Unnamed Tributary to Billy's Creek
Stream Restoration

Franklin County, North Carolina
Cataloging Unit 03020101
State Construction Office Number 010559801
North Carolina Ecosystem Enhancement Program Number 36

FINAL
Mitigation As-Built Report (Baseline Monitoring)

Prepared For:
North Carolina Department of Environment and Natural Resources
North Carolina Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

Ecosystem Enhancement PROGRAM

April 2006

Unnamed Tributary to Billy's Creek Stream Restoration

Franklin County, North Carolina

FINAL
Mitigation As-Built Report (Baseline Monitoring)

Prepared by:

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April 28, 2006

EXECUTIVE SUMMARY

The unnamed tributary to Billy's Creek project reach drains approximately 143 acres within the Tar River Basin. The project reach is constrained on the north and south by culverts for unpaved farm road crossings and is approximately 300 feet upstream of the confluence with Billy's Creek.

The pre-construction conditions consist of a 1,878 linear foot section of degraded, perennial channel and several ditch-like tributaries entering. The upstream portions of the restoration reach retained an active floodplain area, whereas the downstream portions were severely incised (4 to 6 feet). Prior to restoration, the restoration reach was a G5c stream with a small section of E5 according to the Rosgen stream classification system. Another unnamed tributary to Billy's Creek upstream of the Project Study Area was used as the reference reach for this project. The reference reach is a first-order, perennial type E5 stream. The proposed stream classification for the project reach was a meandering E5 channel. Priority 1 restoration (returning the channel to an elevation such that the historic floodplain is utilized for above bankfull flows) and Priority 2 restoration (constructing a floodplain at the channel's existing elevation) was proposed for this project; however, the final design was able to complete the entire project as a Priority 1 system. The restored channel measures 2,101 linear feet.

Approximately 2.6 acres of buffer was planted along the restored stream channel. A 6.2-acre Conservation Easement has been established on the site.

Environmental components monitored in this report are those that allow an evaluation of channel stability and riparian vegetation survivability. Specifically, the success of channel modification, erosion control, seeding, and woody vegetation plantings will be evaluated. This will be accomplished through the following activities for five years after construction.

- Permanent Cross Section Establishment: Four cross sections (2 riffle, 2 pool) will be monitored for five years.
- Longitudinal Profile: A longitudinal profile will be performed after construction, after the first year, and then every two years until the monitoring period has ended.
- Bed Material Analysis: Pebble counts will be performed each year at the location of the permanent cross sections.
- Permanent Photo Reference Points: Permanent reference photo points have been established for each cross section and each vegetation plot.
- Vegetation Plots: Five vegetation plots have been established within the planted area along the stream.

URS will assess the condition of the stream, structures, vegetation, and bank stability during the first year of monitoring. Remedial actions will be performed, if necessary. NCEEP will oversee monitoring for subsequent years to provide five years of monitoring.

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1.0 INTRODUCTION

1.1 Project Goals and Objectives

The goals and objectives for the Unnamed Tributary to Billy's Creek Stream Restoration Project are to:

1. Restore the project reach to a more natural dimension, pattern and profile so that the stream will be able to efficiently transport water and sediment loads provided by the watershed;
2. Reconnect the project reach's channel to its historic floodplain where feasible;
3. Eliminate the excessive sediment contribution to the system by the mass wasting and erosion of the stream banks along the reach; and
4. Repair and restore the riparian corridor along the project reach in order to improve habitat and protect the stream from further erosion.

1.2 Project Location

The section of stream channel included in this restoration project is located south of Montgomery Road (SR 1210), approximately three miles east of US 1 to the northeast of Franklinton in Franklin County (Figure 1 Vicinity Map). The restoration reach lies on property privately held by the Grove family. The restoration reach flows from the north to the south through pastured fields and is defined by unpaved farm roads at each end (Figure 2 Location Map). The restoration reach flows approximately 1,900 feet from the northern property line to the fence line near the southern border of the property.

2.0 SUMMARY

2.1 Project Description and Watershed

The project reach lies within the Tar River Basin, in Cataloging Unit 03020101. The drainage area for the tributary to Billy's Creek is approximately 143 acres (0.22 square miles) (Figure 3 Watershed Area). A ridge approximately 800 feet north of Montgomery Road forms the northern boundary of the project watershed. Montgomery Road runs east-west through the northern third of the watershed. The watershed can be roughly divided in half by the unpaved farm road that crosses east-west at the northern end of the restoration reach. Ridges from the northernmost point form the watershed's western and eastern edges as they slope down towards Billy's Creek. The southern end of project watershed is at the point where an unpaved farm road crosses the restoration reach approximately 300 feet upstream of the confluence with Billy's Creek.

Land use within the watershed is dominated by agriculture, open space/forest, and low density residential areas. The majority of the agricultural lands are used for cattle pasture. Transportation corridors and high density residential areas are also present (Figure 4 Land Use). The entire Project Study Area is zoned as an Agricultural-Residential District. This zoning designation permits a mixture of agricultural, forestry, conservation, and very low-density residential uses with few public services.

Pre-construction conditions of the unnamed tributary to Billy's Creek project reach included a 1,878 linear foot section of degraded, perennial channel and several ditch-like tributaries. The upstream portions of the restoration reach retained an active floodplain area, whereas the downstream portions were severely incised (4 to 6 feet). Prior to restoration, the restoration reach was a G5c stream with a small section of E5 according to the Rosgen stream classification system (Rosgen 1996). The width-to-depth ratio of the stream ranged from 5.2 to 10.4. The entrenchment ratio ranged from 1.3 to 2.9 with a 1.5 percent slope in the G5c section, and a 0.6 percent slope in the E section. Sinuosity was 1.1 in the G5c section and 1.3 in the E section. A Priority 1 restoration was proposed for this project. The proposed stream classification was an E5 channel. The Restoration Plan called for raising the new channel to meet the existing floodplain where feasible and removing the drainage ditches within the pasture, thus allowing the floodplain to function as it has historically. In areas where returning the restoration reach to its original floodplain was not sure to be possible, a Priority 2 restoration was proposed; however, the final design was able to utilize a Priority 1 restoration (Rosgen 1996). The constraints associated with this stream restoration project included two culvert crossings under unpaved agricultural roads at construction limits.

Another unnamed tributary to Billy's Creek upstream of the Project Study Area was used as the reference reach for this project. The reference reach is a first order, perennial type E5 stream.

Approximately 2.6 acres of buffer was planted along the restored stream channel. A 6.2-acre Conservation Easement has been established on the site.

Construction began on March 16, 2005 and ended on June 8, 2005. Planting began December 6, 2005 and ended December 19, 2005. Upon completion, the restoration reach measured approximately 2,101 linear feet.

For a complete description of the existing conditions prior to construction, see the Billy's Creek Stream Restoration Plan designed by URS – North Carolina (URS) in August 2003.

2.2 Methodology

Natural channel design methodology was used while considering watershed and site conditions for the restoration reach to provide the highest level of stability post-construction. Information was collected on existing conditions, reference conditions, and proposed conditions for the stream restoration. The design was intended to transform the G5c/E5 stream to an E5 channel at its completion. Pattern, dimension, and profile were designed to provide the highest level of restoration considering site constraints. The design was developed based upon reference data for the stream type, watershed, and location. The restoration parameters were developed using reference data and hydraulic geometry relationships.

As a guide for taking existing conditions surveys, *The Stream Channel Reference Sites: An Illustrated Guide to Field Technique, US Forest Service General Technical Report RM-245* (Harrelson et al 1994) and *Applied River Morphology* (Rosgen 1996) were used as references to classify the stream and reference reaches. The existing conditions of the surrounding area were first observed and recorded in order to understand what was occurring within the system and why. The field data collected were used to determine width-to-depth ratio, entrenchment ratio, slope, sinuosity, sediment transport analysis, and dominant type of channel material for the existing conditions and reference reaches. This enabled the development of a plan, which focuses on the restoration of the entire system. The plan included the restored channel morphology design, structure design and placement, streambank stabilization measures, and erosion and sediment control plan.

URS provided bid administration assistance to the North Carolina Ecosystem Enhancement Program (NCEEP) and conducted construction management and oversight for the duration of the restoration. McQueen Construction, Inc. completed the construction of the stream. Chas H. Sells Inc. & Surveying, PA, under contract with URS provided the As-Built survey for the project.

2.3 Plan View

As-Built plan sheets are included in Appendix A.

2.4 Points of Contact

Owner:

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(919) 715-1952
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Design Firm:

URS
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Point of Contact – David Brubaker, PLS
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Cary, NC 27513
(919) 678-0035
Mobile (919) 524-9485

Construction Firm:

McQueen Construction Inc.
Point of Contact – Harvey McQueen
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Bahama, NC 27503
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Subcontractors and Material Suppliers as supplied by Construction Firm:

Niall Gillespie, RLS
1801 White Oak Church Road
Apex, NC 27523

Louisburg Lawn
289 Stone-Southerland Road
Louisburg, NC 27549

Guins Excavating Services
2321 Eagle Rock Road
Wendell, NC 27591

Erosion Control Solutions
5508 Peakton Road
Raleigh, NC 27604

CFP, Inc.
PO Box 38327
Charlotte, NC 28278

Martin Marietta
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Charlotte, NC 28275

Carolina Sunrock
PO Box 30727
Charlotte, NC 28230-0727

Fluvial Solutions
3719 Benson Drive
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Hanson Aggregates
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Philadelphia, PA 19175-2390

Hertz Corporation
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3.0 SUCCESS CRITERIA

Environmental components monitored in this report are those that allow an evaluation of channel stability and riparian vegetation survivability. Specifically, the success of channel modification, erosion control, seeding, and woody vegetation plantings will be evaluated. The following elements will be monitored for five years after construction: dimension, pattern and profile, bed material, photo reference sites, and vegetation plots.

3.1 Dimension

Per the October 16, 2003 Scope of Services for Tributary to Billy's Creek between URS and the Wetland Restoration Program (now represented by NCEEP), four permanent cross sections were established at intervals no greater than 500 feet. Two cross sections were established in pools and two in riffles. Each cross section was marked with rebar at the edge of the flood-prone zone on both sides of the channel. A 10-foot length of polyvinyl chloride (PVC) pipe was placed over the rebar on the left bank at each cross section. The pipes are flagged with orange tape. Global Positioning System (GPS) coordinates were collected for each cross section on the left bank. GPS coordinates are located in Appendix B. Permanent cross section locations are shown on the As-Built survey. A common benchmark was used for cross sections to facilitate easy comparison of year-to-year data. The annual cross section survey includes points measured at all breaks in slope, including top of bank, bankfull, and thalweg. Riffle cross sections will be classified using the Rosgen stream classification system.

Success Criteria: It is anticipated that there should be little or no change in cross sections from year-to-year. Changes in dimension should be evaluated to determine if there is potential for the stream to move toward an unstable condition. In some cases such variability may represent an increase in stream stability.

3.2 Pattern and Profile

At the completion of construction, a longitudinal profile was completed as part of the As-Built survey. A longitudinal profile will be completed during each subsequent year of monitoring. Measurements were taken beginning at the head of stream features such as riffle, run, glide, and the maximum pool depth. A permanent benchmark was used for the survey. The As-Built longitudinal profile and cross sections are located in Appendix C.

Success Criteria: The longitudinal profiles should show that the bedform features are remaining stable (e.g. they are not aggrading or degrading over the five-year period). Short term aggradation/degradation may occur depending on the peak annual discharge. The gravel bed pools should remain deep with flat-water surface slopes and the riffles should remain steeper and shallower than the pools. Bedform features observed should be consistent with those observed in E type channels. The pattern, sinuosity, and riffle/pool sequence should remain consistent.

3.3 Bed Material Analysis

Modified Wolman pebble counts were completed at each permanent cross section. Data are presented in Appendix D.

Success Criteria: The pebble counts should show the pools contain a finer material than the riffles, which should show coarsening over the five-year monitoring period. The D50 and D84 will be compared to determine changes in the surface material of the cross section.

3.4 Photo Reference Sites

Photographs were taken at the time of the As-Built survey and will be used to evaluate the restoration of the project reach over time. Stations for photographs were located at the permanent cross sections (Figure 5 Cross Section and Vegetation Plot Location). Photographs will be taken at the photograph stations with a digital camera each year during monitoring of the site. All reference photos are located in Appendix E.

Longitudinal Reference Photos: Photographs will be taken looking upstream and downstream at each cross section location (permanent photo station).

Lateral Reference Photos: Reference photos were also taken at each permanent cross section in a lateral direction. Photographs were taken in a manner to show both banks of each cross section. Subsequent photos should be taken in the same location to consistently provide the same view of these sections over time.

Success Criteria: The photograph documentation will be used to provide a visual evaluation of the channel to identify aggradation and degradation, issues with erosion control, and riparian vegetation success. Photos taken over time will provide an indication of the stages of maturation of the riparian vegetation, the formation of bars within the channel, aggradation along the floodplain, or erosion control issues.

3.5 Vegetation Plots

Survival of vegetation will be evaluated using survival plots and counts. Per the NCEEP monitoring guidance (NCEEP 2005), five 100-square meter plots were randomly established within the planted area (2.6 acres) along the channel. Rebar was used to mark all four corners of the vegetation plots and the southwest corner of each plot was marked with a 10-foot length of PVC pipe flagged with orange tape. GPS coordinates were obtained for each corner and the approximate bearing of each corner from the southwest corner was determined (Appendix B). A reference photograph was taken from the southwest corner, facing the northeast corner, of each plot.

All quadrats were permanently established in the field and records of sampling locations will be maintained. All planted and transplanted woody vegetation was inventoried. This initial inventory will be used as baseline data for future inventories. As-Built vegetation data are located in Appendix F.

Success Criteria: Evaluation of planted vegetation survival will be measured based upon the survival of 320 stems per acre at the end of three years of monitoring. A tolerance of 10 percent mortality rate will be acceptable for years four and five. The final vegetated success criteria will be survival of 260 trees per acre through year five (USACE *et al.* 2003). In addition, survival percentages will also be monitored on a species by species basis.

4.0 MONITORING SCHEDULE AND METHODS

Chas H. Sells Inc. & Surveying, PA conducted the As-Built survey and URS will conduct the first year survey. URS will monitor the site as per the monitoring schedule submitted in this Mitigation Plan. At the end of the first year following construction, URS will conduct a technical assessment of the site (i.e. detailed surveys, stem counts, photographs, pebble counts) and compile the data.

The stability of the stream channel will be monitored approximately six months after restoration is complete or as appropriate following greater than bankfull events. Assessments and measurements taken of the stream channel will focus on lateral (streambank changes), vertical (streambed changes), and overall stability of the stream.

The cross sections will be surveyed each year using a tape and level between the permanent cross section pins. This will include reference photographs taken as outlined in Section 3.4. Pebble counts will also be taken at each cross section.

The longitudinal survey will be completed using a Total Station or laser level for the first year and then every two years for a total of four (As-Built completed in January 2006, monitoring surveys should occur in October of 2006, 2008, and 2010).

The restoration site was inspected during and following completion of the planting to ensure that proper planting methods for spacing, density, and species composition were followed. Vegetation monitoring plots were established and distributed randomly throughout the site. Photo points were established at the southwest corner of each plot and visual observations were recorded (Appendix E).

A quantitative sampling of established vegetation plots will be performed in late summer/early fall (August – November) at the end of the first year of completion and after each growing season for five years of monitoring. These samplings are intended to identify any problem areas early in order to allow for quick remedial measures. Success will be determined based on the survival of planted woody species at the end of a three and five-year period. There should be at least 320 stems per acre through year three and 260 stems per acre through year five (USACE *et al.* 2003). The three-year period is through November 2008 and the five-year period is through November 2010.

Photographs of the site will be taken each year during monitoring. These photos will include those taken at the permanent photo points as identified on the plan view (Appendix A). Photos will be taken at the identified locations each year to provide a visual documentation of the restoration throughout the monitoring period.

URS will use the compiled data to prepare a monitoring report summarizing the results of the first year of restoration. The monitoring report will assess the performance of the project using the success criteria identified in this Mitigation Plan. NCEEP will handle all monitoring activities following the first year's monitoring report in order to fulfill the project's monitoring requirements.

5.0 MITIGATION

5.1 Mitigation Proposal

The proposed mitigation after the completion of the project is 2,101 linear feet of perennial stream restoration credit.

5.2 Design Summary

The stream restoration design for the unnamed tributary to Billy's Creek was based on natural channel design methodologies (Rosgen 1996). The design took into account drainage area, adjacent land use, upstream impoundments, and future development potential.

The design creates an improved profile/bedform of the channel by providing defined riffles and pools. The design includes the following parameters: width-to-depth ratio of 10.1, sinuosity of 1.22, radius of curvature ranging from 12.5 to 34.5 (ratio of 1.4 to 3.8), and average slope of 1.19%. Rock vanes and root wads were used to protect the meander bends. Rock step pools were utilized to diffuse energy through riffle sections.

During construction, some aspects of the site grading and drainage plan were modified with the engineer's approval. The typical design of the rock cross vane was modified to include placement of a large flat rock on the downstream side of the headrock to prevent headcutting and potential undermining of the structure. This rock was placed in such position that would not impede the formation and natural fluctuation of the dimension of the scour hole below the vane structure. Also, a drainage swale located between stations 27+00 and 28+00 was originally to have been filled; however, the plans were modified to accommodate the inflow from this drainage feature. The swale at completion of grading enters the project stream at the upstream side of the step-pool structure located at station 27+70.

The streambanks were matted to five feet beyond bankfull. Temporary and permanent seeding was completed once grading ended. Seedlings and live stakes were installed during dormancy in December, 2005.

5.3 Mitigation Credit

The mitigation credit proposal will be completed by NCEEP.

6.0 MAINTENANCE AND CONTINGENCY PLANS

The project site experienced several significant rain events during the construction period resulting in overbank flows. No areas of concern for stream stability were identified following these events or at other points during the construction period.

Prior to construction, the project site was heavily infested with Chinese privet (*Ligustrum sinense*). Eradication methods employed to remove this species from the project site did not include areas adjacent to the project and a seed-bank remains on most of the surrounding land. This species should be expected to recolonize the project site and further control methods may be required.

URS will assess the condition of the stream, structures, vegetation, and bank stability during the first year of monitoring. NCEEP will oversee monitoring for subsequent years to provide five years of monitoring.

7.0 REFERENCES

Harrelson, C., Rawlins, C.L., and J. Potypondy. 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. US Department of Agriculture, Forest Service. General Technical Report RM-245.

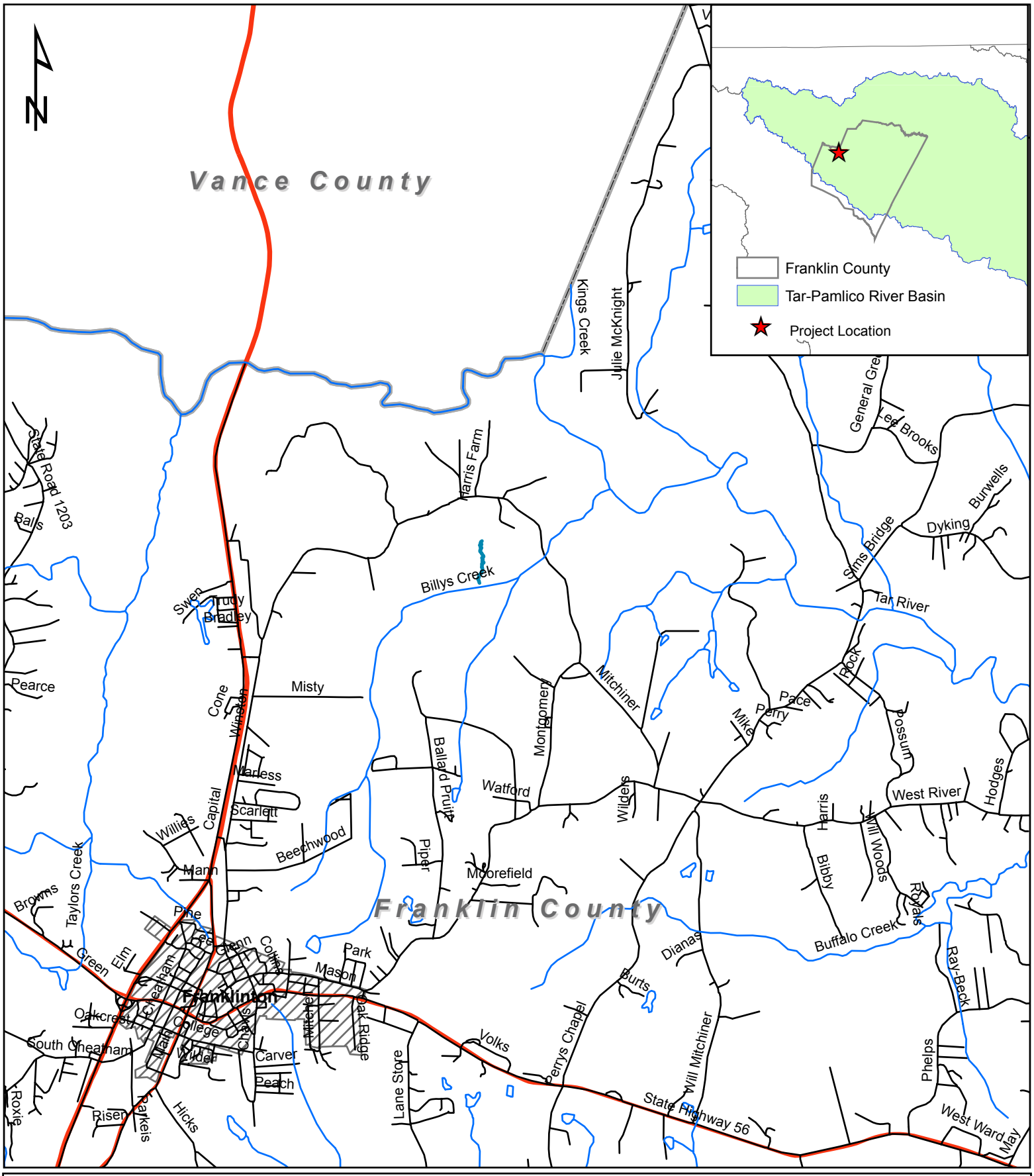
NCEEP. 2005. Content, Format, and Data Requirements for EEP Monitoring Reports. Version 1.1 (9/16/05). NCDENR, NCEEP. 17pp.

Rosgen, D.L. 1996. Applied River Morphology. Wildland Hydrology, Pagosa Springs, CO.

URS Corporation – North Carolina. 2003. Billy's Creek Stream Restoration Plan. August 2003.

USACE, Wilmington District, US Environmental Protection Agency, NC Wildlife Resources Commission, and NC Division of Water Quality. 2003. Stream Mitigation Guidelines. April 2003. 26 pp.

FIGURES



Franklin County

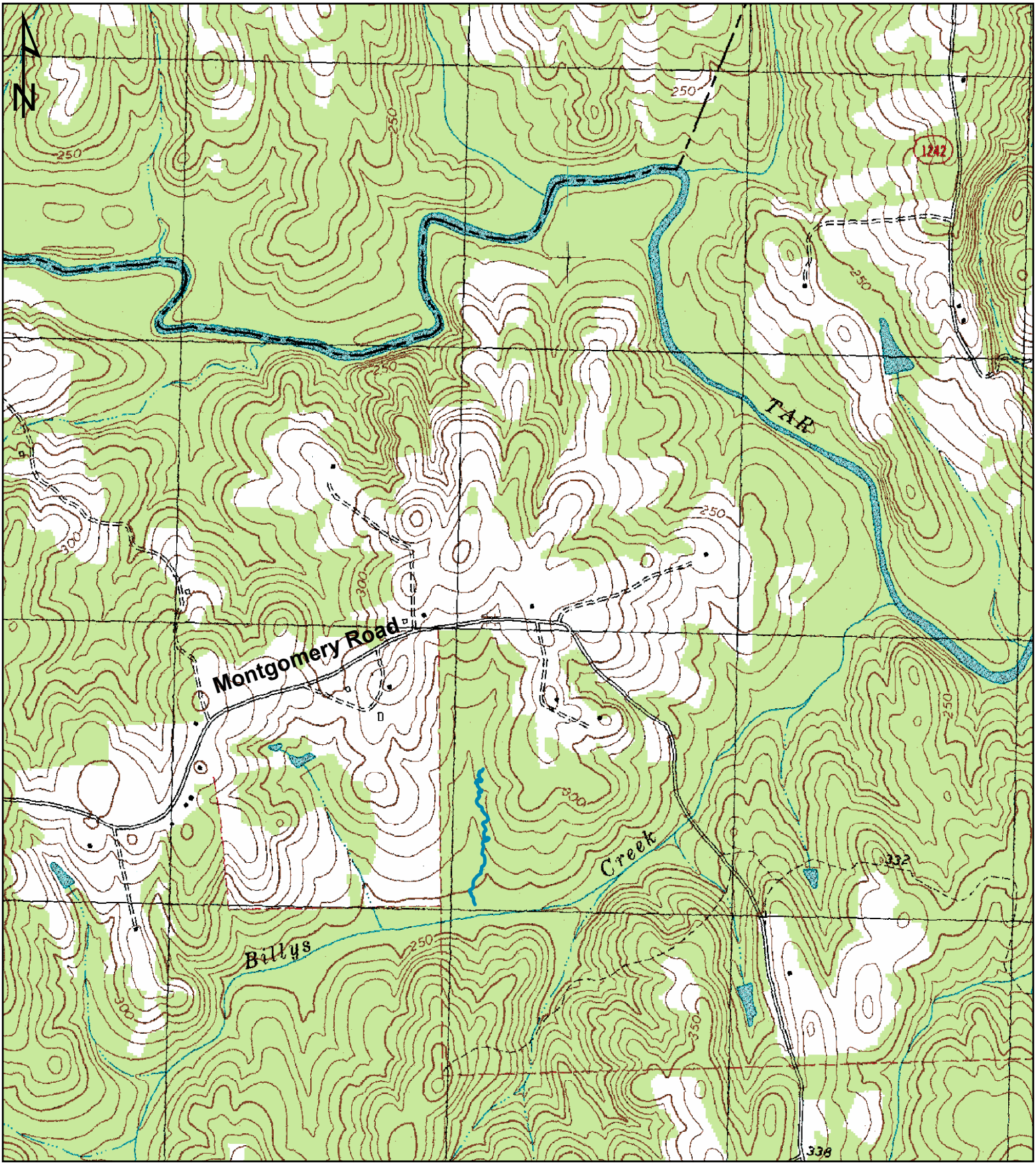
Legend

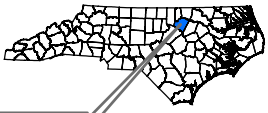
- Project Reach
- Primary Roads
- Hydrography
- Municipal Boundaries
- Roads
- County Boundary

0 0.5 1 2 Miles

UT to Billy's Creek Stream Restoration Project
Franklin County, NC
FIGURE 1
Vicinity Map

Ecosystem Enhancement Program





Legend

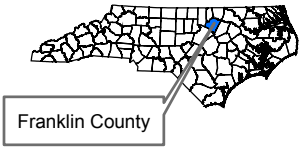
Project Reach

0 750 1,500 3,000 Feet

UT to Billy's Creek Stream Restoration Project
Franklin County, NC

FIGURE 2
Location Map

Ecosystem Enhancement Program



Legend

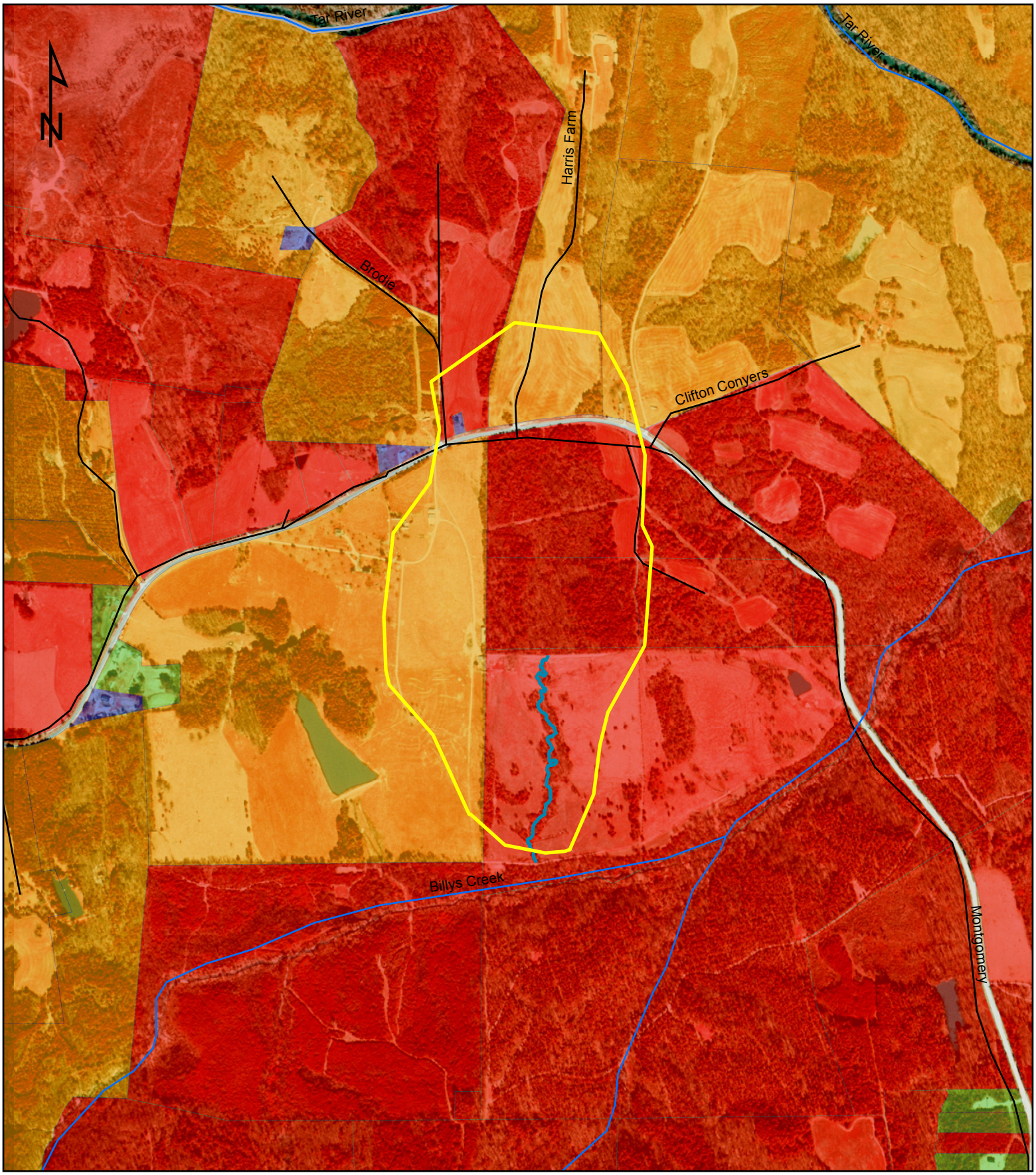
Project Reach
Roads
Watershed Area
County Boundary
Hydrography

0 250 500 1,000 1,500 2,000 2,500 Feet

UT to Billy's Creek Stream Restoration Project Franklin County, NC

FIGURE 3
Watershed Area

Ecosystem Enhancement PROGRAM

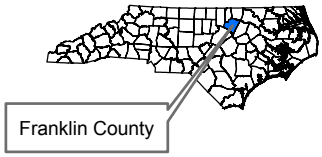


Legend

- Project Reach
- Watershed Area
- Hydrography
- Roads
- County Boundary

LANDUSE

- Agriculture & Open Space
- High Density Residential
- Medium Density Residential
- Residential & Agricultural

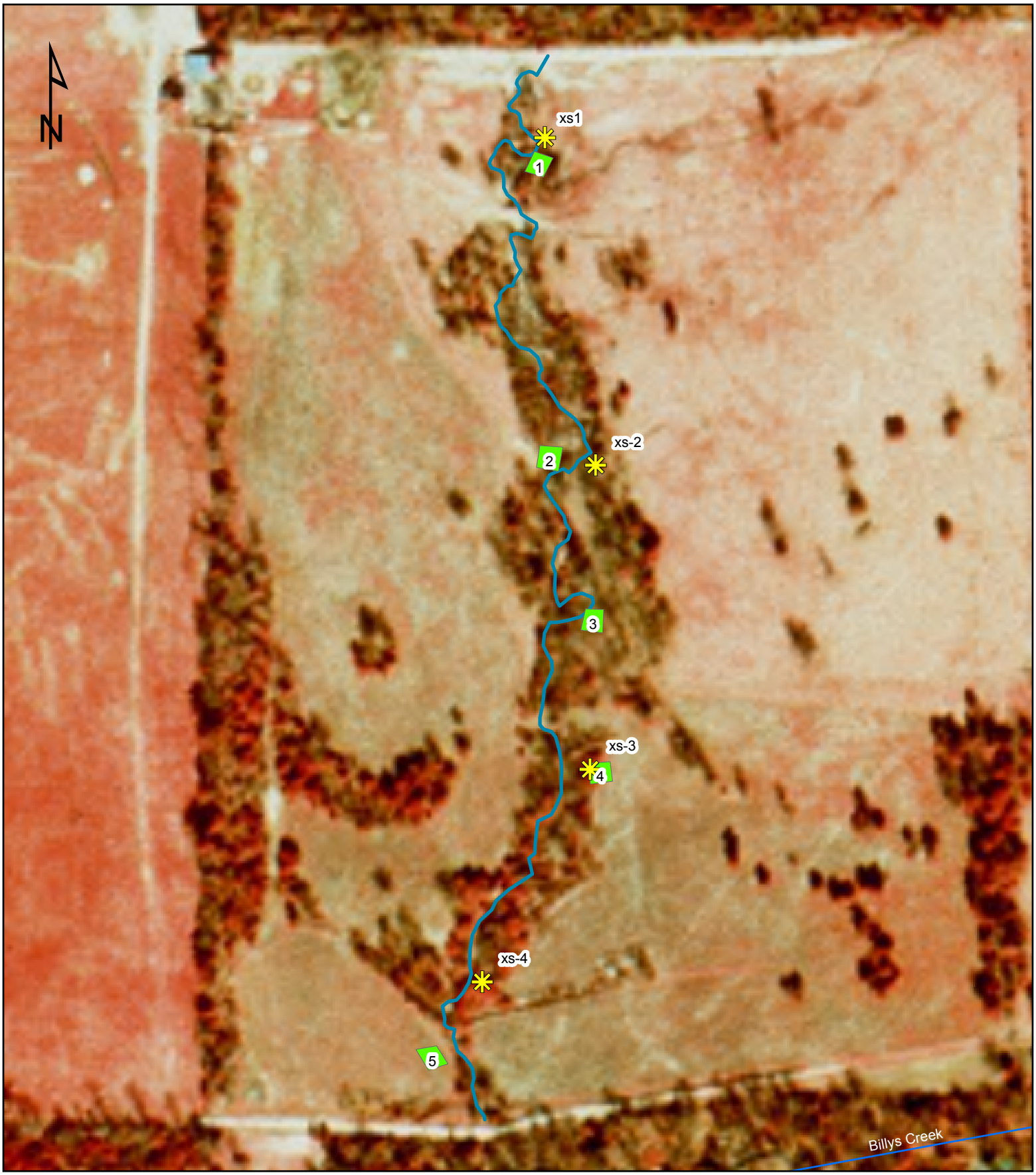


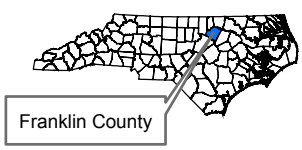
0 250 500 1,000 1,500 2,000 2,500 Feet

UT to Billy's Creek Stream Restoration Project
Franklin County, NC

FIGURE 4
Land Use

Ecosystem Enhancement PROGRAM





Legend

Cross Section
Vegetation Plots
Hydrography
Project Reach

0 250 500 Feet

UT to Billy's Creek Stream Restoration Project
Franklin County, NC

FIGURE 5
Cross Section and Vegetation Plot Location

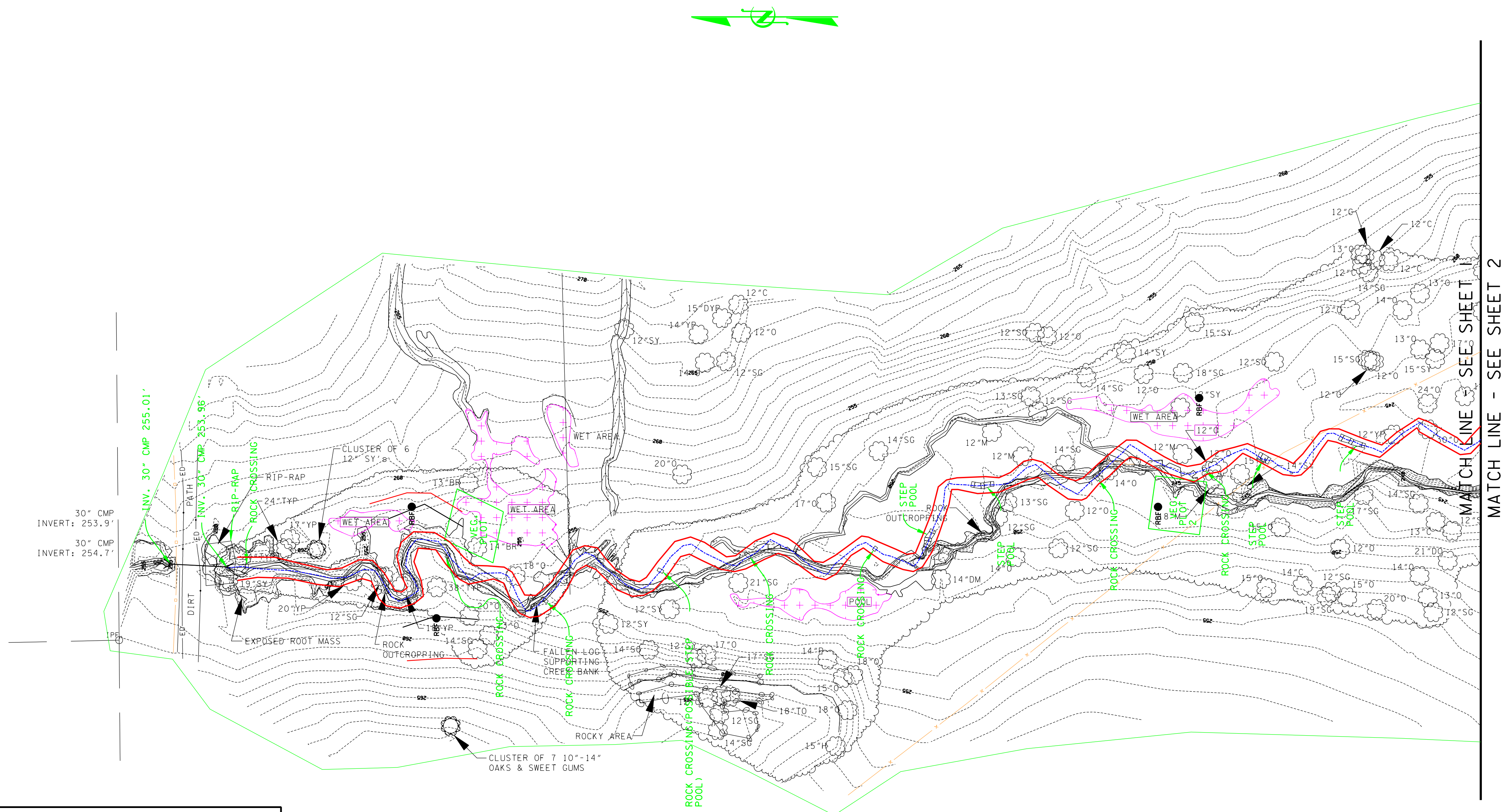
Ecosystem Enhancement PROGRAM

APPENDICES

APPENDIX A. As-Built Plan View
APPENDIX B. GPS Coordinates
APPENDIX C. As-Built Longitudinal Profile and Cross Sections
APPENDIX D. Pebble Count Data
APPENDIX E. Reference Photos
APPENDIX F. Vegetation Data

APPENDIX A

AS-BUILT PLAN VIEW



LEGEND

- ROCK CROSSING (POSSIBLE STEP POOL)
- STEP POOL
- RBF● REBAR PIN FOUND
- VEG. PLOT — VEGETATION PLOTS
- CHANNEL BOUNDARY/BANKFULL
- THALWEG
- EASEMENT BOUNDARY
- FENCING
- TREE LINE
- WET AREA

TREE CODE TABLE

BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
HW	HAWTHORNE
O	OAK
P	PINE
QO	QUADRUPLE OAK
SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

40 20 0 40 80
1" = 40'

REVISIONS

NO.	DATE

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PROJECT: UT TO BILLY'S CREEK
STREAM RESTORATION
FRANKLIN COUNTY

TITLE:

CLIENT: NORTH CAROLINA DEPARTMENT
OF ENVIRONMENT AND
NATURAL RESOURCES

SEAL: NORTH CAROLINA PROFESSIONAL SEAL 27453 ENGINEER RACHEL E. SMITH

DATE: JAN 2006

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING
YEAR 0

SCO I.D.# 010559801

SHEET NO. 1

MATCH LINE - SEE SHEET 1

TEMPORARY BENCH MARK:
RAILROAD SPIKE IN N.E. SIDE OF 12" PINE, 2' ABOVE GROUND.
ELEVATION (NGVD 29): 248.12'.

30" CMP
INVERT: 231.2'

30" CMP
INVERT: 227.8'

INV. 30" CMP 227.72'

INV. 30" CMP 227.57'

TREE CODE TABLE	
BR	BIRCH
C	CEDAR
DM	DOUBLE MAPLE
DO	DOUBLE OAK
DSG	DOUBLE SWEET GUM
H	HICKORY
HW	HAWTHORNE
O	OAK
P	PINE
QO	QUADRUPLE OAK
SG	SWEET GUM
SY	SYCAMORE
TO	TRIPLE OAK
TYP	TRIPLE YELLOW
P	POPLAR
YP	YELLOW POPLAR

LEGEND

- ROCK CROSSING (POSSIBLE STEP POOL)
- STEP POOL
- RBF● REBAR PIN FOUND
- VEG. PLOT — VEGETATION PLOTS
- CHANNEL BOUNDARY/BANKFULL
- THALWEG
- EASEMENT BOUNDARY
- FENCING
- TREE LINE
- WET AREA

40 20 0 40 80
1" = 40'

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NO.	DATE

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PROJECT: UT TO BILLY'S CREEK
STREAM RESTORATION
FRANKLIN COUNTY

TITLE:

CLIENT: NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

SEAL — NORTH CAROLINA PROFESSIONAL SEAL 27453 ENGINEER RACHEL E. SMITH

DATE: JAN 2006

TECHNICIAN: EHJ

CHECKED BY: KM

MONITORING YEAR 0

SCO I.D.# 01055980I

SHEET NO. 2

APPENDIX B

GPS COORDINATES

Permanent Cross Section Locations

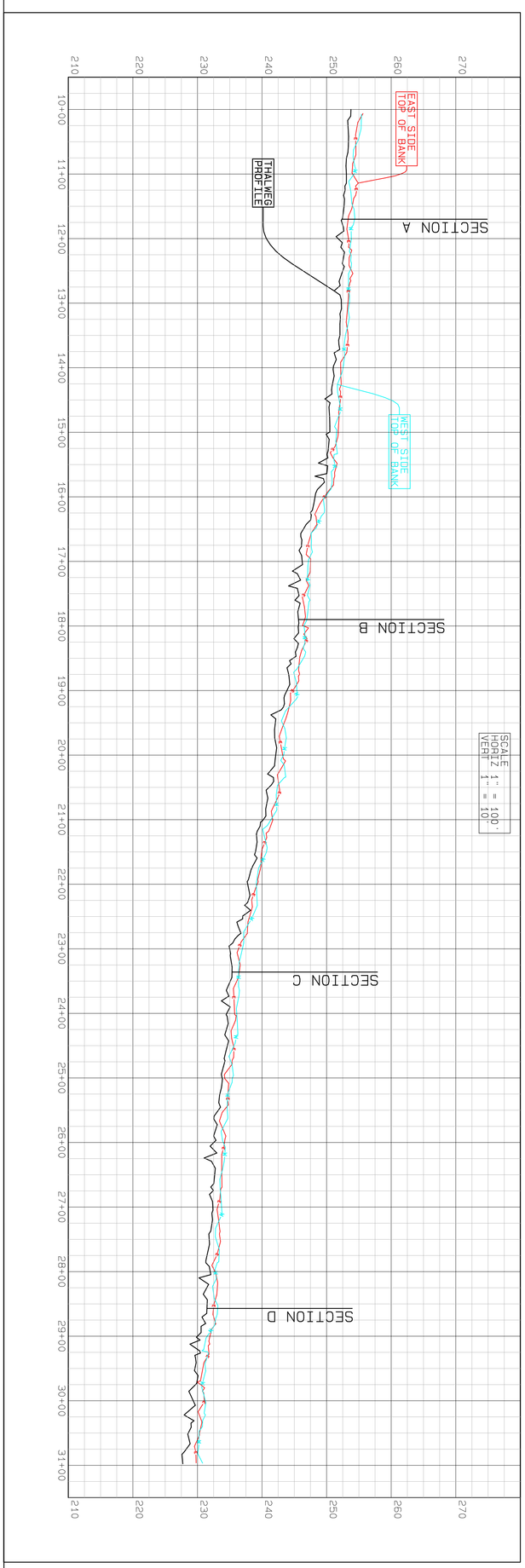
Cross Section	X	Y
1	-78.41984	36.15008
2	-78.41960	36.14874
3	-78.41964	36.14750
4	-78.42019	36.14664

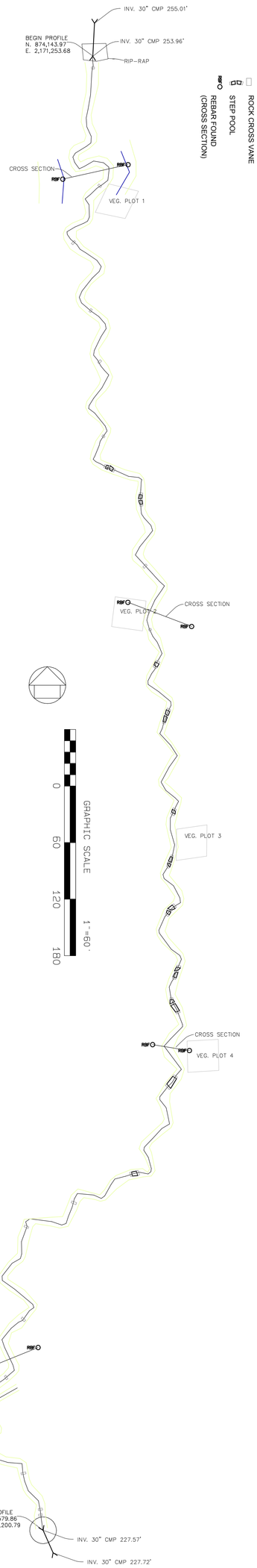
Vegetation Plot Location and Bearings

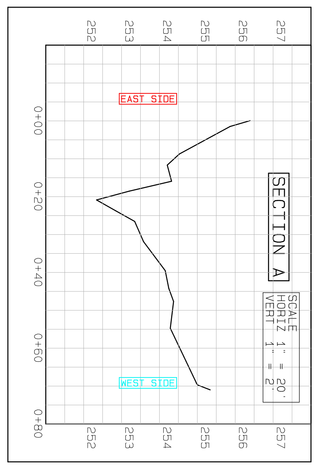
Plot Number	Corner	X	Y	Bearing from SW Corner (degrees)
1	SW	-78.41996	36.14994	--
1	SE	-78.41986	36.14992	110
1	NW	-78.41990	36.15002	40
1	NE	-78.41981	36.14999	80
2	SW	-78.41990	36.14873	--
2	SE	-78.41979	36.14872	115
2	NW	-78.41989	36.14882	18
2	NE	-78.41977	36.14882	58
3	SW	-78.41969	36.14807	--
3	SE	-78.41958	36.14806	90
3	NW	-78.41966	36.14816	10
3	NE	-78.41957	36.14815	50
4	SW	-78.41964	36.14744	--
4	SE	-78.41953	36.14745	90
4	NW	-78.41965	36.14753	0
4	NE	-78.41954	36.14753	50
5	SW	-78.42047	36.14628	--
5	SE	-78.42037	36.14630	70
5	NW	-78.42053	36.14636	340
5	NE	-78.42043	36.14638	20

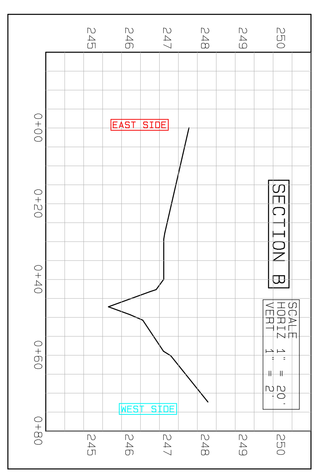
APPENDIX C

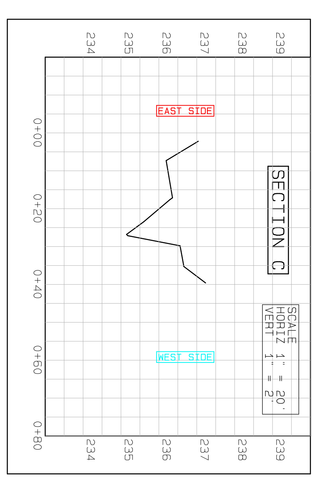
AS-BUILT LONGITUDINAL PROFILE AND CROSS SECTIONS

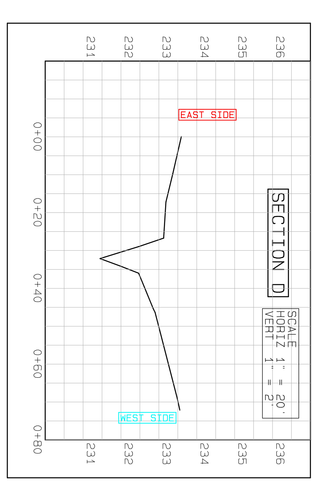












SHEET

TITLE

Project # 03707.001
Drawn by: TS
Date: Apr 26, 2006
Checked by: CB/DB

REVISIONS

URS – GROVE

URS Corporation
1600 Perimeter Park Dr.
Morrisville, North Carolina 27560

PRELIMINARY
NOT FOR
CONSTRUCTION

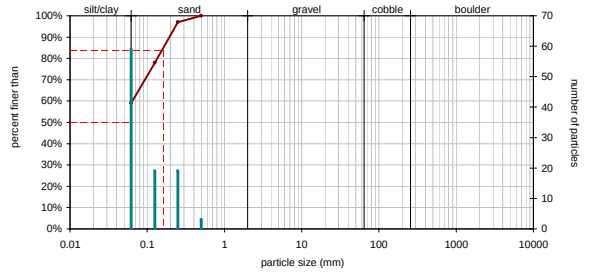
CHAS. H. SELLS, INC.
Consulting Engineers, Surveyors & Photogrammetrists
15401 Weston Parkway
Suite 100
Cary, NC 27513
Tel: 919-678-0035
Fax: 919-678-0206
www.chashsells.com

APPENDIX D

PEBBLE COUNT DATA

Unnamed Tributary to Billy's Creek Stream Restoration As-Built Pebble Counts

Bed Surface Pebble Count, Pool Cross Section #1

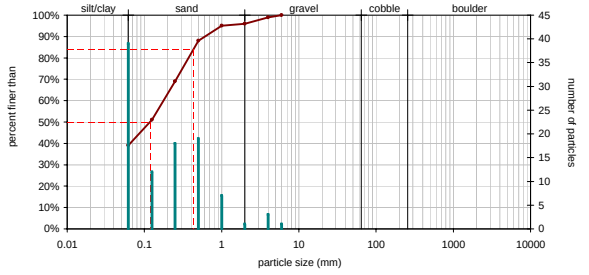


Size (mm)	
D16	0.062
D35	0.062
D50	0.062
D65	0.077
D84	0.16
D95	0.23

Size Distribution	
mean	0.1
dispersion	1.8
skewness	0.32

Type	
silt/clay	59%
sand	41%
gravel	0%
cobble	0%
boulder	0%

Bed Surface Pebble Count, Pool Cross Section #3

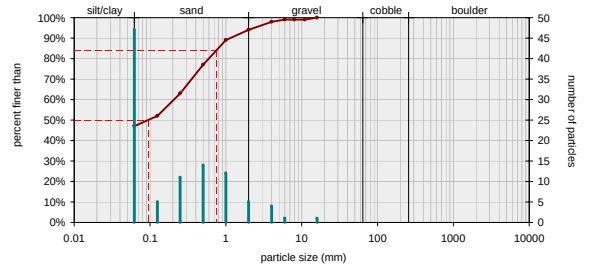


Size (mm)	
D16	0.062
D35	0.062
D50	0.12
D65	0.21
D84	0.43
D95	1

Size Distribution	
mean	0.2
dispersion	2.8
skewness	0.15

Type	
silt/clay	39%
sand	57%
gravel	4%
cobble	0%
boulder	0%

Bed Surface Pebble Count, Riffle Cross Section #2

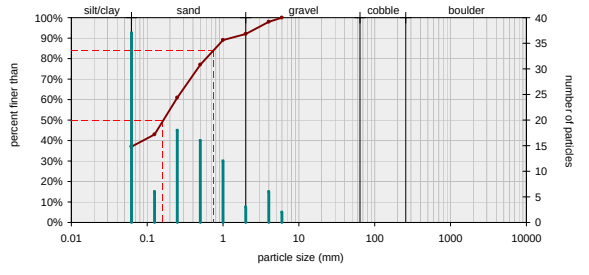


Size (mm)		
D16	0.062	3.4
D35	0.062	12
D50	0.094	17
D65	0.28	20
D84	0.75	29
D95	2.4	39

Size Distribution	
mean	0.2
dispersion	4.7
skewness	0.35

Type	
silt/clay	47%
sand	47%
gravel	6%
cobble	0%
boulder	0%

Bed Surface Pebble Count, Riffle Cross Section #4



Size (mm)		
D16	0.062	3.4
D35	0.062	12
D50	0.16	17
D65	0.3	20
D84	0.75	29
D95	2.8	39

Size Distribution	
mean	0.2
dispersion	3.6
skewness	0.12

Type	
silt/clay	37%
sand	55%
gravel	8%
cobble	0%
boulder	0%

APPENDIX E

REFERENCE PHOTOS

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 1: Right Bank

Cross Section 1: Left Bank

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 1: Upstream

Cross Section 1: Downstream

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 2: Right Bank

Cross Section 2: Left Bank

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 2: Upstream

Cross Section 2: Downstream

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 3: Right Bank

Cross Section 3: Left Bank

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 3: Upstream

Cross Section 3: Downstream

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 4: Right Bank

Cross Section 4: Left Bank

Billy's Creek Stream Restoration
Permanent Cross Section Photos

Cross Section 4: Upstream

Cross Section 4: Downstream

Billy's Creek Stream Restoration
Vegetation Plot Photos

Vegetation Plot 1

Vegetation Plot 2

Billy's Creek Stream Restoration
Vegetation Plot Photos

Vegetation Plot 3

Vegetation Plot 4

Billy's Creek Stream Restoration
Vegetation Plot Photos

Vegetation Plot 5

APPENDIX F

VEGETATION DATA

As-Built Vegetation Data

VEGETATION PLOT NUMBER 1		
Common Name	**Scientific Name**	**Count**
Elderberry	Sambucus canadensis	1
Swamp laurel oak	Quercus laurifolia	4
Tulip poplar	Liriodendron tulipifera	1
Southern red oak	Quercus falcata	3
Willow oak	Quercus phellos	2
Silky dogwood	Cornus amomum	1
Red chokeberry	Aronia arbutifolia	1
LIVE STAKES		
Silky dogwood	Cornus amomum	3
Elderberry	Sambucus canadensis	2
VEGETATION PLOT NUMBER 2		
Common Name	**Scientific Name**	**Count**
Tag alder	Alnus serrulata	7
Winged sumac	Rhus copallina	2
Elderberry	Sambucus canadensis	3
Hackberry or Sugarberry	Celtis sp.	2
Buttonbush	Cephanlanthus occidentalis	1
Flowering dogwood	Cornus florida	1
LIVE STAKES		
Silky dogwood	Cornus amomum	1
Silky willow	Salix sericea	1
VEGETATION PLOT NUMBER 3		
Common Name	**Scientific Name**	**Count**
Elderberry	Sambucus canadensis	3
Possumhaw viburnum	Viburnum nudum	1
Buttonbush	Cephanlanthus occidentalis	1
Willow oak	Quercus phellos	2
Black gum	Nyssa sylvatica	3
Hackberry or Sugarberry	Celtis sp.	3
Southern red oak	Quercus falcata	1
Flowering dogwood	Cornus florida	1
LIVE STAKES		
Silky dogwood	Cornus amomum	7
Elderberry	Sambucus canadensis	5
Black willow	Salix nigra	2
Silky willow	Salix sericea	1
VEGETATION PLOT NUMBER 4		
Common Name	**Scientific Name**	**Count**
Silky dogwood	Cornus amomum	2
Possumhaw viburnum	Viburnum nudum	2
Hackberry or Sugarberry	Celtis sp.	4
Willow oak	Quercus phellos	2
Black gum	Nyssa sylvatica	1
Swamp laurel oak	Quercus laurifolia	1
Tag alder	Alnus serrulata	2
Winged sumac	Rhus copallina	2
Buttonbush	Cephanlanthus occidentalis	1
Elderberry	Sambucus canadensis	1
Beautyberry	Calicarpa americana	2
Red chokeberry	Aronia arbutifolia	1
LIVE STAKES		
Silky willow	Salix sericea	1
VEGETATION PLOT NUMBER 5		
Common Name	**Scientific Name**	**Count**
Willow oak	Quercus phellos	8
Hackberry or Sugarberry	Celtis sp.	2
Swamp laurel oak	Quercus laurifolia	4
Tag alder	Alnus serrulata	2
Elderberry	Sambucus canadensis	1
Possumhaw viburnum	Viburnum nudum	2
River birch	Betula nigra	2
Southern red oak	Quercus falcata	1
Silky dogwood	Cornus amomum	1
LIVE STAKES		
Silky willow	Salix sericea	2