EXECUTIVE SUMMARY

Sungate Design Group, PA (Sungate) entered into a design/build (full delivery) contract with the NC Department of Environment and Natural Resources, Ecosystem Enhancement Program (EEP) on 21 June 2006 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, was selected to meet these overall obligations.

The Site includes a portion 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 unites with Ellington Branch from the west. The project was identified by Sungate in 2005 and selected for full delivery restoration by EEP based its location, attributes, existing condition and overall likelihood for success.

According to topographic information provided by Maptech® (2006), the drainage area of Ellington Branch varies from approximately 0.8 square miles at its southern project boundary (upstream) to approximately 1.1 square miles at its northern project boundary (downstream). The drainage area of the UT at its confluence with Ellington Branch is 0.1 square miles, or approximately 90 acres.

Pre-Construction Site Conditions

Sungate surveyed a total of 4,904 linear feet of existing stream channel within the project area. This specifically included 4,051 linear feet along Ellington Branch and 853 linear feet along its unnamed tributary. Ellington Branch and its UT were severely degraded due to existing land uses and non-restricted cattle access. The existing stream banks on both the main stem and its UT were eroded and the overall channel morphology was significantly altered. Little or no riparian corridors existed along either reach.

Restoration Plan

Sungate submitted the Ellington Branch Stream Restoration Plan in January 2007 proposing to implement a total of 5,079 linear feet of restoration along Ellington Branch and its UT. This was accomplished using natural channel design methods consistent with Priority Level II stream restoration protocols. A total of 3,712 linear feet along Ellington Branch and 1,367 linear feet along its UT were designed for restoration. Streamside buffers and livestock fencing were also implemented, extending a minimum of 50 feet outward along both sides of the channels. A Conservation Easement was filed with the Warren County Register of Deeds on 15 February 2007, protecting the Site for perpetuity.

Post Construction Site Conditions

According to as-built surveys completed during January 2008, a total of 5,063 linear feet of Ellington Branch and its UT were restored using natural channel design methods consistent with Priority Level II stream restoration protocols. This included 3,735 linear feet along Ellington Branch and 1,328 linear feet along its UT. The summary chart provided below denotes the achievements of the project.

Project Restoration Components

Ellington Branch Stream Restoration (Project No. 16-D06045)

Project Segment or Reach ID	Pre-Construction Linear Footage	Type*	Approach*	Post-Construction Linear Footage	Mitigation Ratio	Stream Mitigation Units (SMUs)	Final Stationing	Comment
Reach I – Ellington Br.	1,576	R	P2	1,934	1.0	1,934	10+00 to 29+34.0	Above Confluence with UT
Reach II – Ellington Br.	2,475	R	P2	1,801	1.0	1,801	29+34.0 to 47+35.0	Below Confluence with UT
Reach III - UT	853	R	P2	1,328	1.0	1,328	10+00 to 23+27.8	Entire Reach
Stream Mitigation Unit Summation						**5,063 lf**		

Note* R = Restoration
P2 = Priority Level II

Ecological benefits gained with the restoration of Ellington Branch and its UT include reduced nutrient loading, reduced sediment loading, improved habitat diversity (both terrestrial and aquatic) and improved water quality. By restricting cattle access and implementing riparian buffers along Ellington Branch and its UT, the project will reduce the overall amount of pollution (physical and chemical) leaving the Site and concentrating in the waters downstream. Restoration of the stream channels will ultimately increase foraging and spawning habitat for fish, and other species requiring flowing water. The project will provide an ecological uplift for the entire basin.

Monitoring Plan

Designs for Ellington Branch and its UT initially imitated 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. It is expected that minor channel adjustment will occur throughout the restored reaches. Excessive adjustment and potential stream instability resulting in width/depth ratios greater than 18, bank height ratios greater than 1.4, radius of curvature ratios less than 1.5, and/or the development of head cuts will warrant additional documentation as part of the monitoring report. 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, Sungate will monitor at least 3,000 linear feet of stream channel and 23 cross sections. All bankfull events will be documented. Bank stability assessments, including Bank Erosion Hazard Index (BEHI) assessments and sediment transport evaluations, 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 yearly report.

1.0 Table of Contents

2.0 Narrative

2.1 Project Introduction

The Site is situated approximately four miles south of the Virginia/North Carolina state line in Warren County, North Carolina (Figure 1). SR 1200 (Drewry Road) is approximately 0.3 miles west of the project area, while SR 1221 (Culpepper Road) is approximately 0.2 miles to the east. Existing fences differentiate the property boundaries along the northern and southern termini. The overall underlying parcels associated with the project area cover approximately 219 acres. Sungate recorded a Conservation Easement covering approximately 14.3 acres along the two streams on 15 February 2007. This easement will allow ample area for filtration without impacting the existing land use activities.

Ellington Branch and its UT 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) sub basin 03-02-07.

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.

2.2 Restoration Summary

Ellington Branch and its UT were severely degraded due to existing land uses and non-restricted cattle access. The existing stream banks on both the main stem and its UT were eroded and overall channel morphology was significantly altered.

The goals and objectives of the project were to ultimately create a continuous wooded stream corridor by restoring and revegetating the largest reach of disturbed channel and buffer along Ellington Branch. This in turn, would also improve the overall function and habitat associated with the stream channel and riparian areas. Sungate's restoration plan included restoration (including dimension, pattern and profile) of Ellington Branch and its UT, as well as the establishment and restoration of an active riparian buffer complex. In addition, the goals and objectives were also 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 provided an excellent opportunity to restore and preserve a substantial riparian zone on lands that were currently being utilized for pasture and cattle grazing.

Ellington Branch and its UT were 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 (Rosgen, 1996). The riffle/pool sequence averages five to seven bankfull widths in length (Rosgen, 1996). Its associated stream banks are generally composed of unconsolidated, heterogeneous, non-cohesive, alluvial materials that are finer than the gravel-dominated bed material (Rosgen, 1996). Sediment supplies are generally moderate to high (Rosgen, 1996). This stream type is characterized by the presence of point bars and other depositional features (Rosgen, 1996). It was favored versus the E stream type since shear in the near bank region is greatly reduced, especially for newly constructed channels. Once the vegetation becomes established, the width/depth ratio may naturally reduce to the characteristic of an E stream type, which is a hydraulically efficient channel form, maintaining a high sediment transport capacity.

2.3 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)

2.4 Summary Table

Table 1 depicts the pre-existing lengths, restored reach lengths, proposed levels of restoration, proposed credit ratios and resultant Stream Mitigation Units (SMUs) for the project.

2.5 Other Information

The following information is provided as background information and offers a brief summary of pertinent information associated with the Ellington Branch Stream Restoration Plan, prepared by Sungate in January 2007.

2.5.1 Drainage Areas

According to topographic information provided by Maptech® (2006), 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 UT at its confluence with Ellington Branch is 0.1 square miles, or 90 acres. These areas are also listed in Table 2.

2.5.2 Surface Water Classification and Water Quality

According to NCDWQ (2006), Ellington Branch is identified by Stream Index No. 23-10-2-1. Downstream of the project area, Ellington Branch empties into Newman's Creek, which flows into Smith Creek, 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.

Little to no documented information is available regarding Ellington Branch and its tributaries. Available information corresponds to its receiving water, Smith Creek. Ellington Branch and its tributaries are denoted as Class C waters (NCDWQ, 2006).

2.5.3 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 fields 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.

2.5.4 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 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.

2.5.5 Jurisdictional Wetlands and Streams

Both Ellington Branch and its UT are considered as jurisdictional streams based on regulatory guidance. 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 a combined total of approximately 0.32 acres. They have been severely impacted by cattle. The restoration of Ellington Branch and its UT did not adversely effect either of these areas. Information regarding the methodology and assessment is provided in the ERTR, dated September 2006.

2.5.6 Channel Classifications

Prior to restoration, both Ellington Branch and its UT both classified as *unstable* E5 stream types, based on the Rosgen Classification System (Rosgen, 1994). Stream classification forms were completed for both the Ellington Branch channel and its UT. These forms are provided by the NCDWQ to differentiate between perennial, intermittent and ephemeral channels using a series of primary and secondary indicators supported by a numerical system. The Ellington Branch channel was scored at 41 and its UT was 40.5. The NCDWQ denotes a perennial channel as having numerical values greater than 30.

2.5.7 Discharge (Bankfull, Trends)

According to the NC Piedmont Rural Regional Curve data provided by the Stream Restoration Group at NC State University (Harman et al. 1999), the bankfull discharge for Ellington Branch ranges between 75.8 and 95.4 cubic feet per second. The bankfull discharge for its UT 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.

2.5.8 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 UT prior to construction. The results were a “Poor-Unstable” assessment along both Ellington Branch and its UT according to Pfankuch and “High” to “Very High” BEHI ratings along Ellington Branch and “Extreme” along its UT.

3.0 As-Built Plans

As-built surveys were conducted in January 2008 once planting activities had been completed. Construction implementation was completed in April 2007. Planting activities were discouraged immediately after the implementation due to existing drought conditions and overall timing within the growing season. Temporary vegetation however, was installed during this time to assist with bank stabilization. The Ellington Branch channel was dry during the majority of 2007 growing season and its UT was limited to only a trickle of water during this period. As a result, only limited stabilization and adjustment was observed during the summer and fall months of 2007. Once rain began to fall during November 2007, Sungate staff finally began to note adjustments in both channels. The overall result was both good and bad. Wetland vegetation had taken over the majority of the wetted perimeter along both channels due to the lack of available stream flow. This vegetation helped to stabilize the adjacent banks; however, it increased the channel roughness, which reduced the sediment transport capacity. As the channels began to adjust, a combination of downcutting and aggradation were observed throughout the reaches. Fortunately, frequent grade-control had been established, thus minimizing the overall effect of this equilibrium shift. Sungate anticipates this process to continue into the 2008 growing season.

As-built plans are provided in Appendix A. They denote post construction activities overlaid on top of the proposed design. All structures, easement locations, existing vegetation, stream crossings and longitudinal profiles are shown on the plans. The plans also provide the locations of the permanent cross sections and longitudinal profiles that will be monitored over the next five years, as well as the locations of the vegetation plots.

A morphological table is provided to compare as-built data with pre-construction and design data. The data is presented as part of Table 2.

4.0 Monitoring Plan

Performance criteria set forth for this project will be provided according to EEP's monitoring criteria and format, dated 2005. It covers both stream and vegetation assessments and is based according to federal guidelines for stream mitigation, including the following main parameters: no less than two bankfull events for the five year monitoring period, reference photos, plant survival analyses, and channel stability analyses. Biological data is not required as part of the contract. 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 an annual report.

Natural streams are dynamic systems that are in a constant state of change. Longitudinal profile and cross section surveys may differ somewhat from year to year. Natural channel stability is achieved by allowing the stream to develop a proper dimension, pattern, and profile such that, over time, channel features are maintained and the stream system neither aggrades nor degrades. A stable stream consistently transports its sediment load; however, there may be local deposition and scour. Channel instability occurs when the scouring process leads to degradation, or excessive sediment deposition results in aggradation. The following surveys will be conducted in support of the monitoring assessment.

4.1 Hydrology

Designs for Ellington Branch and its unnamed tributary 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. Two bankfull events, occurring within separate years, must be recorded during the five year monitoring period. Sungate has installed a crest gage immediately upstream of Cross Section #6 along Ellington Branch. This gage will be periodically checked to determine the height in elevation of the water surface related to previous rain events. This height, or stage, will then be compared to the cross sectional area to determine the discharge. Precipitation data will be collected from a nearby source and provided in addition to the hydrological description. Sungate will monitor the frequency of bankfull events throughout the five year period.

4.2 Profile

As previously mentioned, C-stream types are slightly entrenched, meandering, gravel dominated, riffle-pool channels occurring within well developed floodplains. Pool to pool spacing for this stream type averages five-to-seven bankfull channel widths in length. Sungate will conduct annual surveys along a minimum of 3,000 linear feet of Ellington Branch and its UT, as required by USACE (2003). This specifically includes six total segments extending 3,073 linear feet (four segments along Ellington Branch totaling 2,287 and two segments along its UT totaling 786 linear feet). These surveys will be compared on an annual basis to determine the extent of morphological change. Any aggradation and/or degradation of the channel will be noted in each monitoring report. Post-construction profile data is provided in Appendix B.

4.3 Pattern

The stream banks associated with Ellington Branch and its UT are composed of sand and gravel material, with each stream bed exhibiting little difference in pavement and sub-pavement material composition. Rates of lateral migration are influenced by the presence and condition of riparian vegetation. Special emphasis was addressed during the planting period to ensure that maximum protection was afforded to the new channel areas. It is anticipated that the presence of point bars and other depositional features will be susceptible to shifts in both lateral and vertical stability during the first few years as the streams attempt to achieve dynamic equilibrium. Therefore, for monitoring purposes, an average bank height ratio greater than 1.4, radius of curvature ratio less than 1.5 or the development of head cuts will warrant additional documentation as part of the monitoring report.

4.4 Dimension

The design dimension of the channel was based on the design discharge, reference stream data and regional curves. The channel was constructed as a C stream type with the anticipation that it would eventually evolve to an E stream type. E stream types exhibit a lower width/depth ratio than C stream types. The width/depth ratio is expected to get smaller during the monitoring period, assuming bankfull events are frequent. Therefore, excessive adjustment and potential stream instability will be judged to be occurring if the width/depth ratio is measured to be greater than 18. Sungate established 15 cross sections along Ellington Branch and eight along its unnamed tributary. These cross sections are spaced approximately 20 bankfull widths apart on average, and accounts for riffles and pools. Appendices C and D provide post-construction cross section data and post-construction photographs of each cross section, respectively. In addition, Table 3 depicts cross section characteristics.

4.5 Bed Material

The design D_{50} for Ellington Branch ranges between 1.2 and 0.41 throughout the two reaches. It is 0.38 for the UT. During the course of monitoring, both channels are expected to coarsen towards these values. Pebble counts will be taken at each cross section along Ellington Branch and its UT. Success will be measured at the end of the five year monitoring period. If the design channel fails to coarsen and meet the above-listed values, remedial action may be warranted. Failure to meet or exceed these values would denote significant bed/bank problems throughout the two reaches. Once the bed and banks are stabilized, the overall sediment contribution should decrease and thereby coarsen the overall sediment load.

4.6 Vegetation

Vegetation requirements for mitigation purposes state that 320 stems/acre must be viable for success after the three year monitoring period, 288 stems/acre must be viable for the four year monitoring period and 260 stems/acre for the five year monitoring period. This accounts for a ten percent yearly acceptance. The vegetation will be assessed using individual stem counts within strategically placed 10-meter by 10-meter plots. Sungate established a total of 13 vegetation plots along Ellington Branch and its UT. The plot locations were determined prior to planting and are shown on the as-built plans. Annual photographs will document growth and succession.

Vegetation within these plots, as well as the areas surrounding both streams includes a combination of hardwood species including black gum (*Nyssa sylvatica*), flowering dogwood

(*Cornus florida*), green ash (*Fraxinus pennsylvanica*), pawpaw (*Asimina triloba*), sugarberry (*Celtis laevigata*), river birch (*Betula nigra*), swamp chestnut oak (*Quercus michauxii*), white oak (*Quercus alba*) and willow oak (*Quercus phellos*). In addition, live stakes consisting of black willow (*Salix nigra*), elderberry (*Sambucus canadensis*) and silky dogwood (*Cornus amomum*), as well as tublings of tag alder (*Alnus serrulata*) were also planted. A total of 5,400 bare-rooted, 5,300 live stakes and 700 tublings were planted within the 14.3-acre area.

Should the performance criteria outlined above not be met during the monitoring period, Sungate will provide EEP 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 EEP and the regulatory agencies, Sungate will oversee the implementation of the necessary corrective measures.

4.7 Benthos

The contract between Sungate and EEP does not mention any monitoring activities pertaining to benthic macroinvertebrates. No baseline data was assembled prior to, during or immediately after the completion of construction activities in April 2007.

4.8 Bank Hazard Erosion Index

BEHI and sediment export rates were calculated for both Ellington Branch and its UT during existing channel surveys. The BEHI ratings ranged from High to Very High along Ellington Branch and Extreme along the UT. These ratings are expected to dramatically decrease throughout the monitoring period once vegetation becomes established and the soils are stabilized. Sungate expects to achieve a BEHI rating no less than Moderate for both of the restored channels at the end of the monitoring period. Any values less than Moderate would indicate channel instability and be evident during the dimension assessments. Bank stability assessments will be performed during years 3 and 5, post-construction. Problem areas will be documented and shown on a map.

4.9 Schedule and Reporting

Monitoring reports will be submitted to EEP for coordination with the appropriate regulatory agencies on an annual basis. The first-year of monitoring will include two submittals at different time periods; the As-Built drawings and the First Year Annual Monitoring Report. All drawings and monitoring will follow EEP protocols established during the project period. It is understood that EEP 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 EEP and the resource agencies, as applicable, to determine the extent of remedial actions necessary. Monitoring activities will be conducted between the middle and end of the growing season. The reports will be provided no later than November 15 each calendar year. The proposed schedule is provided below detailing the monitoring dates.

Monitoring Schedule

April 2007	Complete construction activities.
January 2008	Complete planting activities and installation of monitoring devices.
February 2008	Submit As-Built Drawings and Mitigation Plan report in draft format.
September 2008	Conduct first year monitoring activities.
October 2008	Submit first year Monitoring Report in draft format.
September 2009	Conduct second year monitoring activities.
October 2009	Submit second year Monitoring Report in draft format.
September 2010	Conduct third year monitoring activities.
October 2010	Submit third year Monitoring Report in draft format.
September 2011	Conduct fourth year monitoring activities.
October 2011	Submit fourth year Monitoring Report in draft format.
September 2012	Conduct fifth year monitoring activities.
October 2012	Submit fifth year Monitoring Report in draft format.

5.0 Maintenance & Contingency Plans

The following information addresses the maintenance and contingency options associated with the project. As previously mentioned, streams are dynamic systems and changes will occur over time. The process undertaken to restore these two channels is based on natural channel design principles; therefore, adjustments in both channels are expected to occur during the first several years following restoration. These adjustments are dependent on local weather conditions and climate variations. Sungate will periodically assess the entire reaches of both channels to ensure that the channels are gradually improving over time. Maintenance issues such as localized erosion, down-cutting or aggradation, establishment of invasive species, etc. may occur during the monitoring period. Sungate will address each of these issues on a case-by-case basis. Any simple remedies will be implemented as necessary. In the event that lingering problems exist and further degradation is observed along the channel or riparian areas, Sungate will implement the following contingency plans based on the issue at hand.

5.1 Streams

A mechanism for contingency will be implemented in the event that stream success criteria are not achieved. This contingency may include, but is not limited to repair of dimension, pattern and profile variables or bank stabilization. The method of contingency is expected to be dependent upon stream variables not in compliance with success criteria. Primary concerns that may jeopardize stream success include headcut migration through the Site or excessive bank erosion.

If headcut migration occurs through the Site, provisions for impeding this migration and repairing any resultant damage may be implemented. This migration can be deterred through the installation of additional grade control and/or restoring stream geometry variables until channel stability is achieved. Both of these methods would require the usage of heavy machinery within the channel and buffer areas, and would be implemented only as absolutely necessary. Each area, if applicable, will be closely monitored to determine whether or not the situation will improve via natural methods. Pending the outcome of the assessments, Sungate will coordinate with EEP to determine the most viable solution.

Excessive bank erosion, the second main concern, can occur anywhere along the channel. It can be limited to very small areas or continue along the entire channel. In the case that excessive or severe bank erosion results in width/depth ratios significantly higher than that of the previous monitoring year, contingency measures to reduce erosion may be implemented. These measures would likely include bank stabilization via one or all of the following: grading, seeding, matting and vegetation. If the resultant bank erosion induces chute cutoffs or channel abandonment, the channel may be modified to reduce overall shear stress.

5.2 Vegetation

Vegetation success will be based on average density calculations from the 13 sample plots. If criteria are not achieved, supplemental planting will be performed with tree species listed in the planting plan for the project. Supplemental planting will be implemented as necessary until vegetation success criteria are met. Development of riparian forests over several decades shall dictate the success in the establishment of desired canopy and understory species, including the overall success in restoration.

6.0 References

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Tables

Table 1. Project Restoration Components
Ellington Branch Stream Restoration (Project No. 16-D06045)

Project Segment or Reach ID	Pre-Construction Linear Footage	Type*	Approach*	Post-Construction Linear Footage	Mitigation Ratio	Stream Mitigation Units (SMUs)	Final Stationing	Comment
Reach I – Ellington Br.	1,576	R	P2	1,934	1.0	1,934	10+00 to 29+34.0	Above Confluence with UT
Reach II – Ellington Br.	2,475	R	P2	1,801	1.0	1,801	29+34.0 to 47+35.0	Below Confluence with UT
Reach III - UT	853	R	P2	1,328	1.0	1,328	10+00 to 23+27.8	Entire Reach
Stream Mitigation Unit Summation						**5,063 lf**		

Note* R = Restoration
P2 = Priority Level II

Table 2. Morphological Table (1 of 2)
Project Number 16-D06045 (Ellington Branch)

Variable	Existing Conditions – Reach One	Existing Conditions – Reach Two	Existing Conditions – Reach Three	Design Conditions – Reach One	Design Conditions – Reach Two	Design Conditions – Reach Three	As-Built Conditions – Reach One	As-Built Conditions – Reach Two	As-Built Conditions – Reach Three	Reference Reach One	Reference Reach Two	Reference Reach Three
Location	Ellington Branch upstream of confluence w/ UT	Ellington Branch at project end downstream of confluence w/ UT	Unnamed Tributary to Ellington Branch	Ellington Branch upstream of confluence w/ UT	Ellington Branch at project end downstream of confluence w/ UT	Unnamed Tributary to Ellington Branch	Ellington Branch upstream of confluence w/ UT	Ellington Branch at project end downstream of confluence w/ UT	Unnamed Tributary to 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	C5	C5	C5	B4c	E5	E5
2. Drainage Area (square miles)	0.8	1.1	0.14	0.8	1.1	0.14	0.8	1.1	0.14	0.05	0.32	0.19
3. Bankfull Width (W_{bkf}) ft	11.5	9.2 – 11.9	8.3 – 14.5	14.5	15.5	8.0	10.1 – 13.4	11.6 – 16.6	6.9 - 9.3	4.1	7.7 – 9.3	4.5 – 6.0
4. Bankfull Mean Depth (d_{bkf}) ft	0.9	1.0 – 1.5	0.4 – 0.6	1.3	1.4	0.6	0.6 – 1.0	0.8 – 1.2	0.6 - 0.7	0.6	1.1 – 1.3	1.3 – 1.6
5. Width/Depth Ratio (W_{bkf}/d_{bkf})	12.8	6.1 – 11.9	14.7 – 32.9	11.2	11.1	13.3	11.6 – 20.2	10.6 – 20.1	10.5 - 14.4	6.5 – 6.7	6.1 – 8.8	3.4 – 3.8
6. Bankfull Cross Sectional Area (A_{bkf}) ft^2	10.2	12.4 – 13.8	4.7 – 6.4	18.3	21.6	4.5	7.0 – 12.1	11.6 – 16.6	4.1 – 6.0	2.5 – 2.6	9.7 – 9.8	5.4 – 9.4
7. Bankfull Mean Velocity (V_{bkf}) fps	3.3 – 3.5	4.1 – 5.0	2.6 – 3.2	5.0 – 5.2	5.5 – 5.8	3.7	3.4 – 4.1	3.9 – 4.7	3.2 – 4.1	3.9 – 4.6	3.7 – 3.9	4.7 – 5.1
8. Bankfull Discharge (Q_{bkf}) cfs	33.7 – 35.9	53.7 – 65.5	14.6 – 17.8	90.8 - 94.9	118.8 - 125.3	16.5	34.0 – 41.0	55.8 – 67.2	15.7 – 20.1	9.8 – 11.6	35.7 – 38.3	28 – 47
9. Maximum Bankfull Depth (d_{max}) ft	1.7	2.1 – 2.2	0.7 – 1.1	1.8	2.0	0.8	1.1 – 1.6	1.6 – 1.9	0.9 – 1.0	1.0	1.6 – 1.8	1.7 – 2.0
10. Ratio of Low Bank Height to Max. Bankfull Depth (lbh/d_{max})	2.6	1.4 – 1.5	1.6 – 4.1	1.0	1.0	1.0	1.0	1.0 – 1.1	1.0	1.3 – 1.5	1.4 – 1.5	1.4 – 1.6
11. Width of Floodprone Area (W_{fpa}) ft	18.6	135 – 220	15.8 – 34.0	>50	>50	>30	33.0 – 50.0	40.0 – 58.0	22.0 – 29.0	6.5 – 7.9	15.8 – 32.5	57 – 100
12. Entrenchment Ratio (W_{fpa}/W_{bkf})	1.6	12.7 – 20.8	1.4 – 3.0	>3.45	>3.22	>3.75	2.8 – 4.2	2.7 – 3.9	2.9 – 3.8	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	74.0 – 150.0	83.8 – 168.0	44.0 – 95.0	2.5 – 10.4	10.2 – 23.2	18 – 80
14. Ratio of Meander Length to Bankfull Width (Lm/W_{bkf})	1.9 –7.6	1.3 – 8.5	2.1 – 7.6	4.7 – 11.8	4.5 – 9.8	3.7 – 12.2	6.3 – 12.7	5.6 – 11.3	5.7 – 12.3	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	18.0 – 47.0	22.0 – 66.0	13.3 – 28.3	1.4 – 7.2	4.0 – 10.6	6 – 25
16. Ratio of Radius of Curvature to Bankfull Width (Rc/W_{bkf})	0.7 – 5.9	0.7 – 6.4	1.0 – 5.1	1.7 – 3.4	1.5 – 3.1	1.6 – 3.1	1.5 – 4.0	1.5 – 4.4	1.7 – 3.7	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	33.5 – 92.0	51.0 – 122.0	36.7 – 60.0	19.1	15.5 – 39.1	8 – 42
18. Meander Width Ratio (W_{blt}/W_{bkf})	1.7 – 7.9	2.1 – 6.0	1.7 – 5.9	1.6 – 5.1	1.3 – 4.6	1.4 – 5.3	2.8 – 7.8	3.4 – 8.2	4.8 – 7.8	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	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	1.5 – 7.9	0.8 – 6.4	1.2 – 7.8	0.7 – 1.9	1.0 – 3.7	n/a
21. Sinuosity (Stream Length/ Valley Distance)	1.4	1.3	1.1	1.3	1.3	1.3	1.3	1.3	1.4	1.5	1.7	1.16
22. Valley Slope ft/ft	0.0056	0.008	0.009	0.0074	0.0074	0.012	0.0074	0.0074	0.012	0.020	0.012	0.013
23. Average Water Surface Slope (S_{avg}) ft/ft	0.0040	0.006	0.0081	0.0056	0.0056	0.0090	0.0058	0.0058	0.0083	0.0130	0.0070	0.0110
24. Pool Slope (S_{pool}) ft/ft	0.000	0.000	0.001	0.000	0.000	0.000	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})	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.008	0.4	0 – 0.8
26. Maximum Pool Depth (d_{pool}) ft	2.1	2.4	1.9	2.7	2.8	1.4	2.9 – 3.6	2.7 – 3.3	1.3 – 1.8	1.3	2.2	1.1 – 3.3
27. Ratio of Max. Pool Depth to Bankfull Mean Depth (d_{pool}/d_{bkf})	2.3	1.9	3.8	2.1	2.0	2.3	3.4 – 4.2	2.8 – 3.4	2.0 – 2.8	2.1	2.1	0.7 – 2.2
28. Pool Width (W_{pool}) ft	16.0	17.0	10.2	23.0	23.0	10.1	14.3 – 17.3	14.3 – 23.4	8.9 – 13.6	4.6	8.1	11 – 14
29. Ratio of Pool Width to Bankfull Width (W_{pool}/W_{bkf})	1.4	1.6	0.9	1.6	1.5	1.3	1.2 – 1.5	1.0 – 1.6	1.2 – 1.8	1.1	0.9	2.1 – 2.6
30. Bankfull Cross Sectional Area at Pool (A_{pool}) ft^2	13.4	18.3	7.7	25.4	25.4	7.3	15.0 – 24.1	21.3 – 29.4	7.4 – 11.6	3.8	11.3	20 – 47
31. Ratio of Pool Area to Bankfull Area (A_{pool}/A_{bkf})	1.3	1.4	1.4	1.4	1.2	1.6	1.5 – 2.4	1.5 – 2.1	1.5 – 2.4	1.5	1.2	2.6 – 6.2

Table 2. Morphological Table (2 of 2)
Project Number 16-D06045 (Ellington Branch)

Variable	Existing Conditions – Reach One	Existing Conditions – Reach Two	Existing Conditions – Reach Three	Design Conditions – Reach One	Design Conditions – Reach Two	Design Conditions – Reach Three	As-Built Conditions – Reach One	As-Built Conditions – Reach Two	As-Built Conditions – Reach Three	Reference Reach One	Reference Reach Two	Reference Reach Three
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	36.8 – 119.1	38.3 – 147.4	19.7 – 86.3	22.6	20.9 – 56.3	23 – 48
33. Ratio of Pool to Pool Spacing to Bankfull Width (p-p/ W_{bkf})	2.9 – 71.6	3.6 – 69.2	n/a	2.3 – 8.6	2.6 – 6.6	3.4 – 11.1	3.1 – 10.1	3.3 – 8.9	2.6 – 11.2	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	13.1 – 39.1	14.3 – 32.2	9.2 – 36.0	3.9	4.9 – 27.9	7 – 16
35. Ratio of Pool Length to Bankfull Width (Lp/ W_{bkf})	1.0 – 7.5	1.3 – 7.2	1.5	0.9 – 3.1	0.6 – 3.2	1.3 – 2.6	1.1 – 3.3	1.2 – 1.9	1.2 – 4.7	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	0.012 – 0.039	0.016 – 0.035	0.012 – 0.039	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	2.1 – 6.7	2.8 – 6.0	1.4 – 4.7	2.8	2.0	n/a
38. Maximum Riffle Depth (d_{riff}) ft	1.7	2.1	0.9	2.0	2.0	0.8	1.1 – 1.8	1.6 – 1.9	0.9 – 1.0	1.0	1.7	n/a
39. Ratio of Maximum Riffle Depth to Bankfull Mean Depth (d_{riff}/ d_{bkf})	1.9	1.7	1.8	1.5	1.4	1.3	1.2 – 2.0	1.7 – 2.0	1.4 – 1.5	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	0.002 – 0.006	0.006 – 0.015	0.012 – 0.037	0.027	0.004	0.002 – 0.068
41. Ratio of Run Slope to Average Slope (S_{run}/ S_{avg})	1.0	0.7	0.9	1.6	2.1	2.3	0.3 – 1.0	1.0 – 2.6	1.4 – 4.4	2.1	0.6	0.2 – 6.2
42. Maximum Run Depth (d_{run}) ft	1.9	2.7	1.2	1.9	2.2	0.8	1.7 – 2.0	1.7 – 2.2	0.8 – 1.3	1.1	1.9	1.7 – 2.0
43. Ratio of Max. Run Depth to Bankfull Mean Depth (d_{run}/ d_{bkf})	2.1	2.2	2.4	1.5	1.6	1.3	2.0 – 2.4	1.8 – 2.3	1.2 – 2.0	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	0.000 – 0.005	0.000 – 0.004	0.000 – 0.009	0.001	0.006	n/a
45. Ratio of Glide Slope to Average Slope (S_{glide}/ S_{avg})	0.3	0.2	0.1	0.4	0.4	0.2	0.0 – 0.9	0.0 – 0.7	0.0 – 1.1	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	1.6 – 2.3	1.9 – 2.8	0.8 – 1.4	1.2	1.6	n/a
47. Ratio of Maximum Glide Depth to Bankfull Mean Depth (d_{glide}/ d_{bkf})	1.8	1.3	2.0	1.5	1.7	1.5	1.9 – 2.7	2.0 – 2.9	1.2 – 2.2	2.0	1.5	n/a

Materials												
Particle Size Distribution of Channel Materials (mm)												
D16	0.11	0.075	<0.1	0.11	0.075	<0.1	0.07	0.075	0.1	0.28	0.097	n/a
D35	0.28	0.26	0.22	0.28	0.26	0.22	0.14	0.14	0.19	0.98	0.2	n/a
D50	1.2	0.41	0.38	1.2	0.41	0.38	0.2	0.2	0.29	1.8	0.31	n/a
D84	10.2	4.0	11.8	10.2	4.0	11.8	0.75	0.75	0.62	10.2	10.9	n/a
D95	22.0	10.0	43.0	22.0	10.0	43.0	4.5	4.5	1.4	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 3. Cross Section Characteristics
Project Number 16-D06045 (Ellington Branch)

Cross Section	Feature	Post-Construction January 2008					Monitoring Year 1 (2008)					Monitoring Year 2 (2009)					Monitoring Year 3 (2010)					Monitoring Year 4 (2011)					Monitoring Year 5 (2012)				
		W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio	W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio	W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio	W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio	W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio	W_{bkf} (ft)	A_{bkf} (ft^2)	d_{bkf} (ft)	d_{max} (ft)	W/d_{bkf} Ratio
1	Pool	14.4	24.0	1.7	3.6																										
2	Riffle	12.1	7.0	0.6	1.1	20.9																									
3	Pool	14.3	24.1	1.7	2.9																										
4	Riffle	10.1	8.6	0.8	1.3	11.9																									
5	Pool	17.5	15.0	0.9	2.4																										
6	Riffle	11.6	12.1	1.0	1.6	11.2																									
7	Riffle	13.4	12.1	0.9	1.3	14.8																									
8	Pool	17.4	21.3	1.2	2.7																										
9	Pool	14.3	24.9	1.7	3.0																										
10	Riffle	13.8	11.6	0.8	1.6	16.5																									
11	Pool	23.1	23.1	1.0	2.9																										
12	Riffle	12.6	14.8	1.2	1.9	10.6																									
13	Pool	22.6	23.9	1.1	2.7																										
14	Riffle	18.3	16.6	0.9	1.6	20.1																									
15	Pool	22.3	29.4	1.3	3.3																										
16	Pool	12.9	11.6	0.9	1.8																										
17	Riffle	7.5	4.1	0.6	1.0	13.7																									
18	Pool	9.7	7.4	0.8	1.6																										
19	Riffle	7.2	4.8	0.7	1.0	10.6																									
20	Pool	8.9	7.4	0.8	1.6																										
21	Riffle	6.9	4.6	0.7	0.9	0.5																									
22	Pool	13.6	8.7	0.6	1.3																										
23	Riffle	9.3	6.0	0.6	1.0	14.4																									

Notes:
W_{bkf} = Bankfull Width
A_{bkf} = Bankfull Cross Sectional Area
d_{bkf} = Bankfull Mean Depth
d_{max} = Bankfull Maximum Depth
W/d_{bkf} Ratio = Width/Depth Ratio

Figures

Appendix A.

As-Built Plans

Appendix B.

Post-Construction Profile Data

Appendix C.

Post-Construction Cross Section Data

Appendix D.

Post-Construction Photographs – January 2008