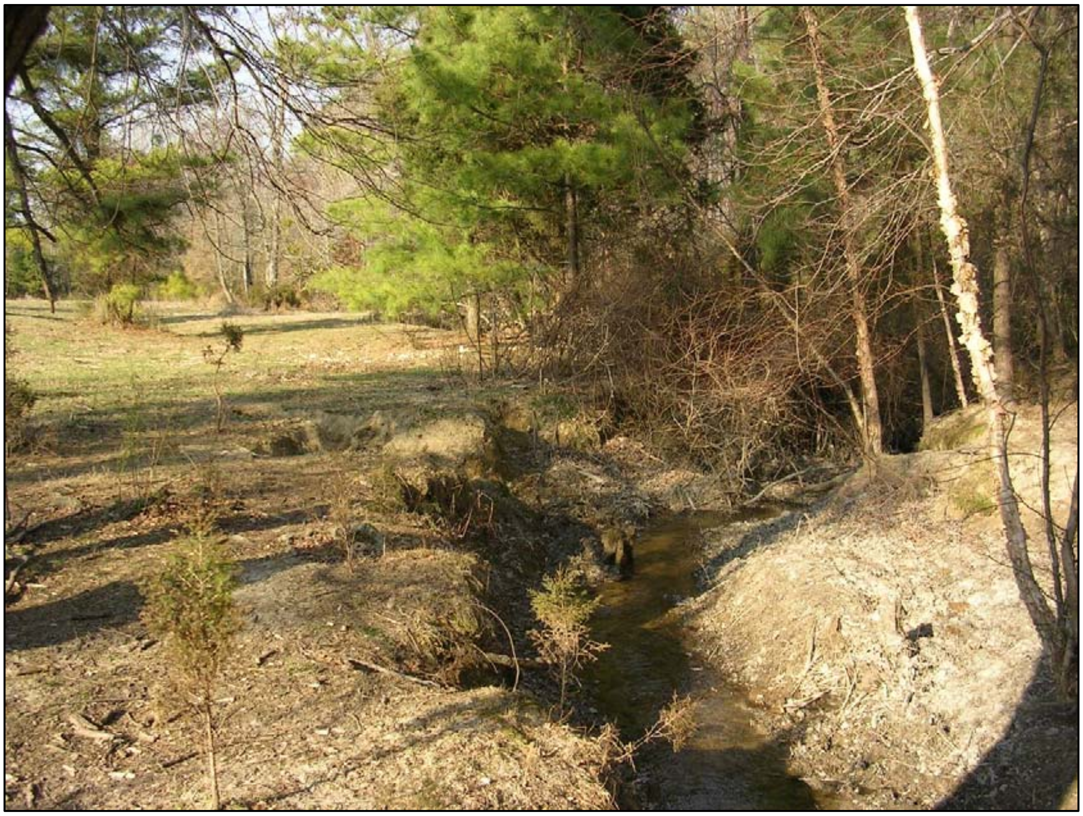
Ellington Branch Stream Restoration Site
Warren County, North Carolina
Project No. 16-D06045



Prepared for:
NC Department of Environment and Natural Resources
Ecosystem Enhancement Program
2728 Capital Boulevard, Suite 1H 103
Raleigh, NC 27604

Ecosystem Enhancement PROGRAM

Stream Restoration Plan

January 2007

Prepared by Sungate Design Group, P.A.

915 Jones Franklin Road
Raleigh, NC 27606

Contact Information:

____
Lane Sauls – Project Manager

____
Jenny S. Fleming, PE – Senior Engineer

(919) 859-2243 phone
(919) 859-6258 fax

lsauls@sungatedesign.com
jfleming@sungatedesign.com

Restoration Plan

Table of Contents

EXECUTIVE SUMMARY

Sungate Design Group, PA (Sungate) has entered into a design/build (full delivery) contract with the NC Department of Environment and Natural Resources, Ecosystem Enhancement Program (EEP) to provide 5,000 Stream Mitigation Units (SMUs) in the Roanoke River Basin. The Ellington Branch Stream Restoration Site (the Site), located in Warren County, North Carolina, will meet these overall obligations.

The Site consists of Ellington Branch and one of its unnamed tributaries. Ellington Branch is a second order, perennial stream originating approximately one-half mile upstream (south) of the project area. The unnamed tributary (UT) is a first order, perennial stream that originates on the same property. It is associated with the outfall of a 2.5-acre farm pond situated west of the Ellington Branch channel.

Riparian buffers will be established along both sides of the main channel and the tributary. The buffers will provide areas to filter pollutants and nutrients before entering the stream channels. This, along with stream restoration, will aid in reducing overall sediment inputs at the site, as well as downstream. In addition, cattle from the on-going beef operation will be effectively fenced out of the conservation easement area, reducing the potential for localized nutrient loading and bank erosion. Restoration of the channels will include changes to dimension, pattern and overall profile. Natural structures consisting of rock cross vanes, single-arm rock vanes, log vanes and root wads will assist in channel stabilization, provide habitat for both aquatic and terrestrial wildlife, and act as mechanisms to add dissolved oxygen to the stream system. Floodplain benches will be established along both sides of the channels to provide additional areas for flood attenuation. This will result in more overall area for flood storage without an increase in the flood elevation.

The Site is situated approximately four miles south of the Virginia/North Carolina state line in Warren County, North Carolina (Figure 1). The project area is bordered to the west by SR 1200 (Drewry Road) and to the east by SR 1221 (Culpepper Road). The north and south limits are current property boundaries with other privately owned parcels. These boundaries are denoted by existing fence lines. The overall project area totals approximately 219 acres. Sungate plans to only purchase an easement covering approximately 14.3 acres along the two streams, which will provide ample area for filtration without further impacting the existing land use activities.

Project Goals and Objectives

Ellington Branch and its tributaries are severely degraded due to existing land uses and non-restricted cattle access. The existing stream banks on both the main stem and its tributaries are eroded and overall channel morphology has been significantly altered. Site photographs are provided in Appendix 1.

The project will create a continuous wooded stream corridor by restoring and re-vegetating the largest reach of disturbed channel and buffer along Ellington Branch. In turn, this restoration will also improve the overall function and habitat associated with the stream channel and riparian areas. Sungate's restoration plan includes the restoration (including dimension, pattern and profile) of Ellington Branch and its tributary, as well as the establishment and restoration of an active riparian buffer complex.

The overall objective of the restoration plan is to restore the primary stream and buffer functions and values associated with nutrient removal and transformation, sediment reduction and retention, flood-flow attenuation, and wildlife (both aquatic and terrestrial) habitat. The Site provides and excellent opportunity to restore and preserve a substantial riparian zone on lands that are currently being utilized for pasture and cattle grazing.

Existing Amount of Stream Channels

Based on the channel surveys conducted in August 2006, there was 4,903.8 linear feet of stream channel within the project area. This specifically includes 4,050.9 linear feet along Ellington Branch and 852.9 linear feet along its unnamed tributary.

Amount of Streams Designed

Sungate will restore a total of 5,079.4 linear feet of Ellington Branch using natural channel design methods consistent with Priority Level II stream restoration protocols. This includes 3,711.5 linear feet along Ellington Branch and 1,366.9 linear feet along its unnamed tributary. A conservation easement will protect the site for perpetuity.

The Priority Level II Protocols are based on a rating system created by Dr. David L. Rosgen, PH, Wildland Hydrology, Inc. His rating system is separated into four main categories, identified and described as the Priority Levels I through IV of Restoration (Rosgen, 1997). This project will utilize Priority Level II restoration methodologies along both of the stream channels.

Priority Level II restoration includes the construction of either a new channel at the same elevation or excavating the streambank walls to establish an active floodplain. The advantages of this restoration-type are that it decreases bank height and streambank erosion, allows for riparian vegetation to help stabilize banks, establishes a floodplain to help reduce stress along the channel during flooding events, improves aquatic habitat, prevents wide-scale flooding of original land surface, reduces sediment contributions and provides easier transition for grade control. The drawbacks include not raising the water table to its previous elevation, shear stresses and velocities are the same or higher during floods and the upper banks must be sloped and stabilized to reduce erosion during flooding events (Rosgen, 1997). Table 1 provides the project restoration structure and objectives for the Ellington Branch Project.

Additional Design Information

On December 19, 2006, Sungate provided a letter to EEP addressing preliminary design concerns with regard to a short section (approximately 450 linear feet) of parallel stream channel near the confluence of Ellington Branch and its unnamed tributary. Concerns were noted by EEP during the review of the Draft Stream Restoration Plan. Sungate addressed these concerns with a letter to EEP. A copy of the letter is provided in Appendix 7. As per conversations with Mr. Guy Pearce, Full Delivery Program Supervisor, EEP, on January 5, 2007, EEP has accepted the letter and requested that Sungate continue with the final design and environmental permitting of this project.

1.0 Project Site Identification and Location

1.1 Directions to Project Site

The Site is situated approximately four miles south of the Virginia/North Carolina state line in Warren County, North Carolina (Figure 1). The project area is bordered to the west by SR 1200 (Drewry Road) and to the east by SR 1221 (Culpepper Road). The north and south limits are current property boundaries with other privately owned parcels. These boundaries are denoted by existing fence lines. The overall project area totals approximately 219 acres. Sungate plans to only purchase an easement covering approximately 14.3 acres along the two streams, which will allow ample area for filtration without impacting the existing land use activities.

The Site can be accessed by using the following directions from Exit 223 along Interstate 85:

- turn left (north) onto SR 1237 (Manson Road), travel approximately 2.5 miles;
- turn right (north) onto Drewry Road, travel approximately 3.0 miles; and
- turn right (east) onto Fleming Farm Road and proceed approximately ¼-mile past homestead and through gate.

1.2 USGS Hydrologic Unit Code and NCDWQ River Basin Designations

Ellington Branch and its tributary are part of the Roanoke River Basin, situated within the following codes and designations:

- US Geologic Survey (USGS) 14-digit Hydrologic Unit Code (HUC) 03010106031010;
- USGS 8-digit HUC 03010106; and
- NC Division of Water Quality (NCDWQ) subbasin 03-02-07.

1.3 Project Vicinity Map

The study area is situated approximately 1.5 miles east of John H. Kerr Reservoir in Warren County. It lies entirely within a 219-acre farm, covering four parcels of land. Ellington Branch flows in a northerly direction across the farm. Its UT flows from west to east and empties into Ellington Branch approximately midway through the portion of the channel proposed for restoration. Figure 2 provides an aerial view of the watershed. Since there are no distinct structures or roads within or adjacent to the easement area, it is best described by decimal degrees using the World Geodetic System of 1984 (WGS84) as the datum. These locations include the following approximations, based on available mapping:

- Ellington Branch – main stem:
  - Begin @ 036.4880780º N and 078.3003346º W (Southern End)
  - End @ 036.4956994º N and 078.2978684º W (Northern End)
- Unnamed Tributary
  - Begin @ 036.4918024º N and 078.3024610º W (Western End)
  - End @ 036.4912162º N and 078.2998670º W (Eastern End)

2.0 Watershed Characteristics

2.1 Drainage Areas

According to topographic information provided by Maptech®, the drainage area of Ellington Branch varies from 0.8 square miles at the southern project boundary (upstream) to 1.1 square miles at the northern project boundary (downstream). The drainage area of the unnamed tributary at its confluence with Ellington Branch is 0.1 square miles, or 90 acres. These areas are also listed in Table 2.

2.2 Surface Water Classification and Water Quality

Ellington Branch and its tributary are considered first and second order streams that originate from perennial spring flows. Both streams classify as highly unstable, incised E stream types. Ellington Branch is identified by Stream Index No. 23-10-2-1 (NCDWQ). Ellington Branch eventually confluences with Newman's Creek, Newman's Creek flows into Smith Creek which is a tributary to Lake Gaston (Roanoke River). Smith Creek has been on the 303(d)-list since 1998. In addition, the Smith Creek sub-basin 31010, within NCDWQ sub-basin 03-02-07, is listed as an Ecosystem Enhancement Program Targeted Local Watershed.

According to the NCDWQ, little to no information is available regarding Ellington Branch and its tributaries. The majority of the information available corresponds to its receiving water, Smith Creek. Ellington Branch and its tributaries are denoted as Class C waters (NCDWQ, 2006b). Class C best uses include aquatic life propagation/ protection and secondary recreation. There have been no sampling efforts in regard to an Index of Biotic Integrity (NCIBI) rating of Ellington Branch and its tributaries. These ratings incorporate information about species richness and composition, indicator species, trophic function, abundance and condition, and reproductive function. The ratings are translated into use support ratings, which denote whether or not the stream system is supporting its use classification. Based on field investigations, Ellington Branch and its tributary are severely degraded, lack effective cattle exclusion and have little to no riparian buffers. As a result, it is anticipated that the majority of detrimental effects to the overall stream system is non-point source pollution, including stormwater runoff and lack of cattle exclusion. These individual impacts may not have a dramatic effect on the overall water quality; however, the cumulative effect of land use activities within this watershed can have a severe and long lasting impact. Preliminary assessments for benthic macro invertebrates yielded little to no on-site data. Sampling conducted downstream along Smith Creek indicated "Fair" bio-classifications for benthic macro invertebrates and a NCIBI rating of "Good-Fair" (NCDWQ, 2006d).

2.3 Physiography, Geology and Soils

The Site is situated in the Piedmont physiographic province of North Carolina. According to the NC Division of Land Resources (1985), the Site is underlain by biotite gneiss and shist associated with the Raleigh belt. This belt includes small masses of granitic rock. The overall landscape is characterized by moderately wide to narrow, rolling, interstream divides, intermixed with moderate slope along well defined drainage ways (NCDLR, 1985).

Elevations across the project area range from a high of approximately 420 feet above mean sea level (msl) near SR 1200 to a low of approximately 320 feet above msl, near the northern property boundary. Within the easement area, elevations range between approximately 328 and 355 feet above msl.

The underlying soils of the Site and surrounding areas are classified as gently sloping to steep, well drained soils with sandy loam surface layers over firm red clay to firm silty clay subsoils. The topography of Warren County is typical of the northeastern Piedmont physiographic province. Gently rolling field and narrow to broad floodplains are indicative of the landscape orientation. The northwestern portion of the county, including the Site is generally high and flat, as compared with other areas throughout the county.

Based on available mapping for Warren County (NRCS, Personal Communication, 2006), the easement associated with the site is underlain with Wedowee soils. These soils range in slope from 5 to 25 percent, depending on their position in the landscape. The Natural Resources Conservation Service (NRCS) is currently in the process of remapping the county and data was assembled based on mapping provided by the County Soil Scientist. This mapping is not yet available in a published format. Sungate was however, able to obtained recent individual soil mapping for this area. It is presented in Figure 3.

Wedowee soils are classified by the NRCS as clayey, kaolinitic, thermic Typic hapludults. These soils are deep, well drained, moderately permeable soils that formed in residuum from weathered acid crystalline rock of the Piedmont plateau. They occur on narrow sides of ridges with slopes ranging from 8 to 40 percent. The typical pedon, taken approximately 8 miles south of the project in Vance County, exhibits an O, Ap, Bt and C horizon. The O horizon varies up to nearly 2 inches in depth and consists primarily of organic material. The Ap horizon is approximately 7 inches in depth and consists of brown, sandy loam. The clayey Bt horizon is 10 to 24 inches in thickness. It is colored yellowish red and is made up of sandy clay. A B3 horizon exists, which is similar in color to the Bt horizon. Its texture is sandy clay loam, clay loam or loam. The C horizon is yellowish red, reddish yellow, pale brown or red saprolite that crushes to sandy loam or sandy clay loam (Hicks, 1980).

2.4 Historical Land Use and Development Trends

Land uses throughout the project and surrounding areas have remained unchanged for the past several decades. New homes have been sporadically constructed; however, the majority of the land has remained either in pasture, row crop or timber. This trend is anticipated to continue into the future. The project area is approximately 1.5 miles from John H. Kerr Lake. It has no direct access or views that would interest development. In addition, Warren County currently does not have any plans for growth or economic development in the area. This is not anticipated to change any time in the near future.

The watershed associated with Ellington Branch covers approximately 1.1 square miles. It is comprised of forest lands, pasture lands, row crops, surface waters (including streams, ponds and other water-related features) and disturbed lands such as homes, barns and lands not within the classifications presented above. Based on aerial photography, the watershed is dominated by forest lands and row crops. Actual percentages of each landuse classification are provided in Table 3.

2.5 Endangered and Threatened Species

According to the US Fish and Wildlife Service (USFWS), there are two Endangered "E" one Threatened "T" species listed as potentially occurring in Warren County (USFWS, 2006). The dwarf wedge mussel (*Alasmidonta heterodon*) and Tar River spinymussel (*Elliptio steinstansana*) are listed as Endangered species while the bald eagle (*Haliaeetus leucocephalus*) is listed as a

Threatened species. According to available information, no other federal Endangered or Threatened species are known to currently inhabit any portions of this county. Summarized biological conclusions regarding each species are presented below. More detailed information, including these and other important species, is provided in the Environmental Resources Technical Report (ERTR), submitted to the Ecosystem Enhancement Program in September 2006.

2.5.1 Dwarf wedge mussel (*Alasmidonta heterodon*)

The dwarf wedge mussel inhabits creeks and rivers that have a slow to moderate current with a sand, gravel, or muddy bed. These streams must be nearly silt free in order to support populations of dwarf-wedge mussels. Toxic effects from industrial, domestic and agricultural pollution are the primary threats to this mussel's survival. The two stream channels at the Site are very sediment-laden, with eroding banks and open cattle access. Smith Creek, the receiving water for Ellington Branch and its associated tributaries, is on the 303(d) list for low dissolved oxygen, sedimentation and impaired biological integrity. Visual assessments for aquatic organisms were conducted on December 28, 2005 and again on June 28, 2006. No mussels or middens were observed during these inspections. Based on the existing conditions at the Site, suitable habitat for the dwarf wedge mussel does not exist on either stream. The NC Natural Heritage Program (NCNHP) does not have any records of this species along the entire Smith Creek drainage, including Ellington Branch and its tributaries. Therefore, short-term impacts to the channels as a result of this restoration project will have No Effect on the dwarf wedge mussel.

2.5.2 Tar River spinymussel (*Elliptio steinstansana*)

The Tar spinymussel lives in relatively silt-free uncompacted gravel and/or coarse sand in fast-flowing, well oxygenated stream reaches. The two stream channels at the Site are very sediment-laden, with eroding banks and open cattle access. Smith Creek, the receiving water for Ellington Branch and its associated tributaries, is on the 303(d) list for low dissolved oxygen, sedimentation and impaired biological integrity. Visual surveys for aquatic organisms were conducted on December 28, 2005 and again on June 28, 2006. No mussels or middens were observed during these assessments. Based on the existing conditions at the Site, suitable habitat for the Tar River spinymussel does not exist on either stream. The NCNHP does not have any records of this species along the entire Smith Creek drainage, including Ellington Branch and its tributaries. Therefore, short-term impacts to the channels as a result of this restoration project will have No Effect on the Tar River spinymussel.

2.5.3 Bald eagle (*Haliaeetus leucocephalus*)

Bald eagles are primarily associated with large bodies of water where food is plentiful. Eagle nests are found in close proximity to water (usually within one-half mile) with a clear flight path to the water. Nests are made in the largest living tree within the area, with an open view of the surrounding land. The project area, at its closest point, is greater than one mile from John H. Kerr Reservoir. Large trees exist along a portion of the easement area; however, they do not provide open views of the surrounding land. In addition, human disturbance, which can cause nest abandonment, is ever-present as part of the daily operations associated with the cattle farm. Visual assessments for eagles and/or large nests were conducted on December 28, 2005 and again on June 28, 2006. No eagles or nests were observed. The NCNHP denotes eagle occurrences and nesting on John H. Kerr Reservoir; however, there are no records of nesting within two miles of the Site. Therefore, implementation of this restoration project will have No Effect on the bald eagle.

As of July 6, 1999, this species is currently under consideration by the USFWS for a proposed de-listing of the threatened status. However, this raptor will still be protected under the Migratory Bird Treaty Act and the Bald and Golden Eagle Protection Act. Populations will continue to be monitored for at least another five years under provisions of the Endangered Species Act. Bald eagles are a year-round and transient species in North Carolina.

In addition, scoping letters requesting review were sent to the USFWS and the NC Wildlife Resources Commission (NCWRC) in late June 2006. A letter was received from the NCWRC stating that "no significant adverse impact to aquatic or terrestrial resources is anticipated" based on the proposed action. As of September 21, 2006, no correspondence has been received from the USFWS. Therefore, it is determined that the USFWS has no comment regarding protected species or their habitats with regard to the proposed stream restoration project. Copies of this letter and all other letters received from the resource agencies are provided in ERTR, dated September 2006.

2.6 Cultural Resources

Site walks were conducted on December 28, 2005 and again on June 28, 2006. These walks included a visual reconnaissance of the study area for any structures, buildings or other items other than natural resources-related issues. None were observed.

No structures, buildings, ruins, or other man-made items, aside from barbed wire fencing and wooden posts, exist within the study area. Several barns, homes and outbuildings exist immediately outside of the study area; however, none of these will be impacted by the restoration of the two stream channels. In addition, a review of properties determined to be eligible for the National Register of Historic Places was conducted by our subconsultant electronically in February 2006. No sites were identified within a one-mile radius of the study area.

No items relating to archaeological resources were observed during the site visit. The property owner has no recollection of every finding any archaeological resources in the study area. A review of the State Historic Preservation Office (SHPO) Archaeological Section database was conducted in February 2006 as part of the technical proposal submittal for this project. No sites are documented within a one-mile radius of the study area.

Based on a letter dated July 27, 2006 from the NC Department of Cultural Resources, State Historic Preservation Office, there are no historic resources that would be affected by the project, and thus no comment on the undertaking as proposed. A copy of this letter is provided in the ERTR, dated September 2006.

2.7 Potential Constraints

No potential constraints have been identified with regard to successful completion of the project. Sungate obtained background data from Environmental Data Resources, Inc. (EDR) regarding the potential for on-site or nearby sources of contamination. All storage tanks, whether above ground or underground, are identified as well as superfund sites, landfills, hazardous waste sites, and other potential hazards. No sites exist on their database within a one mile radius of the project site (EDR, 2006a). Detailed information, including search parameters and methodology and findings, is provided in the ERTR, dated September 2006.

2.7.1 Property Ownership and Boundary

Mr. John Wilson Fleming owns the four parcels that compose the Ellington Branch Site. Mr. Fleming resides on the farm at 134 Fleming Farm Road, Manson, NC, 27553. The parcels are listed below.

- Parcel 1: 146.1 total acres, ID number A3 28
- Parcel 2: 25.0 total acres, ID number A3 25
- Parcel 3: 47.9 total acres, ID number A3 24
- Parcel 4: 3.1 total acres, ID number A3 23

It is important to note that only the floodplain areas associated with Ellington Branch and its tributary will be purchased and placed under a conservation easement.

2.7.2 Site Access

As mentioned in Section 1.1, the Site is bordered to the west by Drewry Road and to the east by Culpepper Road. The site can be accessed by either of these roads. Direct access is provided via the Fleming Farm Road which intersects Drewry Road. This farm road provides vehicular access to both stream channels. One gate must be opened along this road.

2.7.3 Utilities

There are no known utilities within the easement area.

2.7.4 FEMA and Hydrologic Trespass

Both Ellington Branch and its unnamed tributary are outside of the Federal Emergency Management Agency's (FEMA) 100-year flood boundary and do not appear on the associated FEMA mapping.

Based on the overall size of the property and the valley type surrounding the restoration project, no hydrological trespass will occur as a result of project construction. Additional floodplain area will be created adjacent to the restored channels, allowing for increased flood attenuation within the buffer and floodprone areas. As a result, the areas outside of the buffer and floodplain will actually receive less water from over-bank flooding, once the project is completed.

2.8 Jurisdictional Wetlands and Streams

Both Ellington Branch and its unnamed tributary are considered as jurisdictional streams based on regulatory guidance. Figure 4 depicts the existing hydrological features on the property. Stream and wetland verifications were conducted with the US Army Corps of Engineers (USACE) representative Eric Alsmeyer on 5 October 2006. Representatives from the NCDWQ were also invited; however, they were unable to attend based on schedule conflicts. A verification could not be issued at the time of the site visit due to the current wetlands jurisdictional authority being debated in the US Supreme Court; however, Mr. Alsmeyer did concur verbally with the delineation boundaries shown on the plan sheets. These wetlands were delineated according to the protocols found in the 1987 Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory, 1987)

Two areas of jurisdictional wetlands are present within and adjacent to the easement area. The first area, associated with a seepage along the toe of the western side slope, is immediately downstream of the confluence between Ellington Branch and its unnamed tributary. The second area is situated near the end of the project along the west side of Ellington Branch. It is also associated with a seepage along the toe of the adjacent side slope.

Both areas are linear in nature and cover combined total of approximately 0.32 acres. They are severely impacted by cattle. The restoration of Ellington Branch and its unnamed tributary will not adversely effect either of these areas. Their locations are provided in Figure 5 and a copy of the data forms are provided in Appendix 2. Information regarding the methodology and assessment is provided in the ERTR, dated September 2006.

3.0 Project Site Streams (Existing Conditions)

3.1 Channel Classifications

Ellington Branch and its unnamed tributary both classify as *unstable* E5 stream types, based on the Rosgen Classification System (Rosgen, 1994). The stable E5 stream types are channel systems with low to moderate sinuosities, gently to moderately steep channel gradients and very low channel width/depth ratios. This stream type is typically observed as a riffle/pool system with channel slopes less than 2 percent. Streambanks are composed of materials finer than that of dominant channel materials, and are typically stabilized with extensive riparian or wetland vegetation that forms densely rooted sod mats from grasses and grass-like plants, as well as woody species. The E5 stream channel has high meander width ratios, high sinuosities and low width/depth ratios. They are hydraulically efficient channels forms and they maintain a high sediment transport capacity. Both channels are unstable due to cattle access and grazing. The streambanks are eroding, especially along the outsides of the meanderbends and cattle trails are prevalent along the streambanks and channels throughout both reaches.

Stream classification forms were completed for both the Ellington Branch channel and its unnamed tributary. These forms are provided by the NCDWQ and differentiate between perennial, intermittent and ephemeral channels using a series of primary and secondary indicators. The Ellington Branch channel was scored at 41 and its unnamed tributary was 40.5. The NCDWQ denotes a perennial channel as being greater than 30, an intermittent channel if point range is between 19 and 30 and ephemeral if less than 19. Copies of the forms are presented in Appendix 3.

3.2 Discharge (Bankfull, Trends)

According to the NC Piedmont Rural Regional Curve data provided by the Water Quality Group at NC State University (Harman et al. 1999), the bankfull discharge for Ellington Branch should range between 75.8 and 95.4 cubic feet per second. The bankfull discharge for its unnamed tributary is approximately 17.0 cubic feet per second. Based on our calculations, the discharge for Ellington Branch ranges between 92.8 and 122.2 cfs, which is within the 95% confidence interval of the predicted discharges. The calculated bankfull discharge for the unnamed tributary was 16.5, which also consistent with the existing regression line. These calculated discharges correspond with a 1.2-year return interval.

Based on existing and proposed future landuses, the amount of impervious surfaces within the watershed is not anticipated to significantly change in the next decade. Due to its close proximity to John H. Kerr Lake, development is anticipated on the farm at some point in time. This, however, is not anticipated any time in the near future. Therefore, the bankfull discharges for both Ellington Branch and its unnamed tributary are expected to remain consistent for the near future.

3.3 Channel Morphology (Pattern, Dimension and Profile)

Intensive channel surveys were conducted along Ellington Branch and its unnamed tributary to ascertain morphological data in August 2006. The results of the surveys are shown on Sheet 1, which provides a topographical layout (plan view) of the existing hydrological resources in the project area. Morphological data for both channels is provided in Table 4.

3.4 Channel Stability Assessment

Sungate utilized two methods, Pfankuch and Bank Erosion Hazard Index (BEHI), to determine and document channel stability along Ellington Branch and its unnamed tributary.

Pfankuch (1975) developed a system to rate channel stability which has been widely used by stream restoration professionals. This system is used to quantitatively describe the potential for sediment material detachment and changes in sediment supply due to changes in streamflow and/ or changes in watershed condition. It has also been used to generally assess fisheries habitat conditions, and to indirectly assess streambank damage resulting from cattle grazing. Since this method was developed prior to the classification system, the good, fair and poor rating values have been adjusted by stream type (Rosgen, 1996). Both Ellington Branch and its unnamed tributary classified as “poor – unstable” according to this assessment.

Streambank erosion rates were calculated using the BEHI method combined with the near bank shear stress method as taught by Dave Rosgen, PhD., PH, Wildland Hydrology, Inc. Bank erosion occurs as a result of a number of processes including dry ravel, mass wasting, surface erosion, liquification, freeze-thaw, fluvial entrainment and ice scour. The ability of streambanks to resist erosion is primarily determined by the following factors:

- the ratio of streambank height to bankfull stage;
- the ratio of riparian vegetation rooting depth to streambank height;
- the degree of rooting density;
- the composition of streambank materials;
- streambank angle (i.e., slope);
- bank material stratigraphy and presence of soil lenses; and
- bank surface protection afforded by debris and vegetation.

Vertical streambanks throughout Ellington Branch and its unnamed tributary were measured to determine an approximate erosion rate per year. The BEHI ratings ranged between “High” and “Very High” for Ellington Branch and “Extreme” along its unnamed tributary while near bank shear stresses ranged between “Low” and “Extreme” for Ellington Branch and “High” for its unnamed tributary. Based on the calculations, erosion rates along Ellington Branch may reach as high as 2.1 ft/year. The predicted erosion rates along its unnamed tributary are higher, ranging up to approximately 2.3 ft/year. Table 5 provides BEHI and sediment export rates for Ellington Branch and its unnamed tributary.

3.5 Bankfull Verification

The US Geological Survey (USGS) has 10 streamflow gages within the Roanoke River Basin. Unfortunately, all of these gages are well downstream of the project area and cover large, expansive drainage areas, including 8 stations along the Roanoke River. Resulting surveys of these gages would prove to be unfeasible with regards to obtaining bankfull verifications for Ellington Branch and its unnamed tributary.

These verifications were obtained using HEC-RAS modeling software. Field-observed bankfull data points, including the uppermost scour lines and in some cases, the backs of point bars, were surveyed and compared to data output from the model. Bankfull elevations were consistent with the 1.2-year storm, which is the common recurrence interval in North Carolina.

3.6 Vegetation

The Site is typical of most farms in the surrounding areas. It exhibits a combination of pasture lands, wooded lands and agricultural lands. Pasture lands generally dominate the sloping areas along and adjacent to the stream channels, while agricultural lands are situated along the ridge tops and areas of higher elevation. Wooded lands are intermixed throughout these areas and are primarily utilized for timber and livestock shading purposes. Vegetation at the Site is divided into two specific communities: disturbed Piedmont Alluvial Forest and pasture land.

The disturbed Piedmont Alluvial Forest is present along the majority of the eastern side of Ellington Branch. Cattle are the main culprits of the disturbance. They are free-ranging throughout this community. According to Schafale and Weakley (1990) Piedmont Alluvial Forests generally occur along river and stream floodplains where separate fluvial landforms and associated vegetation zones are too small to distinguish. They are underlain by various alluvial soils, most typically Chewacla (Fluvaquentic dystrochrept) or Congaree (Typic udifluvent). Vegetation throughout this community is dominated with a mixture of bottomland and mesophytic trees, including river birch (*Betula nigra*), sycamore (*Platanus occidentalis*), sweetgum (*Liquidambar styraciflua*), tulip poplar (*Liriodendron tulipifera*), American elm (*Ulmus america*), hackberry (*Celtis laevigata*), green ash (*Fraxinus pennsylvanica*), red maple (*Acer rubrum*) and loblolly pine (*Pinus taeda*). Understory and shrub species are American holly (*Ilex opaca*), ironwood (*Carpinus caroliniana*), Eastern red cedar *(Juniperus virginiana*) and Florida dogwood (*Cornus florida*). The herbaceous layer is sparse and includes mainly saplings from the canopy, undestory and shrub layers. Christmas fern (*Polystichum acrostichoides*), cardinal flower (*Lobelia cardinalis*), jewelweed (*Impatiens capensis*) and other small grasses and weeds were observed. Generally, the herbaceous layer of the Piedmont Alluvial Forest is lush; however, it is assumed that cattle have had a detrimental impact to this stratum. In addition, the invasion and ultimate presence of exotic species such as Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), Chinese privet (*Ligustrum sinense*) and stilt grass (*Microstegium vimineum*) have also impacted the herbaceous statum.

Flood-carried sediment provides nutrient inputs to this community type, as well as serving as a natural disturbance factor. Small areas of the forest may be eroded or disturbed by catastrophic floods. Beavers also may occasionally create impoundment along the stream channels. These communities are distinguished from the communities of larger floodplains partly for convenience by mainly because of differences in the ecosystems. In smaller floodplains, the relief and size of the fluvial landforms, which differentiate the communities in large floodplains, become smaller. Smaller watersheds exhibit more variable flooding regimes. These factors reduce the ecological differences between the different fluvial landforms, resulting in a highly variable mixture of the species of the communities of larger river floodplains (Schafale and Weakley, 1990).

Pasture land, the second community mentioned, is situated along the entire western side of Ellington Branch, several small areas along the eastern side and along both side of the unnamed tributary. This land is used for cattle grazing and comprised of mainly herbaceous species with the exception of a few loblolly pines and Eastern red cedars. These species include fescue (*Festuca* sp.), blackberry (*Rubus* sp.), dog fennel (*Eupatorium capillifolium*), golden rod (*Solidago* sp.), ragweed (*Ambrosia* sp.), aster (*Aster* sp.) and other various weeds.

4.0 Reference Streams

With the overall amount of disturbance associated with agriculture, including row crops, timber and livestock management, stable channels were very difficult to locate throughout Warren and Vance Counties. Fortunately, Sungate was able to identify and survey two reference streams with regard to this project. They are identified as an UT to Ellington Branch and Hawtree Creek. These reference streams were selected based on their proximity, land use, land orientation, stream order and overall watershed characteristics. While these streams are not pristine in nature, they appear stable and are effectively moving their sediment loads without aggrading or degrading. In addition, Sungate is also comparing this data with a third reference reach located approximately 30 miles southeast of the project area. This E5 stream type was surveyed in 1991 by others and is being used for comparison purposes only.

4.1 Watershed Characterizations

UT Ellington Branch Reference Reach
The first stream, an unnamed tributary of Ellington Branch, is situated immediately upstream of the farm pond associated with the unnamed tributary to undergo restoration (Figure 6a). It is one of two tributaries entering the pond. The watershed associated with the unnamed tributary to Ellington Branch is within the same watershed identified with the project. It covers approximately 27 acres. Based on existing aerial photography, the watershed appears to be approximately 50 percent forested, 25 percent row crops and 25 percent manipulated via roads, homes, barns, sheds or other type of disturbance. The overall amount of impervious surface is less than three percent of the entire watershed. An aerial photograph depicting the watershed is provided in Figure 7a.

Hawtree Creek Reference Reach
The second stream, identified as Hawtree Creek, is located approximately 9 miles east of the Site near Warren Plains (Figure 6b). Hawtree Creek, was selected due to its riparian area, limited slope, limited amount of disturbance, slope and overall appearance. Its watershed is considerably larger, covering approximately 190 acres. Based on aerial photography, the Hawtree Creek watershed is comprised of approximately 43 percent forest, 26 percent pasture, 20 percent row crops and five percent surface waters (including ponds). The remaining 6 percent is manipulated lands consisting of roads, homes, barns, sheds and other types of disturbance. Impervious surfaces cover less than three percent of the entire watershed. The watershed associated with Hawtree Creek is shown on the aerial photograph in Figure 7b.

Site photographs of both the Ellington Branch UT and Hawtree Creek are provided in Appendix 4. The two streams were also assessed using the NCDWQ Classification Worksheets. The UT scored 39.5, while Hawtree Creek received a score of 49.0. As previously mentioned, channels must receive a score of 30 or higher in order to be classified as a perennial stream. Copies of the NCDWQ Stream Classification Forms are provided in Appendix 5.

4.2 Channel Classifications

The unnamed tributary of Ellington Branch reference stream classifies as a B4c stream type. This is based on an entrenchment ratio averaging 1.8, a width/depth ratio averaging 6.6, a sinuosity of 1.5 and an overall water surface slope of 1.2%. This reference reach was surveyed only as a comparison stream. Due to its stream type, the available ratios were not used to formulate any designs.

Hawtree Creek classifies as an E5 stream type. It was used as the primary design model stream for this project. With an entrenchment ratio of 2.6, a width/depth ratio of 8.8, a sinuosity of 1.7 and water surface slope of 0.7%, this stream falls completely within E stream classification.

4.3 Discharge (Bankfull, Trends)

Bankfull discharge along the two streams were derived using the Continuity Equation ($Q_{bkf} = V_{bkf}$ x $A_{bkf,}$ where Q is the discharge, V is the velocity and A is the cross sectional area at the bankfull elevation). According to the calculations, the discharges along the unnamed tributary and Hawtree Creek reference reaches averaged 10.8 cfs and 36.8 cfs, respectively. Both of these values are within the 95% confidence interval associated with the existing regression lines provided by the NC Stream Restoration Institute.

Based on current and proposed future conditions, these variables are not anticipated to change in the near future. Little or no development nor any changes with regards to landuse are anticipated in the immediate future.

4.4 Channel Morphology (Pattern, Dimension and Profile)

Intensive channel surveys were conducted along the UT to Ellington Branch and Hawtree Creek to ascertain morphological data in July 2006. Morphological data for both channels is provided in Table 4.

4.5 Channel Stability Assessments

Sungate also utilized Pfankuch and Bank Erosion Hazard Index (BEHI) methods along the reference reaches to determine and document channel stability. Both the UT to Ellington Branch and Hawtree Creek classified as “good – stable” according to the Pfankuch assessment. Results of the BEHI assessment yielded a “Low” and “Moderate” classifications for the UT and Hawtree Creek, respectively. Based on the near bank shear stress calculations, erosion rates along Hawtree Creek may reach as high as 0.32 ft/year, while the UT is approximately 0.04 ft/year. Table 6 provides BEHI and sediment export rates for Ellington Branch and its unnamed tributary.

4.6 Bankfull Verifications

Due to the stable nature of the existing reference streams, bankfull verifications were not required as part of normal surveying procedures. Bankfull features were commonly observed along both of the stream channels. These features were surveyed and compared with the existing regional curve data. There were no discrepancies.

4.7 Soils

UT to Ellington Branch Reference Reach

Wedowee soils underlie the UT to Ellington Branch site (Figure 8a). These are deep, well drained, moderately permeable soils that formed in residuum from weathered crystalline rock of the Piedmont plateau. These soils are on narrow, gently sloping to very steep uplands, where slopes range from 6 to 10 percent. Wedowee soils are classified as clayey, kaolinitic, thermic Typic Hapludults. Its typical pedon exhibits a sandy loam A horizon from 0 to 4 inches that is dark grayish brown in color, a yellow loam E horizon from 4 to 10 inches, a brownish yellow loam BE horizon from 10 to 14 inches, a strong brown sandy clay Bt horizon from 14 to 24 inches, a strong brown sandy clay loam BC horizon from 24 to 32 inches and a C horizon composed of yellowish red saprolite of sandy clay loam texture from 32 to 60 inches (NRCS, personal communication, 2006).

Hawtree Creek Reference Reach
The soils underlying the Hawtree Creek site are mapped as the Louisburg-Wake-Ashlar complex (Figure 8b). Louisburg soils are classified as coarse-loamy, mixed, semiactive, thermic Typic Hapludults, while Wake soils classify as mixed, thermic Lithic Udipsamments and Ashlar soils as coarse-loamy, mixed, semiactive, thermic Typic Dystrudepts. These soils are well to excessively drained and moderately to rapidly permeable. Slopes range 0 to 70 percent; however, the topography along the reference is between 0 and 5 percent. All three series exhibit an ochric epipedon ranging in depth from 4 to 9 inches. The Louisburg series has an argillic horizon (Bt1 and Bt2 horizons) ranging from 7 to 26 inches below the surface while the Wake series has lithic contact (hard bedrock) around 12 inches and the Ashlar series exhibits a cambic horizon (Bw horizon) from 9 to 18 inches (NRCS, personal communication, 2006). More data will be available once county-wide mapping is finalized by the NRCS.

4.8 Vegetation

Both reference sites exhibit typical vegetation found throughout the county. The watersheds include a combination of pasture lands, wooded lands and agricultural lands.

UT to Ellington Branch Reference Reach
Vegetation along the UT is characteristic of the Mesic Mixed Hardwood Forest, as described by Shafale and Weakley (1990). Dominant canopy and understory species include sweetgum, tulip poplar, Chinese privet, American holly (*Ilex Americana*), red cedar and loblolly pine (*Pinus taeda*).Herbaceous species were stilt grass, dayflower (*Commelina communis*) and false nettle (*Boehmeria cylindrica*).

Hawtree Creek Reference Reach
The Hawtree Creek reference reach is situated entirely within mature forest. Based on its landscape position, vegetation is also characteristic of the Mesic Mixed Hardwood Forest, as described by Shafale and Weakley (1990). Dominant canopy and understory species observed were tulip poplar, red maple, sweetgum, Eastern red cedar, green ash, white oak (*Quercus alba*), river birch, American beech (*Fagus grandifolia*) and ironwood. The herbaceous stratum was sparse in overall density and included mainly stilt grass, with jewelweed and Jack-in-the-pulpit (*Arisaema triphyllum*) seen on an occasional basis.

5.0 Project Site Restoration Plan

5.1 Restoration Goals and Objectives

Ellington Branch and its tributaries are severely degraded due to existing land uses and non-restricted cattle access. The existing stream banks on both the main stem and its tributaries are eroded and overall channel morphology has been significantly altered. Site photographs are provided in Appendix 1.

The project will create a continuous wooded stream corridor by restoring and revegetating the largest reach of disturbed channel and buffer along Ellington Branch. In turn, this restoration will also improve the overall function and habitat associated with the stream channel and riparian areas. Sungate's restoration plan will include restoration (including dimension, pattern and profile) of Ellington Branch and its tributary, as well as the establishment and restoration of an active riparian buffer complex.

The overall objective of the restoration plan is to restore the primary stream and buffer functions and values associated with nutrient removal and transformation, sediment reduction and retention, flood-flow attenuation, and wildlife (both aquatic and terrestrial) habitat. The Site provides and excellent opportunity to restore and preserve a substantial riparian zone on lands that are currently being utilized for pasture and cattle grazing.

5.1.1 Designated Channel Classifications

Ellington Branch and its unnamed tributary will be restored with methodology consistent with the C stream type. This stream type is a slightly entrenched, meandering, gravel dominated, riffle/pool channel with a well developed floodplain. C stream types have gentle gradients less than two percent, display a high width/depth ratio and exhibit sinuosities greater than 1.2. The riffle/pool sequence averages five to seven bankfull widths in length. Its associated stream banks are generally composed of unconsolidated, heterogeneous, non-cohesive, alluvial materials that are finer than the gravel-dominated bed material. Sediment supplies are generally moderate to high. This stream type is characterized by the presence of point bars and other depositional features. It is favored versus the E stream type since shear in the near bank region is greatly reduced, especially for a newly constructed channel. Once the vegetation becomes established, the width/depth ratio may naturally reduce to the characteristic of an E stream type. Based on this assumption, the width/depth ratio for the design channels was kept between the C and E classification.

5.1.2 Target Vegetation and Buffer Communities

As mentioned in Section 3.6, the Site is composed of two vegetative communities. Both are disturbed by livestock. Establishment of riparian corridors, via new plantings and/or enhancement, is one of the goals set forth for the project. Target vegetation and buffer communities will be planted and/or enhanced to that of the Piedmont Alluvial Forest, as described by Schafale and Weakley (1990). This community is briefly described in Section 3.6; however, several additional description factors are provided in the following text.

Piedmont Alluvial Forests are distinguished from other communities by their location along the floodplain area. Alluvial species including sycamore, river birch and box elder (*Acer negundo*) generally distinguish this community from other mesic communities. The absence or poor development of the depositional fluvial landforms determining vegetation distinguish it from communities of larger floodplains such as the Piedmont Levee Forest, Swamp Forest and Bottomland Forest. Levees, sloughs and ridges may be visible in parts of alluvial forest communities but they are generally small, often on the same size scale as individual trees (Schafale and Weakley, 1990).

The small size and heterogeneous nature of small floodplains compared to the larger floodplains may in some cases make them less likely to deliberately be disturbed by activities such as agriculture or forestry. It does, however, make them vulnerable to indirect damage by actions on adjacent lands. Continued channelization of the small streams associated with these communities is very destructive. The project will improve nearly one mile of channel associated with Ellington Branch and result in the establishment and preservation of a riparian zone along both sides of the channel. It will ultimately provide perpetual protection to both the buffer area and channel.

Target species associated with the Piedmont Alluvial Forest community are presented in Table 7. It is anticipated that the species composition will include canopy, understory and herbaceous stratum types. Actual species types will depend on availability during the construction period.

5.2 Sediment Transport Analyses

Sediment analyses are generally divided into measurements of bedload and suspended sediment, changes in sediment storage, size distributions and source areas. Sediment plays a major role in the influence of the channel stability and morphology (Rosgen, 1996). A stable stream has the capacity to move its sediment load without aggrading or degrading. Washload is normally composed of fine sands, silts and clays transported in suspension at a rate that is determined by availability and not hydraulically controlled. Bedload is transported by rolling, sliding, or hopping (saltating) along the bed. At higher discharges, some portion of the bedload can be suspended, especially controlled by the size and nature of the bed material and hydraulic conditions (Hey and Rosgen, 1997).

5.2.1 Methodology

Two measures are used to calculate sediment loads for natural channel design projects: sediment transport competency and sediment transport capacity. Competency is a stream's ability to move particles of a given size. It is expressed as a measure of force (lbs/ft^2). Capacity is a stream's ability to move a quantity of sediment and is a measurement of stream power expressed in units of lbs/ft·sec. These analyses are conducted to ensure that the design streambeds do not aggrade or degrade during bankfull conditions. Brief descriptions of these two analyses are presented in the following sub-sections.

5.2.2 Calculations and Discussion

Boundary shear stresses were calculated and compared with Shield's Curve to predict sediment competency. The shear stress placed on the sediment particles represents the force that entrains and moves the particles downstream. The equation for shear stress is presented below.

$\tau = \gamma RS$ where,

τ	=	shear stress (lb/ft^2)
γ	=	specific gravity of water (62 lb/ft^3)
R	=	hydraulic radius (ft)
S	=	average channel slope (ft/ft)

The shear stress placed on the sediment particles is the force that entrains and moves the particles. The critical shear for the proposed channel has to be sufficient to move the D_{84} of the bed material. The critical shear stress was calculated and plotted on Shield's Curve to determine the approximate size of particles that will be moved. Based on Shield's Curve, particle from 25 to 100 mm could be moved with an average value of 65 mm. The D_{84} of Ellington Branch is 12 mm and the D_{84} of its unnamed tributary is 8 mm. The D_{100} of Ellington Branch (64 mm) and its unnamed tributary (24 mm) fell within the predicted values. Therefore, the proposed channel has sufficient shear stress to move the bedload associated with both streams.

In addition, grade control will be established along both ends of Ellington Branch. These structures will help to prevent and/or control degradation along the main channel. Control will also be established along the unnamed tributary immediately upstream of its confluence with Ellington Branch. Rock cross vanes will be used as the primary methods for grade control.

Stream power was also calculated for both the existing and design channel condition to determine the effect o the restoration on sediment transport capacity. A stream's capacity is defined as the maximum load a given stream can move at a given time. The capacity of a stream to move sediment is directly related to velocity and stream power. Ellington Branch and its unnamed tributary currently exhibit an excess of stream power. By increasing width/depth ratios and providing a floodplain at the bankfull stage, the proposed designs reduce both stream power and velocity, thus, reducing capacity to only that needed to move the sediment supplied by the watershed.

In summary, the calculations for competency, aggradation, degradation and capacity, bankfull conditions in the design channels for Ellington Branch and its unnamed tributary will entrain particles ranging from 25 to 100 mm and 14 to 45 mm, respectively. Ellington Branch exhibits a D_{100} of 64 mm while its tributary has a D_{100} of 22 mm. The design channels are predicted to remain stable over time based on the establishment of proper dimension, pattern, profile and an active floodplain. The addition of riparian vegetation will further enhance the long term stability of the entire system.

5.3 HEC-RAS Analyses

Approximate limits of flooding for the existing and proposed channels were determined using HEC-RAS software, Version 3.1.1 from the US Army Corps of Engineers Hydrologic

Engineering Center. Water surface profiles for the bankfull and 100-year events were computed. This data is presented in Appendix 6.

According to the model, restoration along both the main branch and tributary will not adversely effect existing flood elevations throughout and downstream of the project area. A total of 17 cross sections along Ellington Branch and 8 along its UT were incorporated into the model. The results showed maximum increases of the 100-year storm elevation of 0.28 and 0.48 feet for Ellington Branch and its UT, respectively. Other small increases were also observed on several of the other cross sections. Based on the locations of these cross sections, any increases in water elevations during flooding will remain in the easement area and will not pose any hydrologic trespass concerns. The proposed channels will not raise the flood elevations near the end of the project. It will have no impact on any structures, dwellings or other human-related aspects that would require flood insurance or detailed flood studies. In addition, flooding associated with the predicted overall rise in elevation is contained within the existing property boundaries. The proposed design ties into the existing water surface elevation at both the upstream and downstream limits of the study.

5.3.1 No Impact

All streams associated with the Ellington Branch project are outside of the Federal Emergency Management Agency's (FEMA's) 100-year flood boundary and do not appear on current FEMA mapping. Therefore, a No Impact assessment is not required as part of project implementation.

5.3.2 Hydrologic Trespass

Based on the overall size of the property, the surrounding topography and existing valley type, no hydrological trespass will occur as a result of project construction. Additional floodprone area will be created adjacent to the restored channels, allowing for increased flood attenuation within the buffer and easement areas. As a result, the areas outside of the buffer and easement may actually receive less waters from over-bank flooding occurring during normal rain events, once the project is completed.

5.4 Stormwater Best Management Practices

Based on the nature and existing conditions associated with the project, no stormwater best management practices (BMPs) are proposed as part of overall implementation. Riparian buffers will help to capture and filter pollutants as they enter the easement areas. In addition, land use outside of the easement area is predominately rural with little or no impervious surfaces. No changes in overall landuse are predicted anytime in the near future.

5.5 Soil Restoration

The soils underlying the project site are considered as non-renewable resources according to the geological timescales required for regeneration. Typical practices regarding soil removal and reinstatement requires that soils be returned as closely and quickly as possible to their original state after disturbance. When this happens, site restoration benefits from rapid re-establishment of vegetation. The primary objective is to minimize the degradation of this resource and to promote the re-establishment of a functional plant-soil system. Soil erosion will be minimized as much as practicable through a detailed erosion and sediment control plan. As a result, the loss of organic matter and nutrients, as well as compaction, runoff, sediment loading and mixing will either not occur or occur at a reduced rate. Since soil stripping is likely to be proposed in areas requiring additional floodplain or bankfull benching, it will be imperative that the topsoil and subsoil horizons are not mixed. If these are mixed, it may lead to a significant decline in overall soil quality and productivity. Special attention will be required during the construction phase to ensure all variables associated with the erosion and sediment control plan are followed to the maximum extent practicable.

5.5.1 Narrative of Soil Preparation and Amendment

Sungate is currently having the existing soils analyzed by the NRCS lab in Raleigh. Once the data has been received, all erosion and sediment control plans will be updated according to the recommendations set forth by the lab.

5.6 Natural Community Restoration

Natural community restoration at the project site will follow the community description consistent with the Piedmont Alluvial Forest (Shafale and Weakley, 1990). The existing, disturbed community is described in Section 3.6. The project will propose to only enhance this community type. This community is distinguished from the Mesic communities associated with the two reference reaches by its location in a floodplain and by the presence of species such as sycamore, river birch and box elder (*Acer negundo*). Variation is probably most related to frequency and recentness of destructive flooding. Sites may vary due to different alluvial material and its effect on soil fertility, but almost all alluvial sites are more fertile than their surrounding uplands.

5.6.1 Narrative of Plant Community Restoration

The planting plan for the riparian and streamside buffers will provide post-construction erosion control and riparian habitat enhancement. It will also attempt to blend existing vegetative communities into recently restored areas. Plantings in the buffer areas will include native species appropriate for the Piedmont physiographic province and the project site. Plants within the floodplain will be flood tolerant species, which can accommodate periodic flooding events throughout the year. A variety of trees and shrubs will be planted to provide cover and habitat for wildlife as well as soil stabilization.

Tree and shrub species will be planted in specific planting zones. These planting zones will accommodate plant species which have specific requirements for growth. Hydrology and topography are main factors that dictate a plant's ability to survive and to thrive following planting. These planting zones will be created around these requirements and will include the following zones: Zone 1 (stream banks) and Zone 2 (riparian buffer). A list of species in each Zone is presented in Table VII.

Shrubs and trees with extensive, deep rooting systems will assist in stabilizing the banks in the long term. Native grasses, transplants, and live stakes will be utilized at the site for immediate stabilization as well as erosion control matting along the newly created stream banks. Vegetation will be planted in a random fashion in an effort to mimic natural plant communities. Colonization of local herbaceous vegetation will inevitably occur, which will provide additional soil stability. Tree species will be planted as bare root stock on random eight-foot centers at a frequency between 600 and 680 stems per acre. Shrub species will be dispersed among these tree species also on random eight-foot centers. Larger plant stock, if available, will be established in areas immediately adjacent to channel structures. These areas will also receive much denser plantings in order to expedite the stabilization of the soil through greater rooting mass. Planting stock will be culled to remove inferior specimens, allowing only healthy, viable stock to be planted at the project site. Planting of species will utilize dormant plant stock and will be performed to the extent practicable between November 3rd and March 30th.

5.6.2 On-site Invasive Species Management

Invasive species control at the project site will be focused on Japanese honeysuckle, multiflora rose and Chinese privet from the riparian areas along Ellington Branch and its tributary. Eliminating these invasive species will provide long-term benefits for existing plant species and those that will be established. Controlling these species will likely involve both mechanical and chemical control mechanisms. Sungate will oversee and maintain the invasive species effort.

Japanese honeysuckle, stiltgrass, multiflora rose and Chinese privet are generally difficult to control due to either their growth habits or waxy leaf surface. Initially, mechanical control of this species is the best method. Mechanical control will significantly reduce the plants statures, whereby stimulating a cluster of young growth, which provide an easier, more effective herbicide application. Mechanical control of this species should be done in early spring or late fall. Applications of 4 to 6 pints per acre of imazapyr herbicide during the active growing season will provide effective control of these species.

6.0 Performance Criteria

Performance criteria set forth for this project will be provided according the Ecosystem Enhancement Program's monitoring criteria and format. It will cover both stream and vegetation assessments.

6.1 Streams

Designs for Ellington Branch and its unnamed tributary will initially imitate the parameters of a C stream type; however, during the course of monitoring, the channels are expected to classify between the C and E stream types. C-stream types are slightly entrenched, meandering, gravel dominated, riffle-pool channels with well developed floodplains. Pool to pool spacing for this stream type averages five-to-seven bankfull channel widths in length. The stream banks are generally composed of sand and gravel material, with stream beds exhibiting little difference in pavement and sub-pavement material composition. Rates of lateral migration are influenced by the presence and condition of riparian vegetation. The C-stream type, is best characterized by the presence of point bars and other depositional features, it is very susceptible to shifts in both lateral and vertical stability caused by direct channel disturbance and changes in the flow and sediment regimes of the contributing watershed. As a result, stream success criteria will be based on overall stability. It is expected that channel adjustment will occur throughout the restored reaches; however, excessive adjustment and potential stream instability will be judged to be occurring if the width/depth ratio is measured to be greater than 18, the bank height ratio is greater than 1.4; radius of curvature ratio is less than 1.5, or the development of head cuts occur. These limits are established based on reference reach data for C and E stream types in North Carolina.

Stream dimensions and profiles will be assessed according to the protocols stated in the US Army Corps of Engineers Stream Mitigation Guidelines (dated 2003). Based on the overall length of the project, monitoring activities will assess no more than 3,000 linear feet. All bankfull events will be documented. Bank stability assessments will be performed during years 3 and 5, post-construction. Problem areas will be documented and color coded on a plan view map. In addition, these areas will also be discussed in a table. Photographs will depict the annual progress of the project. Tables will be provided documenting stability and quantitative summary data. All of this information will be summarized and combined with the vegetation information in a report.

6.2 Stormwater Management Devices

Stormwater management devices may be designed and installed at the landowner's request. The Ecosystem Enhancement Program currently does not receive any mitigation credits for the installation and/or maintenance of these devices. Therefore, no performance criteria will be placed on these structures. These structures, if implemented, will be reviewed by the designer to ensure they are functioning properly.

6.3 Vegetation

Vegetation requirements for mitigation purposes state that 260 stems/acre must be viable for success after the five year monitoring period. Should the performance criteria outlined above not be met during the monitoring period, Sungate will provide the Ecosystem Enhancement Program with a remediation proposal, detailing corrective actions and/or maintenance actions proposed, and an implementation schedule. Upon review and approval/modification of proposed corrective measures by the Ecosystem Enhancement Program and the regulatory agencies, Sungate will oversee the implementation of the necessary corrective measures.

The vegetation will be assessed using several variables. Sungate will provide preliminary soil data underlying the Site. Secondly, vegetative problem areas will be identified and discussed. Sungate will then provide a problem area plan view drawing depicting all of the vegetation problem areas, if any, with regard to the scale and layout of the entire project. Stem counts will be conducted within strategically placed 10-meter by 10-meter plots. The plots locations will be determined once construction has been completed. Photos will also be provided as part of this task. Lastly, this information will be summarized with the stream assessment information a assembled into a report.

6.4 Schedule and Reporting

Monitoring reports will be submitted to the Ecosystem Enhancement Program for coordination with the appropriate regulatory agencies on an annual basis. The first-year of monitoring will include two submittals; the As-Built drawings and the First Year Annual Monitoring Report. All drawings and monitoring will follow Ecosystem Enhancement Program protocols established during the project period. It is understood that the Ecosystem Enhancement Program will coordinate any necessary monitoring report submittals with the regulatory agencies. If the monitoring reports indicate any deficiencies in achieving the success criteria on schedule, Sungate will coordinate with the Ecosystem Enhancement Program and the resource agencies, as applicable, to determine the extent of remedial actions necessary. Sungate will provide a remedial action plan, if necessary, in the annual monitoring reports. Sungate personnel will be available to coordinate any agency site visits, both before and after restoration activities have been completed. Vegetative monitoring will be conducted during the summer months (growing season) of each monitoring year. The reports will be provided no later than December 15. The proposed schedule is provided below detailing the monitoring dates.

Monitoring Schedule

March 2007	Complete construction/planting activities.
May 2007	Submit As-Built Drawings and Mitigation Plan report in draft format.
October 2007	Conduct first year monitoring activities.
December 2007	Submit first year Monitoring Report in draft format.
July 2008	Conduct second year monitoring activities
December 2008	Submit second year Monitoring Report in draft format.
July 2009	Conduct third year monitoring activities
December 2009	Submit third year Monitoring Report in draft format.
July 2010	Conduct fourth year monitoring activities
December 2010	Submit fourth year Monitoring Report in draft format.
July 2011	Conduct fifth year monitoring activities
December 2011	Submit fifth year Monitoring Report in draft format.

7.0 References

Andrews, E.D., 1983. Entrainment of Gravel from Naturally Sorted Riverbed Material. Geological Society of America Bulletin 94. pp 1225-1231.

Bogan, Arthur E., 2002. Workbook and Key to the Freshwater Bivalves of North Carolina. North Carolina Museum of Natural Sciences, Raleigh, NC.

Brunte, K. and S.R. Abt, 2001. Sampling Surface and Subsurface Particle-Size Distributions in Wadable Gravel- and Cobble-bed Stream for Analysis in Sediment Transport, Hydraulics and Streambed Monitoring. USDA Forest Service Report RMRS-GTR-74. Rocky Mountain Experiment Station. Fort Collins, CO.

Clarke, A.H. 1981. The Tribe Alasmidontini (Unionidae: Anodontinae), Part 1: Pegias, Alasmidonta, and Aricidens. Smiths. Contrib. Zool. No. 326. 101 pp.

Conant R., and J. T. Collins, 1998. A Field Guide to Reptiles and Amphibians of Eastern and Central North America. Third Edition, Expanded. Peterson Field Guides. Houghton Mifflin Publishers, New York, NY.

Cowardin, L. M., V. Carter, F. C. Golet and E. T. LaRoe, 1979. Classification of Wetlands and Deepwater Habitat of the United States. Fish and Wildlife Service, United States Department of the Interior. US Government Printing Office, Washington, DC.

Environmental Data Resources (EDR), 2006a. The EDR Radius Map with Geo-Check– Fleming Farm. Inquiry No. 1617851.10s. 35pp.

Environmental Data Resources (EDR), 2006b. The EDR NEPA Check– Fleming Farm. Inquiry No. 1617851.13s. 29pp.

Environmental Laboratory, 1987. Corps of Engineers Wetlands Delineation Manual; Technical Report Y-87-1. United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

Federal Emergency Management Association (FEMA). 2006. http://www.fema.org.

Harman, W.H. et al., 1999. Bankfull Hydraulic Geometry Relationships for North Carolina Streams. AWRA Wildland Hydrology Symposium Proceedings. Edited by: D.S. Olsen and J.P. Potyondy. AWRA Summer Symposium. Bozeman, MT.

Harrelson, C.C., C.L. Rawlins, and J.P. Potyondy, 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. General Technical Report RM-245. USDA Forest Service, Rocky Mountain Forest and Range Experiment Station. Fort Collins, CO.

Hey, Richard and Dave Rosgen, 1997. Fluvial Geomorphology for Engineers. Wildland Hydrology, Pagosa Springs, CO.

Hicks, Jesse L., 1980. Soil Survey of Vance County, North Carolina. United States Department of Agriculture, Soil Conservation Service, in cooperation with the North Carolina Agricultural Research Service and the Vance County Board of Commissioners.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr., 1980 et seq. Atlas of North American Freshwater Fishes. North Carolina Museum of Natural History, North Carolina Department of Agriculture, Raleigh, NC. North Carolina Biological Survey #1980-12.

Leupold, L.B., M.G. Wolman, and J.P. Miller, 1992. Fluvial Processes in Geomorphology. Dover Publications, Inc., New York, NY.

Leupold, L.B., 1994. A View of the River. Harvard University Press, Cambridge, Mass.

Martof, Bernard S., William M. Palmer, Joseph R. Bailey, Julian R. Harrison, and Jack Dermid, 1980. Amphibians and Reptiles of the Carolinas and Virginia. The University of North Carolina Press. Chapel Hill, NC.

Michaelson, D.L. and R.J. Neves, 1995. Life history and habitat of the endangered dwarf wedge mussel *Alasmidonta heterodon* (Bivalvia: Unionidae). Journal of the North American Benthological Society 14(2):324-340.

Mitsch, W.J. and J.G. Gosselink, 2000. Wetlands, Third Edition. John Wiley & Sons, Inc., New York, NY.

Moser, G. Andrew, 1993. Dwarf Wedge Mussell (*Alasmidonta heterodon*) Recovery Plan. Region Five, United States Fish and Wildlife Service. Hadley, MA.

Natural Resources Conservation Service (NRCS), 2000. Official Soil Series Description Query Facility. Available: http://www.ortho.ftw.nrcs.usda.gov.

Natural Resources Conservation Service (NRCS), 1998. Keys to Taxonomy, Eighth Edition. USDA. Available: http://statlab.iastate.edu/soils/keytax/KeystoSoilTaxonomy1998.pdf.

North Carolina Division of Land Resources (NCDLR), 1985. Geologic Map of North Carolina. Department of Natural Resources and Community Development.

North Carolina Division of Water Quality (NCDWQ), 2006a. North Carolina Waterbodies Listed by County. Available at: http://h2o.enr.state.nc.us

North Carolina Division of Water Quality (NCDWQ), 2006b. Surface Water Classifications. Available at: http://h2o.enr.state.nc.us

North Carolina Division of Water Quality (NCDWQ), 2006c. Basinwide Planning Program, 2001 Roanoke River Basinwide Water Quality Plan. Available at: http://h2o.enr.state.nc.us

North Carolina Division of Water Quality (NCDWQ), 2006d. Basinwide Assessment Report, Roanoke River Basin – April 2005. Available at: http://h2o.enr.state.nc.us

North Carolina Division of Water Quality (NCDWQ), 2006e. Stream Identification Form, Version 3.1, Effective February 28, 2005. Available via world wide web at: http://h2o.enr.state.nc.us/ncwetlands/documents.

North Carolina Division of Water Quality (NCDWQ), 2005. Identification Methods for the Origins of Intermittent and Perennial Streams, Version 3.1. North Carolina Department of Environment and Natural Resources, Division of Environmental Management; Raleigh, NC.

North Carolina Division of Water Quality (NCDWQ), 1995. Guidance for Rating the Values of Wetlands in North Carolina - 4th Version. North Carolina Department of Environment and Natural Resources, Division of Environmental Management; Raleigh, NC.

North Carolina Geologic Survey (NCGS), 1991. Generalized Geologic Map of North Carolina. Division of Land Resources. Raleigh, NC.

North Carolina Natural Heritage Program (NCNHP), 2006. Element Search Results, Warren County, North Carolina. Available at: http://207.4.179.38/nhp/county.html.

North Carolina State University (NCSU), 1999. Soil Systems in North Carolina. Technical Bulletin 314. Soil Science Department, Raleigh, NC.

Radford, A. E., H. E. Ahles, and C. R. Bell, 1968. Manual of the Vascular Flora of the Carolinas. University of North Carolina Press, Chapel Hill, NC.

Reed, P.B. Jr., 1988. National List of Plant Species that Occur in Wetlands: Southeast (Region 2). Prepared for National Wetlands Inventory and US Fish and Wildlife Service in Cooperation with the US Army Corps of Engineers, US Environmental Protection Agency and US Soil Conservation Service.

Rosgen, D.L. and D. Hockett, 2005. River Restoration Design Implementation Short Course and Manual. Wildland Hydrology, Inc. Fort Collins, CO.

Rosgen, D.L., 2005. Natural Channel Design Engineers' Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 2002. River Restoration and Natural Channel Design Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 2002. Natural Channel Design Engineers' Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 2001. River Assessment and Monitoring Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 2001. River Morphology and Applications Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen D.L., 2000. Applied Fluvial Geomorphology Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 1999. River Restoration and Natural Channel Design Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 1999. River Assessment and Monitoring Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, D.L., 1999. River Morphology and Applications Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen D.L., 1998. Applied Fluvial Geomorphology Short Course and Manual. Wildland Hydrology, Inc. Pagosa Springs, CO.

Rosgen, David L., 1997. A Geomorphological Approach to Restoration of Incised Rivers. Proceedings of the Conference on Management of Landscapes Disturbed by Channel Incision. Wildland Hydrology, Inc., Pagosa Springs, CO.

Rosgen, David L., 1996. Applied River Morphology. Wildland Hydrology Books, Inc. Pagosa Springs, CO. 385 pp.

Rosgen, D. L., 1994. "A Classification of Natural Rivers," Catena, Vol. 22, pp. 169- 199.

Schafale, M. P. and A. S. Weakley, 1990. Classification of the Natural Communities of North Carolina, A Third Approximation. North Carolina Natural Heritage Program, Division of Parks and Recreation, Department of Environment, Health and Natural Resources, Raleigh, NC.

Stokes, Donald and Lillian Stokes, 1996. Stokes Field Guide to Birds, Eastern Region. Little, Brown, and Company, New York, NY.

US Army Corps of Engineers (USACE), 2006. Stream Quality Assessment Worksheet, Updated August 2003. Web: http://www.saw.usace.army.mil/wetlands/Forms/stream_quality.pdf

US Fish and Wildlife Service (USFWS), 2006. Endangered Species, Threatened Species, Federal Species of Concern, and Candidate Species, Warren County, North Carolina. Updated 27 April 2006. Available at: http://nc-es.fws.gov/es/cntylist/warren.html.

Weakley, A.S., K.D. Patterson, S. Landaal, M. Pyne and others (compilers), 1998. International Classification of Ecological Communities: Terrestrial Vegetation of the Southeastern US. Working Draft of March 1998. The Nature Conservancy, Southeast Regional Office, Southern Conservation Science Department, Community Ecology Group, Chapel Hill, NC.

Webster, W. D., J. F. Parnell, and W. C. Biggs, Jr., 1985. Mammals of the Carolinas, Virginia, and Maryland. University of North Carolina Press, Chapel Hill, NC.

Tables

Table 1. Project Restoration Structure and Objectives Project Number 16-D06045 (Ellington Branch)						
Restoration Segment/ Reach ID	**Station Range**	**Restoration Type**	**Priority Approach**	**Existing Linear Footage**	**Designed Linear Footage**	**Comment**
Reach I – Ellington Br.	10+00 to 29+43.5	Restoration	Priority Level II	1,575.0	1,923.5	Includes channel relocation at the same thalweg elevation along with other modifications to the existing channel
Reach II – Ellington Br.	29+43.5 to 47+52.5	Restoration	Priority Level II	2,475.9	1,809.0	Includes channel relocation at the same thalweg elevation along with other modifications to the existing channel
Reach III – Tributary	10+00 to 23+43.7	Restoration	Priority Level II	852.9	1,366.9	Includes channel relocation at the same thalweg elevation along with other modifications to the existing channel

Table 2. Drainage Areas Project Number 16-D06045 (Ellington Branch)		
Reach		**Drainage Area**
Reach One –	Ellington Branch from project beginning to upstream of confluence w/ Tributary	0.8 square miles (515.4 acres)
Reach Two –	Ellington Branch from confluence w/ Tributary to downstream project end.	1.1 square miles (695.8 acres)
Tributary –	From origination at dam outlet to confluence with Ellington Branch	0.1 square miles (90 acres)

Table 3. Land Use of Watershed Project Number 16-D06045 (Ellington Branch)		
Land Use	**Acreage**	**Percentage**
Disturbed	29.9 ac	4.3 %
Mixed Forest	290.9 ac	41.8 %
Pasture/ Hay	97.8 ac	14.1 %
Row Crops	259.4 ac	37.3 %
Waters (ponds, swamps, etc.)	17.8 ac	2.5 %
TOTAL	695.8 acres	100 %

Table 4. Morphological Table (1 of 4)
Project Number 16-D06045 (Ellington Branch)

Variable	Existing Conditions – Reach One	Existing Conditions – Reach Two	Existing Conditions – Reach Three	Designed Conditions – Reach One	Designed Conditions – Reach Two	Designed Conditions – Reach Three	Reference Reach One	Reference Reach Two	Reference Reach Three
Location	Ellington Branch upstream of confluence w/ Tributary	Ellington Branch at project end downstream of confluence w/ Tributary	Unnamed Tributary of Ellington Branch	Ellington Branch upstream of confluence w/ Tributary	Ellington Branch at project end downstream of confluence w/ Tributary	Unnamed Tributary of Ellington Branch	Unnamed Tributary of Ellington Branch upstream of Tributary within watershed	Hawtree Creek, Warren County, NC	Unnamed Tributary of Taylor's Creek, Franklin County, NC* (Comparison Only)
1. Stream Type	Unstable E5	Unstable E5	Unstable E5	C5	C5	C5	B4c	E5	E5
2. Drainage Area	0.8 sq. mi	1.1 sq. mi	0.14 sq. mi	0.8 sq. mi	1.1 sq. mi	0.14 sq. mi	0.05 sq. mi	0.32 sq. mi	0.19 sq. mi
3. Bankfull Width (W_{bkf}) ft	8.9	12.2 – 14.9	8.3 – 14.5	14.5	15.5	8.0	4.1	7.7 – 9.3	4.5 – 6.0
4. Bankfull Mean Depth (d_{bkf}) ft	2.0	1.3 – 1.8	0.4 – 0.6	1.3	1.4	0.6	0.6	1.1 – 1.3	1.3 – 1.6
5. Width/Depth Ratio (W_{bkf}/d_{bkf})	4.5	6.7 – 11.2	14.7 – 32.9	11.2	11.1	13.3	6.5 – 6.7	6.1 – 8.8	3.4 – 3.8
6. Bankfull Cross Sectional Area (A_{bkf}) ft^2	17.9	19.9 – 22.1	4.7 – 6.4	18.3	21.6	4.5	2.5 – 2.6	9.7 – 9.8	5.4 – 9.4
7. Bankfull Mean Velocity (V_{bkf}) fps	5.0 – 5.3	5.9 – 6.4	2.6 – 3.2	5.1	5.7	3.7	3.9 – 4.6	3.7 – 3.9	4.7 – 5.1
8. Bankfull Discharge (Q_{bkf}) cfs	89.5 – 95.0	123.9 – 134.4	14.6 – 17.8	92.8	122.0	16.5	9.8 – 11.6	35.7 – 38.3	28 – 47
9. Maximum Bankfull Depth (d_{max}) ft	2.7	2.8 – 3.0	0.7 – 1.1	1.8	2.0	0.8	1.0	1.6 – 1.8	1.7 – 2.0
10. Ratio of Low Bank Height to Max. Bankfull Depth (lbh/d_{max})	1.6	1.0 – 1.2	1.6 – 4.1	1.0	1.0	1.0	1.3 – 1.5	1.4 – 1.5	1.4 – 1.6
11. Width of Floodprone Area (W_{fpa}) ft	185	135 – 220	15.8 – 34.0	>50	>50	>30	6.5 – 7.9	15.8 – 32.5	57 – 100
12. Entrenchment Ratio (W_{fpa}/W_{bkf})	20.8	11.1 – 14.8	1.4 – 3.0	>3.45	>3.22	>3.75	1.6 – 1.9	2.1 – 3.8	10 – 22
13. Meander Length (Lm) ft	21.3 – 87.8	14.0 – 90.2	23.7 – 87.0	68.7 – 164.2	70.5 – 151.9	29.7 – 97.8	2.5 – 10.4	10.2 – 23.2	18 – 80

Table 4. Morphological Table Continued (2 of 4) Project Number 16-D06045 (Ellington Branch)									
Variable	**Existing Conditions – Reach One**	**Existing Conditions – Reach Two**	**Existing Conditions – Reach Three**	**Designed Conditions – Reach One**	**Designed Conditions – Reach Two**	**Designed Conditions – Reach Three**	**Reference Reach One**	**Reference Reach Two**	**Reference Reach Three**
14. Ratio of Meander Length to Bankfull Width (Lm/W_{bkf})	2.4 – 9.9	1.0 – 6.7	2.1 – 7.6	4.7 – 11.3	4.5 – 9.8	3.7 – 12.2	0.6 – 2.5	1.1 – 2.5	3.4 – 15.2
15. Radius of Curvature (Rc) ft	8.4 – 70.0	7.7 – 67.6	11.1 – 58.4	24.0 – 50.0	24.0 – 47.8	13.0 – 25.0	1.4 – 7.2	4.0 – 10.6	6 – 25
16. Ratio of Radius of Curvature to Bankfull Width (Rc/W_{bkf})	0.9 – 7.9	0.6 – 5.0	1.0 – 5.1	1.7 – 3.4	1.5 – 3.1	1.6 – 3.1	0.3 – 1.8	0.4 – 1.1	1.1 – 4.8
17. Belt Width (W_{blt}) ft	19.9 – 90.5	22.5 – 64.0	19.8 – 67.0	23.7 – 74.0	20.7 – 71.1	11.4 – 42.5	19.1	15.5 – 39.1	8 – 42
18. Meander Width Ratio (W_{blt}/W_{bkf})	2.2 – 10.2	1.7 – 4.7	1.7 – 5.9	1.6 – 5.1	1.3 – 4.6	1.4 – 5.3	4.7	1.7 – 4.2	1.5 – 8.0
19. Arc Length (La) ft	19.9 – 90.1	17.8 – 93.5	23.7 – 104.0	22.5 – 118.4	11.0 – 90.1	9.5 – 63.0	2.7 – 7.9	9.3 – 34.2	n/a
20. Ratio of Arc Length to Bankfull Width (La/W_{bkf})	2.2 – 10.1	1.3 – 6.9	2.1 – 9.1	1.6 – 8.2	0.7 – 5.8	1.2 – 7.9	0.7 – 1.9	1.0 – 3.7	n/a
21. Sinuosity (Stream Length/ Valley Distance)	1.37	1.30	1.11	1.32	1.32	1.33	1.5	1.7	1.16
22. Valley Slope ft/ft	0.0055	0.008	0.009	0.0074	0.0074	0.012	0.020	0.012	0.013
23. Average Water Surface Slope (S_{avg}) ft/ft	0.0040	0.0060	0.0081	0.0056	0.0056	0.0090	0.0130	0.0070	0.0110
24. Pool Slope (S_{pool}) ft/ft	0.001	0.001	0.001	0.000	0.000	0.000	0.001	0.003	0.001 – 0.009
25. Ratio of Pool Slope to Average Slope (S_{pool}/S_{avg})	0.25	0.17	0.1	0.0	0.0	0.0	0.008	0.4	0 – 0.8
26. Maximum Pool Depth (d_{pool}) ft	2.8	2.8	1.9	2.7	2.8	1.4	1.3	2.2	1.1 – 3.3
27. Ratio of Max. Pool Depth to Bankfull Mean Depth (d_{pool}/d_{bkf})	1.4	1.8	3.8	2.1	2.0	2.3	2.1	2.1	0.7 – 2.2
28. Pool Width (W_{pool}) ft	18.3	18.3	10.2	23.0	23.0	10.1	4.6	8.1	11 – 14

Table 4. Morphological Table Continued (3 of 4) Project Number 16-D06045 (Ellington Branch)									
Variable	**Existing Conditions – Reach One**	**Existing Conditions – Reach Two**	**Existing Conditions – Reach Three**	**Designed Conditions – Reach One**	**Designed Conditions – Reach Two**	**Designed Conditions – Reach Three**	**Reference Reach One**	**Reference Reach Two**	**Reference Reach Three**
29. Ratio of Pool Width to Bankfull Width (W_{pool}/ W_{bkf})	2.1	1.4	0.9	1.6	1.5	1.3	1.1	0.9	2.1 – 2.6
30. Bankfull Cross Sectional Area at Pool (A_{pool}) ft^2	25.9	25.7	7.7	25.4	25.4	7.3	3.8	11.3	20 – 47
31. Ratio of Pool Area to Bankfull Area (A_{pool}/ A_{bkf})	1.4	1.2	1.4	1.4	1.2	1.6	1.5	1.2	2.6 – 6.2
32. Pool to Pool Spacing (p-p) ft	33.4 – 823.7	33.4 – 823.7	n/a	34.0 – 125.0	40.0 – 103.0	27.0 – 89.0	22.6	20.9 – 56.3	23 – 48
33. Ratio of Pool to Pool Spacing to Bankfull Width (p-p/ W_{bkf})	3.8 – 92.6	2.7 – 55.3	n/a	2.3 – 8.6	2.6 – 6.6	3.4 – 11.1	5.5	2.7 – 6.6	4.3 – 9.1
34. Pool Length (Lp) ft	11.6 – 85.7	11.6 – 85.7	17.2	13.0 – 45.0	9.0 – 50.0	10.0 – 21.0	3.9	4.9 – 27.9	7 – 16
35. Ratio of Pool Length to Bankfull Width (Lp/ W_{bkf})	1.3 – 9.6	1.0 – 5.8	1.5	0.9 – 3.1	0.6 – 3.2	1.3 – 2.6	1.0	0.6 – 3.3	n/a
36. Riffle Slope (S_{riff}) ft/ft	0.022	0.022	0.019	0.015	0.015	0.02	0.035	0.014	n/a
37. Ratio of Riffle Slope to Average Slope (S_{riff}/ S_{avg})	5.5	3.7	2.7	2.7	2.7	2.2	2.8	2.0	n/a
38. Maximum Riffle Depth (d_{riff}) ft	2.7	2.9	0.9	2.0	2.0	0.8	1.0	1.7	n/a
39. Ratio of Maximum Riffle Depth to Bankfull Mean Depth (d_{riff}/ d_{bkf})	1.4	1.9	1.8	1.5	1.4	1.3	1.7	1.6	n/a
40. Run Slope (S_{run}) ft/ft	0.004	0.004	0.006	0.009	0.012	0.021	0.027	0.004	0.002 – 0.068
41. Ratio of Run Slope to Average Slope (S_{run}/ S_{avg})	1.0	0.7	0.74	1.6	2.1	2.3	2.1	0.6	0.2 – 6.2

Table 4. Morphological Table Continued (4 of 4) Project Number 16-D06045 (Ellington Branch)									
Variable	**Existing Conditions – Reach One**	**Existing Conditions – Reach Two**	**Existing Conditions – Reach Three**	**Designed Conditions – Reach One**	**Designed Conditions – Reach Two**	**Designed Conditions – Reach Three**	**Reference Reach One**	**Reference Reach Two**	**Reference Reach Three**
42. Maximum Run Depth (d_{run}) ft	3.1	3.1	1.2	1.9	2.2	0.8	1.1	1.9	1.7 – 2.0
43. Ratio of Max. Run Depth to Bankfull Mean Depth (d_{run}/ d_{bkf})	1.6	2.0	2.4	1.5	1.6	1.3	1.8	1.8	1.1 – 1.3
44. Glide Slope (S_{glide}) ft/ft	0.001	0.001	0.001	0.002	0.002	0.002	0.001	0.006	n/a
45. Ratio of Glide Slope to Average Slope (S_{glide}/ S_{avg})	0.3	0.2	0.1	0.3	0.3	0.2	0.1	0.9	n/a
46. Maximum Glide Depth (d_{glide}) ft	1.6	1.6	1.0	2.0	2.3	0.9	1.2	1.6	n/a
47. Ratio of Maximum Glide Depth to Bankfull Mean Depth (d_{glide}/ d_{bkf})	0.8	1.0	2.0	1.5	1.7	1.5	2.0	1.5	n/a

Materials									
Particle Size Distribution of Channel Material (mm)									
D16	0.11	0.075	<0.1	0.11	0.075	<0.1	0.28	0.097	n/a
D35	0.28	0.26	0.22	0.28	0.26	0.22	0.98	0.2	n/a
D50	1.2	0.41	0.38	1.2	0.41	0.38	1.8	0.31	n/a
D84	10.2	4.0	11.8	10.2	4.0	11.8	10.2	10.9	n/a
D95	22.0	10.0	43.0	22.0	10.0	43.0	10.8	37.0	n/a
Particle Size Distribution of Bar Material (mm)									
D16	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	n/a
D35	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	n/a
D50	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	3.2	<0.1	n/a
D84	2.5	3.2	<0.1	2.5	3.2	<0.1	10.4	<0.1	n/a
D95	12.0	13.0	6.0	12.0	13.0	6.0	28.0	7.0	n/a
Largest Particle on Bar	20.0	30.0	22.0	20.0	30.0	22.0	50.0	22.0	n/a

Note*

Reference Reach 3 is used for comparison purposes only. It was surveyed nearly four years ago by non-Sungate personnel.

Table 5. BEHI and Sediment Export Rates for Project Site Streams Project Number 16-D06045 (Ellington Branch)																
Time Point	**Segment/ Reach**	**Linear Footage**	**Extreme**		**Very High**		**High**		**Moderate**		**Low**		**Very Low**		**Sediment Export**
			ft	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**Ton/y**
Pre-construction	Ellington Branch – Upstream of Confluence	1,500					1,500	37							44.9
Pre-construction	Ellington Branch – Downstream of Confluence	2,550			2,550	63									682.8
														Total for Ellington Branch	**727.7**
Pre-construction	Unnamed Tributary of Ellington Branch	853	853	100											217.8
														Total for the Unnamed Tributary of Ellington Branch	**217.8**

Table 6. BEHI and Sediment Export Rates for Reference Streams Project Number 16-D06045 (Ellington Branch)															
Time Point	**Segment/ Reach**	**Linear Footage**	**Extreme**		**Very High**		**High**		**Moderate**		**Low**		**Very Low**		**Sediment Export**
			ft	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**ft**	**%**	**Ton/y**
Reference Stream #1	UT Ellington Branch Upstream of Project	120									120	100			3.2
Reference Stream #2	Hawtree Creek	2,500							2,500	100					90.0

Table 7. Designated Vegetative Communities (By Zone)			
Zone Description	**Stratum**	**Species**	
		Common Name	**Scientific Name**
Zone 1 (Piedmont Streamside)			
	Canopy	Sycamore	*Platanus occidentalis*
		Black willow	*Salix nigra*
	Understory (sub-canopy)	Buttonbush	*Cephalanthus occidentalis*
		Silky dogwood	*Cornus amomum*
		Elderberry	*Sambucus canadensis*
		Tag alder	*Alnus serrulata*
		Yellow root	*Xanthorhiza simplicissima*
Zone 2 (Piedmont Riparian Buffer)			
	Canopy	American elm	*Ulmus americana*
		Swamp chestnut oak	*Quercus michauxii*
		Green ash	*Fraxinus pennsylvanica*
		River birch	*Betula nigra*
		Willow oak	*Quercus phellos*
		Sugarberry	*Celtis laevigata*
		White oak	*Quercus alba*
		Mockernut hickory	*Carya tomentosa*
	Understory (sub-canopy)	Spicebush	*Lindera benzoin*
		Flowering dogwood	*Cornus florida*
		Eastern redbud	*Cercis canadensis*
		Paw paw	*Asimina triloba*
		Eastern red cedar	*Juniperus virginiana*
		Persimmon	*Diospyros virginiana*
		Flowering dogwood	*Cornus florida*
Piedmont Riparian Seed Mix (Permanent)			
	Herbaceous	Switchgrass	*Panicum virgatum*
		Marsh mallow	*Hibiscus mosheutos*
		Virginia wild rye	*Elymus virginicus*
		Coreopsis	*Coreopsis lanceolata*
		Deer tongue	*Panicum clandestinum*
		Pennsylvania smartweed	*Polygonum pennsylvanicum*
		Little bluestem	*Schizachyrium scoparium*
		Partridge pea	*Chamaecrista fasciculata*
		Fox sedge	*Carex vulpinoidea*
		Showy tick trefoil	*Desmodium canadense*
		Sedge	*Carex intumescens*
		Joe pye weed	*Eupatorium fistulosum*
		Cardinal flower	*Lobelia cardinalis*
Piedmont Temporary Seed Mix (Throughout)			
	Herbaceous	Orchard grass	*Dactylis glomerata*
		Weeping love grass	*Eragrostis curvula*
		Brown top millet	*Panicum ramosum*
		Grain rye	*Secale cereale*
		German millet	*Setaria italica*

Figures

Designed Sheets

Appendix 1.

Site Photographs

Appendix 2.

Project Site USACE Routine Wetland Determination Data Forms

Appendix 3.

Project Site NCDWQ Stream Classification Forms

Appendix 4.

Reference Site Photographs

Appendix 5.

Reference Site NCDWQ Stream Classification Forms

Appendix 6.

HEC-RAS Analysis

Appendix 7.

Letter to EEP Addressing Design Concerns