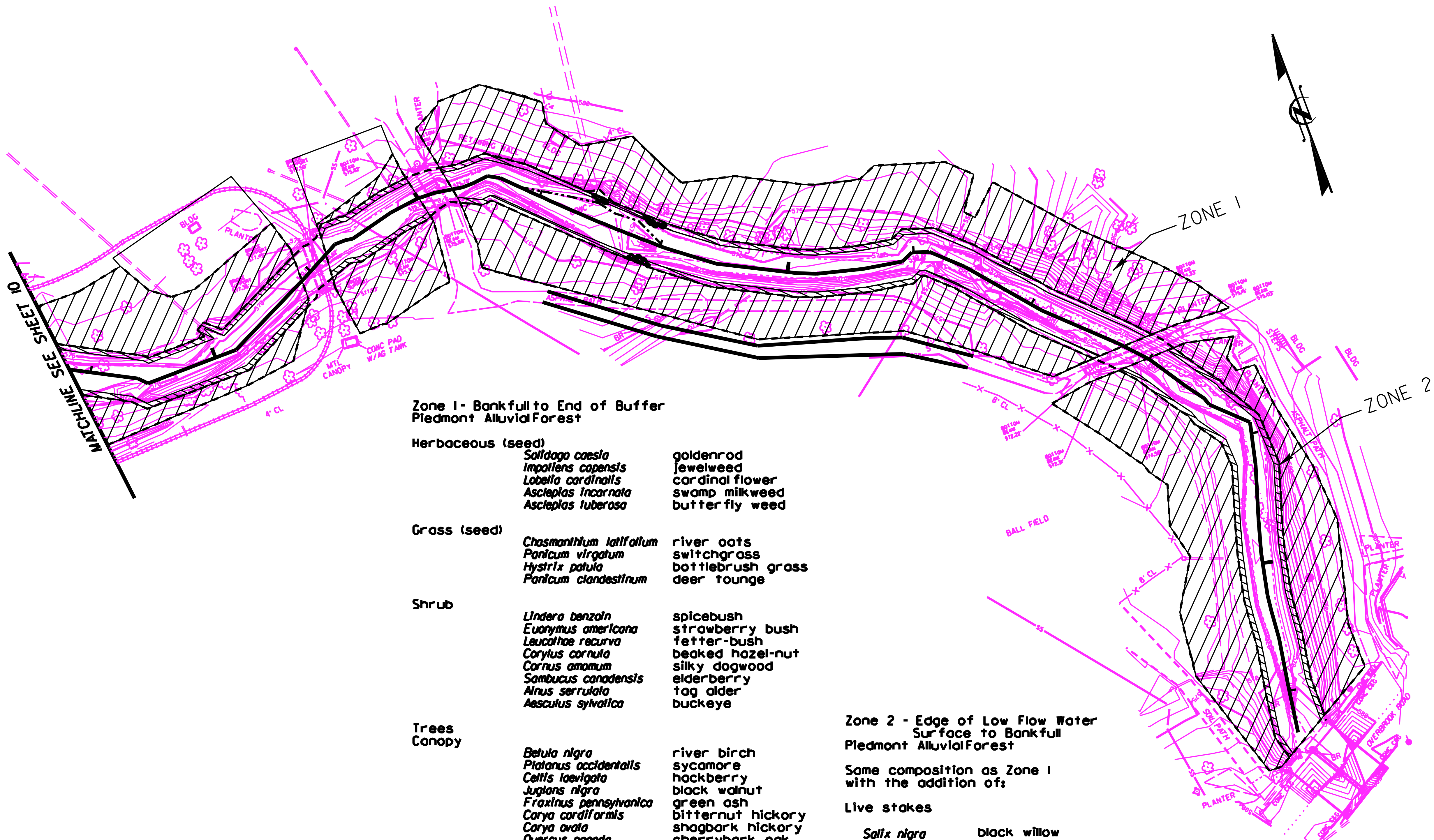
	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMO	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

PLANTING PLAN — SHEET NO. 10

Date:2/19/2008
Filename:g:\ira\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_PP10.dgn



Zone 1 - Bankfull to End of Buffer
Piedmont Alluvial Forest

Herbaceous (seed)

Solidago caesia	goldenrod
Impatiens capensis	jewelweed
Lobelia cardinalis	cardinal flower
Asclepias incarnata	swamp milkweed
Asclepias tuberosa	butterfly weed

Grass (seed)

Chasmanthium latifolium	river oats
Panicum virgatum	switchgrass
Hystrix patula	bottlebrush grass
Panicum clandestinum	deer tounge

Shrub

Lindera benzoin	spicebush
Euonymus americana	strawberry bush
Leucothoe recurva	fetter-bush
Corylus cornuta	beaked hazel-nut
Cornus amomum	silky dogwood
Sambucus canadensis	elderberry
Alnus serrulata	tag alder
Aesculus sylvatica	buckeye

Trees
Canopy

Betula nigra	river birch
Platanus occidentalis	sycamore
Celtis laevigata	hackberry
Juglans nigra	black walnut
Fraxinus pennsylvanica	green ash
Carya cordiformis	bitternut hickory
Carya ovata	shagbark hickory
Quercus pagoda	cherrybark oak
Quercus michauxii	swamp chestnut oak

Understory

Asimina triloba	paw paw
Ilex opaca	American holly
Carpinus caroliniana	ironwood
Cornus florida	flowering dogwood

Zone 2 - Edge of Low Flow Water Surface to Bankfull
Piedmont Alluvial Forest

Same composition as Zone 1 with the addition of:

Live stakes

Salix nigra	black willow
Cephalanthus occidentalis	button bush
Cornus amomum	silky dogwoog

20' 0 40'
SCALE

LEGEND

PIEDMONT ALLUVIAL FOREST (ZONE 1)
PIEDMONT ALLUVIAL FOREST (ZONE 2)

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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

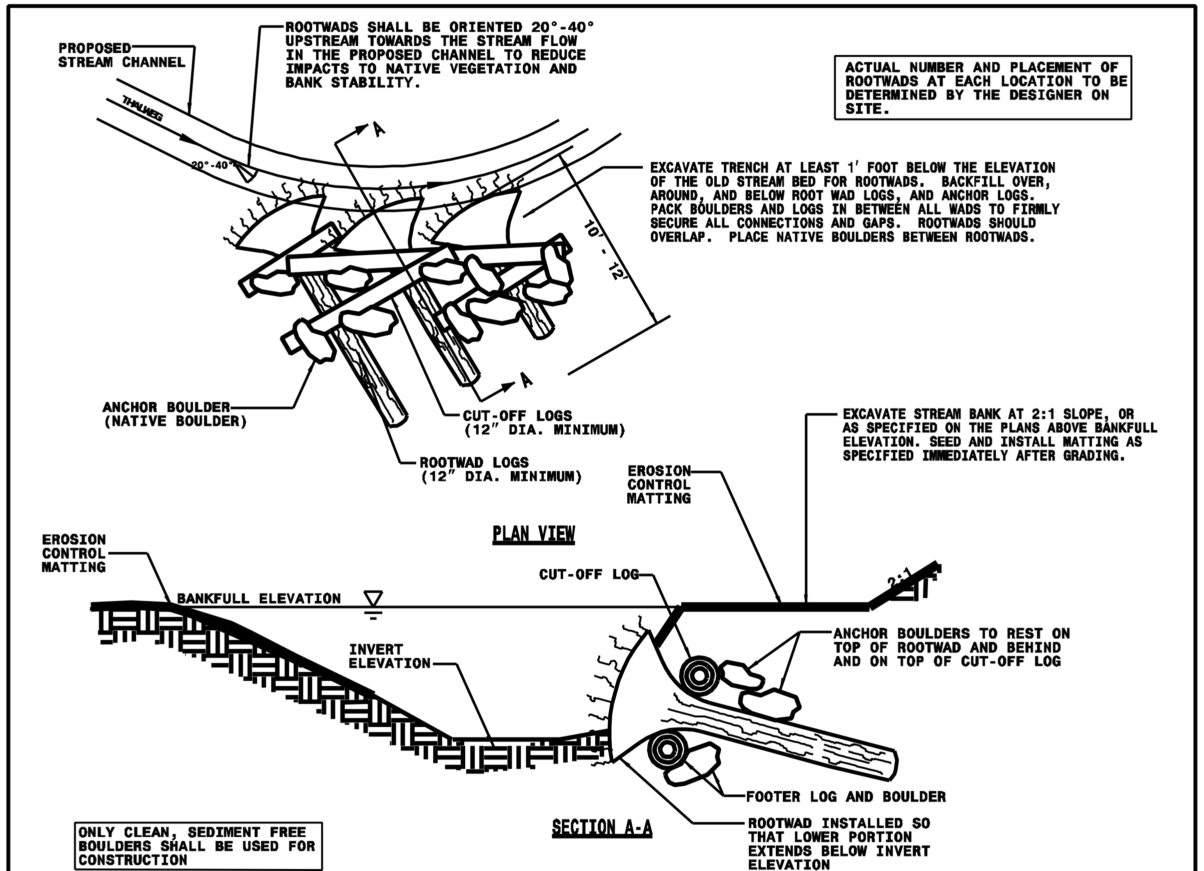
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

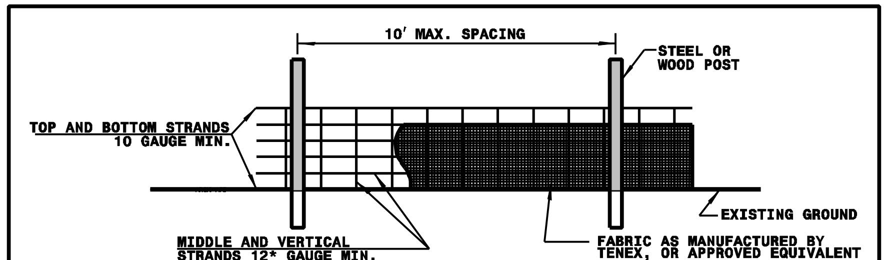
PLANTING PLAN SHEET NO. 10A

Date:2/19/2008
Filename:g:\ira\607003_burlingtonstreams\littlealamance\ustation\Little_Alamance_PP10A.dgn

Details – LITTLE ALAMANCE CREEK

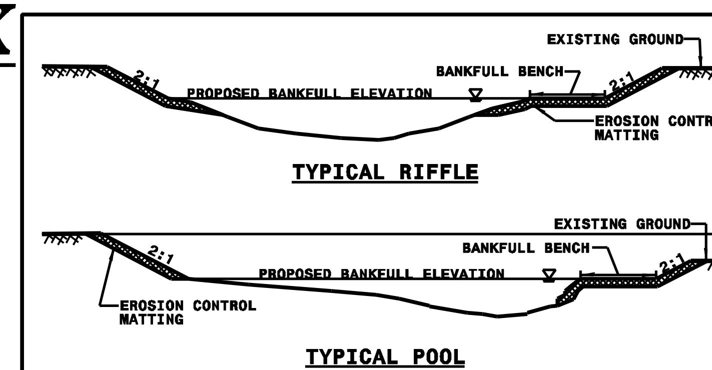


ROOTWAD INSTALLATION
NTS



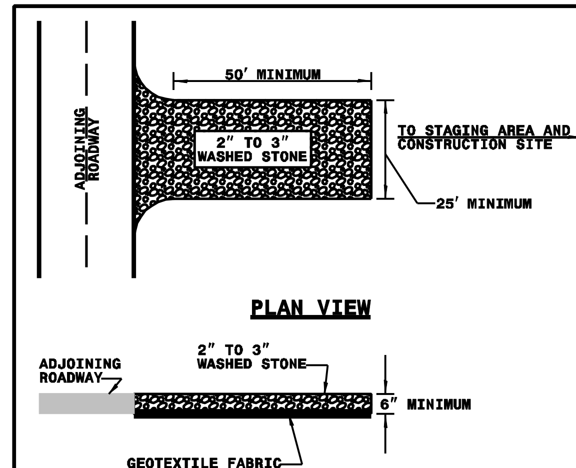
NOTE:
INSTALL FENCING AS SHOWN ON PLANS AND MAINTAIN UNTIL COMPLETION OF CONSTRUCTION OR AS DIRECTED BY DESIGNER

TREE PROTECTION/CONSTRUCTION LIMITS FENCING
NTS



NOTES:
1. EROSION CONTROL MATTING TO BE PLACED ON CONSTRUCTED BANKFULL BENCHES AND SLOPES.
2. MATTING TO BE PROPERLY INSTALLED, KEYED IN, AND SECURED PER MANUFACTURERS RECOMMENDATIONS.
3. TEMPORARY AND PERMANENT SEED MIXTURES, LIME, AND FERTILIZER TO BE SPREAD PER THE PROJECT SPECIFICATIONS ON CONSTRUCTED BANKFULL BENCHES AND SLOPES IMMEDIATELY PRIOR TO THE PLACEMENT OF EROSION CONTROL MATTING.

TYPICAL EROSION CONTROL MATTING PLACEMENT
NTS



NOTES:
1. PUT SILT FENCE OR TREE PROTECTION FENCE UP TO DIVERT ALL EQUIPMENT TRAFFIC IN ORDER TO ENSURE CONSTRUCTION ENTRANCE IS USED.
2. TURNING RADIUS SUFFICIENT TO ACCOMODATE LARGE TRUCKS IS TO BE PROVIDED.
3. ENTRANCE(S) SHOULD BE LOCATED TO PROVIDE FOR MAXIMUM UTILIZATION BY ALL CONSTRUCTION VEHICLES.
4. ENTRANCE(S) MUST BE MAINTAINED IN A CONDITION WHICH WILL PREVENT TRACKING OR DIRECT FLOW OF MUD ONTO ADJOINING ROADWAY. PERIODIC TOP DRESSING WITH STONE WILL BE NECESSARY. ANY MATERIAL WHICH STILL MAKES IT ONTO THE ROADWAY MUST BE CLEANED UP IMMEDIATELY. IF MUD CONTINUES TO BE TRACKED ONTO THE ADJOINING ROADWAY, THE GOVERNING AUTHORITY WILL CLEAN THE AREA AND INVOICE THE FINANCIALLY RESPONSIBLE PERSON AS INDICATED ON THE FINANCIAL RESPONSIBILITY FORM.
5. PLACE CONSTRUCTION ENTRANCE AT ALL POINTS OF INGRESS AND EGRESS UNTIL THE SITE IS STABILIZED. FREQUENT CHECKS OF THE DEVICE AND TIMELY MAINTENANCE MUST BE PROVIDED.

GRAVEL CONSTRUCTION ENTRANCE
NTS

Date:2/19/2008
Filename:G:\TRA\607003_BurlingtonStreams\LittleAlamance\Ustation\Little_Alamance_Details.dgn

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WWW.ARCADIS-US.COM
801 Corporate Center Drive, Suite 300
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DESIGN ENGINEER

PRELIMINARY PLANS
DO NOT USE FOR CONSTRUCTION

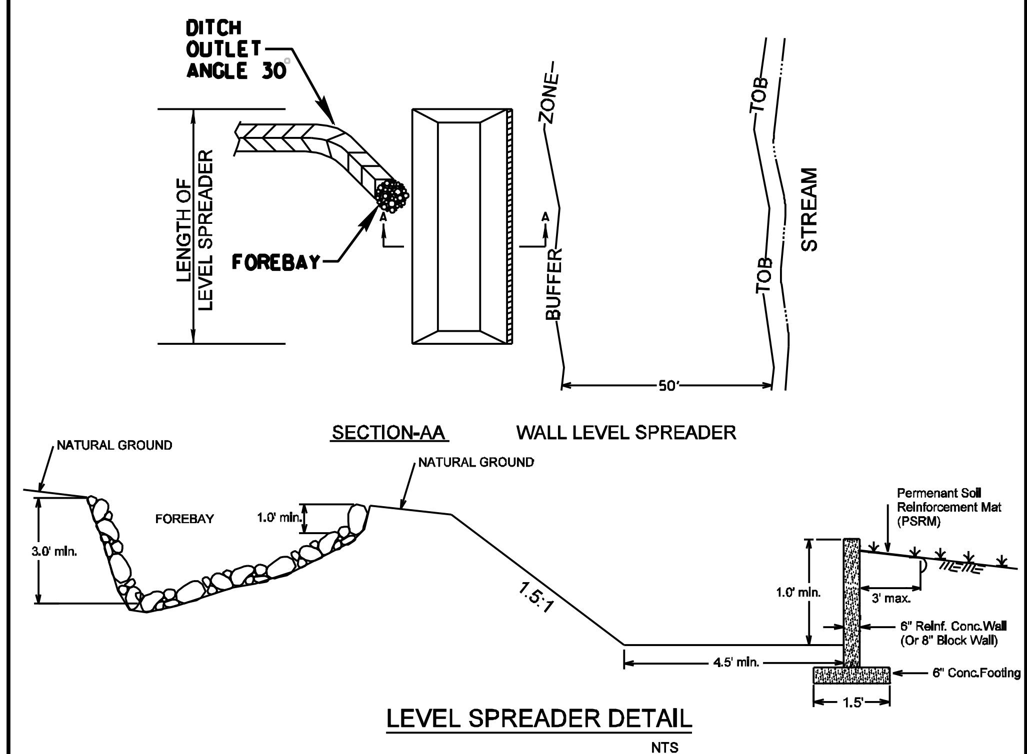
	BY	DATE	DESCRIPTION OF REVISION
5			
4			
3			
2	WMD	1/25/08	RESTORATION PLAN
1	REB	10/24/07	DRAFT RESTORATION PLAN

NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

DETAILS SHEET NO. 8

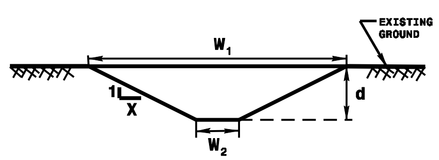
Details – LITTLE ALAMANCE CREEK



LEVEL SPREADER DETAIL

NTS

FROM STA. TO STA.

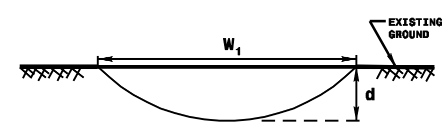


LOCATION	W_1	W_2	d	X	SLOPE FT/FT
STATION 32+00 RT	14'	2'	1.5'	5*	0.04
STATION 40+00 RT	7'	2'	1.5'	4	0.04

*SECOND SIDE SLOPE SHOULD MATCH DOWNHILL, NATURAL (FLATTER) SLOPE.

TRAPEZOIDAL SWALE

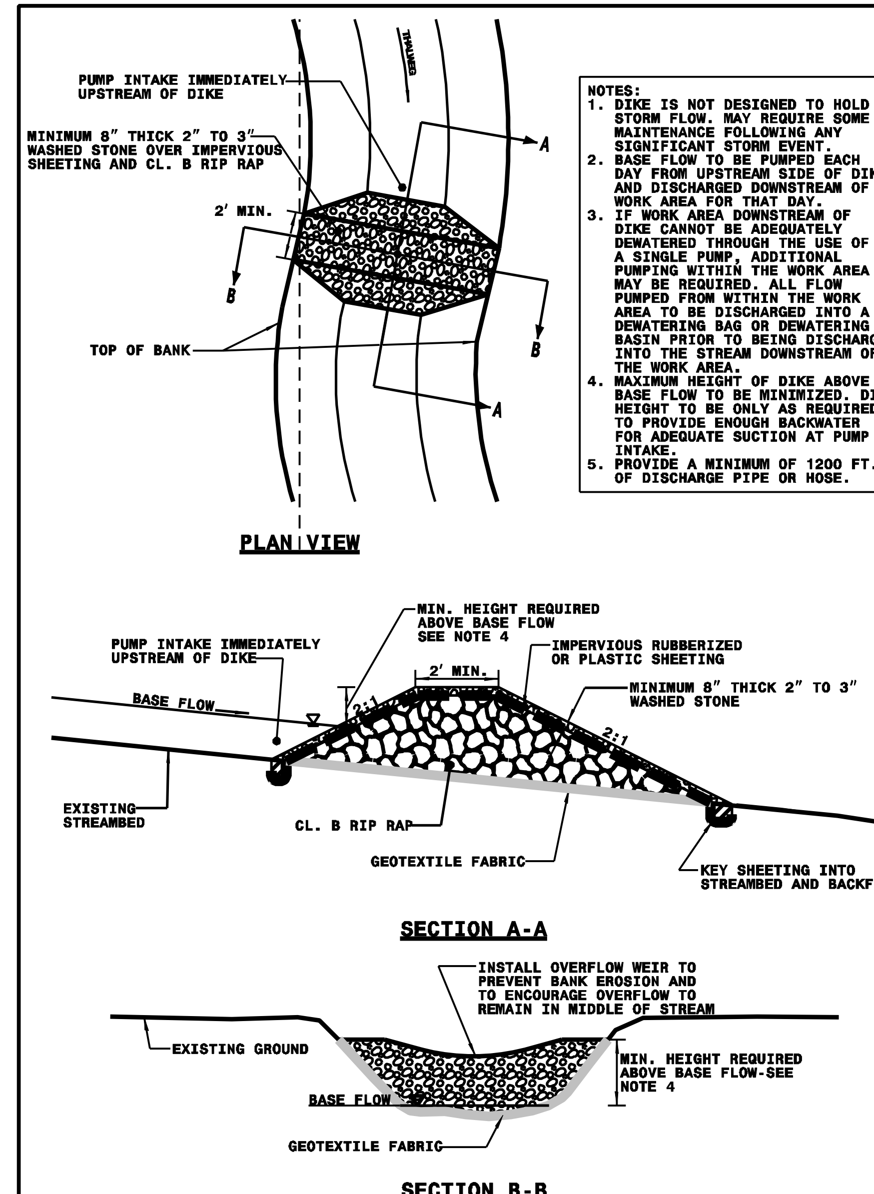
NTS



LOCATION	W_1	d	SLOPE FT/FT
STATION 17+25 RT	2'	2'	0.035
STATION 18+75 RT	3'	2'	0.025
STATION 25+00 RT	3'	2'	0.035

PARABOLIC SWALE

NTS



NOTES:
1. DIKE IS NOT DESIGNED TO HOLD STORM FLOW. MAY REQUIRE SOME MAINTENANCE FOLLOWING ANY SIGNIFICANT STORM EVENT.
2. BASE FLOW TO BE PUMPED EACH DAY FROM UPSTREAM SIDE OF DIKE AND DISCHARGED DOWNSTREAM OF WORK AREA FOR THAT DAY.
3. IF WORK AREA DOWNSTREAM OF DIKE CANNOT BE ADEQUATELY DEWATERED THROUGH THE USE OF A SINGLE PUMP, ADDITIONAL PUMPING WITHIN THE WORK AREA MAY BE REQUIRED. ALL FLOW PUMPED FROM WITHIN THE WORK AREA TO BE DISCHARGED INTO A DEWATERING BAG OR DEWATERING BASIN PRIOR TO BEING DISCHARGED INTO THE STREAM DOWNSTREAM OF THE WORK AREA.
4. MAXIMUM HEIGHT OF DIKE ABOVE BASE FLOW TO BE MINIMIZED. DIKE HEIGHT TO BE ONLY AS REQUIRED TO PROVIDE ENOUGH BACKWATER FOR ADEQUATE SUCTION AT PUMP INTAKE.
5. PROVIDE A MINIMUM OF 1200 FT. OF DISCHARGE PIPE OR HOSE.

IMPERVIOUS DIKE FOR STREAM PUMPING

NTS

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DESIGN ENGINEER

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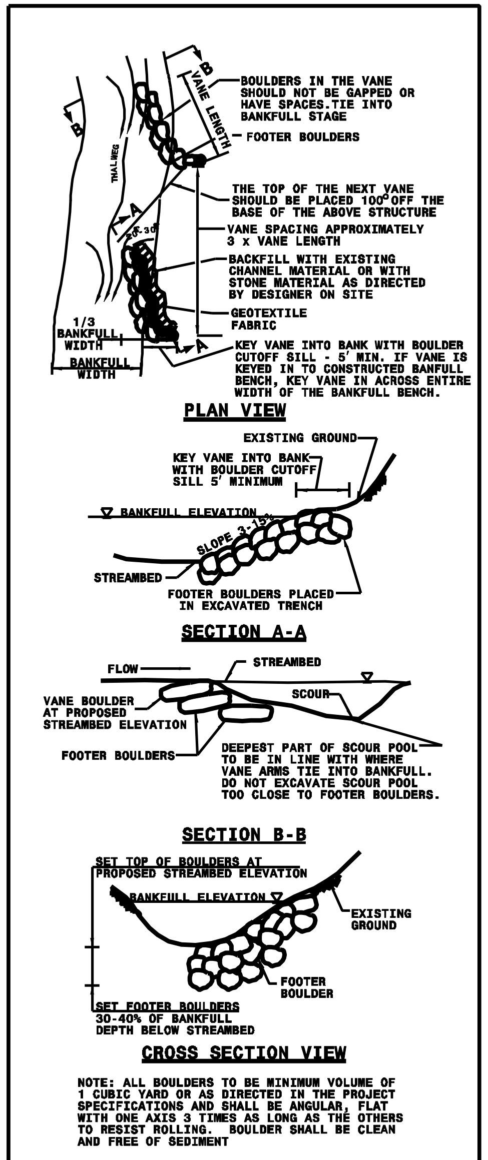
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

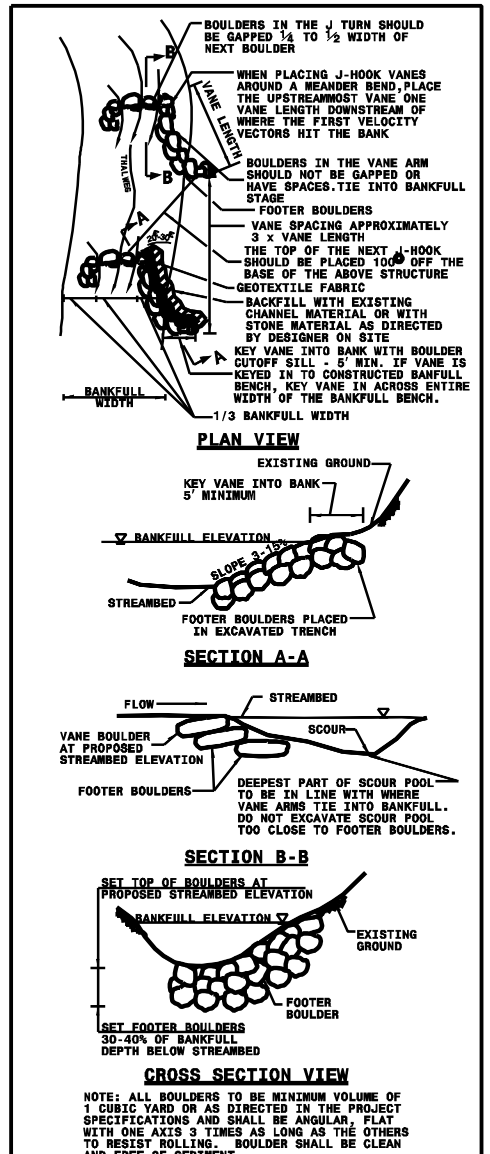
DETAILS SHEET NO. 12

Date:2/19/2008
Filename:G:\TRA\607003_BurlingtonStreams\LittleAlamance\Ustation\Little_Alamance_Details.dgn

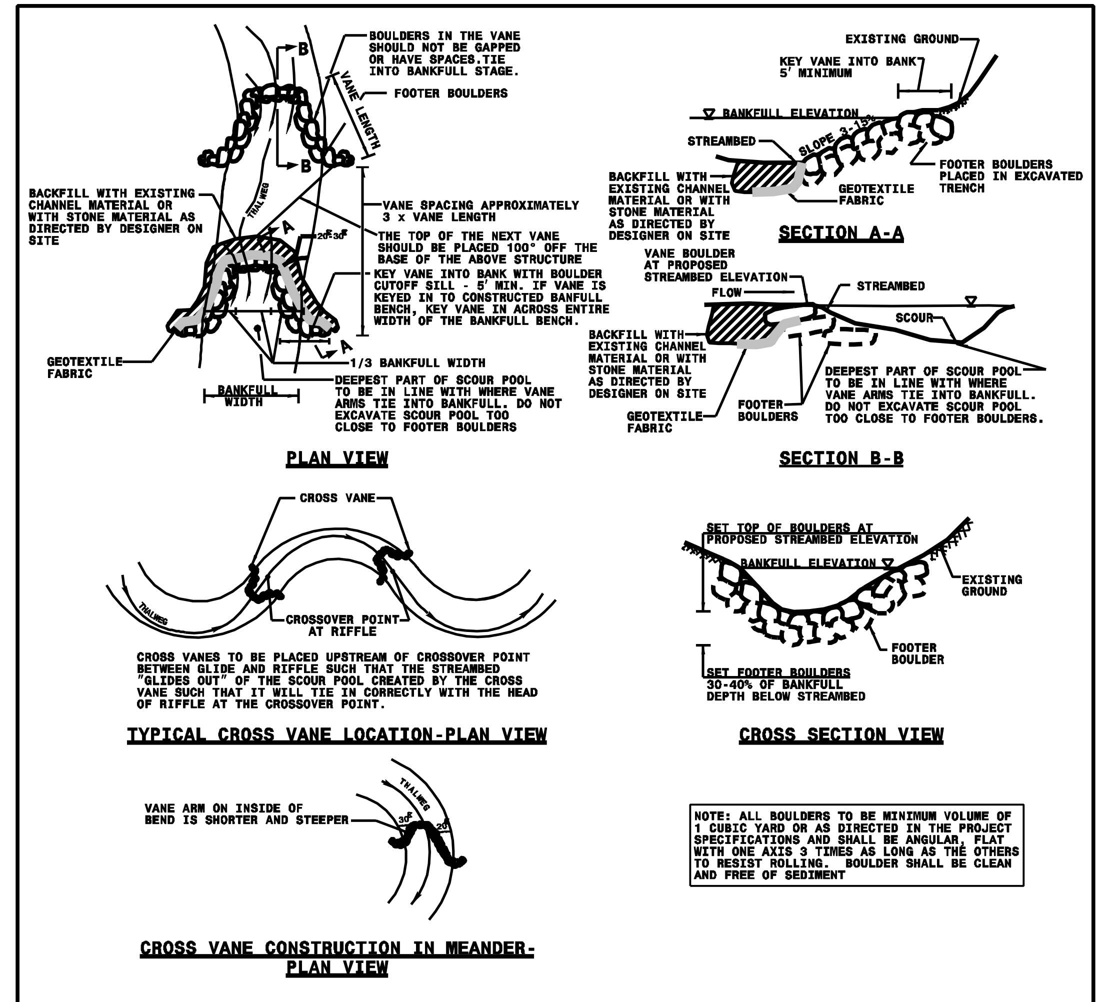
Details – LITTLE ALAMANCE CREEK



BOULDER VANE WITH GEOTEXTILE FABRIC
NTS



BOULDER J-HOOK VANE WITH GEOTEXTILE FABRIC
NTS



BOULDER CROSS VANE WITH GEOTEXTILE FABRIC
NTS

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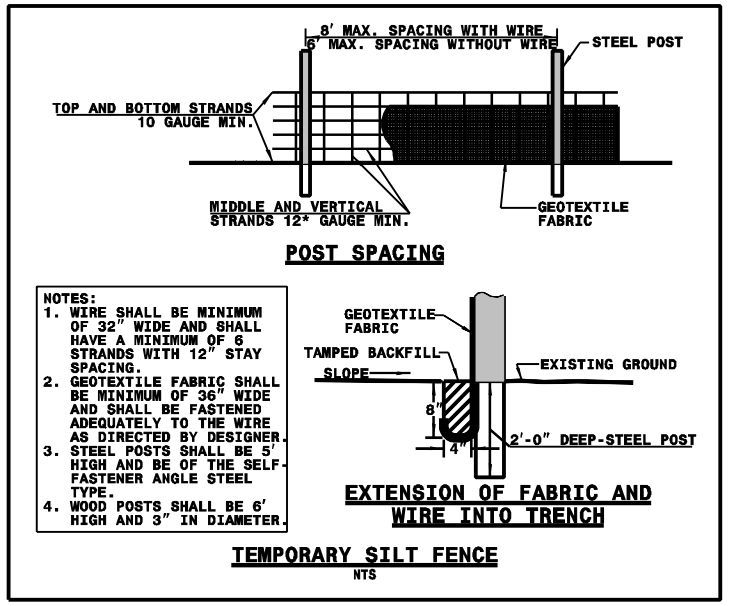
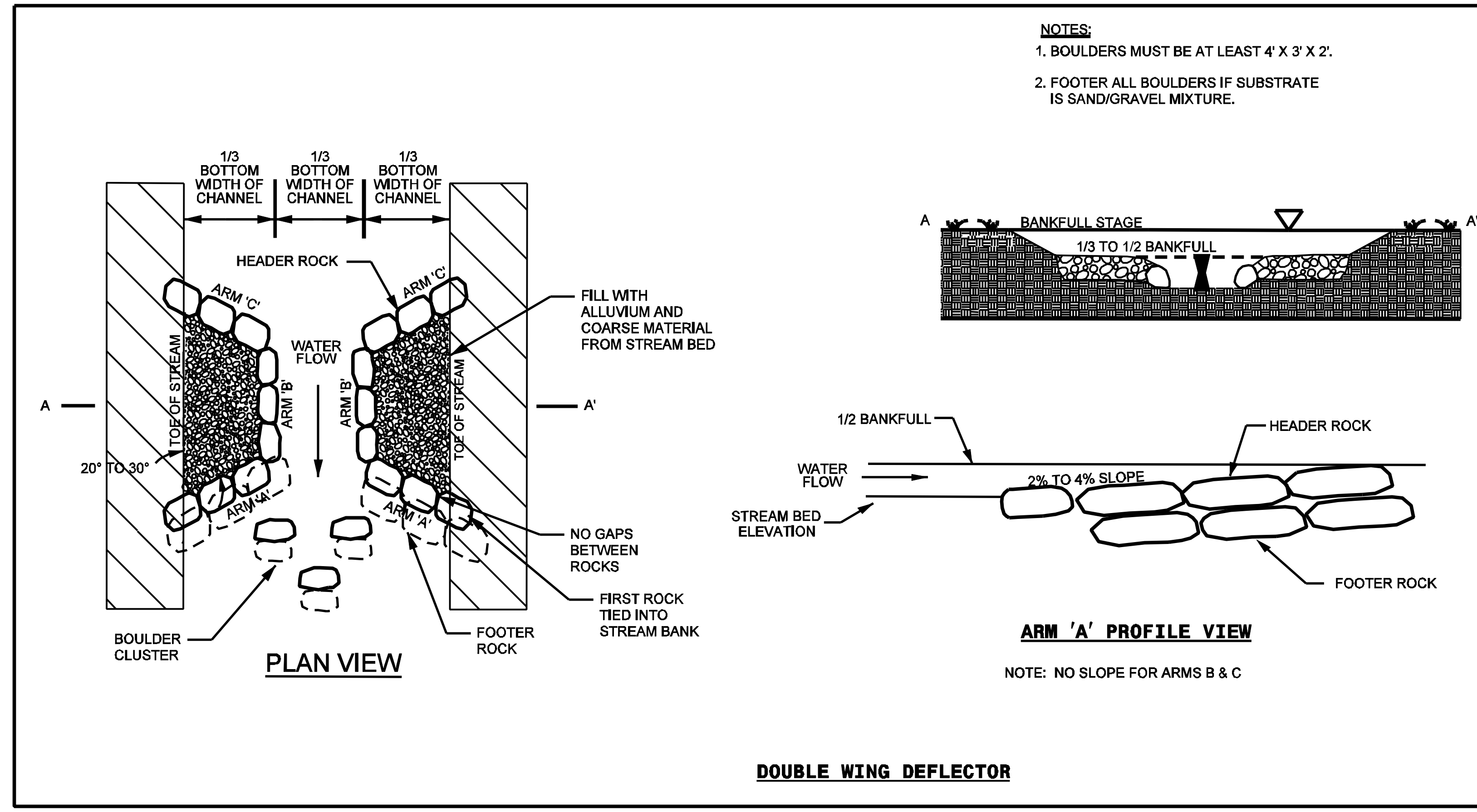
NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

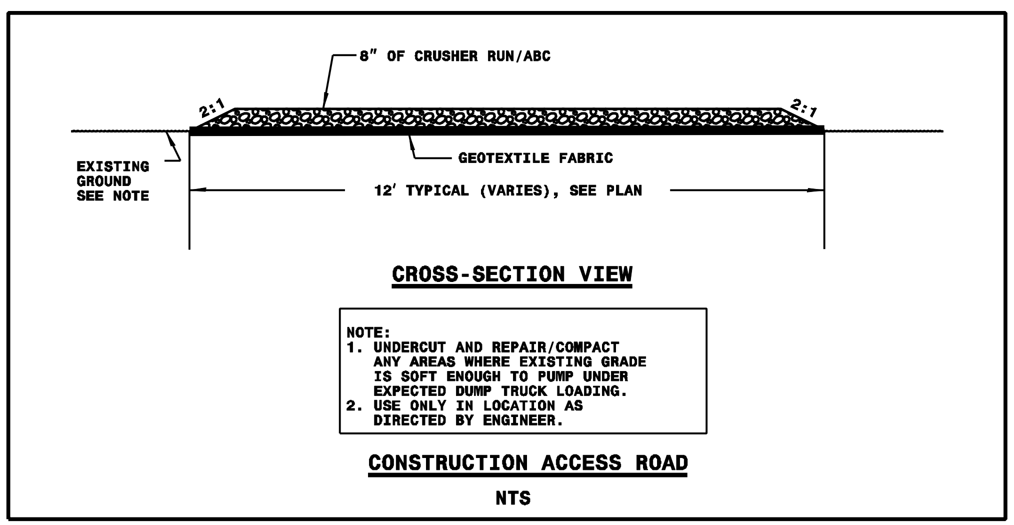
LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

DETAILS SHEET NO. 13

Details – LITTLE ALAMANCE CREEK







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NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES
ECOSYSTEM ENHANCEMENT PROGRAM

LITTLE ALAMANCE CREEK
ALAMANCE COUNTY, NORTH CAROLINA

DETAILS SHEET NO. 14

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