Blockhouse Creek Restoration Project
Mitigation Plan and As-built Baseline Report
Polk County, North Carolina

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)

Monitoring Firm POC: Micky Clemmons

Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Guy Pearce

Report Prepared By: Michael Baker Engineering, Inc.
797 Haywood Road, Suite 201
Asheville, NC 28806

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DRAFT

EXECUTIVE SUMMARY

The Blockhouse Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents base-line, as-built monitoring data for the five-year monitoring period. The stream mitigation units developed on the project exceed the number of units that Baker contracted with the North Carolina Ecosystem Enhancement Program (NCEEP) to provide, as shown in Table 1. Table 1 summarizes site conditions before and after restoration as well as what was predicted in the restoration plan. The monitoring plan and as-built baseline data are discussed in Sections 2.1 through 2.5 of this report.

Table 1. Background Information
Blockhouse Creek Restoration Project

Preconstruction Site Conditions			
Site			
Location	Polk County, approximately three miles east of the town of Tryon		
USGS Hydro Unit	03050105150020		
NCDWQ Subbasin	03-08-06		
Contract Mitigation Units (SMUs)	5,550 SMUs		
Stream			
Reach	**Length**	**Condition**	**Drainage Area**
Blockhouse Creek	3,998 LF	Channelized; incised; bank erosion	2.44 Mi^2 Total
UT 1	540 LF	Incised; bank erosion	211.2 Ac
UT 2	1,224 LF	Channelized; incised; over-wide	57.6 Ac
UT 3	430 LF		38.4 Ac
Restoration Plan			
Stream			
Reach	**Restoration/Enhancement Type**		**Length**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile		887 LF
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile		340 LF
Blockhouse Creek Reach 3	Restoration of dimension and profile		950 LF
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile		1,821 LF
UT 1	Restoration of dimension and profile		523 LF
UT 2	Restoration of dimension, pattern and profile		1,240 LF
UT 3	Preservation of channel corridor		430 LF
Post-Construction Site Conditions			
Stream			
Reach	**Restoration/Enhancement Type**	**Length**	**SMUs**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile	1070 LF	1070
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile	340 LF	340
Blockhouse Creek Reach 3	Restoration of dimension and profile	950 LF	633
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile	1,780 LF	1,780

UT 1	Restoration of dimension and profile	580 LF	580
UT 2	Restoration of dimension, pattern and profile	1,155 LF	1,155
UT 3	Preservation of channel corridor	430 LF	86
Riparian Buffer Acreage			
Conservation Easement	8.6 Acres		
Vegetation Monitoring Plots			
Average Stems Per Acre	764 Stems	# of Plots: 10	
Ecological Benefits			
Water Quality	Erosion reduction; Increased dissolved oxygen concentrations; Improved stream bank stability		
Water Quantity/Flood Attenuation	Increased water storage/flood control; Reduced downstream flooding by reconnecting stream with its floodplain; Improved groundwater recharge; Improved/restored hydrologic connections		
Aquatic and Terrestrial Habitat	Improved substrate and in-stream cover; Addition of large woody debris; Reduced water temperature by increasing shading; Restoration of terrestrial habitat; Improved aesthetics		
Monitoring Plan			
Success Criteria	Success is measured with permanent cross-section, vegetation plots, and longitudinal profile conducted for a period of five years.		
Methodology	Cross-sections and longitudinal profiles are surveyed annually. Both surveying parameters are tied to a common benchmark. Each tree within the 100-square-meter vegetation plots are flagged and identified. Measurements of height and diameter are also taken and annual survival rates are recorded.		
Remedial Action	N/A		

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1.0 BACKGROUND INFORMATION

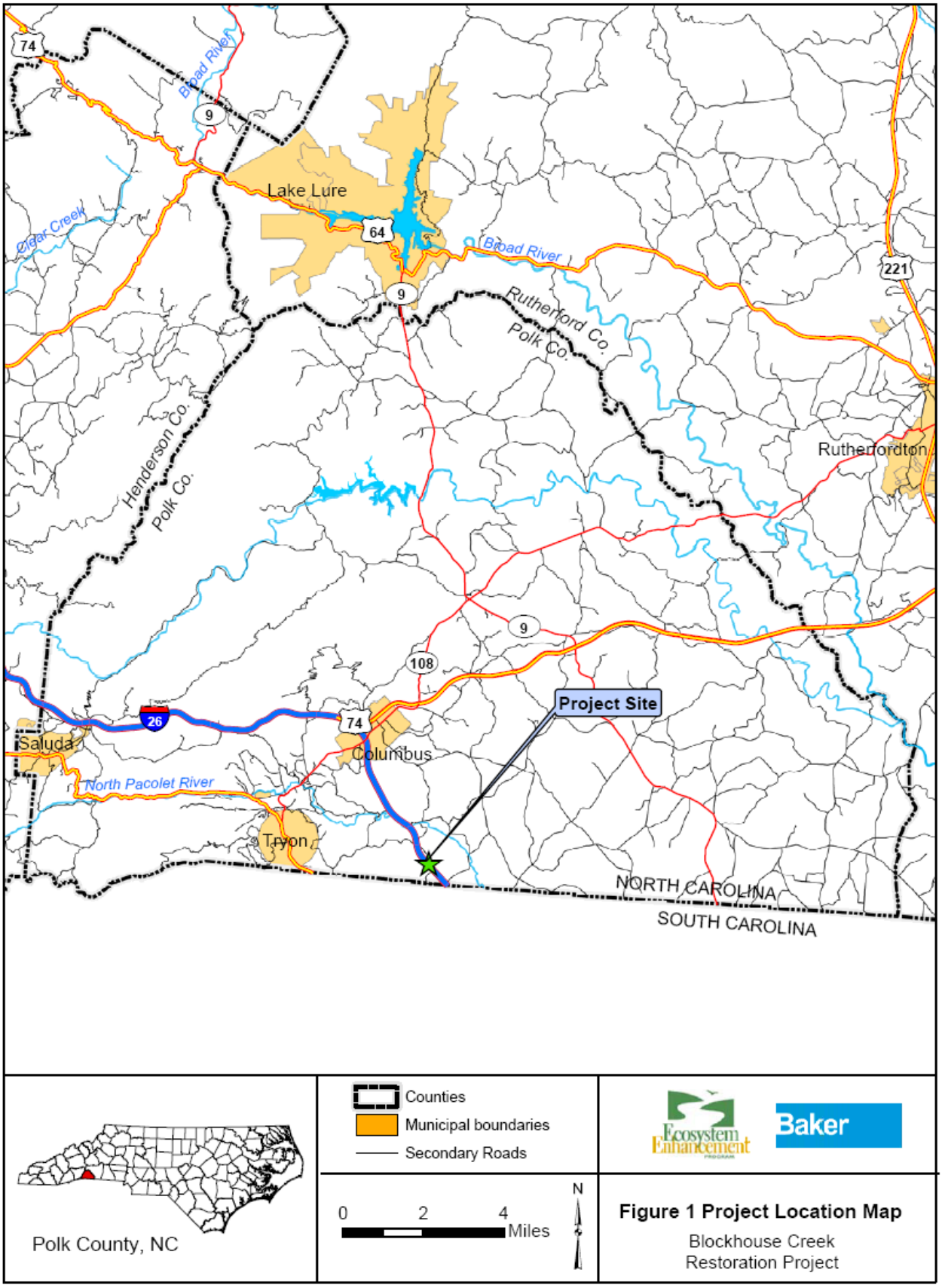
The Blockhouse Creek Restoration site is located within the Foothills Equestrian Nature Center (FENCE), approximately three miles east of Tryon, in Polk County, North Carolina (Figure 1). The project site is situated in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-06 and United States Geologic Survey (USGS) hydrologic unit 03050105150020. Since the late 1980s, the project area has been used as an equestrian/recreational complex. Surrounding lands are currently used for pasture land, hay production and residential use. Prior to the establishment of an equestrian and nature center, the FENCE property was used for agriculture activities and timber production. At that time, riparian buffers were removed and streams were channelized which was a common practice. There is also evidence on some tributaries of ephemeral gullies which most likely resulted from clear cutting. More recent development in the watershed has resulted in additional changes to Blockhouse Creek and its tributaries. Construction of the equestrian facility, nature trails and Interstate 26 has required the installation of bridged and culverted stream crossings that have been detrimental to stream stability. These structures have also impacted the flow pattern and velocity of the project streams, resulting in changes to the cross-sectional area, and often facilitating the deepening of the channel. This deepening of the channel resulted in the streams becoming incised and losing their connection to the adjacent floodplain.

The project involved restoration, enhancement or preservation of 6,305 linear feet (LF) of four on-site streams: Blockhouse Creek and three smaller unnamed tributaries (UTs) identified in the project as UT1, UT2, and UT3. Blockhouse Creek is a “blue-line” stream, as shown on the USGS topographic quadrangle for the site, and is considered to be perennial based on field evaluations using NCDWQ stream assessment protocols. The three tributaries were all identified as perennial during initial project scoping, although UT2 and UT3 have little or no flow during extreme drought conditions as observed during the past two summers.

1.1 Restoration Summary

1.1.1 Project Location

The Blockhouse Creek mitigation site is located on the Foothills Equestrian Nature Center (FENCE) property approximately three miles east of Tryon, in Polk County, North Carolina. From Asheville, take South Carolina Exit #1 from I-26, toward Landrum, S.C. Go 1.5 miles, and turn right onto Bomar Road (look for the Land Mart on the corner). Go one short block and turn right onto Prince Road. After 1.7 miles, turn left onto Hunting Country Road, just before the I-26 bridge. Go .5 mile to the FENCE entrance on the left or another .1 miles (going under I-26) to the second entrance on the right. The Blockhouse Creek site starts at the upper limits of the horse stables accessed through the first entrance. Figure 1 illustrates the physical location of the project site. Figure 2 depicts the project streams, easement boundaries and monitoring reference data.


74
Broad River
9
Lake Lure
Cedar Creek
64
Broad River
221
9
Rutherford Co.
Polk Co.
Henderson Co.
Polk Co.
Rutherfordton
9
108
Project Site
26
74
Saluda
Columbus
North Pacolet River
Tryon
NORTH CAROLINA
SOUTH CAROLINA
Polk County, NC
Counties
Municipal boundaries
Secondary Roads
0
2
4
Miles
N
Ecosystem Enhancement Program
Baker
Figure 1 Project Location Map
Blockhouse Creek
Restoration Project

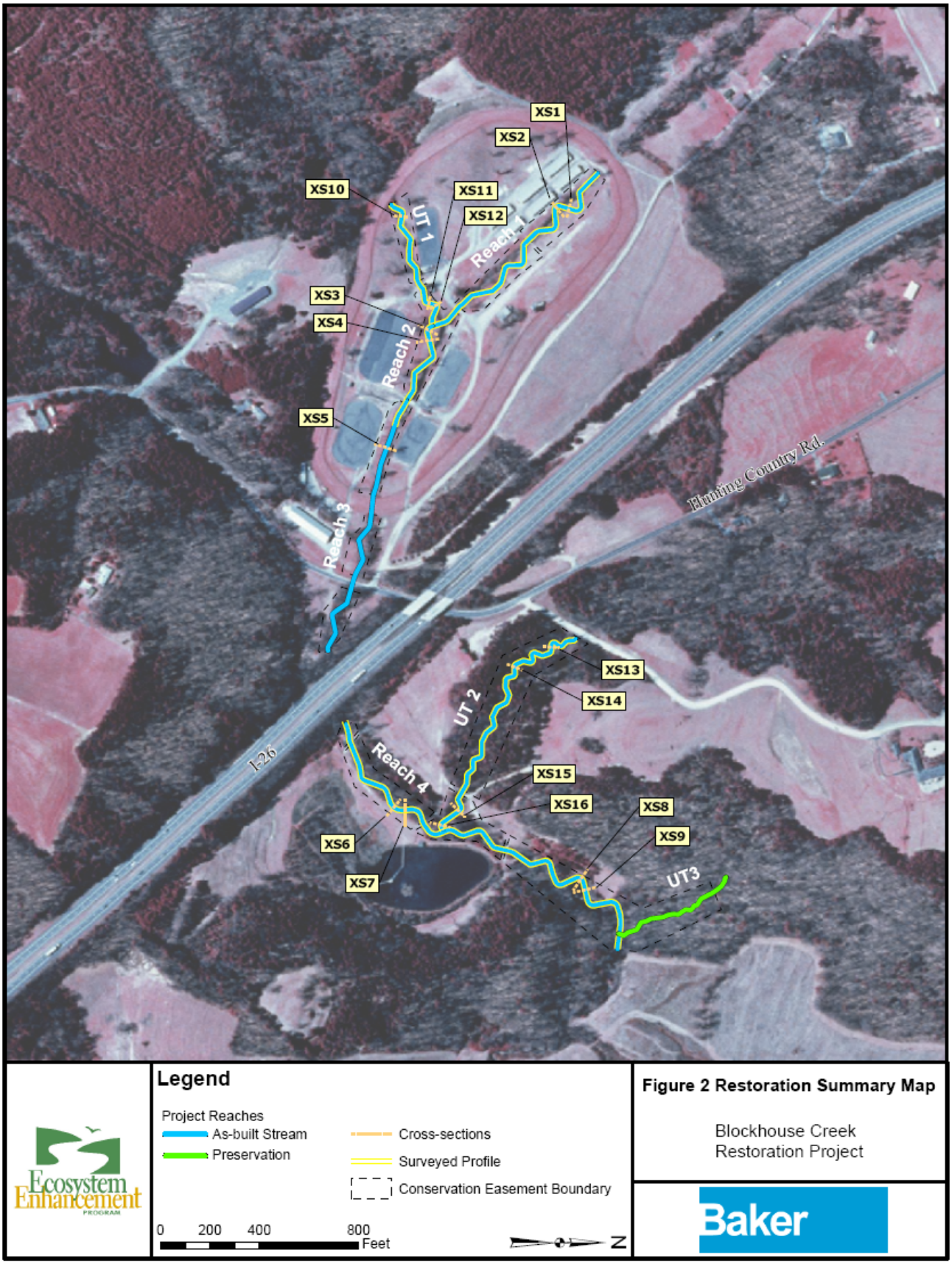


Figure 2 Restoration Summary Map

Blockhouse Creek
Restoration Project

1.1.2 Project Objectives

The specific design objectives of the project included:

- Restoration or enhancement of channel dimension, pattern and profile;
- Improvements to water quality in the Blockhouse Creek watershed through nutrient removal, sediment removal, improved recreational opportunities, streambank stability, and erosion control;
- Improved water quantity/flood attenuation through water storage and flood control, reduction in downstream flooding due to the reconnection of stream and floodplain, improved ground water recharge, and improved and restored hydrologic connections;
- Enhancement of aquatic and terrestrial habitats through improved substrate and instream cover, addition of woody debris, reduction in water temperature due to shading, restoration of terrestrial habitat, increase of spatial extent of natural area, and improved aesthetics.

1.1.3 Project Description and Restoration Approach

Restoration of site hydrology involved the restoration of natural stream functions to impaired reaches on the site. The streams in their historic condition were channelized and, as a result, were highly incised. Because of the extent of the incision, a Rosgen Priority I restoration, which would connect the stream to the abandoned floodplain (terrace), would not have been feasible without extending the project reach several thousand feet upstream and significantly altering the channel profile. However, there was sufficient space in areas within the project boundaries to implement Rosgen Priority II restoration by excavating the floodplain and creating a new meandering channel. With the exception of a small section of UT2, the restored streams were designed as Rosgen "E" channels with design dimensions based on those of reference parameters. The upper project reach on UT2 was designed as an "E" channel while the lower section of the project reach (approximately 200 feet) was designed as a "B" channel. The preserved reach on UT3 was determined to be a "B" channel that transitions to an "E" channel.

The design for restored sections of the streams involved the construction of new, meandering channels across excavated floodplains. This new channel system was constructed through grassed fields. The streams through the site were restored to a stable dimension, pattern, and profile. Total stream length across the project was increased from approximately 6,191 LF to 6,305 LF. The design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing streambank stress. Instream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. Rootwad and log vane structures installed will protect streambanks and promote habitat diversity in pool sections. Constructed riffles were used to promote both hydraulic and habitat heterogeneity to the channel. Where grade control was a design consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

1.1.4 Construction Summary

In accordance with the approved restoration plan for the site, construction activities began in January 2008. Project activity on Blockhouse Creek and UT1 and UT2 consisted of making adjustments to channel dimension, pattern, and profile. A primary design consideration for this project was to allow stream flows larger than bankfull events to spread onto a floodplain, dissipating flow energies and reducing streambank stress. The design for most of the restoration reaches involved a priority II approach with the construction of new, meandering channels across a floodplain that was excavated to the elevation of the creek. The lower part of reach 4 was not incised and did not require this approach. Along this section the overly sinuous channel was realigned in a more stable pattern at the existing elevation. Total stream length across the project increased from approximately 6,191 LF to 6,305 LF.

Access sites and stockpile areas were established at the beginning of site construction. Site stakeout and the harvesting of root wads also began during the beginning stages of construction and occurred throughout the construction phase. Materials were stockpiled as needed for the initial stages of construction.

After stakeout was completed, the floodplain was excavated and graded within discrete work areas of the site to reach design grade. Grading activities commenced at the upstream limits of the project site near the equestrian center and continued downstream below highway Interstate-26 (I-26), through the nature center area. Restoration activities on the project tributaries commenced once construction crews reached each confluence between Blockhouse Creek and the respective tributaries. Excavated material was placed in a field on the property and kept at least 75 feet from any stream. Where necessary, silt fencing was installed to prevent erosion of sediment into the nearest waterbody.

Once the design floodplain elevations were achieved, new stream channel segments were graded and constructed in the dry by pumping stream flows around the construction segment. Upon completion of new channel segments, instream structures, matting and transplants were installed and the new channel was tied to the existing streambed. Once fully prepared, temporary sediment traps at the downstream ends of the channels were removed, and water was directed into the newly constructed channel. Remnant channels were immediately filled and graded. As-built cross sections and longitudinal profiles are shown in Appendix B.

Rootwads, rock and log vanes and other structures were used to protect streambanks and promote habitat diversity in pool sections. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

Modifications made during construction of this project involved the location and selection of instream structures and bank stabilization practices as well as minor adjustments in channel alignment. Structure substitutions were made based on availability of materials and professional judgment. At the upstream project limits on UT2 from Station 0+00 to 4+20, the channel location was adjusted to avoid mature trees in the vicinity of the project. Slight adjustments to the proposed channel alignment were also made during construction along the mainstem of Blockhouse Creek between Stations 7+50 to 9+25. This adjustment was made to take advantage of a highly stable, vegetated section of streambank on Blockhouse Creek. The adjustment also improved the angle of approach of Blockhouse Creek to a bridge crossing. These changes are documented in the attached as-built drawings. Table 2 provides a summation of the as-built lengths and restoration approaches applied within the project site. The final as-built stream length for the restoration and enhancement reaches of the project site was 5,875 LF.

Tables 3 through 6 provide additional information regarding the Blockhouse Creek restoration project.

Table 2. Summary of As-built Lengths, Mitigation Units, and Restoration Approaches

Reach Name	As-built Length (ft)	Existing Length (ft)	SMUs	Restoration Approach
Blockhouse Cr. Reach 1	1070	887	1,070	Priority II Restoration
Blockhouse Cr. Reach 2	340	340	340	Priority II Restoration
Blockhouse Cr. Reach 3	950	950	633	Enhancement Level I
Blockhouse Cr. Reach 4	1780	1,821	1,780	Priority II Restoration
UT 1	580	523	580	Priority II Restoration
UT 2	1155	1,240	1155	Priority II Restoration
UT 3	430	430	86	Preservation
Total Length	**6305**	**6,191**	**5,644***	

*This represents 94 SMUs more than our EEP contract requires.

1.2 Project History, Contacts and Attribute Data

Table 3. Project Restoration Components

Blockhouse Creek Restoration Project

Project Segment or Reach ID	Existing Feet/ Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Blockhouse Cr. Reach 1	887 LF	R	P2	1070 LF	1.0	1,070	0+00-10+70	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 2	340 LF	R	P2	340 LF	1.0	340	10+70-14+14	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 3	950 LF	E	I	950 LF	1.5	633	14+34-25+44	Constraints prevented restoration; bankfull benches established, structures installed, pattern stabilized.
Blockhouse Cr. Reach 4	1,821 LF	R	P2	1,780 LF	1.0	1,780	28+37-46+17	Meandering channel construction; floodplain excavation
UT 1	523 LF	R	P2	580 LF	1.0	580	0+00-5+23	Meandering channel construction; floodplain excavation
UT 2	1,240 LF	R	P2	1,155 LF	1.0	1,155	0+00-12+40	Only incised at lower end, upper 1000 LF realigned to a more stable pattern with only minor floodplain grading

UT 3	430 LF	P	-	430 LF	5.0	86	0+00-4+30	No channel alteration (preservation)

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
5,644	NA	NA	NA	8.6	

Table 4. Project Activity and Reporting History
Blockhouse Creek Restoration Project

Activity or Report	Data Collection Complete	Completion or Delivery
Categorical Exclusion Approved	---	January 2007
Conservation Easement Signed	---	September 2007
Restoration Plan Approved	---	October 2007
Project Permit Approval	---	December 2007/ January 2008
Final Design-90%	---	October 2007
Construction		
`Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	May 2008
Permanent seed mix and riparian vegetation applied to project site		
Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	June 2008
Vegetation Plots , Crest Gauges and Photo Stations Established	July 2008	September 2008
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2008	October 2008
Year 1 Monitoring	July 2009	December 2009
Year 2 Monitoring	July 2010	December 2010
Year 3 Monitoring	July 2011	December 2011
Year 4 Monitoring	July 2012	December 2012
Year 5 Monitoring	July 2013	December 2013

Table 5. Project Contact Table **Blockhouse Creek Restoration Project**	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002

Table 6. Project Background Table **Blockhouse Creek Restoration Project**	
Project County	Polk County, NC
Drainage Area (Square Miles or Acres)	
Blockhouse Creek Reach 1	1.63 mi^2
Blockhouse Creek Reach 2	1.97 mi^2
Blockhouse Creek Reach 3	2.21 mi^2
Blockhouse Creek Reach 4	2.44 mi^2
UT 1	211.2 Ac.
UT 2	57.6 Ac.
UT 3	38.4 Ac.
Drainage impervious cover estimate (%)	<1%

Stream Order	Second Order
Physiographic Region	Piedmont Province. Borders Blue Ridge Escarpment
Ecoregion	Southern Inner Piedmont
Rosgen Classification of As-built	
Blockhouse Creek Reach 1	C4
Blockhouse Creek Reach 2	C4
Blockhouse Creek Reach 3	E4/Bc4
Blockhouse Creek Reach 4	E4
UT 1	C4
UT 2	Bc5 (upper)/Cb (lower)
UT 3	B-E (lower)
Cowardin Classification	Riverine
Dominant Soil Types	
Blockhouse Creek Reach 1	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 2	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 3	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 4	Chewacla Loam, Pacolet Sandy Clay Loam, Rion Sandy Loam
UT 1	Chewacla Loam, Pacolet Sandy Clay Loam
UT 2	Pacolet Sandy Clay Loam,
UT 3	Chewacla Loam, Pacolet Sandy Clay Loam, Hiwassee Clay Loam
Reference Site ID	Reference reach used for upper portion of project area located 350 LF upstream of project. Big Branch, Surry County was also identified in the NCDOT reference reach database as a suitable reference for design ratios
USGS HUC for Project and Reference Sites	Blockhouse Creek HUC#: 03050105 Big Branch HUC#: 03040101
Any portion of project segment(s) on NC 303d List?	No
Any portion of project upstream of a 303d Listed Segment?	No
Reasons for 303d Listing or Stressor	N/A
% of Project Easement Fenced	None of the easement area is presently fenced.

2.0 MONITORING PLAN

The five-year monitoring plan for the Blockhouse Creek restoration project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built drawing sheets. Reference photo points were selected to show cross-sections, structures (i.e. vanes and weirs), and other important channel areas along the restored stream.

2.1 Stream Monitoring and Success Criteria

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration. Monitored stream parameters include bankfull flows, channel dimension (cross-sections), profile (longitudinal survey), changes to bed composition, bank stability assessment, and stability of reference sites documented by photographs. The methods used and any related success criteria are described below for each parameter

2.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Three crest gauges were installed on the floodplain within 10 feet of the restored channels. One crest gauge was placed on UT 2, while 2 gauges were set up on Blockhouse Creek. The first gauge on the main channel was set up on the right bank below the confluence of UT 1 and Blockhouse Creek. The second crest gauge was set up, at the downstream end of the project, just upstream of the confluence of UT3 and Blockhouse Creek on the right bank. The crest gauge on UT2 was placed above the vehicle crossing at the lower end of the tributary. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring may have to be continued until two bankfull events have been documented in separate years.

2.1.2 Cross-Sections

Sixteen permanent cross-sections were installed to help evaluate the success of the restoration project. Cross-sections selected for monitoring were located in representative riffle and pool reaches as well as downstream of the confluences between Blockhouse Creek and UT1 and UT2. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

2.1.3 Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed conditions over time. A longitudinal profile was conducted for the entire project length on UT1 and UT2. An additional 3,396 linear feet of stream channel was surveyed on Blockhouse Creek. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, inner berm, bankfull, and top of low bank, if the features are present. All measurements will be taken at the head of each feature (e.g., riffle, or pool) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark. Permanent cross-section and longitudinal profile data are provided in Appendix B.

The longitudinal profiles should show that the bed features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain

steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type.

2.1.4 Bed Material Analyses

Bed material analyses will include pebble counts taken during each geomorphic survey. These samples will reveal any changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

Two bulk sediment samples will be processed along the mainstem of Blockhouse Creek. One bulk sediment sample will be collected in a riffle upstream of I-26. The second bulk sample will be collected from a riffle downstream of the interstate in the vicinity of the pond adjacent to the project site. During the monitoring period, if the bulk samples show a coarsening of the bed and gravel becomes a larger component of the bed, then a pebble count will be added above and below I-26. Bedload samples will be taken one year after construction and at two-year intervals thereafter, at the time the longitudinal field surveys are performed. Sediment data will be plotted on a semi-log graph and compared with data from previous years.

2.1.5 Bank Stability Assessments

To aid the NCEEP in evaluating the risk of erosion from changes in channel and bank stability and subsequent sediment yield from the project area, Baker is prepared to assign numeric values to streambank and channel features. This will occur during Year 5 of the monitoring period. These numeric scores will be derived using the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) evaluation methods. The scores will then be used to evaluate channel stability and project sediment export. Results from a visual stability assessment are provided in Table 7.

Table 7. Categorical Stream Feature Visual Stability Assessment
Blockhouse Creek Restoration Project

Features	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Stability	100%					
G. Vanes	100%					
H. Rootwads, Boulders, Geolifts	100%					

2.1.6 Photo Reference Sites

Photographs will be used to document restoration success qualitatively. Reference stations will be photographed during the as-built survey and for five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) are utilized during each monitoring period. Reference photographs are shown in Appendix A.

2.1.6.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will

be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.6.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored stream are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2 Vegetation Monitoring

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, 10 vegetation monitoring quadrants were installed across the restoration site as required by the NCEEP. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between May and July.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

2.3 Maintenance and Contingency Plans

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed

- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in future monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP approval will be obtained prior to any remedial action.

2.4 Monitoring Results – 2008 As-Built Data

The five-year monitoring plan for the Blockhouse Creek Site includes criteria to evaluate the success of the vegetative and geomorphic components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built sheets. Photo points, located along the stream restoration project, are also shown.

2.4.1 Morphology

For monitoring stream success criteria, 16 permanent cross-sections and 3 crest gauges were installed. The permanent cross-sections will be used to monitor channel dimension over time. The crest gauges will be used to document the occurrence of bankfull events. In addition, a complete longitudinal survey was completed for the restored stream channels to provide a base-line for evaluating changes in bed conditions over time. The permanent cross-section and longitudinal data are provided in Appendix B. The location of the permanent cross-sections and the crest gauges are shown on the as-built plan sheets in Appendix C.

2.4.1.1 Results and Discussion

No results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2009.

2.4.2 Vegetation

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stake, bare root trees, and live brush in the geolift structures have also begun to grow and are providing streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A 30-foot buffer was established along of the majority of the restored stream and the width exceeds this minimum in most places. However at crossings the easement “pinches” in to meet the crossing structure and along one section of Reach 3 the easement on the left bank is less than 30 feet due to existing constraints; however, the total width is greater than 60 feet. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in May 2008. Species planted and as-built densities are summarized in Table 8.

Table 8. Rooted trees, live stakes and seeding planted in the riparian zone of Blockhouse Creek. The species composition for two different areas is shown; with one area being upstream of I-26 and the second area being downstream of I-26.		
Planting Plan		
Scientific name	**Common name**	**Percent Planted by Species**
Blockhouse Creek upstream of I-26 and UT1 (40% trees/ 60% shrubs) planted at 680 stems/A		
Trees - Planted 13'x13'		
Acer rubrum	Red maple	13
Fraxinus pennsylvanica	Green ash	13
Juglans nigra	Black walnut	13
Liriodendron tulipfera	Tulip poplar	0.5
Platanus occidentalis	Sycamore	0.5
Understory Trees/Shrubs- Planted 10'x10'		
Alnus serrulata	Tag alder	9
Calicanthus floridus	Sweet Shrub	10
Cornus florida	Flowering dogwood	12
Cercis canadensis	Redbud	10
Carpinus caroliniana	Ironwood	9
Asimina triloba	Paw paw	9
Blockhouse Creek downstream of I-26 and UT2 (60% Trees/ 40% shrubs) planted at 680 stems/A		
Trees - Planted 10'x10'		
Acer rubrum	Red maple	4
Diospyros virginiana	Persimmon	6
Juglans nigra	Black walnut	12
Liriodendron tulipfera	Tulip poplar	10
Platanus occidentalis	Sycamore	10
Prunus serotina	Black Cherry	6
Quercus phellos	Willow oak	6
Quercus rubra	Red oak	6
Understory Trees/Shrubs- Planted 13'x13'		
Alnus serrulata	Tag alder	6
Calicanthus floridus	Sweet Shrub	6
Cornus florida	Flowering dogwood	9
Cercis canadensis	Redbud	8
Carpinus caroliniana	Ironwood	6
Asimina triloba	Paw paw	5
Woody Vegetation for Live Stakes - Planted 3’ x 3’ on center		
Salix sericea	Silky willow	30
Physocarpus opulifolius	Ninebark	25
Sambucus canadensis	Elderberry	15
Cornus amomum	Silky Dogwood	30
Note: Species selection may change due to availability at the time of planting.		

The restoration plan for the Blockhouse Creek Site specifies that the number of quadrants required were based on the species/area curve method, as described in NCEEP monitoring guidance documents, with a minimum of three quadrants. The size of individual quadrants are 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of ten vegetation plots, each 10 by 10 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 9. The average density of planted bare root stems, based on the data from the ten monitoring plots, is 764 stems per acre. The locations of the vegetation plots are shown on the as-built plan sheets.

2.4.2.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

Table 9. CVS Level 1 Stem Count Arranged by Plot (As-Built)
Blockhouse Creek Restoration Site

Tree Species	Plots										As-built Totals	Year 1 Totals	Year 3 Totals	Year 5 Totals	Site Average Stems/acre
	1	2	3	4	5	6	7	8	9	10					
Betula nigra		1		1	5		2			5	14				
Acer rubrum	3	5		2							10				
Fraxinus pennsylvanica	2	3			4	8	2		4	3	26				
Juglans nigra	3	2		1			1	8			15				
Platanus occidentalis	3	4	7	10	4		3	3	10		44				
Liriodendron tulipfera			2			1		5		7	15				
Quercus phellos					1		1	7			9				
Quercus rubra			4	2	2	3		3			14				
Diospyros virginiana				1	5	8	2				16				
Shrub Species															
Alnus serrulata	1	1									2				
Calicanthus floridus	2	1	4	2							9				
Halesia carolina				3							3				
Cercis canadensis	2	1	2								5				
Asimina triloba					1	1					2				
Cornus florida	1	1									2				
Cornus amomum							1	3		1	5				
Stems/plot	17	19	19	22	22	21	12	29	14	16					
Stems/acre As-built	680	760	760	880	880	840	480	1160	560	640					764

2.5 Areas of Concern

There are two factors of concern at this project site. Neither have to do with specific sites on the channel. The first concern is the rate of overland flow that the site experiences above Interstate 26. Due to the buildings on this site and the high compaction of the soil from heavy use by horse show participants, the runoff from the land adjoining the stream is high. This has not affected the channel proper but is the source of some minor rutting along terrace slopes leading down to the floodplain. Baker is working with FENCE to seek grant funding to address this issue. The second concern is that two of the three box culverts under Interstate 26 are two thirds full of sand. During any high flow event this sand mobilizes into the channel downstream of the interstate. This is causing some pools to fill with sand and the loss of pool depth. The channel is moving this material and it will eventually correct the problem but it will affect the lower end of the project of the next several years. NCDOT has been contacted about this issue but they do not appear interested in addressing it.

The project area has received little precipitation in the time since ground cover and woody vegetation was planted in the riparian buffers. Considering the drought conditions that have persisted in the region where the project site is located, vegetation survival has been excellent. Mortality rates for woody vegetation planted appear to be low though some sections of the project have experienced higher rates of mortality as evidenced by the vegetative plot data listed in Table 9. Early observations indicate that the vegetation treatments have been effective at establishing herbaceous ground cover in the majority of the project site. Areas of sparser vegetation will be replanted if suitable cover is not found to be established during Year 1 monitoring.

Beyond these issues no areas of concern have been identified during the first months following completion of the project.

APPENDIX A

SELECTED PROJECT PHOTOGRAPHS

APPENDIX B

AS-BUILT CROSS-SECTIONS AND LONGITUDINAL PROFILES

APPENDIX C

AS-BUILT PLAN SHEETS

Blockhouse Creek Restoration Project
Mitigation Plan and As-built Baseline Report
Polk County, North Carolina

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)

Monitoring Firm POC: Micky Clemmons

Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Guy Pearce

Report Prepared By: Michael Baker Engineering, Inc.
797 Haywood Road, Suite 201
Asheville, NC 28806

Contract Number: D06027-A

Date Submitted: November 2008

DRAFT

EXECUTIVE SUMMARY

The Blockhouse Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents base-line, as-built monitoring data for the five-year monitoring period. The stream mitigation units developed on the project exceed the number of units that Baker contracted with the North Carolina Ecosystem Enhancement Program (NCEEP) to provide, as shown in Table 1. Table 1 summarizes site conditions before and after restoration as well as what was predicted in the restoration plan. The monitoring plan and as-built baseline data are discussed in Sections 2.1 through 2.5 of this report.

Table 1. Background Information
Blockhouse Creek Restoration Project

Preconstruction Site Conditions			
Site			
Location	Polk County, approximately three miles east of the town of Tryon		
USGS Hydro Unit	03050105150020		
NCDWQ Subbasin	03-08-06		
Contract Mitigation Units (SMUs)	5,550 SMUs		
Stream			
Reach	**Length**	**Condition**	**Drainage Area**
Blockhouse Creek	3,998 LF	Channelized; incised; bank erosion	2.44 Mi^2 Total
UT 1	540 LF	Incised; bank erosion	211.2 Ac
UT 2	1,224 LF	Channelized; incised; over-wide	57.6 Ac
UT 3	430 LF		38.4 Ac
Restoration Plan			
Stream			
Reach	**Restoration/Enhancement Type**		**Length**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile		887 LF
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile		340 LF
Blockhouse Creek Reach 3	Restoration of dimension and profile		950 LF
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile		1,821 LF
UT 1	Restoration of dimension and profile		523 LF
UT 2	Restoration of dimension, pattern and profile		1,240 LF
UT 3	Preservation of channel corridor		430 LF
Post-Construction Site Conditions			
Stream			
Reach	**Restoration/Enhancement Type**	**Length**	**SMUs**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile	1070 LF	1070
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile	340 LF	340
Blockhouse Creek Reach 3	Restoration of dimension and profile	950 LF	633
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile	1,780 LF	1,780

UT 1	Restoration of dimension and profile	580 LF	580
UT 2	Restoration of dimension, pattern and profile	1,155 LF	1,155
UT 3	Preservation of channel corridor	430 LF	86
Riparian Buffer Acreage			
Conservation Easement	8.6 Acres		
Vegetation Monitoring Plots			
Average Stems Per Acre	764 Stems	# of Plots: 10	
Ecological Benefits			
Water Quality	Erosion reduction; Increased dissolved oxygen concentrations; Improved stream bank stability		
Water Quantity/Flood Attenuation	Increased water storage/flood control; Reduced downstream flooding by reconnecting stream with its floodplain; Improved groundwater recharge; Improved/restored hydrologic connections		
Aquatic and Terrestrial Habitat	Improved substrate and in-stream cover; Addition of large woody debris; Reduced water temperature by increasing shading; Restoration of terrestrial habitat; Improved aesthetics		
Monitoring Plan			
Success Criteria	Success is measured with permanent cross-section, vegetation plots, and longitudinal profile conducted for a period of five years.		
Methodology	Cross-sections are surveyed annually and longitudinal profiles are surveyed in Monitoring Years 1, 3, and 5. Both surveying parameters are tied to a common benchmark. Each tree within the 100-square-meter vegetation plots are flagged and identified. Measurements of height and diameter are also taken and annual survival rates are recorded.		
Remedial Action	N/A		

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Tables and Figures

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1.0 BACKGROUND INFORMATION

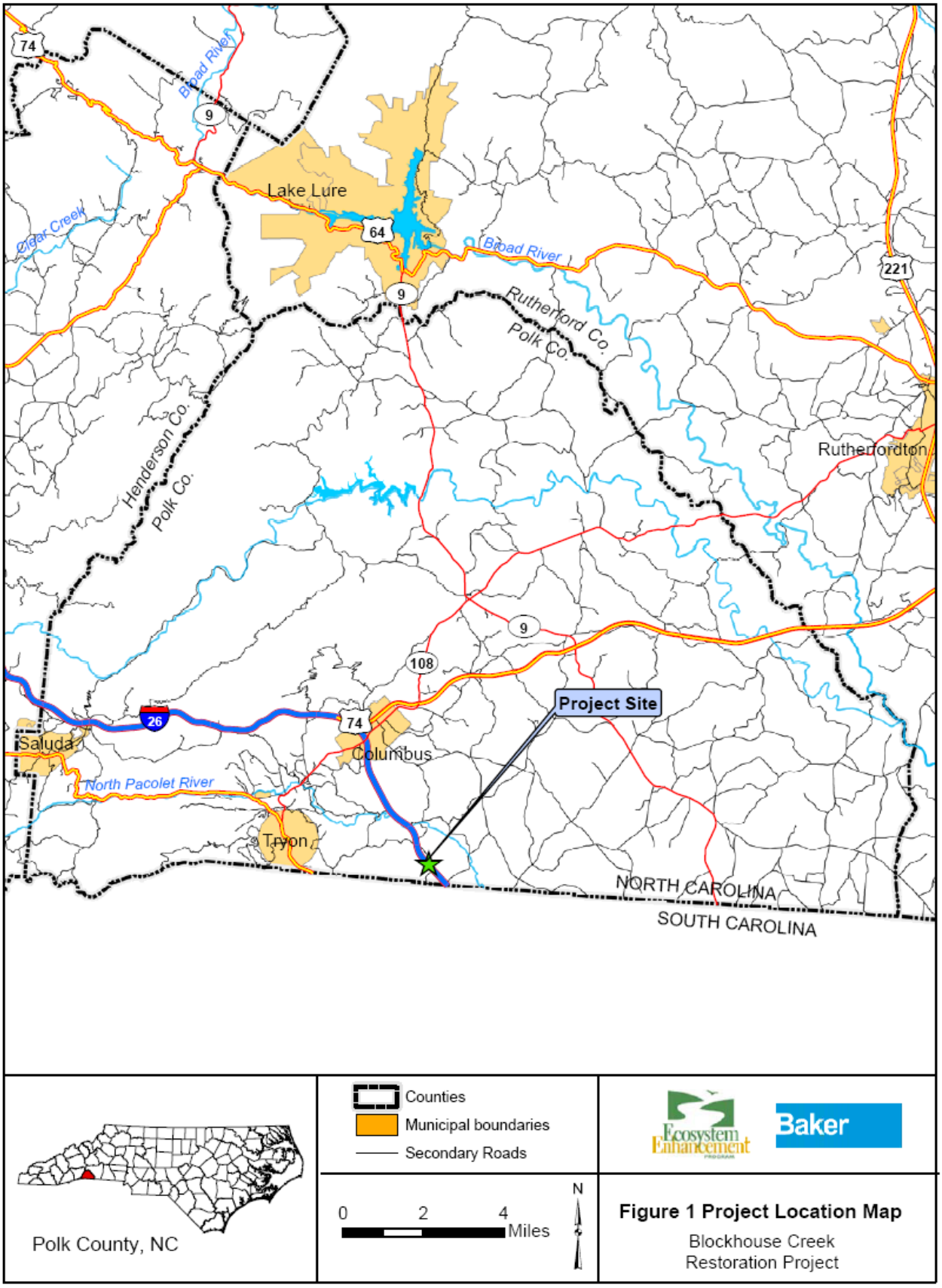
The Blockhouse Creek Restoration site is located within the Foothills Equestrian Nature Center (FENCE), approximately three miles east of Tryon, in Polk County, North Carolina (Figure 1). The project site is situated in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-06 and United States Geologic Survey (USGS) hydrologic unit 03050105150020. Since the late 1980s, the project area has been used as an equestrian/recreational complex. Surrounding lands are currently used for pasture land, hay production and residential use. Prior to the establishment of an equestrian and nature center, the FENCE property was used for agriculture activities and timber production. At that time, riparian buffers were removed and streams were channelized which was a common practice. There is also evidence on some tributaries of ephemeral gullies which most likely resulted from clear cutting. More recent development in the watershed has resulted in additional changes to Blockhouse Creek and its tributaries. Construction of the equestrian facility, nature trails and Interstate 26 has required the installation of bridged and culverted stream crossings that have been detrimental to stream stability. These structures have also impacted the flow pattern and velocity of the project streams, resulting in changes to the cross-sectional area, and often facilitating the deepening of the channel. This deepening of the channel resulted in the streams becoming incised and losing their connection to the adjacent floodplain.

The project involved restoration, enhancement or preservation of 6,305 linear feet (LF) of four on-site streams: Blockhouse Creek and three smaller unnamed tributaries (UTs) identified in the project as UT1, UT2, and UT3. Blockhouse Creek is a “blue-line” stream, as shown on the USGS topographic quadrangle for the site, and is considered to be perennial based on field evaluations using NCDWQ stream assessment protocols. The three tributaries were all identified as perennial during initial project scoping, although UT2 and UT3 have little or no flow during extreme drought conditions as observed during the past two summers.

1.1 Restoration Summary

1.1.1 Project Location

The Blockhouse Creek mitigation site is located on the Foothills Equestrian Nature Center (FENCE) property approximately three miles east of Tryon, in Polk County, North Carolina. From Asheville, take South Carolina Exit #1 from I-26, toward Landrum, S.C. Go 1.5 miles, and turn right onto Bomar Road (look for the Land Mart on the corner). Go one short block and turn right onto Prince Road. After 1.7 miles, turn left onto Hunting Country Road, just before the I-26 bridge. Go .5 mile to the FENCE entrance on the left or another .1 miles (going under I-26) to the second entrance on the right. The Blockhouse Creek site starts at the upper limits of the horse stables accessed through the first entrance. Figure 1 illustrates the physical location of the project site. Figure 2 depicts the project streams, easement boundaries and monitoring reference data.


74
Broad River
9
Lake Lure
Cedar Creek
64
Broad River
221
9
Rutherford Co.
Polk Co.
Henderson Co.
Polk Co.
Rutherfordton
9
108
Project Site
26
74
Saluda
Columbus
North Pacolet River
Tryon
NORTH CAROLINA
SOUTH CAROLINA
Polk County, NC
Counties
Municipal boundaries
Secondary Roads
0
2
4
Miles
N
Ecosystem Enhancement Program
Baker
Figure 1 Project Location Map
Blockhouse Creek
Restoration Project

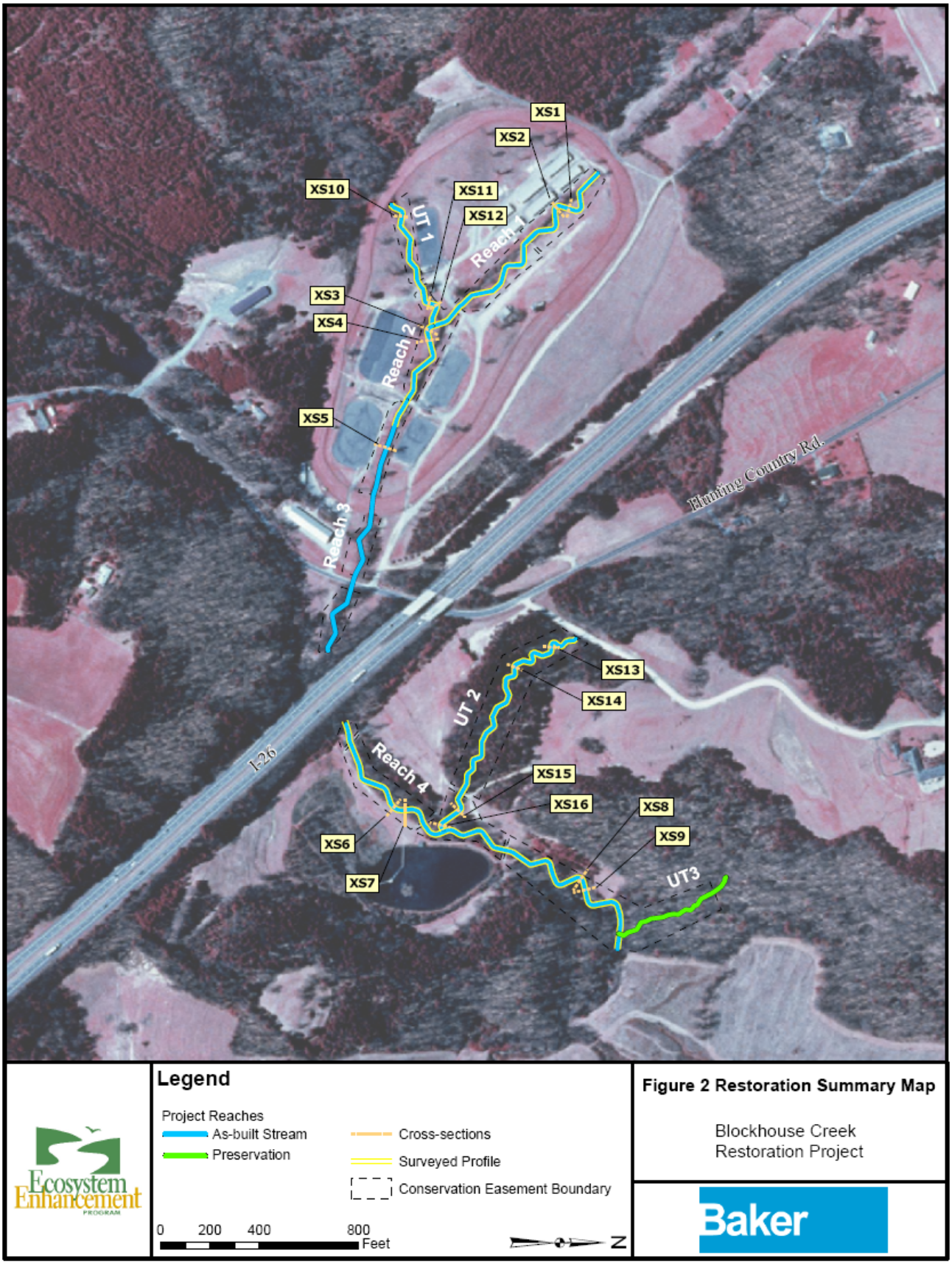


Figure 2 Restoration Summary Map

Blockhouse Creek
Restoration Project

1.1.2 Project Objectives

The specific design objectives of the project included:

- Restoration or enhancement of channel dimension, pattern and profile;
- Improvements to water quality in the Blockhouse Creek watershed through nutrient removal, sediment removal, improved recreational opportunities, streambank stability, and erosion control;
- Improved water quantity/flood attenuation through water storage and flood control, reduction in downstream flooding due to the reconnection of stream and floodplain, improved ground water recharge, and improved and restored hydrologic connections;
- Enhancement of aquatic and terrestrial habitats through improved substrate and instream cover, addition of woody debris, reduction in water temperature due to shading, restoration of terrestrial habitat, increase of spatial extent of natural area, and improved aesthetics.

1.1.3 Project Description and Restoration Approach

Restoration of site hydrology involved the restoration of natural stream functions to impaired reaches on the site. The streams in their historic condition were channelized and, as a result, were highly incised. Because of the extent of the incision, a Rosgen Priority I restoration, which would connect the stream to the abandoned floodplain (terrace), would not have been feasible without extending the project reach several thousand feet upstream and significantly altering the channel profile. However, there was sufficient space in areas within the project boundaries to implement Rosgen Priority II restoration by excavating the floodplain and creating a new meandering channel. With the exception of a small section of UT2, the restored streams were designed as Rosgen "E" channels with design dimensions based on those of reference parameters. The upper project reach on UT2 was designed as an "E" channel while the lower section of the project reach (approximately 200 feet) was designed as a "B" channel. The preserved reach on UT3 was determined to be a "B" channel that transitions to an "E" channel.

The design for restored sections of the streams involved the construction of new, meandering channels across excavated floodplains. This new channel system was constructed through grassed fields. The streams through the site were restored to a stable dimension, pattern, and profile. Total stream length across the project was increased from approximately 6,191 LF to 6,305 LF. The design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing streambank stress. Instream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. Rootwad and log vane structures installed will protect streambanks and promote habitat diversity in pool sections. Constructed riffles were used to promote both hydraulic and habitat heterogeneity to the channel. Where grade control was a design consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

1.1.4 Construction Summary

In accordance with the approved restoration plan for the site, construction activities began in January 2008. Project activity on Blockhouse Creek and UT1 and UT2 consisted of making adjustments to channel dimension, pattern, and profile. A primary design consideration for this project was to allow stream flows larger than bankfull events to spread onto a floodplain, dissipating flow energies and reducing streambank stress. The design for most of the restoration reaches involved a priority II approach with the construction of new, meandering channels across a floodplain that was excavated to the elevation of the creek. The lower part of reach 4 was not incised and did not require this approach. Along this section the overly sinuous channel was realigned in a more stable pattern at the existing elevation. Total stream length across the project increased from approximately 6,191 LF to 6,305 LF.

Access sites and stockpile areas were established at the beginning of site construction. Site stakeout and the harvesting of root wads also began during the beginning stages of construction and occurred throughout the construction phase. Materials were stockpiled as needed for the initial stages of construction.

After stakeout was completed, the floodplain was excavated and graded within discrete work areas of the site to reach design grade. Grading activities commenced at the upstream limits of the project site near the equestrian center and continued downstream below highway Interstate-26 (I-26), through the nature center area. Restoration activities on the project tributaries commenced once construction crews reached each confluence between Blockhouse Creek and the respective tributaries. Excavated material was placed in a field on the property and kept at least 75 feet from any stream. Where necessary, silt fencing was installed to prevent erosion of sediment into the nearest waterbody.

Once the design floodplain elevations were achieved, new stream channel segments were graded and constructed in the dry by pumping stream flows around the construction segment. Upon completion of new channel segments, instream structures, matting and transplants were installed and the new channel was tied to the existing streambed. Once fully prepared, temporary sediment traps at the downstream ends of the channels were removed, and water was directed into the newly constructed channel. Remnant channels were immediately filled and graded. As-built cross sections and longitudinal profiles are shown in Appendix B.

Rootwads, rock and log vanes and other structures were used to protect streambanks and promote habitat diversity in pool sections. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

Modifications made during construction of this project involved the location and selection of instream structures and bank stabilization practices as well as minor adjustments in channel alignment. Structure substitutions were made based on availability of materials and professional judgment. At the upstream project limits on UT2 from Station 0+00 to 4+20, the channel location was adjusted to avoid mature trees in the vicinity of the project. Slight adjustments to the proposed channel alignment were also made during construction along the mainstem of Blockhouse Creek between Stations 7+50 to 9+25. This adjustment was made to take advantage of a highly stable, vegetated section of streambank on Blockhouse Creek. The adjustment also improved the angle of approach of Blockhouse Creek to a bridge crossing. These changes are documented in the attached as-built drawings. Table 2 provides a summation of the as-built lengths and restoration approaches applied within the project site. The final as-built stream length for the restoration and enhancement reaches of the project site was 5,875 LF.

Tables 3 through 6 provide additional information regarding the Blockhouse Creek restoration project.

Table 2. Summary of As-built Lengths, Mitigation Units, and Restoration Approaches

Reach Name	As-built Length (ft)	Existing Length (ft)	SMUs	Restoration Approach
Blockhouse Cr. Reach 1	1070	887	1,070	Priority II Restoration
Blockhouse Cr. Reach 2	340	340	340	Priority II Restoration
Blockhouse Cr. Reach 3	950	950	633	Enhancement Level I
Blockhouse Cr. Reach 4	1780	1,821	1,780	Priority II Restoration
UT 1	580	523	580	Priority II Restoration
UT 2	1155	1,240	1155	Priority II Restoration
UT 3	430	430	86	Preservation
Total Length	**6305**	**6,191**	**5,644***	

*This represents 94 SMUs more than our EEP contract requires.

1.2 Project History, Contacts and Attribute Data

Table 3. Project Restoration Components

Blockhouse Creek Restoration Project

Project Segment or Reach ID	Existing Feet/ Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Blockhouse Cr. Reach 1	887 LF	R	P2	1070 LF	1.0	1,070	0+00-10+70	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 2	340 LF	R	P2	340 LF	1.0	340	10+70-14+14	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 3	950 LF	E	I	950 LF	1.5	633	14+34-25+44	Constraints prevented restoration; bankfull benches established, structures installed, pattern stabilized.
Blockhouse Cr. Reach 4	1,821 LF	R	P2	1,780 LF	1.0	1,780	28+37-46+17	Meandering channel construction; floodplain excavation
UT 1	523 LF	R	P2	580 LF	1.0	580	0+00-5+23	Meandering channel construction; floodplain excavation
UT 2	1,240 LF	R	P2	1,155 LF	1.0	1,155	0+00-12+40	Only incised at lower end, upper 1000 LF realigned to a more stable pattern with only minor floodplain grading

UT 3	430 LF	P	-	430 LF	5.0	86	0+00-4+30	No channel alteration (preservation)

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
5,644	NA	NA	NA	8.6	

Table 4. Project Activity and Reporting History
Blockhouse Creek Restoration Project

Activity or Report	Data Collection Complete	Completion or Delivery
Categorical Exclusion Approved	---	January 2007
Conservation Easement Signed	---	September 2007
Restoration Plan Approved	---	October 2007
Project Permit Approval	---	December 2007/ January 2008
Final Design-90%	---	October 2007
Construction		
`Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	May 2008
Permanent seed mix and riparian vegetation applied to project site		
Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	June 2008
Vegetation Plots , Crest Gauges and Photo Stations Established	July 2008	September 2008
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2008	October 2008
Year 1 Monitoring	July 2009	December 2009
Year 2 Monitoring	July 2010	December 2010
Year 3 Monitoring	July 2011	December 2011
Year 4 Monitoring	July 2012	December 2012
Year 5 Monitoring	July 2013	December 2013

Table 5. Project Contact Table **Blockhouse Creek Restoration Project**	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002

Table 6. Project Background Table **Blockhouse Creek Restoration Project**	
Project County	Polk County, NC
Drainage Area (Square Miles or Acres)	
Blockhouse Creek Reach 1	1.63 mi^2
Blockhouse Creek Reach 2	1.97 mi^2
Blockhouse Creek Reach 3	2.21 mi^2
Blockhouse Creek Reach 4	2.44 mi^2
UT 1	211.2 Ac.
UT 2	57.6 Ac.
UT 3	38.4 Ac.
Drainage impervious cover estimate (%)	<1%
Stream Order	Second Order
Physiographic Region	Piedmont Province. Borders Blue Ridge Escarpment

Ecoregion	Southern Inner Piedmont
Rosgen Classification of As-built	
Blockhouse Creek Reach 1	C4
Blockhouse Creek Reach 2	C4
Blockhouse Creek Reach 3	E4/Bc4
Blockhouse Creek Reach 4	E4
UT 1	C4
UT 2	Bc5 (upper)/Cb (lower)
UT 3	B-E (lower)
Cowardin Classification	Riverine
Dominant Soil Types	
Blockhouse Creek Reach 1	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 2	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 3	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 4	Chewacla Loam, Pacolet Sandy Clay Loam, Rion Sandy Loam
UT 1	Chewacla Loam, Pacolet Sandy Clay Loam
UT 2	Pacolet Sandy Clay Loam,
UT 3	Chewacla Loam, Pacolet Sandy Clay Loam, Hiwassee Clay Loam
Reference Site ID	Reference reach used for upper portion of project area located 350 LF upstream of project. Big Branch, Surry County was also identified in the NCDOT reference reach database as a suitable reference for design ratios
USGS HUC for Project and Reference Sites	Blockhouse Creek HUC#: 03050105 Big Branch HUC#: 03040101
Any portion of project segment(s) on NC 303d List?	No
Any portion of project upstream of a 303d Listed Segment?	No
Reasons for 303d Listing or Stressor	N/A
% of Project Easement Fenced	None of the easement area is presently fenced.

2.0 MONITORING PLAN

The five-year monitoring plan for the Blockhouse Creek restoration project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built drawing sheets. Reference photo points were selected to show cross-sections, structures (i.e. vanes and weirs), and other important channel areas along the restored stream.

2.1 Stream Monitoring and Success Criteria

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration. Monitored stream parameters include bankfull flows, channel dimension (cross-sections), profile (longitudinal survey), changes to bed composition, bank stability assessment, and stability of reference sites documented by photographs. The methods used and any related success criteria are described below for each parameter

2.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Three crest gauges were installed on the floodplain within 10 feet of the restored channels. One crest gauge was placed on UT 2, while 2 gauges were set up on Blockhouse Creek. The first gauge on the main channel was set up on the right bank below the confluence of UT 1 and Blockhouse Creek. The second crest gauge was set up, at the downstream end of the project, just upstream of the confluence of UT3 and Blockhouse Creek on the right bank. The crest gauge on UT2 was placed above the vehicle crossing at the lower end of the tributary. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring may have to be continued until two bankfull events have been documented in separate years.

2.1.2 Cross-Sections

Sixteen permanent cross-sections were installed to help evaluate the success of the restoration project. Cross-sections selected for monitoring were located in representative riffle and pool reaches as well as downstream of the confluences between Blockhouse Creek and UT1 and UT2. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

2.1.3 Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed conditions over time. A longitudinal profile was conducted for the entire project length on UT1 and UT2. An additional 3,396 linear feet of stream channel was surveyed on Blockhouse Creek. Longitudinal profiles will be replicated in years one, three, and five of the monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, inner berm, bankfull, and top of low bank, if the features are present. All measurements will be taken at the head of each feature (e.g., riffle, or pool) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark. Permanent cross-section and longitudinal profile data are provided in Appendix B.

The longitudinal profiles should show that the bed features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain

steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type.

2.1.4 Bed Material Analyses

Bed material analyses will include pebble counts taken during each geomorphic survey. These samples will reveal any changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

Two bulk sediment samples will be processed along the mainstem of Blockhouse Creek. One bulk sediment sample will be collected in a riffle upstream of I-26. The second bulk sample will be collected from a riffle downstream of the interstate in the vicinity of the pond adjacent to the project site. During the monitoring period, if the bulk samples show a coarsening of the bed and gravel becomes a larger component of the bed, then a pebble count will be added above and below I-26. Bedload samples will be taken one year after construction and at two-year intervals thereafter, at the time the longitudinal field surveys are performed. Sediment data will be plotted on a semi-log graph and compared with data from previous years.

2.1.5 Bank Stability Assessments

To aid the NCEEP in evaluating the risk of erosion from changes in channel and bank stability and subsequent sediment yield from the project area, Baker is prepared to assign numeric values to streambank and channel features. This will occur during Year 5 of the monitoring period. These numeric scores will be derived using the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) evaluation methods. The scores will then be used to evaluate channel stability and project sediment export. Results from a visual stability assessment are provided in Table 7.

Table 7. Categorical Stream Feature Visual Stability Assessment
Blockhouse Creek Restoration Project

Features	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Stability	100%					
G. Vanes	100%					
H. Rootwads, Boulders, Geolifts	100%					

2.1.6 Photo Reference Sites

Photographs will be used to document restoration success qualitatively. Reference stations will be photographed during the as-built survey and for five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) are utilized during each monitoring period. Reference photographs are shown in Appendix A.

2.1.6.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will

be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.6.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored stream are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2 Vegetation Monitoring

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, 10 vegetation monitoring quadrants were installed across the restoration site as required by the NCEEP. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between May and July.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

2.3 Maintenance and Contingency Plans

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed

- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in future monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP approval will be obtained prior to any remedial action.

2.4 Monitoring Results – 2008 As-Built Data

The five-year monitoring plan for the Blockhouse Creek Site includes criteria to evaluate the success of the vegetative and geomorphic components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built sheets. Photo points, located along the stream restoration project, are also shown.

2.4.1 Morphology

For monitoring stream success criteria, 16 permanent cross-sections and 3 crest gauges were installed. The permanent cross-sections will be used to monitor channel dimension over time. The crest gauges will be used to document the occurrence of bankfull events. In addition, a complete longitudinal survey was completed for the restored stream channels to provide a base-line for evaluating changes in bed conditions over time. The permanent cross-section and longitudinal data are provided in Appendix B. The location of the permanent cross-sections and the crest gauges are shown on the as-built plan sheets in Appendix C.

2.4.1.1 Results and Discussion

No results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2009.

2.4.2 Vegetation

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stake, bare root trees, and live brush in the geolift structures have also begun to grow and are providing streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A 30-foot buffer was established along of the majority of the restored stream and the width exceeds this minimum in most places. However at crossings the easement “pinches” in to meet the crossing structure and along one section of Reach 3 the easement on the left bank is less than 30 feet due to existing constraints; however, the total width is greater than 60 feet. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in May 2008. Species planted and as-built densities are summarized in Table 8.

Table 8. Rooted trees, live stakes and seeding planted in the riparian zone of Blockhouse Creek. The species composition for two different areas is shown; with one area being upstream of I-26 and the second area being downstream of I-26.		
Planting Plan		
Scientific name	**Common name**	**Percent Planted by Species**
Blockhouse Creek upstream of I-26 and UT1 (40% trees/ 60% shrubs) planted at 680 stems/A		
Trees - Planted 13'x13'		
Acer rubrum	Red maple	13
Fraxinus pennsylvanica	Green ash	13
Juglans nigra	Black walnut	13
Liriodendron tulipfera	Tulip poplar	0.5
Platanus occidentalis	Sycamore	0.5
Understory Trees/Shrubs- Planted 10'x10'		
Alnus serrulata	Tag alder	9
Calicanthus floridus	Sweet Shrub	10
Cornus florida	Flowering dogwood	12
Cercis canadensis	Redbud	10
Carpinus caroliniana	Ironwood	9
Asimina triloba	Paw paw	9
Blockhouse Creek downstream of I-26 and UT2 (60% Trees/ 40% shrubs) planted at 680 stems/A		
Trees - Planted 10'x10'		
Acer rubrum	Red maple	4
Diospyros virginiana	Persimmon	6
Juglans nigra	Black walnut	12
Liriodendron tulipfera	Tulip poplar	10
Platanus occidentalis	Sycamore	10
Prunus serotina	Black Cherry	6
Quercus phellos	Willow oak	6
Quercus rubra	Red oak	6
Understory Trees/Shrubs- Planted 13'x13'		
Alnus serrulata	Tag alder	6
Calicanthus floridus	Sweet Shrub	6
Cornus florida	Flowering dogwood	9
Cercis canadensis	Redbud	8
Carpinus caroliniana	Ironwood	6
Asimina triloba	Paw paw	5
Woody Vegetation for Live Stakes - Planted 3’ x 3’ on center		
Salix sericea	Silky willow	30
Physocarpus opulifolius	Ninebark	25
Sambucus canadensis	Elderberry	15
Cornus amomum	Silky Dogwood	30
Note: Species selection may change due to availability at the time of planting.		

The restoration plan for the Blockhouse Creek Site specifies that the number of quadrants required were based on the species/area curve method, as described in NCEEP monitoring guidance documents, with a minimum of three quadrants. The size of individual quadrants are 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of ten vegetation plots, each 10 by 10 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 9. The average density of planted bare root stems, based on the data from the ten monitoring plots, is 764 stems per acre. The locations of the vegetation plots are shown on the as-built plan sheets.

2.4.2.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

Table 9. CVS Level 1 Stem Count Arranged by Plot (As-Built)
Blockhouse Creek Restoration Site

Tree Species	Plots										As-built Totals	Year 1 Totals	Year 3 Totals	Year 5 Totals	Site Average Stems/acre
	1	2	3	4	5	6	7	8	9	10					
Betula nigra		1		1	5		2			5	14				
Acer rubrum	3	5		2							10				
Fraxinus pennsylvanica	2	3			4	8	2		4	3	26				
Juglans nigra	3	2		1			1	8			15				
Platanus occidentalis	3	4	7	10	4		3	3	10		44				
Liriodendron tulipfera			2			1		5		7	15				
Quercus phellos					1		1	7			9				
Quercus rubra			4	2	2	3		3			14				
Diospyros virginiana				1	5	8	2				16				
Shrub Species															
Alnus serrulata	1	1									2				
Calicanthus floridus	2	1	4	2							9				
Halesia carolina				3							3				
Cercis canadensis	2	1	2								5				
Asimina triloba					1	1					2				
Cornus florida	1	1									2				
Cornus amomum							1	3		1	5				
Stems/plot	17	19	19	22	22	21	12	29	14	16					
Stems/acre As-built	680	760	760	880	880	840	480	1160	560	640					764

2.5 Areas of Concern

There are two factors of concern at this project site. Neither have to do with specific sites on the channel. The first concern is the rate of overland flow that the site experiences above Interstate 26. Due to the buildings on this site and the high compaction of the soil from heavy use by horse show participants, the runoff from the land adjoining the stream is high. This has not affected the channel proper but is the source of some minor rutting along terrace slopes leading down to the floodplain. Baker is working with FENCE to seek grant funding to address this issue. The second concern is that two of the three box culverts under Interstate 26 are two thirds full of sand. During any high flow event this sand mobilizes into the channel downstream of the interstate. This is causing some pools to fill with sand and the loss of pool depth. The channel is moving this material and it will eventually correct the problem but it will affect the lower end of the project of the next several years. NCDOT has been contacted about this issue but they do not appear interested in addressing it.

The project area has received little precipitation in the time since ground cover and woody vegetation was planted in the riparian buffers. Considering the drought conditions that have persisted in the region where the project site is located, vegetation survival has been excellent. Mortality rates for woody vegetation planted appear to be low though some sections of the project have experienced higher rates of mortality as evidenced by the vegetative plot data listed in Table 9. Early observations indicate that the vegetation treatments have been effective at establishing herbaceous ground cover in the majority of the project site. Areas of sparser vegetation will be replanted if suitable cover is not found to be established during Year 1 monitoring.

Beyond these issues no areas of concern have been identified during the first months following completion of the project.

APPENDIX A

SELECTED PROJECT PHOTOGRAPHS

Blockhouse Creek Restoration Project
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 3: facing downstream

Photo Point 4: facing downstream

Photo Point 5: facing downstream

Photo Point 6: facing downstream

Photo Point 7: facing downstream

Photo Point 8: facing downstream

Photo Point 9: facing downstream

Photo Point 10: facing downstream

Photo Point 11: facing downstream

Photo Point 12: facing downstream

Photo Point 13: facing downstream

Photo Point 14: facing downstream

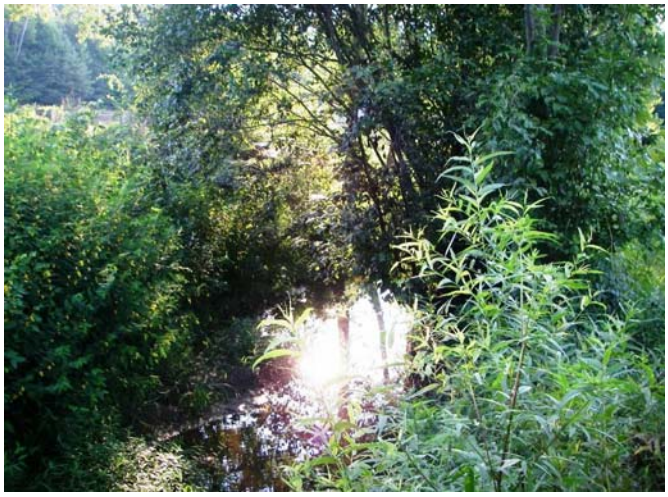


Photo Point 15: facing downstream

Photo Point 16: facing downstream

Photo Point 17: facing downstream

Photo Point 18: facing upstream

Photo Point 18: facing downstream

Photo Point 19: facing downstream

Photo Point 20: facing upstream

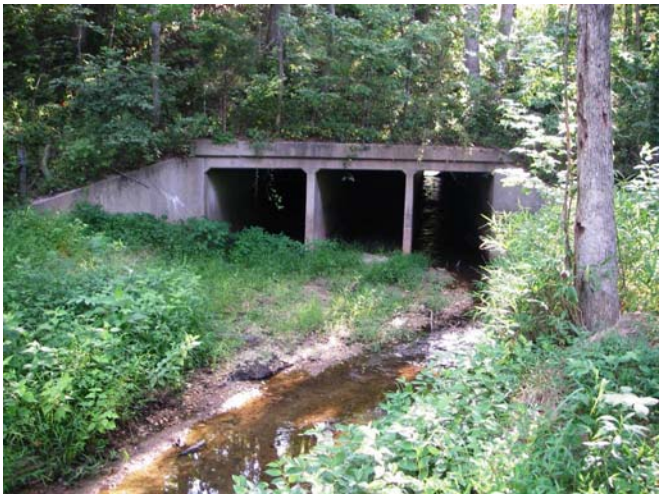


Photo Point 20: facing downstream

Photo Point 21: facing upstream

Photo Point 21: facing downstream

Photo Point 22: facing upstream

Photo Point 22: facing downstream

Photo Point 23: facing upstream

Photo Point 23: facing downstream

Photo Point 24: facing downstream

Photo Point 25: facing upstream

Photo Point 25: facing downstream

Photo Point 26: facing upstream

Photo Point 26: facing downstream

Photo Point 27: facing downstream

Photo Point 28: facing upstream

Photo Point 28: facing downstream

Photo Point 29: facing downstream

Photo Point 30: facing downstream

Photo Point 31: facing downstream

Photo Point 32: facing upstream

Photo Point 32: facing downstream

Blockhouse Creek Restoration Project: UT1
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 3: facing downstream

Photo Point 4: facing downstream

Photo Point 5: facing upstream

Photo Point 5: facing downstream

Photo Point 6: facing upstream

Photo Point 6: facing downstream

Blockhouse Creek Restoration Project: UT2
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing downstream

Photo Point 3: facing downstream

Photo Point 4: facing upstream

Photo Point 4: facing downstream

Photo Point 5: facingn downstream

Photo Point 6: facing upstream

Photo Point 6: facing downstream

Photo Point 7: facing upstream

Photo Point7: facing downstream

Photo Point 8: facing upstream

Photo Point 8: facing downstream

Photo Point 9: facing upstream

Photo Point 9: facing downstream

Photo Point 10: facing upstream

Photo Point: facing downstream

Photo Point 11: facing downstream

Blockhouse Creek Restoration Project: UT3
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 4: facing downstream

Photo Point 5: facing downstream

Photo Point 6: facing upstream

Photo Point 7: facing upstream

Photo Point 8: facing upstream

Photo Point 9: facing downstream

Blockhouse Creek Restoration Project
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

7/8/2009

Photo Point 1: Veg Plot 1

7/8/2009

Photo Point 2: Veg Plot 2

7/8/2009

Photo Point 3: Veg Plot 3

7/8/2009

Photo Point 4: Veg Plot 4

7/8/2009

Photo Point 5: Veg Plot 5

7/8/2009

Photo Point 6: Veg Plot 6

7/8/2009

Photo Point 7: Veg Plot 7

7/8/2009

Photo Point 8: Veg Plot 8

7/8/2009

Photo Point 9: Veg Plot 9

7/8/2009

Photo Point 10: Veg Plot 10

APPENDIX B

AS-BUILT CROSS-SECTIONS AND LONGITUDINAL PROFILES

Morphology and Hydraulic Monitoring Summary - As-Built Monitoring

Blockhouse Creek Restoration Project

	Blockhouse Creek Reach 1 (1,070 ft)												**Blockhouse Creek Reach 2 (340ft)**											
Parameter	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Pool						Cross Section 4 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	21.69						23.48						23.01						22.57					
Floodprone Width (ft)	>54						>54						>48						>57					
BF Cross Sectional Area (ft2)	29.00						30.80						34.20						34.90					
BF Mean Depth (ft)	1.34						1.31						1.49						1.54					
BF Max Depth (ft)	2.29						2.81						3.45						2.92					
Width/Depth Ratio	16.20						17.89						15.49						14.62					
Entrenchment Ratio	2.50						2.30						2.10						2.50					
Wetted Perimeter (ft)	24.37						26.10						25.99						25.65					
Hydraulic Radius (ft)	1.19						1.18						1.32						1.36					
Substrate																								
d50 (mm)	10.75						----						----						----					
d84 (mm)	22.60						----						----						----					

	Blockhouse Creek Reach 3 (950ft)						**Blockhouse Creek Reach 4 (1,780 ft)**																	
Parameter	Cross Section 5 Riffle						Cross Section 6 Pool						Cross Section 7 Riffle						Cross Section 8 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	21.50						24.40						19.62						18.35					
Floodprone Width (ft)	>44						>36						>53						>61					
BF Cross Sectional Area (ft2)	33.00						35.40						34.80						35.80					
BF Mean Depth (ft)	1.54						1.45						1.77						1.95					
BF Max Depth (ft)	3.20						2.88						3.15						4.50					
Width/Depth Ratio	13.99						16.83						11.08						9.41					
Entrenchment Ratio	2.10						1.50						2.70						3.30					
Wetted Perimeter (ft)	24.58						27.30						23.16						22.25					
Hydraulic Radius (ft)	1.34						1.30						1.50						1.61					

	Blockhouse Creek Reach 4 (1,780 ft)					
Parameter	Cross Section 9 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5
Dimension						
BF Width (ft)	19.01					
Floodprone Width (ft)	>59					
BF Cross Sectional Area (ft2)	35.10					
BF Mean Depth (ft)	1.84					
BF Max Depth (ft)	2.98					
Width/Depth Ratio	10.30					
Entrenchment Ratio	3.10					
Wetted Perimeter (ft)	22.69					
Hydraulic Radius (ft)	1.55					
Substrate						
d50 (mm)	2.24					
d84 (mm)	26.23					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	55.00	144.00	99.50															
Radius of Curvature (ft)	15.50	36.00	25.75															
Meander Wavelength (ft)	109.00	216.00	162.50															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	15.00	80.00	47.50															
Riffle Slope (ft/ft)	0.00	0.04	0.02															
Pool Length (ft)	10.00	25.00	17.50															
Pool Spacing (ft)	30.00	122.00	76.00															
Substrate																		
d50 (mm)	2.24	10.75	6.50															
d84 (mm)	22.60	26.23	24.42															
Additional Reach Parameters																		
Valley Length (ft)	2939.00																	
Channel Length (ft)	4140.00																	
Sinuosity	1.12	1.19	1.16															
Water Surface Slope (ft/ft)	0.00	0.01	0.01															
BF Slope (ft/ft)	0.00	0.02	0.01															
Rosgen Classification	C4/Bc4/E4																	

UT1 Reach (580 ft)																		
Parameter	Cross Section 10 Riffle						Cross Section 11 Riffle						Cross Section 12 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	12.43						11.42						12.95					
Floodprone Width (ft)	>39						>41						>30					
BF Cross Sectional Area (ft2)	10.70						10.30						10.40					
BF Mean Depth (ft)	0.86						0.90						0.80					
BF Max Depth (ft)	1.76						1.66						1.58					
Width/Depth Ratio	14.48						12.66						16.16					
Entrenchment Ratio	3.10						3.60						2.30					
Wetted Perimeter (ft)	14.15						13.22						14.55					
Hydraulic Radius (ft)	0.76						0.78						0.71					
Substrate																		
d50 (mm)	----						----						----					
d84 (mm)	----						----						----					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	35.00	80.00	57.50															
Radius of Curvature (ft)	10.00	20.00	15.00															
Meander Wavelength (ft)	70.00	120.00	95.00															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	19.00	74.00	46.50															
Riffle Slope (ft/ft)	0.03	0.04	0.03															
Pool Length (ft)	7.00	15.00	11.00															
Pool Spacing (ft)	13.00	60.00	36.50															
Substrate																		
d50 (mm)	----	----	16.00															
d84 (mm)	----	----	26.89															
Additional Reach Parameters																		
Valley Length (ft)	525.00																	
Channel Length (ft)	580.00																	
Sinuosity	1.12	1.13	1.12															
Water Surface Slope (ft/ft)	----	----	0.02															
BF Slope (ft/ft)	----	----	0.02															
Rosgen Classification	C4																	

UT2 Reach (1,155 ft)																								
Parameter	Cross Section 13 Riffle						Cross Section 14 Pool						Cross Section 15 Riffle						Cross Section 16 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	10.93						6.21						8.55						6.87					
Floodprone Width (ft)	>24						>21						>29						>27					
BF Cross Sectional Area (ft2)	4.90						4.50						5.20						4.90					
BF Mean Depth (ft)	0.45						0.72						0.61						0.71					
BF Max Depth (ft)	1.07						1.24						1.00						1.05					
Width/Depth Ratio	24.52						8.59						14.00						9.63					
Entrenchment Ratio	2.20						3.40						3.40						3.90					
Wetted Perimeter (ft)	11.83						7.65						9.77						8.29					
Hydraulic Radius (ft)	0.41						0.59						0.53						0.59					
Substrate																								
d50 (mm)	----						----						----						----					
d84 (mm)	----						----						----						----					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	25.00	56.00	40.50															
Radius of Curvature (ft)	7.00	14.00	10.50															
Meander Wavelength (ft)	49.00	84.00	66.50															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	5.00	41.00	23.00															
Riffle Slope (ft/ft)	0.03	0.05	0.04															
Pool Length (ft)	3.00	15.00	9.00															
Pool Spacing (ft)	12.00	38.00	25.00															
Substrate																		
d50 (mm)	0.73	1.23	0.98															
d84 (mm)	1.90	4.47	3.19															
Additional Reach Parameters																		
Valley Length (ft)	946.00																	
Channel Length (ft)	1155.00																	
Sinuosity	1.14	1.28	1.21															
Water Surface Slope (ft/ft)	0.01	0.03	0.02															
BF Slope (ft/ft)	0.02	0.03	0.02															
Rosgen Classification	Bc5/Cb/E4																	

Baseline Stream Summary
Blockhouse Creek: Reach 1

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	16.48	-----	16.92	-----	18.50	20.00	21.50	18.50	20.00	21.50	21.69	22.59	23.48
Floodprone Width (ft)	-----	-----	33.00	-----	-----	-----	-----	-----	70+	-----	53.90	54.05	54.20
Bankfull Mean Depth (ft)	1.82	-----	1.80	-----	1.80	2.30	2.80	-----	1.9	-----	1.31	1.33	1.34
Bankfull Max Depth (ft)	-----	-----	3.00	-----	2.50	3.30	4.10	-----	2.5	-----	2.29	2.55	2.80
Bankfull Cross Sectional Area (ft2)	29.88	-----	30.60	-----	39.60	47.05	54.50	-----	29.4	-----	29.00	29.90	30.80
Width/Depth Ratio	-----	-----	9.40	-----	9.19	10.57	11.94	-----	8.2	-----	16.20	17.05	17.89
Entrenchment Ratio	-----	-----	1.90	-----	6.05	6.40	6.74	-----	>2.2	-----	2.30	2.40	2.50
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.05	-----	0.90	1.25	1.60
Bankfull Velocity (fps)	-----	-----	2.94	-----	3.50	4.25	5.00	-----	3.06	-----	3.10	3.01	2.92
Pattern													
Channel Beltwidth (ft)	-----	6.31	10.16	14.00	30.50	37.25	44.00	55.00	89.50	124.00	59.00	80.50	102.00
Radius of Curvature (ft)	-----	-----	----	-----	42.30	52.70	63.10	16.00	23.50	31.00	15.50	23.25	31.00
Meander Wavelength (ft)	-----	-----	----	-----	185.00	222.50	260.00	109.00	147.50	186.00	108.50	150.15	191.80
Meander Width Ratio	-----	-----	0.60	-----	1.50	1.83	2.16	2.97	4.37	5.77	2.72	3.53	4.34
Profile													
Riffle Length (ft)	-----	-----	----	-----	-----	-----	-----	25.00	70.00	115.00	18.76	36.50	73.00
Riffle Slope (ft/ft)	-----	-----	----	-----	0.0150	0.0170	0.0190	0.0081	0.00	0.0011	0.0030	0.0085	0.0140
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	8.00	21.50	35.00	13.00	17.0000	21.00
Pool Spacing (ft)	-----	-----	----	-----	97.50	138.65	179.80	62.00	85.50	109.00	65.00	77.50	90.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	0.3 / 0.58 /1.0/5.7/12.4			----			0.3 / 0.58 /1.0/5.7/12.4			NA/5.01/10.75/22.6/31.09		
Reach Shear Stress (competency) lb/f2	-----	-----	0.38	-----	-----	-----	-----	-----	0.33	-----	-----	0.32	-----
Stream Power (transport capacity) W/m2	-----	-----	1.13	-----	-----	-----	-----	-----	1.02	-----	-----	0.96	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	887.00	-----	-----	330.00	-----	-----	1070.00	-----	-----	1070.00	-----
Drainage Area (SM)	-----	-----	1.63	-----	0.20	1.90	2.30	-----	1.63	-----	-----	1.63	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4	-----
Bankfull Discharge (cfs)	126.72	-----	90.00	-----	-----	----	-----	-----	90.00	-----	-----	90.00	-----
Sinuosity	-----	-----	1.01	-----	-----	1.10	-----	-----	1.10	-----	-----	1.18	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0067	-----	-----	0.0054	-----

Baseline Stream Summary
Blockhouse Creek: Reach 2

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	17.71	----	25.6	----	18.50	20.00	21.50	18.50	20.00	21.50	22.57	22.79	23.01
Floodprone Width (ft)	-----	----	37.5	----	----	----	----	-----	70+	-----	47.70	52.50	57.30
Bankfull Mean Depth (ft)	1.92	----	1.94	----	1.80	2.30	2.80	-----	2.25	-----	1.49	1.52	1.54
Bankfull Max Depth (ft)	-----	----	3.3	----	2.50	3.30	4.10	-----	3.00	-----	2.92	3.19	3.45
Bankfull Cross Sectional Area (ft2)	33.98	----	49.7	----	39.60	47.05	54.50	-----	35.6	-----	34.20	34.55	34.90
Width/Depth Ratio	-----	----	13.2	----	9.19	10.57	11.94	-----	8.00	-----	14.62	15.06	15.49
Entrenchment Ratio	-----	----	1.5	----	6.05	6.40	6.74	-----	>2.2	-----	2.10	2.30	2.50
Bank Height Ratio	-----	----	2.0	----	1.00	1.05	1.10	-----	1.00	-----	0.90	0.90	0.90
Bankfull Velocity (fps)	-----	----	2.41	----	3.50	4.25	5.00	-----	3.37	-----	3.51	3.47	3.44
Pattern													
Channel Beltwidth (ft)	-----	5.09	8.70	12.30	30.50	37.25	44.00	63.00	103.50	144.00	57.30	78.70	100.10
Radius of Curvature (ft)	-----	----	----	----	42.30	52.70	63.10	18.00	27.00	36.00	30.79	34.06	37.32
Meander Wavelength (ft)	-----	----	----	----	185.00	63.60	260.00	126.00	171.00	216.00	145.67	165.94	186.21
Meander Width Ratio	-----	----	0.34	----	1.50	1.83	2.16	3.41	5.05	6.70	2.54	3.47	4.39
Profile													
Riffle Length (ft)	-----	----	----	----	-----	-----	-----	25.00	55.00	85.00	35.00	55.50	76.00
Riffle Slope (ft/ft)	-----	----	----	----	0.0150	0.0170	0.0190	0.0081	0.0046	0.0011	0.0109	0.02	0.0350
Pool Length (ft)	-----	----	----	----	-----	-----	-----	8.00	21.5000	35.00	15.00	20.00	25.00
Pool Spacing (ft)	-----	----	----	----	97.50	138.65	179.80	72.00	99.00	126.00	58.00	89.00	120.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.87/2.99/7.6/19/21.8			-----			.87/2.99/7.6/19/21.8			NA/5.01/10.75/22.6/31.09		
Reach Shear Stress (competency) lb/f2	-----	-----	0.45	-----	-----	-----	-----	-----	0.54	-----	-----	0.50	-----
Stream Power (transport capacity) W/m2	-----	-----	1.09	-----	-----	-----	-----	-----	1.83	-----	-----	1.74	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	340.00	-----	-----	330.00	-----	-----	340.00	-----	-----	340.00	-----
Drainage Area (SM)	-----	-----	1.97	-----	0.20	1.90	2.30	-----	1.97	-----	-----	1.97	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	C4	-----
Bankfull Discharge (cfs)	145.30	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.02	-----	-----	1.10	----	-----	1.10	-----	-----	0.38	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0121	-----	-----	0.0183	-----

Baseline Stream Summary
Blockhouse Creek: Reach 3

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	18.50	----	21.2	----	18.50	20.00	21.50	18.50	20.00	21.50	----	21.50	----
Floodprone Width (ft)	-----	----	>150	----	----	----	----	-----	45+	-----	----	44.20	----
Bankfull Mean Depth (ft)	1.99	----	2.31	----	1.80	2.30	2.80	-----	2.25	-----	----	1.54	----
Bankfull Max Depth (ft)	-----	----	3.3	----	2.50	3.30	4.10	-----	3.00	-----	----	3.20	----
Bankfull Cross Sectional Area (ft2)	36.75	----	49.1	----	39.60	47.05	54.50	-----	35.6	-----	----	33.00	----
Width/Depth Ratio	-----	----	9.2	----	9.19	10.57	11.94	-----	8.00	-----	----	13.99	----
Entrenchment Ratio	-----	----	>7	----	6.05	6.40	6.74	-----	>2.2	-----	----	2.10	----
Bank Height Ratio	-----	----	1.1	----	1.00	1.05	1.10	-----	1.00	-----	----	0.80	----
Bankfull Velocity (fps)	-----	----	2.44	----	3.50	4.25	5.00	-----	3.37	-----	-----	3.64	-----
Pattern													
Channel Beltwidth (ft)	-----	8.69	33.02	57.34	30.50	37.25	44.00	63.00	103.50	144.00	54.70	60.85	67.00
Radius of Curvature (ft)	-----	----	----	----	42.30	52.70	63.10	18.00	27.00	36.00	26.49	34.25	42.00
Meander Wavelength (ft)	-----	----	----	----	185.00	63.60	260.00	126.00	171.00	216.00	125.06	160.07	195.07
Meander Width Ratio	-----	----	1.56	----	1.50	1.83	2.16	3.15	5.18	7.20	2.54	2.83	3.12
Profile													
Riffle Length (ft)	-----	----	----	----	-----	-----	-----	25.00	60.00	95.00	35.00	52.50	70.00
Riffle Slope (ft/ft)	-----	----	----	----	0.0150	0.0170	0.0190	0.0038	0.00	0.0038	0.0120	0.03	0.0420
Pool Length (ft)	-----	----	----	----	-----	-----	-----	10.00	22.50	35.00	10.00	17.00	24.00
Pool Spacing (ft)	-----	----	----	----	97.50	138.65	179.80	72.00	99.00	126.00	30.00	76.00	122.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.5/2.12/6.1/18.1/21.1			-----			.5/2.12/6.1/18.1/21.1			NA/.31/2.24/26.23/55.59		
Reach Shear Stress (competency) lb/f2	-----	-----	0.54	-----	-----	-----	-----	-----	0.50	-----	-----	0.50	-----
Stream Power (transport capacity) W/m2	-----	-----	1.33	-----	-----	-----	-----	-----	1.69	-----	-----	1.82	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	950.00	-----	-----	330.00	-----	-----	950.00	-----	-----	950.00	-----
Drainage Area (SM)	-----	-----	2.21	-----	0.20	1.90	2.30	-----	2.21	-----	-----	2.21	-----
Rosgen Classification	-----	-----	C4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4/Bc4	-----
Bankfull Discharge (cfs)	157.88	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.06	-----	-----	1.10	----	-----	1.10	-----	-----	1.03	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0004	-----	-----	0.0032	-----

Baseline Stream Summary
Blockhouse Creek: Reach 4

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	19.21	18.2	18.85	19.5	18.50	20.00	21.50	18.50	20.00	21.50	18.35	20.35	24.40
Floodprone Width (ft)	-----	23.2	41.60	60	----	----	----	----	50+	-----	36.00	44.40	61.30
Bankfull Mean Depth (ft)	2.05	1.83	1.92	2.0	1.80	2.30	2.80	-----	2.25	-----	1.45	1.75	1.95
Bankfull Max Depth (ft)	-----	3.0	3.10	3.2	2.50	3.30	4.10	-----	3.00	-----	2.98	3.38	4.50
Bankfull Cross Sectional Area (ft2)	39.30	35.6	35.95	36.3	39.60	47.05	54.50	-----	35.6	-----	34.80	35.28	35.80
Width/Depth Ratio	-----	9.1	9.90	10.7	9.19	10.57	11.94	-----	8.00	-----	9.41	11.91	16.83
Entrenchment Ratio	-----	1.3	2.15	3	6.05	6.40	6.74	-----	>2.2	-----	1.50	2.65	3.30
Bank Height Ratio	-----	1.7	2.80	3.9	1.00	1.05	1.10	-----	1.00	-----	1.10	1.15	1.20
Bankfull Velocity (fps)	-----	-----	3.34	-----	3.50	4.25	5.00	-----	3.37	-----	3.45	3.40	3.35
Pattern													
Channel Beltwidth (ft)	-----	5.47	44.56	83.65	30.50	37.25	44.00	63.00	103.50	144.00	47.00	72.80	98.60
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	18.00	27.00	36.00	16.00	24.90	33.80
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	63.60	260.00	126.00	171.00	216.00	81.40	106.20	131.00
Meander Width Ratio	-----	-----	2.36	-----	1.50	1.83	2.16	3.15	5.18	7.20	2.31	3.58	4.85
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	25.00	65.00	105.00	27.00	53.50	80.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0075	0.01	0.0100	0.0110	0.01	0.0160
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	10.00	22.50	35.00	10.00	15.50	21.00
Pool Spacing (ft)	-----	-----	-----	-----	97.50	138.65	179.80	72.00	99.00	126.00	12.00	63.00	114.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.3/.58/1.0/5.7/12.4			-----			.3/.58/1.0/5.7/12.4			NA/.31/2.24/26.23/55.59		
Reach Shear Stress (competency) lb/f2	-----	-----	0.49	-----	-----	-----	-----	-----	0.54	-----	-----	0.56	-----
Stream Power (transport capacity) W/m2	-----	-----	1.64	-----	-----	-----	-----	-----	1.83	-----	-----	1.90	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	1821.00	-----	-----	330.00	-----	-----	1780.00	-----	-----	1780.00	-----
Drainage Area (SM)	-----	-----	2.44	-----	0.20	1.90	2.30	-----	2.44	-----	-----	2.44	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4	-----
Bankfull Discharge (cfs)	169.59	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.29	-----	-----	1.10	----	-----	1.10	-----	-----	1.19	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0047	-----	-----	0.0043	-----

Baseline Stream Summary
UT1

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	8.98	----	9.3	-----	18.50	20.00	21.50	-----	10.00	-----	11.42	12.27	12.95
Floodprone Width (ft)	-----	----	23.6	-----	----	----	----	30+	32.5+	35+	29.50	39.75	40.60
Bankfull Mean Depth (ft)	1.13	-----	.91	-----	1.80	2.30	2.80	-----	1.05	-----	0.80	0.85	0.90
Bankfull Max Depth (ft)	-----	-----	1.5	-----	2.50	3.30	4.10	-----	1.50	-----	1.58	1.67	1.76
Bankfull Cross Sectional Area (ft2)	10.08	-----	8.4	-----	39.60	47.05	54.50	-----	10.50	-----	10.30	10.47	10.70
Width/Depth Ratio	-----	-----	10.2	-----	9.19	10.57	11.94	-----	9.50	-----	12.66	14.43	16.16
Entrenchment Ratio	-----	-----	2.6	-----	6.05	6.40	6.74	-----	>2.2	-----	2.30	3.00	3.60
Bank Height Ratio	-----	-----	3.2	-----	1.00	1.05	1.10	-----	1.00	-----	0.90	0.97	1.00
Bankfull Velocity (fps)	-----	-----	3.57	-----	3.50	4.25	5.00	-----	2.86	-----	2.91	2.87	2.80
Pattern													
Channel Beltwidth (ft)	-----	5.30	9.47	13.63	30.50	37.25	44.00	35.00	57.50	80.00	22.60	33.64	44.68
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	10.00	15.00	20.00	10.78	15.20	19.62
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	63.60	260.00	70.00	95.00	120.00	32.86	38.77	44.68
Meander Width Ratio	-----	-----	1.02	-----	1.50	1.83	2.16	3.50	5.75	8.00	1.98	2.74	3.45
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	25.00	50.00	75.00	19.00	46.50	74.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0200	0.02	0.0270	0.0250	0.03	0.0370
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	8.00	14.00	20.00	7.00	11.00	15.00
Pool Spacing (ft)	-----	-----	-----	-----	97.50	138.65	179.80	40.00	55.00	70.00	13.00	36.50	60.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	9.68/13.27/16.00/25.97/31.45			----			9.68/13.27/16.00/25.97/31.45			1.68/11.71/16/26.89/34.85		
Reach Shear Stress (competency) lb/f2	-----	-----	0.94	-----	-----	-----	-----	-----	0.92	-----	-----	0.80	-----
Stream Power (transport capacity) lb/ft2	-----	-----	3.37	-----	-----	-----	-----	-----	2.62	-----	-----	3.40	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	523.00	-----	-----	330.00	-----	-----	580.00	-----	-----	580.00	-----
Drainage Area (SM)	-----	-----	0.33	-----	0.20	1.90	2.30	-----	0.33	-----	-----	0.33	-----
Rosgen Classification	-----	-----	E4	-----	-----	-----	-----	-----	E4	-----	-----	C4	-----
Bankfull Discharge (cfs)	39.98	-----	30.00	-----	----	----	----	----	30.00	----	-----	30.00	-----
Sinuosity	-----	-----	1.05	-----	-----	1.10	----	1.15	1.10	1.18	-----	1.12	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0142	-----	-----	0.0176	-----

Baseline Stream Summary
UT2

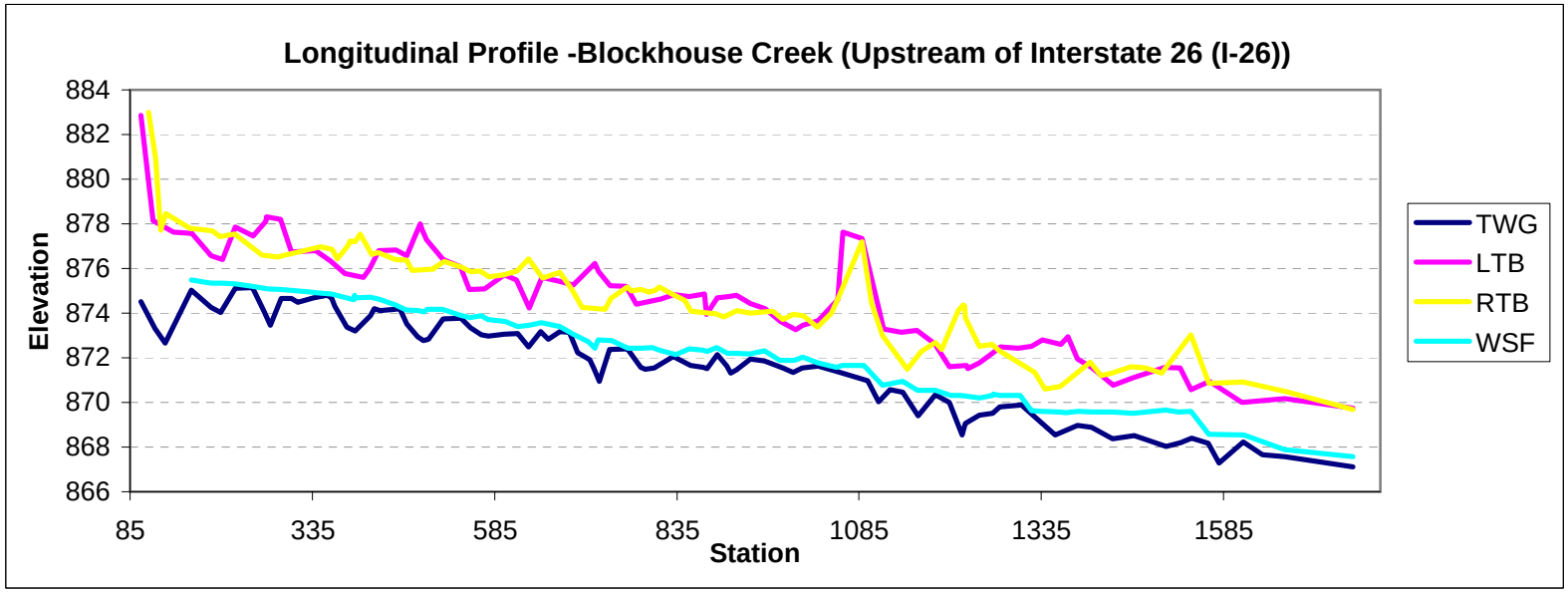
Parameter	Regional Curve	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built		
	Equation	(Upper Reach)						(Upper Reach)					
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	5.48	-----	6.30	-----	18.50	20.00	21.50	-----	7.00	-----	6.21	8.57	10.93
Floodprone Width (ft)	-----	-----	22.60	-----	----	----	----	----	35+	----	21.20	22.65	24.10
Bankfull Mean Depth (ft)	0.76	-----	0.61	-----	1.80	2.30	2.80	-----	0.70	-----	0.45	0.59	0.72
Bankfull Max Depth (ft)	-----	-----	0.90	-----	2.50	3.30	4.10	-----	1.00	-----	1.07	1.16	1.24
Bankfull Cross Sectional Area (ft2)	4.17	-----	3.80	-----	39.60	47.05	54.50	-----	5.00	-----	4.50	4.70	4.90
Width/Depth Ratio	-----	-----	10.30	-----	9.19	10.57	11.94	-----	10.00	-----	8.59	16.56	24.52
Entrenchment Ratio	-----	-----	3.60	-----	6.05	6.40	6.74	----	>2.2	----	2.20	2.80	3.40
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.00	-----	0.70	0.85	1.00
Bankfull Velocity (fps)	-----	-----	3.42	-----	3.50	4.25	5.00	-----	2.60	-----	2.89	2.77	2.65
Pattern													
Channel Beltwidth (ft)	-----	6.80	29.55	52.30	30.50	37.25	44.00	25.00	40.50	56.00	20.34	31.67	43.00
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	7.00	10.50	14.00	12.18	31.72	51.26
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	222.50	260.00	49.00	66.50	84.00	46.87	74.30	101.72
Meander Width Ratio	-----	-----	4.69	-----	1.50	1.83	2.16	3.50	5.75	8.00	3.28	3.70	3.93
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	18.00	34.00	50.00	7.00	24.00	41.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0270	0.03	0.0360	0.0270	0.03	0.0360
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3.50	9.25	15.00	4.00	9.50	15.00
Pool Spacing (ft)	----	-----	-----	-----	97.50	138.65	179.80	28.00	38.50	49.00	22.00	30.00	38.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.25 /.41 / .6 /1.7 /2.4			-----			.25 /.41 / .6 /1.7 /2.4			.13/.43/.73/1.9/2.97		
Reach Shear Stress (competency) lb/f2	-----	-----	0.40	-----	-----	-----	-----	-----	0.30	-----	-----*	-----*	-----*
Stream Power (transport capacity) W/m2	-----	-----	1.36	-----	-----	-----	-----	-----	0.78	-----	-----*	-----*	-----*
Additional Reach Parameters													
Channel length (ft)	-----	-----	1616.00	-----	-----	330.00	-----	-----	950.00	-----	-----	950.00	-----
Drainage Area (SM)	-----	-----	0.09	-----	0.20	1.90	2.30	-----	0.09	-----	-----	0.09	-----
Rosgen Classification	-----	-----	E5	-----	-----	B	-----	-----	E4	-----	-----	Bc5	-----
Bankfull Discharge (cfs)	15.64	-----	13.00	-----	----	-----	----	-----	13.00	-----	-----	13.00	-----
Sinuosity	-----	-----	1.34	-----	-----	1.10	----	-----	1.28	-----	-----	0.82	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0164	-----	-----	0.0292	-----

Notes: UT 2 was dry during the time as-built surveying was conducted. Therefore, water surface slope and transport parameters could not be calculated.

Baseline Stream Summary
UT2

Parameter	Regional Curve Equation	Pre-Existing Condition (Lower Reach)			Reference Reach(es) Data			Design (Lower Reach)			As-Built		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max				Min	Mean	Max
Bankfull Width (ft)	5.48	-----	6.30	-----	-----	7.00	-----	-----	7.00	-----	6.87	7.71	8.55
Floodprone Width (ft)	-----	-----	22.60	-----	-----	-----	-----	-----	35+	-----	26.90	28.20	29.50
Bankfull Mean Depth (ft)	0.76	-----	0.61	-----	-----	0.71	-----	-----	0.70	-----	0.61	0.66	0.71
Bankfull Max Depth (ft)	-----	-----	0.90	-----	-----	1.00	-----	-----	1.00	-----	1.00	1.03	1.05
Bankfull Cross Sectional Area (ft2)	4.17	-----	3.80	-----	-----	5.00	-----	-----	5.00	-----	4.90	5.05	5.20
Width/Depth Ratio	-----	-----	10.30	-----	12.00	15.00	18.00	-----	10.00	-----	9.63	11.82	14.00
Entrenchment Ratio	-----	-----	3.60	-----	-----	>2.2	-----	-----	>2.2	-----	3.40	3.65	3.90
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.00	-----	1.00	1.45	1.90
Bankfull Velocity (fps)	-----	-----	3.42	-----	4.00	5.00	6.00	-----	2.60	-----	2.65	2.57	2.50
Pattern													
Channel Beltwidth (ft)	-----	5.69	11.85	18.00	-----	-----	-----	25.00	40.50	56.00	34.28	43.54	52.80
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	23.72	25.92	28.12
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	120.46	-----
Meander Width Ratio	-----	-----	1.88	-----	2.00	5.00	8.00	-----	5.79	-----	4.99	5.65	6.18
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	5.00	10.00	15.00	5.00	9.50	14.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0320	0.0420	0.0520	0.0320	0.04	0.0520	0.0320	0.04	0.0520
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	4.00	6.50	9.00	3.00	4.00	5.00
Pool Spacing (ft)	-----	-----	-----	-----	10.50	22.75	35.00	10.50	22.75	35.00	12.00	15.50	19.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.25 /.41 / .6 /1.7 /2.4			-----			.25 /.41 / .6 /1.7 /2.4			.11/.68/1.23/4.47/67.74		
Reach Shear Stress (competency) lb/f2	-----	-----	1.36	-----	-----	-----	-----	-----	1.15	-----	-----*	-----*	-----*
Stream Power (transport capacity) W/m2	-----	-----	4.66	-----	-----	-----	-----	-----	3.00	-----	-----*	-----*	-----*
Additional Reach Parameters													
Channel length (ft)	-----	-----	205.00	-----	-----	-----	-----	-----	205.00	-----	-----	205.00	-----
Drainage Area (SM)	-----	-----	0.09	-----	-----	-----	-----	-----	0.09	-----	-----	0.09	-----
Rosgen Classification	-----	-----	E5	-----	-----	B	-----	-----	B4	-----	-----	Cb/E4	-----
Bankfull Discharge (cfs)	15.64	-----	13.00	-----	-----	-----	-----	-----	13.00	-----	-----	13.00	-----
Sinuosity	-----	-----	1.34	-----	1.10	1.15	1.20	-----	1.14	-----	-----	1.11	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0232	-----	-----	0.0173	-----

Notes: UT 2 was dry during the time as-built surveying was conducted. Therefore, water surface slope and transport parameters could not be calculated.


Longitudinal Profile -Blockhouse Creek (Upstream of Interstate 26 (I-26))
Elevation
884
882
880
878
876
874
872
870
868
866
85
335
585
835
1085
1335
1585
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	29	21.69	1.34	2.29	16.2	1.6	2.5	876.97	878.46

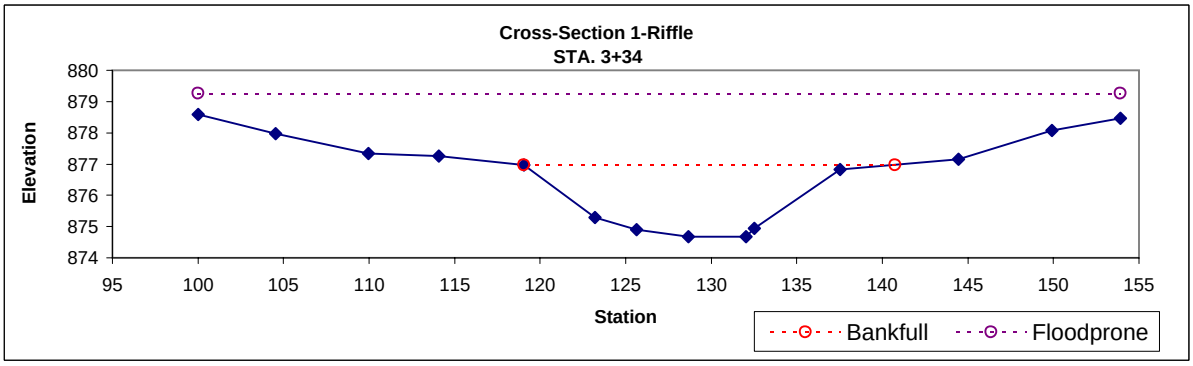


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	30.8	23.48	1.31	2.81	17.89	0.9	2.3	876	875.6

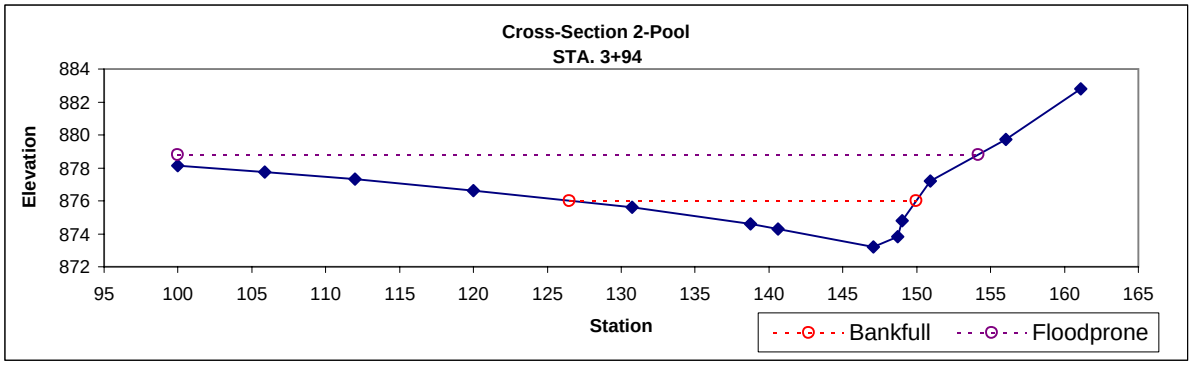


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Bc	34.2	23.01	1.49	3.45	15.49	0.9	2.1	872	871.66

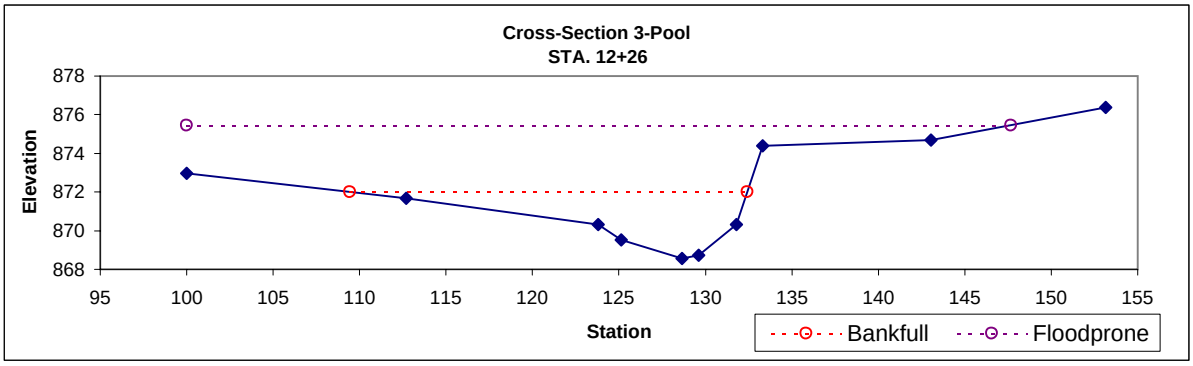


Photo 5: XS-3 facing right bank

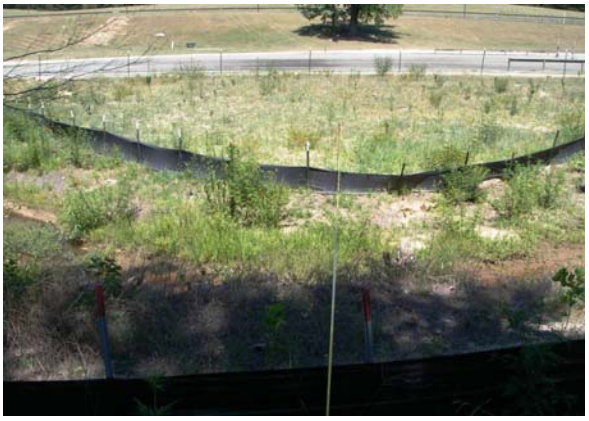


Photo 6: XS-3 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	34.9	22.57	1.54	2.92	14.62	0.9	2.5	872.4	872.25

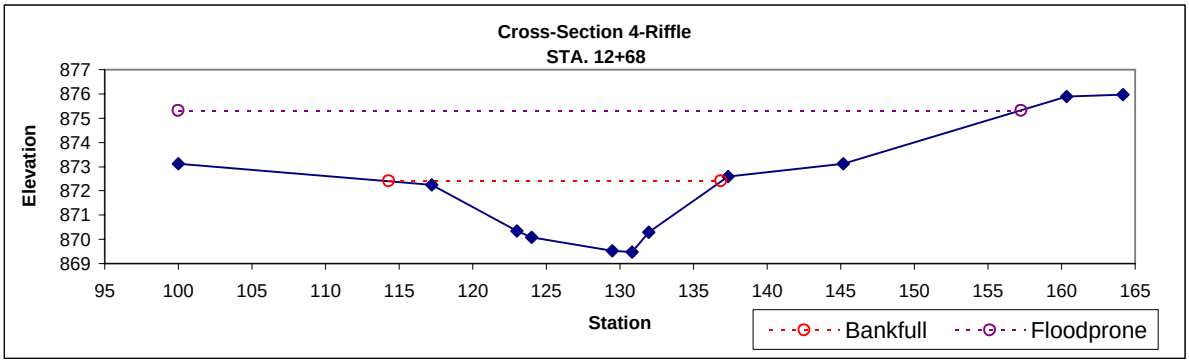


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	33	21.5	1.54	3.2	13.99	0.8	2.1	870.3	869.67

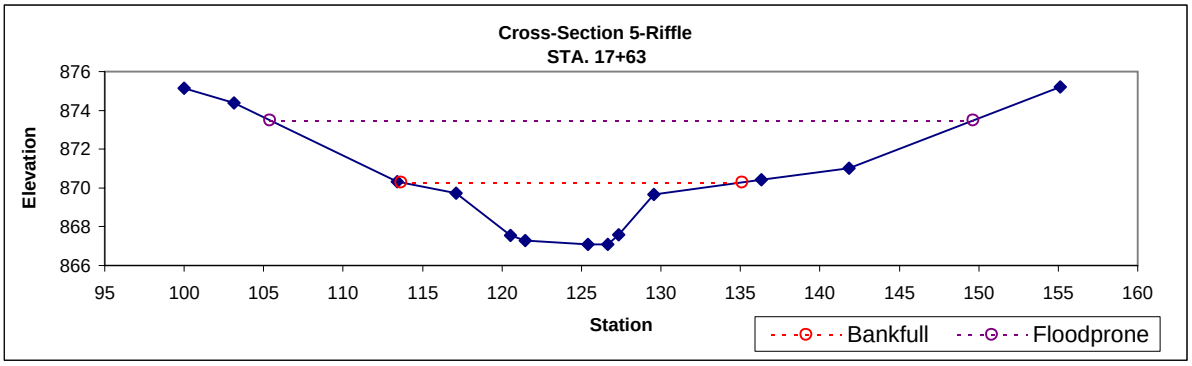
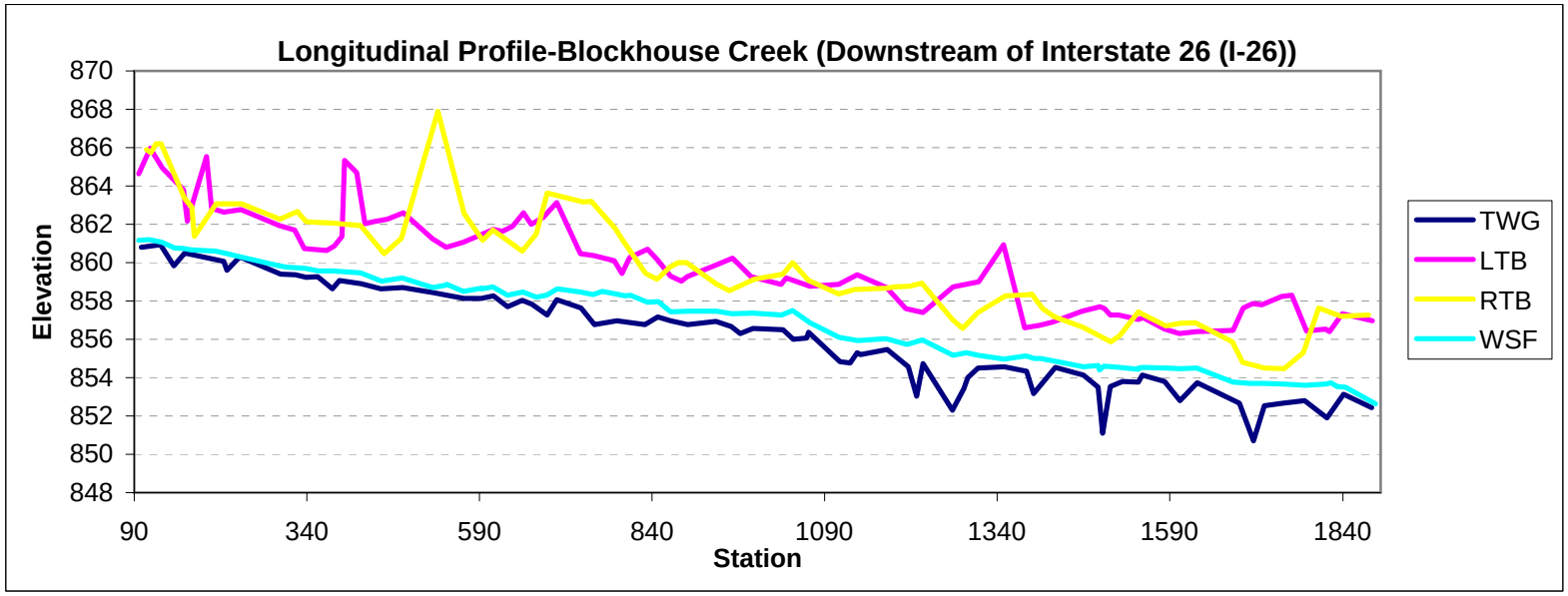


Photo 11: XS-5 facing right bank

Photo 12: XS-5 facing left bank


Longitudinal Profile-Blockhouse Creek (Downstream of Interstate 26 (I-26))
Elevation
870
868
866
864
862
860
858
856
854
852
850
848
90
340
590
840
1090
1340
1590
1840
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	35.4	24.4	1.45	2.88	16.83	1.2	1.5	861.17	861.62

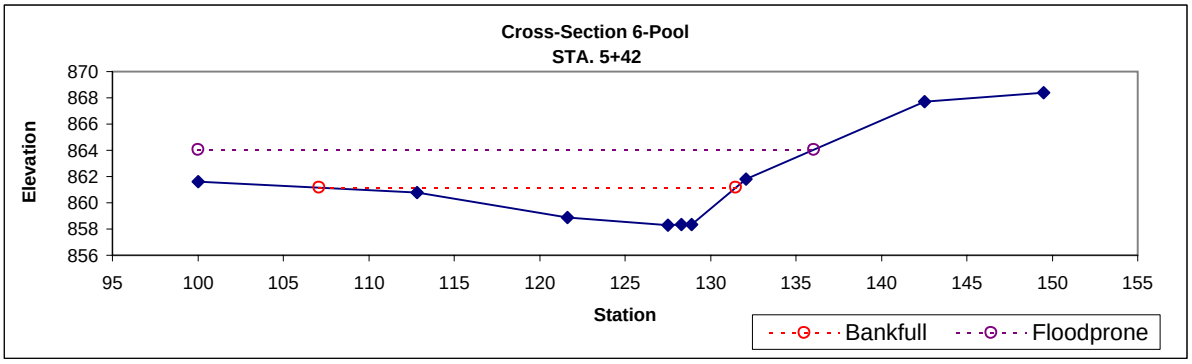


Photo 11: XS-6 facing right bank

Photo 12: XS-6 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	34.8	19.62	1.77	3.15	11.08	1.2	2.7	861.27	861.93

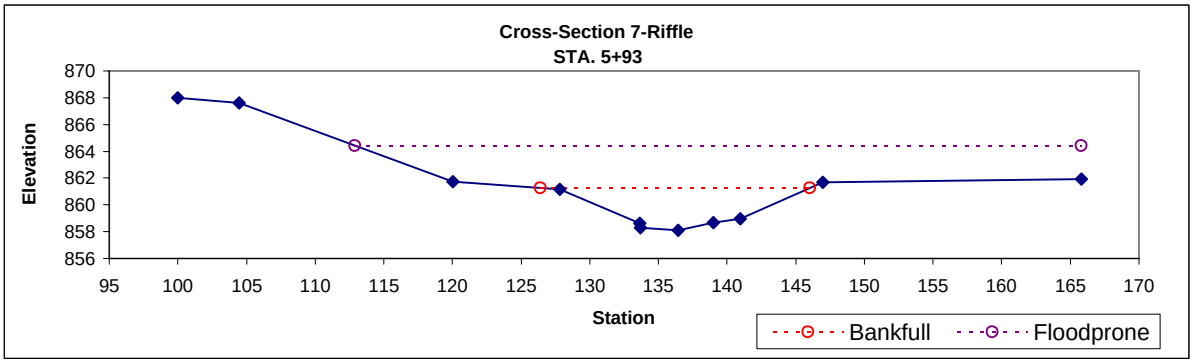


Photo 13: XS-7 facing right bank

Photo 14: XS-7 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E4	35.8	18.35	1.95	4.5	9.41	1.1	3.3	855.47	855.87

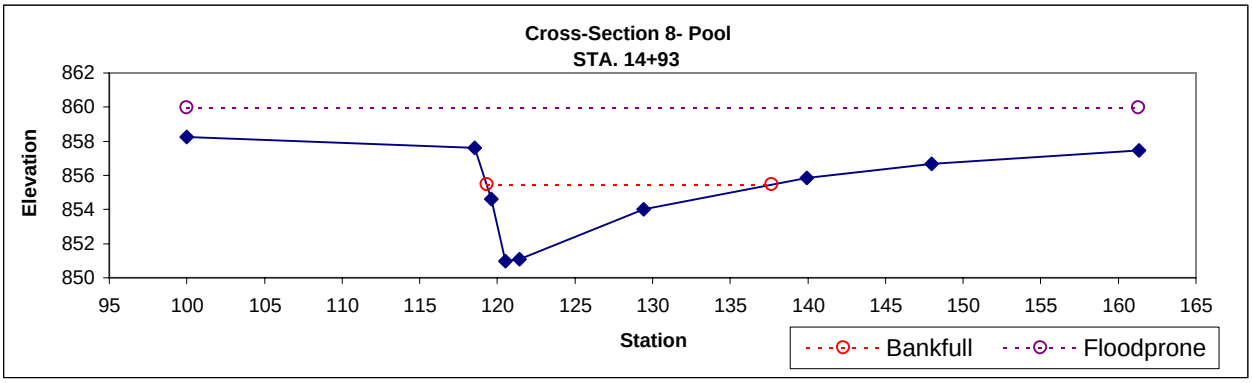


Photo 15: XS-8 facing right bank

Photo 16: XS-8 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	35.1	19.01	1.84	2.98	10.3	1.1	3.1	856.75	857.05

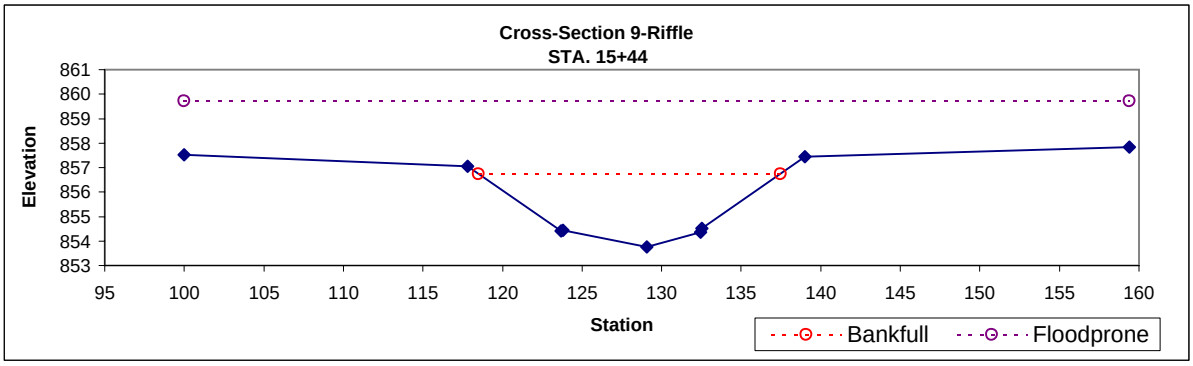
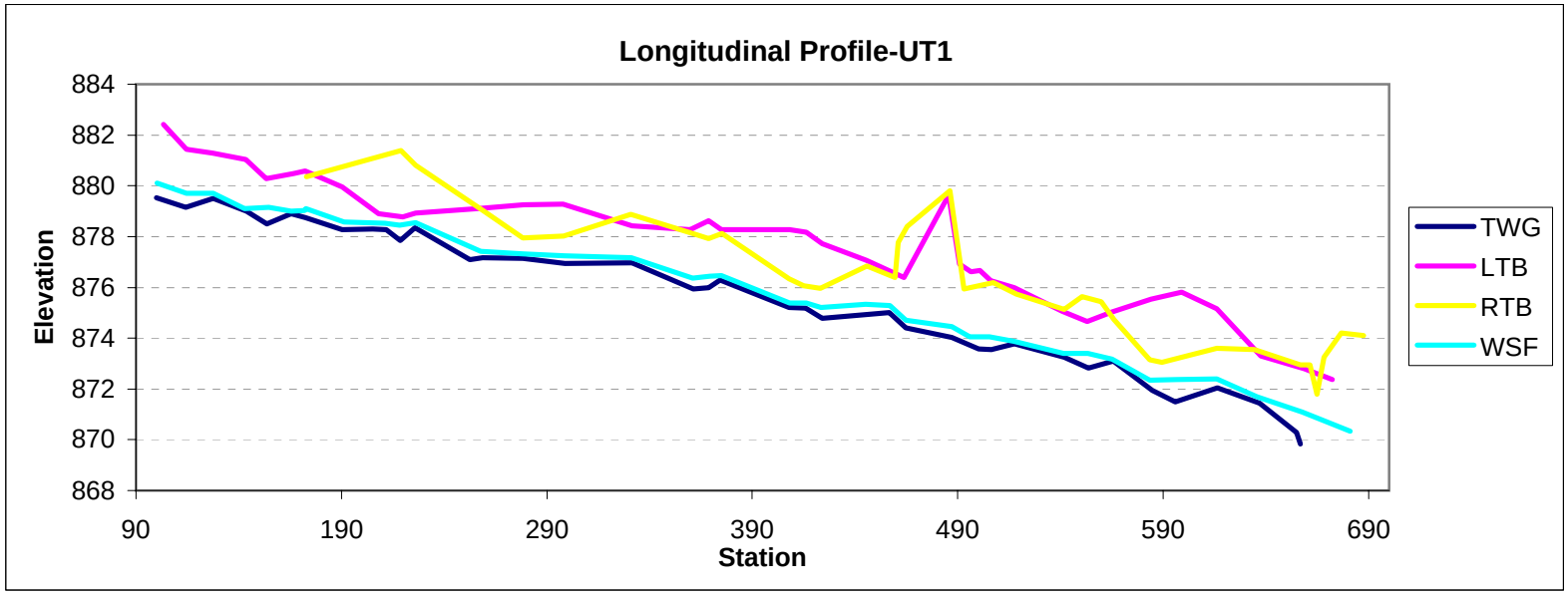


Photo 17: XS-9 facing right bank

Photo 18: XS-9 facing left bank


Longitudinal Profile-UT1
884
882
880
878
876
874
872
870
868
Elevation
90
190
290
390
490
590
690
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	10.7	12.43	0.86	1.76	14.48	0.9	3.1	880.5	880.36

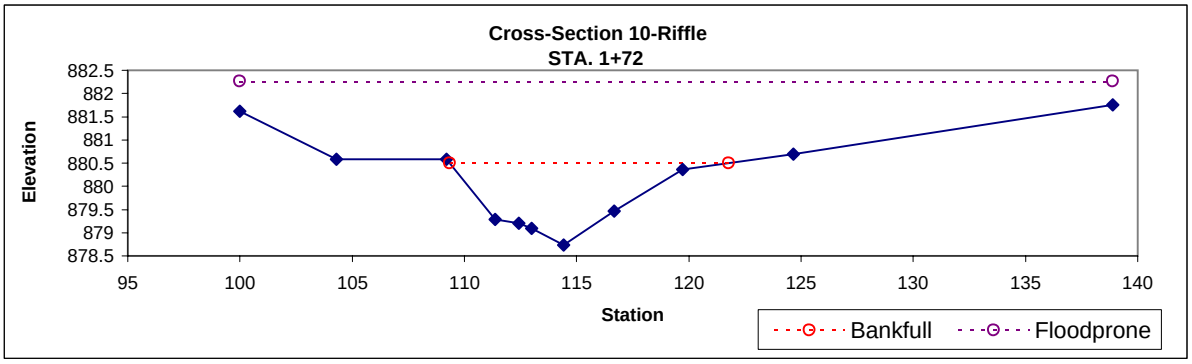


Photo 19: XS-10 facing right bank

Photo 20: XS-10 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	10.3	11.42	0.9	1.66	12.66	1	3.6	874.77	874.74

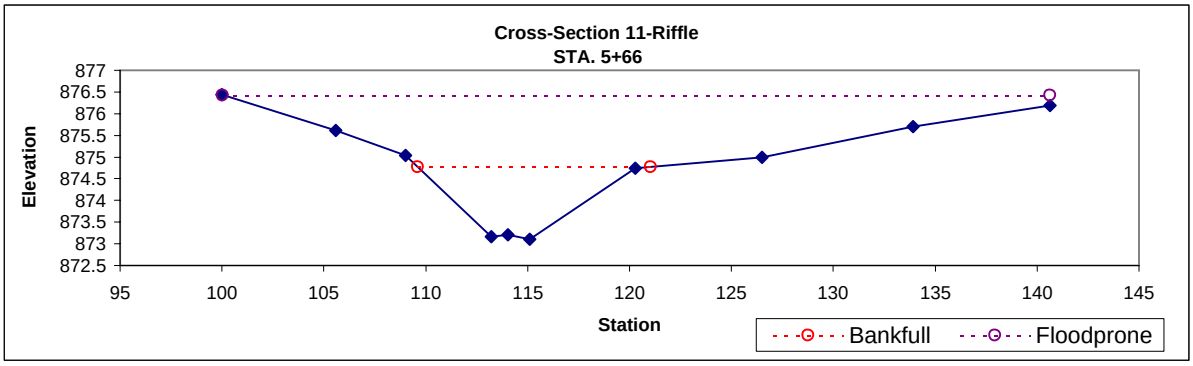


Photo 21: XS-11 facing right bank

Photo 22: XS-11 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	10.4	12.95	0.8	1.58	16.16	1	2.3	873.08	873.06

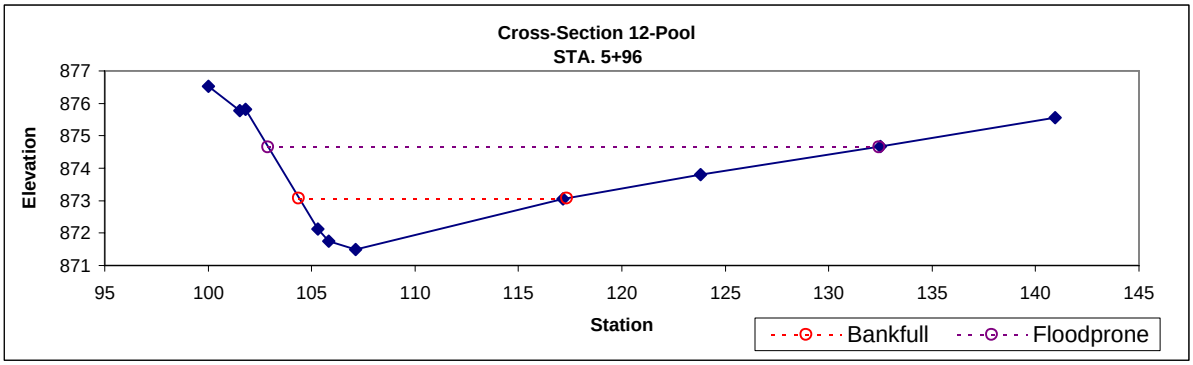
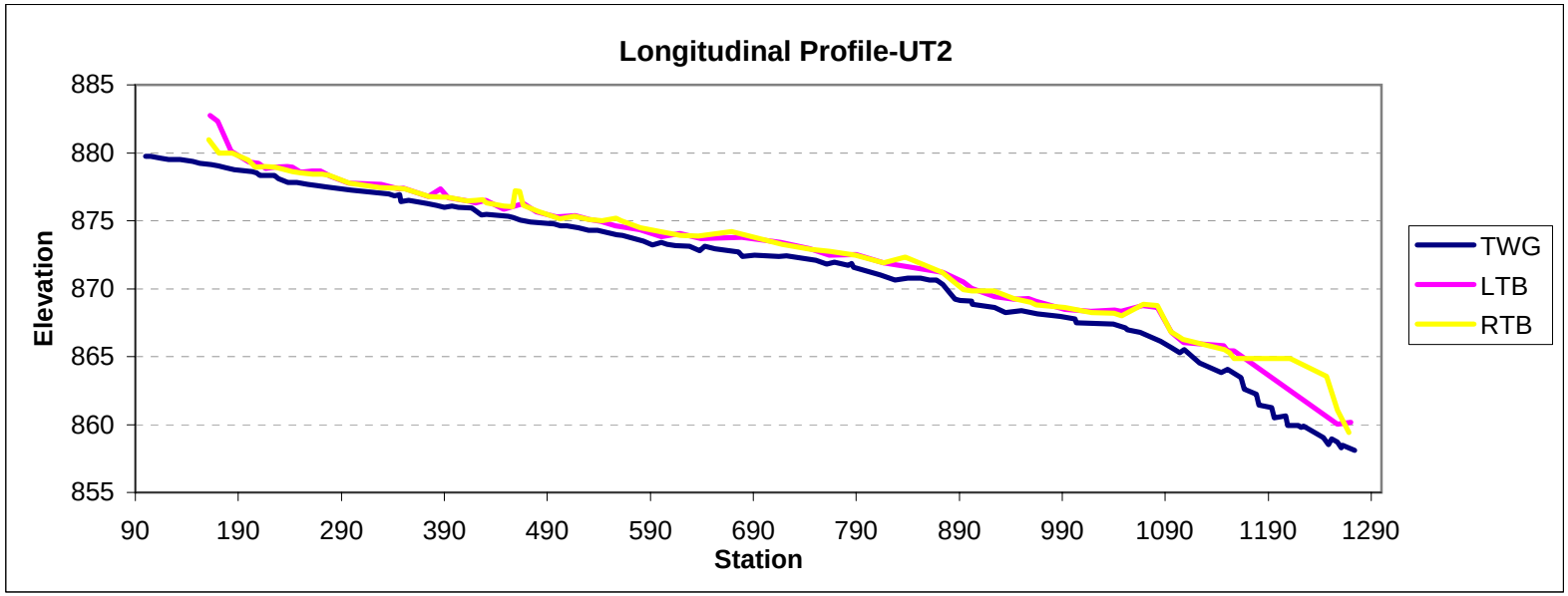


Photo 23: XS-12 facing right bank

Photo 24: XS-12 facing left bank


Longitudinal Profile-UT2
Elevation
885
880
875
870
865
860
855
90
190
290
390
490
590
690
790
890
990
1090
1190
1290
Station
TWG
LTB
RTB

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	4.9	10.93	0.45	1.07	24.52	0.7	2.2	878.86	878.54

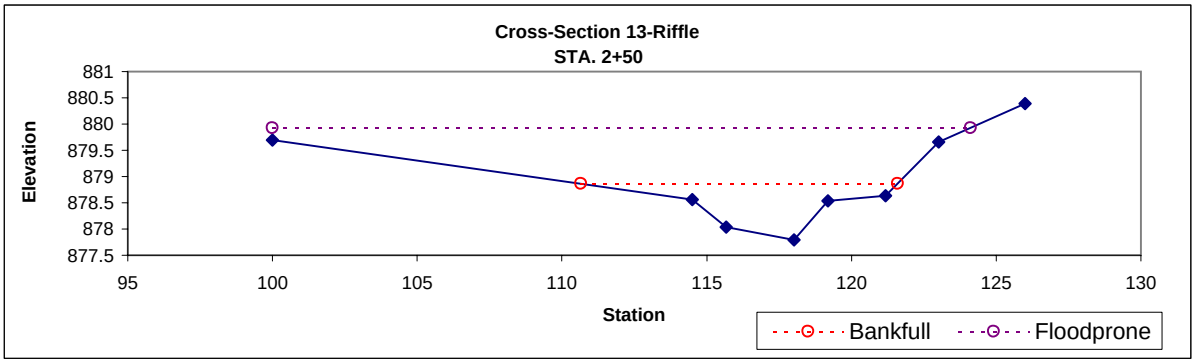


Photo 25: XS-13 facing right bank

Photo 26: XS-13 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E5	4.5	6.21	0.72	1.24	8.59	1	3.4	876.28	876.24

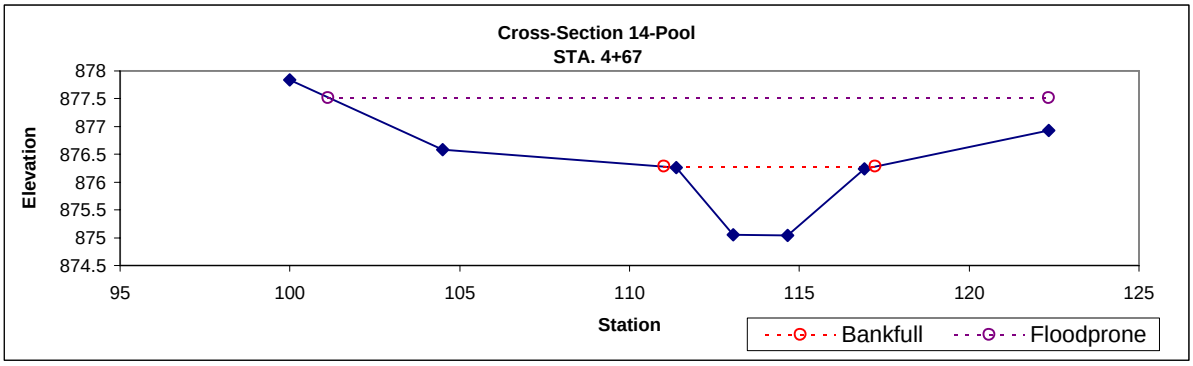


Photo 27: XS-14 facing right bank

Photo 28: XS-14 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb5	5.2	8.55	0.61	1	14	1	3.4	864.86	864.86

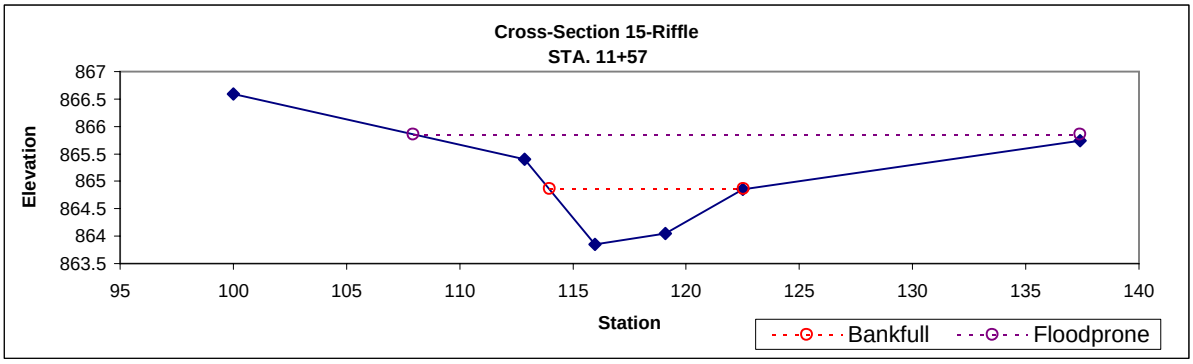


Photo 29: XS-15 facing right bank

Photo 30: XS-15 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E5	4.9	6.87	0.71	1.05	9.63	1.9	3.9	859.64	860.62

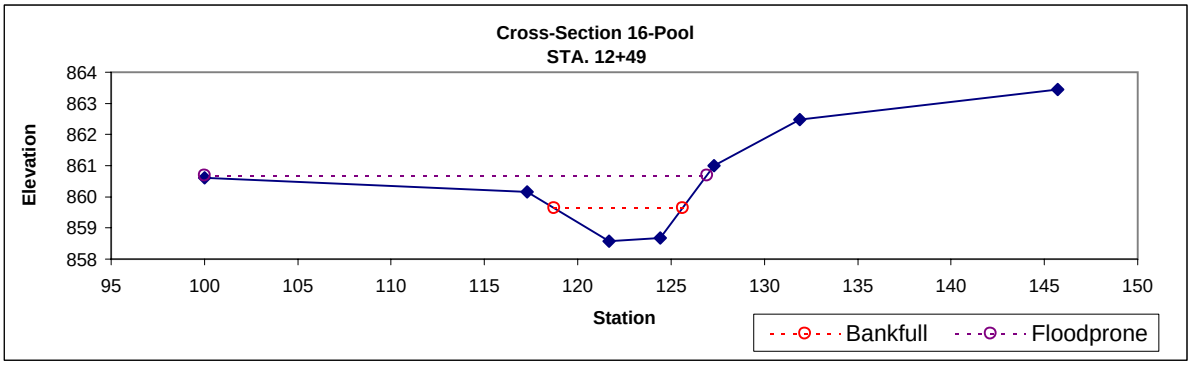


Photo 31: XS-16 facing right bank

Photo 32: XS-16 facing left bank

APPENDIX C

AS-BUILT PLAN SHEETS

Blockhouse Creek Restoration Project
Mitigation Plan and As-built Baseline Report
Polk County, North Carolina

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)

Monitoring Firm POC: Micky Clemmons

Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Guy Pearce

Report Prepared By: Michael Baker Engineering, Inc.
797 Haywood Road, Suite 201
Asheville, NC 28806

Contract Number: D06027-A

Date Submitted: November 2008

DRAFT

EXECUTIVE SUMMARY

The Blockhouse Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents base-line, as-built monitoring data for the five-year monitoring period. The stream mitigation units developed on the project exceed the number of units that Baker contracted with the North Carolina Ecosystem Enhancement Program (NCEEP) to provide, as shown in Table 1. Table 1 summarizes site conditions before and after restoration as well as what was predicted in the restoration plan. The monitoring plan and as-built baseline data are discussed in Sections 2.1 through 2.5 of this report.

Table 1. Background Information
Blockhouse Creek Restoration Project

Preconstruction Site Conditions			
Site			
Location	Polk County, approximately three miles east of the town of Tryon		
USGS Hydro Unit	03050105150020		
NCDWQ Subbasin	03-08-06		
Contract Mitigation Units (SMUs)	5,550 SMUs		
Stream			
Reach	**Length**	**Condition**	**Drainage Area**
Blockhouse Creek	3,998 LF	Channelized; incised; bank erosion	2.44 Mi^2 Total
UT 1	540 LF	Incised; bank erosion	211.2 Ac
UT 2	1,224 LF	Channelized; incised; over-wide	57.6 Ac
UT 3	430 LF		38.4 Ac
Restoration Plan			
Stream			
Reach	**Restoration/Enhancement Type**		**Length**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile		887 LF
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile		340 LF
Blockhouse Creek Reach 3	Restoration of dimension and profile		950 LF
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile		1,821 LF
UT 1	Restoration of dimension and profile		523 LF
UT 2	Restoration of dimension, pattern and profile		1,240 LF
UT 3	Preservation of channel corridor		430 LF
Post-Construction Site Conditions			
Stream			
Reach	**Restoration/Enhancement Type**	**Length**	**SMUs**
Blockhouse Creek Reach 1	Restoration of dimension, pattern, and profile	1070 LF	1070
Blockhouse Creek Reach 2	Restoration of dimension, pattern, and profile	340 LF	340
Blockhouse Creek Reach 3	Restoration of dimension and profile	950 LF	633
Blockhouse Creek Reach 4	Restoration of dimension, pattern, and profile	1,780 LF	1,780

UT 1	Restoration of dimension and profile	580 LF	580
UT 2	Restoration of dimension, pattern and profile	1,155 LF	1,155
UT 3	Preservation of channel corridor	430 LF	86
Riparian Buffer Acreage			
Conservation Easement	8.6 Acres		
Vegetation Monitoring Plots			
Average Stems Per Acre	764 Stems	# of Plots: 10	
Ecological Benefits			
Water Quality	Erosion reduction; Increased dissolved oxygen concentrations; Improved stream bank stability		
Water Quantity/Flood Attenuation	Increased water storage/flood control; Reduced downstream flooding by reconnecting stream with its floodplain; Improved groundwater recharge; Improved/restored hydrologic connections		
Aquatic and Terrestrial Habitat	Improved substrate and in-stream cover; Addition of large woody debris; Reduced water temperature by increasing shading; Restoration of terrestrial habitat; Improved aesthetics		
Monitoring Plan			
Success Criteria	Success is measured with permanent cross-section, vegetation plots, and longitudinal profile conducted for a period of five years.		
Methodology	Cross-sections are surveyed annually and longitudinal profiles are surveyed in Monitoring Years 1, 3, and 5. Both surveying parameters are tied to a common benchmark. Each tree within the 100-square-meter vegetation plots are flagged and identified. Measurements of height and diameter are also taken and annual survival rates are recorded.		
Remedial Action	N/A		

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Tables and Figures

Appendices

1.0 BACKGROUND INFORMATION

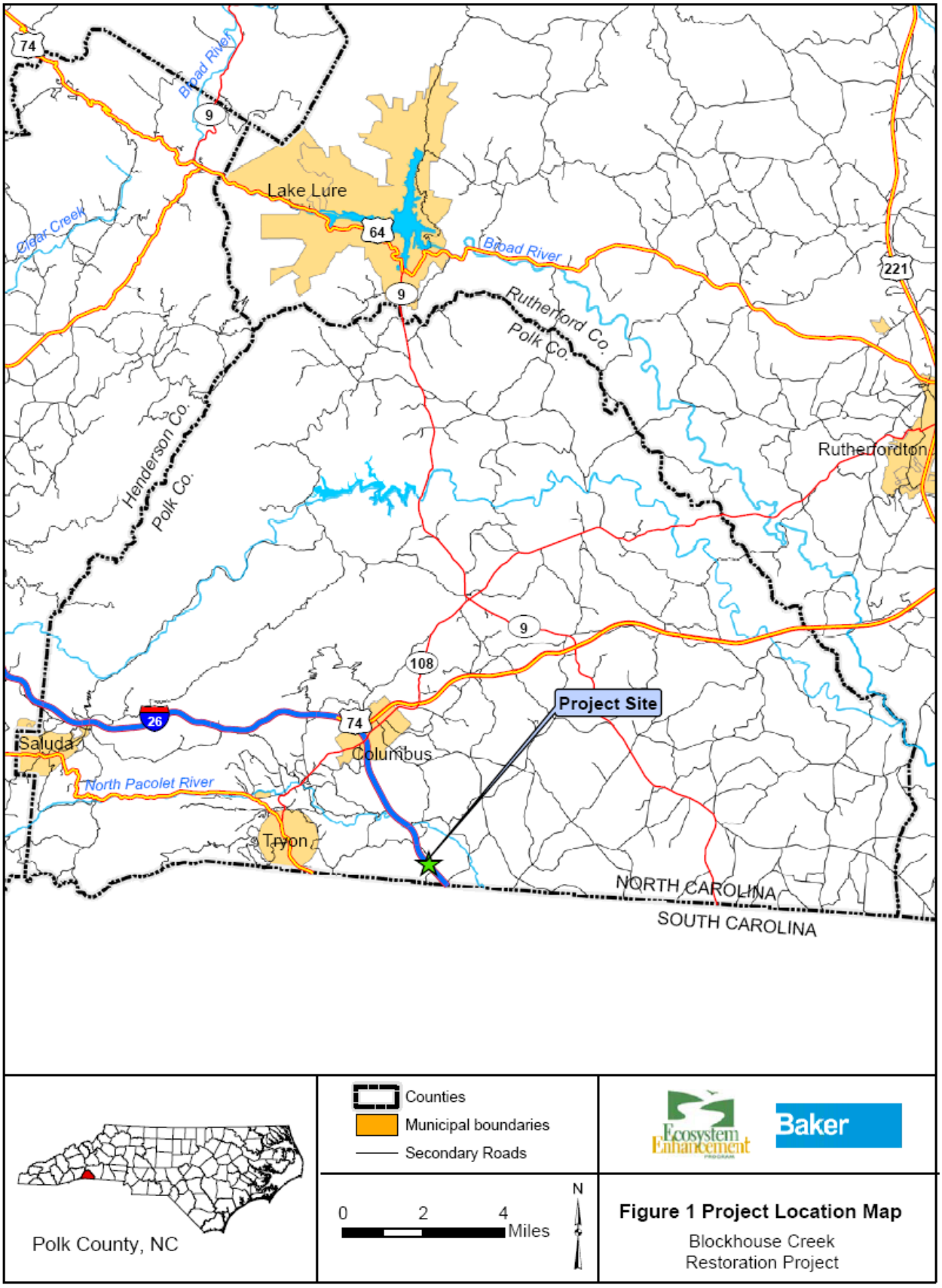
The Blockhouse Creek Restoration site is located within the Foothills Equestrian Nature Center (FENCE), approximately three miles east of Tryon, in Polk County, North Carolina (Figure 1). The project site is situated in the Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 03-08-06 and United States Geologic Survey (USGS) hydrologic unit 03050105150020. Since the late 1980s, the project area has been used as an equestrian/recreational complex. Surrounding lands are currently used for pasture land, hay production and residential use. Prior to the establishment of an equestrian and nature center, the FENCE property was used for agriculture activities and timber production. At that time, riparian buffers were removed and streams were channelized which was a common practice. There is also evidence on some tributaries of ephemeral gullies which most likely resulted from clear cutting. More recent development in the watershed has resulted in additional changes to Blockhouse Creek and its tributaries. Construction of the equestrian facility, nature trails and Interstate 26 has required the installation of bridged and culverted stream crossings that have been detrimental to stream stability. These structures have also impacted the flow pattern and velocity of the project streams, resulting in changes to the cross-sectional area, and often facilitating the deepening of the channel. This deepening of the channel resulted in the streams becoming incised and losing their connection to the adjacent floodplain.

The project involved restoration, enhancement or preservation of 6,305 linear feet (LF) of four on-site streams: Blockhouse Creek and three smaller unnamed tributaries (UTs) identified in the project as UT1, UT2, and UT3. Blockhouse Creek is a “blue-line” stream, as shown on the USGS topographic quadrangle for the site, and is considered to be perennial based on field evaluations using NCDWQ stream assessment protocols. The three tributaries were all identified as perennial during initial project scoping, although UT2 and UT3 have little or no flow during extreme drought conditions as observed during the past two summers.

1.1 Restoration Summary

1.1.1 Project Location

The Blockhouse Creek mitigation site is located on the Foothills Equestrian Nature Center (FENCE) property approximately three miles east of Tryon, in Polk County, North Carolina. From Asheville, take South Carolina Exit #1 from I-26, toward Landrum, S.C. Go 1.5 miles, and turn right onto Bomar Road (look for the Land Mart on the corner). Go one short block and turn right onto Prince Road. After 1.7 miles, turn left onto Hunting Country Road, just before the I-26 bridge. Go .5 mile to the FENCE entrance on the left or another .1 miles (going under I-26) to the second entrance on the right. The Blockhouse Creek site starts at the upper limits of the horse stables accessed through the first entrance. Figure 1 illustrates the physical location of the project site. Figure 2 depicts the project streams, easement boundaries and monitoring reference data.


74
Broad River
9
Lake Lure
Cedar Creek
64
Broad River
221
9
Rutherford Co.
Polk Co.
Henderson Co.
Polk Co.
Rutherfordton
9
108
Project Site
26
74
Saluda
Columbus
North Pacolet River
Tryon
NORTH CAROLINA
SOUTH CAROLINA
Polk County, NC
Counties
Municipal boundaries
Secondary Roads
0
2
4
Miles
N
Ecosystem Enhancement Program
Baker
Figure 1 Project Location Map
Blockhouse Creek
Restoration Project

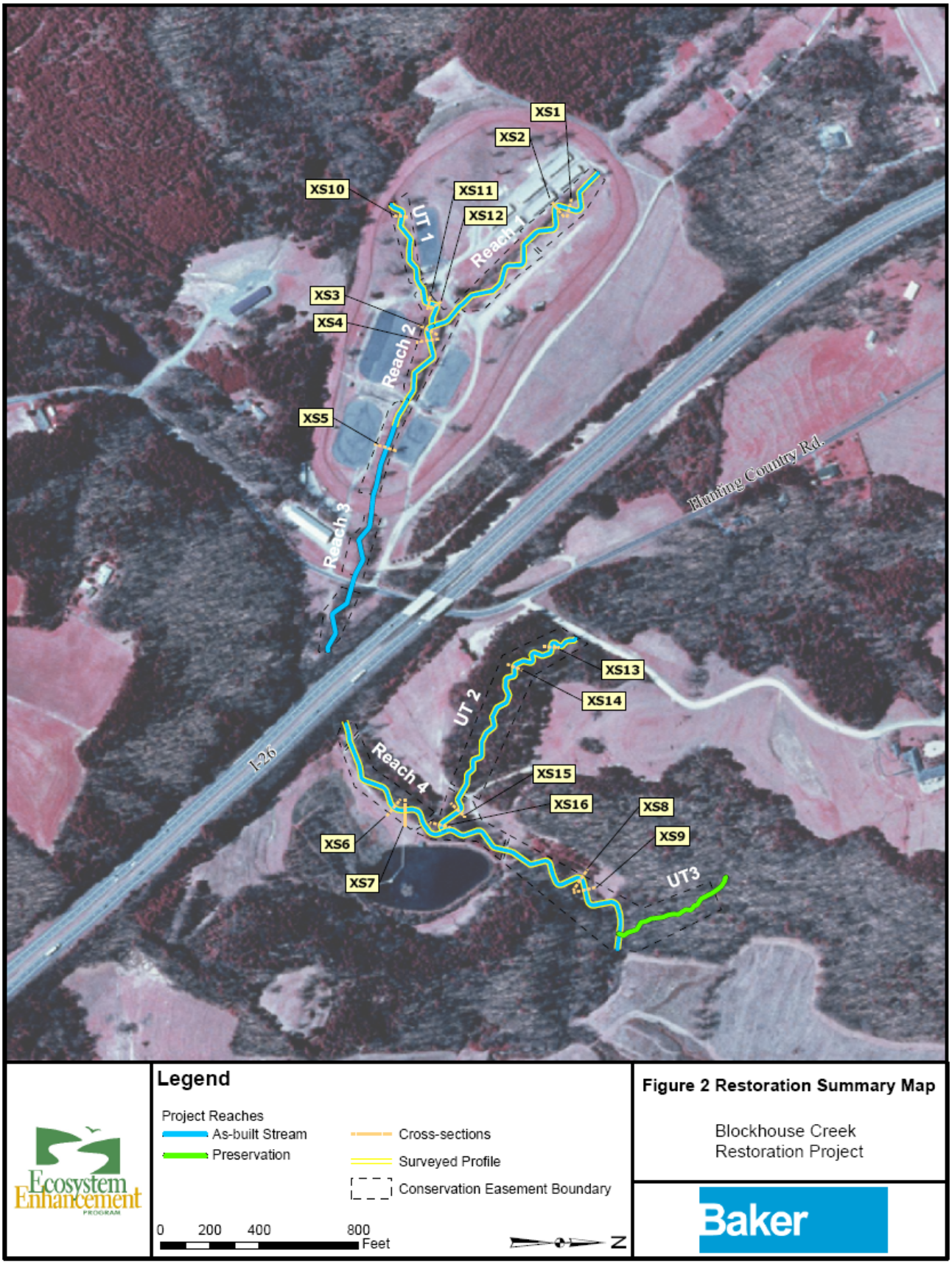


Figure 2 Restoration Summary Map

Blockhouse Creek
Restoration Project

1.1.2 Project Objectives

The specific design objectives of the project included:

- Restoration or enhancement of channel dimension, pattern and profile;
- Improvements to water quality in the Blockhouse Creek watershed through nutrient removal, sediment removal, improved recreational opportunities, streambank stability, and erosion control;
- Improved water quantity/flood attenuation through water storage and flood control, reduction in downstream flooding due to the reconnection of stream and floodplain, improved ground water recharge, and improved and restored hydrologic connections;
- Enhancement of aquatic and terrestrial habitats through improved substrate and instream cover, addition of woody debris, reduction in water temperature due to shading, restoration of terrestrial habitat, increase of spatial extent of natural area, and improved aesthetics.

1.1.3 Project Description and Restoration Approach

Restoration of site hydrology involved the restoration of natural stream functions to impaired reaches on the site. The streams in their historic condition were channelized and, as a result, were highly incised. Because of the extent of the incision, a Rosgen Priority I restoration, which would connect the stream to the abandoned floodplain (terrace), would not have been feasible without extending the project reach several thousand feet upstream and significantly altering the channel profile. However, there was sufficient space in areas within the project boundaries to implement Rosgen Priority II restoration by excavating the floodplain and creating a new meandering channel. With the exception of a small section of UT2, the restored streams were designed as Rosgen "E" channels with design dimensions based on those of reference parameters. The upper project reach on UT2 was designed as an "E" channel while the lower section of the project reach (approximately 200 feet) was designed as a "B" channel. The preserved reach on UT3 was determined to be a "B" channel that transitions to an "E" channel.

The design for restored sections of the streams involved the construction of new, meandering channels across excavated floodplains. This new channel system was constructed through grassed fields. The streams through the site were restored to a stable dimension, pattern, and profile. Total stream length across the project was increased from approximately 6,191 LF to 6,305 LF. The design allows stream flows larger than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing streambank stress. Instream structures were used to control streambed grade, reduce streambank stress, and promote bedform sequences and habitat diversity. Rootwad and log vane structures installed will protect streambanks and promote habitat diversity in pool sections. Constructed riffles were used to promote both hydraulic and habitat heterogeneity to the channel. Where grade control was a design consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

1.1.4 Construction Summary

In accordance with the approved restoration plan for the site, construction activities began in January 2008. Project activity on Blockhouse Creek and UT1 and UT2 consisted of making adjustments to channel dimension, pattern, and profile. A primary design consideration for this project was to allow stream flows larger than bankfull events to spread onto a floodplain, dissipating flow energies and reducing streambank stress. The design for most of the restoration reaches involved a priority II approach with the construction of new, meandering channels across a floodplain that was excavated to the elevation of the creek. The lower part of reach 4 was not incised and did not require this approach. Along this section the overly sinuous channel was realigned in a more stable pattern at the existing elevation. Total stream length across the project increased from approximately 6,191 LF to 6,305 LF.

Access sites and stockpile areas were established at the beginning of site construction. Site stakeout and the harvesting of root wads also began during the beginning stages of construction and occurred throughout the construction phase. Materials were stockpiled as needed for the initial stages of construction.

After stakeout was completed, the floodplain was excavated and graded within discrete work areas of the site to reach design grade. Grading activities commenced at the upstream limits of the project site near the equestrian center and continued downstream below highway Interstate-26 (I-26), through the nature center area. Restoration activities on the project tributaries commenced once construction crews reached each confluence between Blockhouse Creek and the respective tributaries. Excavated material was placed in a field on the property and kept at least 75 feet from any stream. Where necessary, silt fencing was installed to prevent erosion of sediment into the nearest waterbody.

Once the design floodplain elevations were achieved, new stream channel segments were graded and constructed in the dry by pumping stream flows around the construction segment. Upon completion of new channel segments, instream structures, matting and transplants were installed and the new channel was tied to the existing streambed. Once fully prepared, temporary sediment traps at the downstream ends of the channels were removed, and water was directed into the newly constructed channel. Remnant channels were immediately filled and graded. As-built cross sections and longitudinal profiles are shown in Appendix B.

Rootwads, rock and log vanes and other structures were used to protect streambanks and promote habitat diversity in pool sections. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and geolifts. Transplants provided immediate living root mass to increase streambank stability and create shaded holding areas for fish and aquatic biota. Native vegetation was planted across the site, and the entire restoration site is protected through a permanent conservation easement.

Modifications made during construction of this project involved the location and selection of instream structures and bank stabilization practices as well as minor adjustments in channel alignment. Structure substitutions were made based on availability of materials and professional judgment. At the upstream project limits on UT2 from Station 0+00 to 4+20, the channel location was adjusted to avoid mature trees in the vicinity of the project. Slight adjustments to the proposed channel alignment were also made during construction along the mainstem of Blockhouse Creek between Stations 7+50 to 9+25. This adjustment was made to take advantage of a highly stable, vegetated section of streambank on Blockhouse Creek. The adjustment also improved the angle of approach of Blockhouse Creek to a bridge crossing. These changes are documented in the attached as-built drawings. Table 2 provides a summation of the as-built lengths and restoration approaches applied within the project site. The final as-built stream length for the restoration and enhancement reaches of the project site was 5,875 LF.

Tables 3 through 6 provide additional information regarding the Blockhouse Creek restoration project.

Table 2. Summary of As-built Lengths, Mitigation Units, and Restoration Approaches

Reach Name	As-built Length (ft)	Existing Length (ft)	SMUs	Restoration Approach
Blockhouse Cr. Reach 1	1070	887	1,070	Priority II Restoration
Blockhouse Cr. Reach 2	340	340	340	Priority II Restoration
Blockhouse Cr. Reach 3	950	950	633	Enhancement Level I
Blockhouse Cr. Reach 4	1780	1,821	1,780	Priority II Restoration
UT 1	580	523	580	Priority II Restoration
UT 2	1155	1,240	1155	Priority II Restoration
UT 3	430	430	86	Preservation
Total Length	**6305**	**6,191**	**5,644***	

*This represents 94 SMUs more than our EEP contract requires.

1.2 Project History, Contacts and Attribute Data

Table 3. Project Restoration Components

Blockhouse Creek Restoration Project

Project Segment or Reach ID	Existing Feet/ Acres	Type	Approach	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Blockhouse Cr. Reach 1	887 LF	R	P2	1070 LF	1.0	1,070	0+00-10+70	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 2	340 LF	R	P2	340 LF	1.0	340	10+70-14+14	Meandering channel construction; excavation of floodplain
Blockhouse Cr. Reach 3	950 LF	E	I	950 LF	1.5	633	14+34-25+44	Constraints prevented restoration; bankfull benches established, structures installed, pattern stabilized.
Blockhouse Cr. Reach 4	1,821 LF	R	P2	1,780 LF	1.0	1,780	28+37-46+17	Meandering channel construction; floodplain excavation
UT 1	523 LF	R	P2	580 LF	1.0	580	0+00-5+23	Meandering channel construction; floodplain excavation
UT 2	1,240 LF	R	P2	1,155 LF	1.0	1,155	0+00-12+40	Only incised at lower end, upper 1000 LF realigned to a more stable pattern with only minor floodplain grading

UT 3	430 LF	P	-	430 LF	5.0	86	0+00-4+30	No channel alteration (preservation)

Mitigation Unit Summations

Stream (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
5,644	NA	NA	NA	8.6	

Table 4. Project Activity and Reporting History
Blockhouse Creek Restoration Project

Activity or Report	Data Collection Complete	Completion or Delivery
Categorical Exclusion Approved	---	January 2007
Conservation Easement Signed	---	September 2007
Restoration Plan Approved	---	October 2007
Project Permit Approval	---	December 2007/ January 2008
Final Design-90%	---	October 2007
Construction		
`Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	May 2008
Permanent seed mix and riparian vegetation applied to project site		
Upstream of Interstate-26	January 2008	March 2008
Downstream of Interstate-26	March 2008	June 2008
Vegetation Plots , Crest Gauges and Photo Stations Established	July 2008	September 2008
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2008	October 2008
Year 1 Monitoring	July 2009	December 2009
Year 2 Monitoring	July 2010	December 2010
Year 3 Monitoring	July 2011	December 2011
Year 4 Monitoring	July 2012	December 2012
Year 5 Monitoring	July 2013	December 2013

Table 5. Project Contact Table **Blockhouse Creek Restoration Project**	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: Will Pedersen, Tel. 919.459.9001
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200 Cary, NC 27511 Contact: George Morris, Tel. 919.459.9001
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201 Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002

Table 6. Project Background Table **Blockhouse Creek Restoration Project**	
Project County	Polk County, NC
Drainage Area (Square Miles or Acres)	
Blockhouse Creek Reach 1	1.63 mi^2
Blockhouse Creek Reach 2	1.97 mi^2
Blockhouse Creek Reach 3	2.21 mi^2
Blockhouse Creek Reach 4	2.44 mi^2
UT 1	211.2 Ac.
UT 2	57.6 Ac.
UT 3	38.4 Ac.
Drainage impervious cover estimate (%)	<1%
Stream Order	Second Order
Physiographic Region	Piedmont Province. Borders Blue Ridge Escarpment

Ecoregion	Southern Inner Piedmont
Rosgen Classification of As-built	
Blockhouse Creek Reach 1	C4
Blockhouse Creek Reach 2	C4
Blockhouse Creek Reach 3	E4/Bc4
Blockhouse Creek Reach 4	E4
UT 1	C4
UT 2	Bc5 (upper)/Cb (lower)
UT 3	B-E (lower)
Cowardin Classification	Riverine
Dominant Soil Types	
Blockhouse Creek Reach 1	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 2	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 3	Chewacla Loam, Pacolet Sandy Clay Loam
Blockhouse Creek Reach 4	Chewacla Loam, Pacolet Sandy Clay Loam, Rion Sandy Loam
UT 1	Chewacla Loam, Pacolet Sandy Clay Loam
UT 2	Pacolet Sandy Clay Loam,
UT 3	Chewacla Loam, Pacolet Sandy Clay Loam, Hiwassee Clay Loam
Reference Site ID	Reference reach used for upper portion of project area located 350 LF upstream of project. Big Branch, Surry County was also identified in the NCDOT reference reach database as a suitable reference for design ratios
USGS HUC for Project and Reference Sites	Blockhouse Creek HUC#: 03050105 Big Branch HUC#: 03040101
Any portion of project segment(s) on NC 303d List?	No
Any portion of project upstream of a 303d Listed Segment?	No
Reasons for 303d Listing or Stressor	N/A
% of Project Easement Fenced	None of the easement area is presently fenced.

2.0 MONITORING PLAN

The five-year monitoring plan for the Blockhouse Creek restoration project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built drawing sheets. Reference photo points were selected to show cross-sections, structures (i.e. vanes and weirs), and other important channel areas along the restored stream.

2.1 Stream Monitoring and Success Criteria

Geomorphic monitoring of restored stream reaches will be conducted over the next five years to evaluate the effectiveness of the restoration. Monitored stream parameters include bankfull flows, channel dimension (cross-sections), profile (longitudinal survey), changes to bed composition, bank stability assessment, and stability of reference sites documented by photographs. The methods used and any related success criteria are described below for each parameter

2.1.1 Bankfull Events

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Three crest gauges were installed on the floodplain within 10 feet of the restored channels. One crest gauge was placed on UT 2, while 2 gauges were set up on Blockhouse Creek. The first gauge on the main channel was set up on the right bank below the confluence of UT 1 and Blockhouse Creek. The second crest gauge was set up, at the downstream end of the project, just upstream of the confluence of UT3 and Blockhouse Creek on the right bank. The crest gauge on UT2 was placed above the vehicle crossing at the lower end of the tributary. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring may have to be continued until two bankfull events have been documented in separate years.

2.1.2 Cross-Sections

Sixteen permanent cross-sections were installed to help evaluate the success of the restoration project. Cross-sections selected for monitoring were located in representative riffle and pool reaches as well as downstream of the confluences between Blockhouse Creek and UT1 and UT2. Each cross-section was marked on both banks with permanent pins to establish the exact transect used. A common benchmark will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections will be classified using the Rosgen Stream Classification System.

There should be little change in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio).

2.1.3 Longitudinal Profile

A longitudinal profile was completed for the restored streams to provide a baseline for evaluating changes in channel bed conditions over time. A longitudinal profile was conducted for the entire project length on UT1 and UT2. An additional 3,396 linear feet of stream channel was surveyed on Blockhouse Creek. Longitudinal profiles will be replicated in years one, three, and five of the monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, inner berm, bankfull, and top of low bank, if the features are present. All measurements will be taken at the head of each feature (e.g., riffle, or pool) and the maximum pool depth. Elevations of grade control structures will also be included in longitudinal profiles surveyed. Surveys will be tied to a permanent benchmark. Permanent cross-section and longitudinal profile data are provided in Appendix B.

The longitudinal profiles should show that the bed features are remaining stable; i.e., they are not aggrading or degrading. The pools should remain deep with flat water surface slopes, and the riffles should remain

steeper and shallower than the pools. Bed form observations should be consistent with those observed for channels of the design stream type.

2.1.4 Bed Material Analyses

Bed material analyses will include pebble counts taken during each geomorphic survey. These samples will reveal any changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

Two bulk sediment samples will be processed along the mainstem of Blockhouse Creek. One bulk sediment sample will be collected in a riffle upstream of I-26. The second bulk sample will be collected from a riffle downstream of the interstate in the vicinity of the pond adjacent to the project site. During the monitoring period, if the bulk samples show a coarsening of the bed and gravel becomes a larger component of the bed, then a pebble count will be added above and below I-26. Bedload samples will be taken one year after construction and at two-year intervals thereafter, at the time the longitudinal field surveys are performed. Sediment data will be plotted on a semi-log graph and compared with data from previous years.

2.1.5 Bank Stability Assessments

To aid the NCEEP in evaluating the risk of erosion from changes in channel and bank stability and subsequent sediment yield from the project area, Baker is prepared to assign numeric values to streambank and channel features. This will occur during Year 5 of the monitoring period. These numeric scores will be derived using the Bank Erosion Hazard Index (BEHI) and Near Bank Stress (NBS) evaluation methods. The scores will then be used to evaluate channel stability and project sediment export. Results from a visual stability assessment are provided in Table 7.

Table 7. Categorical Stream Feature Visual Stability Assessment
Blockhouse Creek Restoration Project

Features	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%					
B. Pools	100%					
C. Thalweg	100%					
D. Meanders	100%					
E. Bed General	100%					
F. Bank Stability	100%					
G. Vanes	100%					
H. Rootwads, Boulders, Geolifts	100%					

2.1.6 Photo Reference Sites

Photographs will be used to document restoration success qualitatively. Reference stations will be photographed during the as-built survey and for five years following construction. Reference photos will be taken once a year, from a height of approximately five to six feet. Permanent markers will be established to ensure that the same locations (and view directions) are utilized during each monitoring period. Reference photographs are shown in Appendix A.

2.1.6.1 Lateral Reference Photos

Reference photo transects will be taken at each permanent cross-section. Photographs will be taken of both banks at each cross-section. A survey tape will be centered in the photographs of the bank. The water line will be located in the lower edge of the frame, and as much of the bank as possible will

be included in each photo. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.1.6.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored stream are included within the photographs taken at reference photo stations. Photographers will make every effort to consistently maintain the same area in each photo over time.

Photographs will be used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2 Vegetation Monitoring

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, 10 vegetation monitoring quadrants were installed across the restoration site as required by the NCEEP. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred. Individual quadrant data will be provided and will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

At the end of the first growing season, species composition, density, and survival will be evaluated. For each subsequent year, until the final success criteria are achieved, the restored site will be evaluated between May and July.

The interim measure of vegetative success for the site will be the survival of at least 320, 3-year old, planted trees per acre at the end of year three of the monitoring period. The final vegetative success criteria will be the survival of 260, 5-year old, planted trees per acre at the end of year five of the monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

2.3 Maintenance and Contingency Plans

Maintenance requirements vary from site to site and are generally driven by the following conditions:

- Projects without established, woody floodplain vegetation are more susceptible to erosion from floods than those with a mature, hardwood forest
- Projects with sandy, non-cohesive soils are more prone to short-term bank erosion than cohesive soils or soils with high gravel and cobble content
- Alluvial valley channels with wide floodplains are less vulnerable than confined channels
- Wet weather during construction can make accurate channel and floodplain excavations difficult
- Extreme and/or frequent flooding can cause floodplain and channel erosion
- Extreme hot, cold, wet, or dry weather during and after construction can limit vegetation growth, particularly temporary and permanent seed

- The presence and aggressiveness of invasive species can affect the extent to which a native buffer can be established.

Maintenance issues and recommended remediation measures will be detailed and documented in future monitoring reports. Factors that may have caused any maintenance needs, including any of the conditions listed above, shall be discussed. NCEEP approval will be obtained prior to any remedial action.

2.4 Monitoring Results – 2008 As-Built Data

The five-year monitoring plan for the Blockhouse Creek Site includes criteria to evaluate the success of the vegetative and geomorphic components of the project. The specific locations of vegetation plots, permanent cross-sections, and crest gauges are shown on the as-built sheets. Photo points, located along the stream restoration project, are also shown.

2.4.1 Morphology

For monitoring stream success criteria, 16 permanent cross-sections and 3 crest gauges were installed. The permanent cross-sections will be used to monitor channel dimension over time. The crest gauges will be used to document the occurrence of bankfull events. In addition, a complete longitudinal survey was completed for the restored stream channels to provide a base-line for evaluating changes in bed conditions over time. The permanent cross-section and longitudinal data are provided in Appendix B. The location of the permanent cross-sections and the crest gauges are shown on the as-built plan sheets in Appendix C.

2.4.1.1 Results and Discussion

No results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2009.

2.4.2 Vegetation

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stake, bare root trees, and live brush in the geolift structures have also begun to grow and are providing streambank stability. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A 30-foot buffer was established along of the majority of the restored stream and the width exceeds this minimum in most places. However at crossings the easement “pinches” in to meet the crossing structure and along one section of Reach 3 the easement on the left bank is less than 30 feet due to existing constraints; however, the total width is greater than 60 feet. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in May 2008. Species planted and as-built densities are summarized in Table 8.

Table 8. Rooted trees, live stakes and seeding planted in the riparian zone of Blockhouse Creek. The species composition for two different areas is shown; with one area being upstream of I-26 and the second area being downstream of I-26.		
Planting Plan		
Scientific name	**Common name**	**Percent Planted by Species**
Blockhouse Creek upstream of I-26 and UT1 (40% trees/ 60% shrubs) planted at 680 stems/A		
Trees - Planted 13'x13'		
Acer rubrum	Red maple	13
Fraxinus pennsylvanica	Green ash	13
Juglans nigra	Black walnut	13
Liriodendron tulipfera	Tulip poplar	0.5
Platanus occidentalis	Sycamore	0.5
Understory Trees/Shrubs- Planted 10'x10'		
Alnus serrulata	Tag alder	9
Calicanthus floridus	Sweet Shrub	10
Cornus florida	Flowering dogwood	12
Cercis canadensis	Redbud	10
Carpinus caroliniana	Ironwood	9
Asimina triloba	Paw paw	9
Blockhouse Creek downstream of I-26 and UT2 (60% Trees/ 40% shrubs) planted at 680 stems/A		
Trees - Planted 10'x10'		
Acer rubrum	Red maple	4
Diospyros virginiana	Persimmon	6
Juglans nigra	Black walnut	12
Liriodendron tulipfera	Tulip poplar	10
Platanus occidentalis	Sycamore	10
Prunus serotina	Black Cherry	6
Quercus phellos	Willow oak	6
Quercus rubra	Red oak	6
Understory Trees/Shrubs- Planted 13'x13'		
Alnus serrulata	Tag alder	6
Calicanthus floridus	Sweet Shrub	6
Cornus florida	Flowering dogwood	9
Cercis canadensis	Redbud	8
Carpinus caroliniana	Ironwood	6
Asimina triloba	Paw paw	5
Woody Vegetation for Live Stakes - Planted 3’ x 3’ on center		
Salix sericea	Silky willow	30
Physocarpus opulifolius	Ninebark	25
Sambucus canadensis	Elderberry	15
Cornus amomum	Silky Dogwood	30
Note: Species selection may change due to availability at the time of planting.		

The restoration plan for the Blockhouse Creek Site specifies that the number of quadrants required were based on the species/area curve method, as described in NCEEP monitoring guidance documents, with a minimum of three quadrants. The size of individual quadrants are 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. A total of ten vegetation plots, each 10 by 10 meters in size, were established across the restored site. The initial planted density within each of the vegetation monitoring plots is given in Table 9. The average density of planted bare root stems, based on the data from the ten monitoring plots, is 764 stems per acre. The locations of the vegetation plots are shown on the as-built plan sheets.

2.4.2.1 Results and Discussion

No monitoring results are available at the submittal of this report. As-built data will be compared with first year monitoring data in the Year 1 Monitoring Report, scheduled for submittal to NCEEP during December 2008.

Table 9. CVS Level 1 Stem Count Arranged by Plot (As-Built)
Blockhouse Creek Restoration Site

Tree Species	Plots										As-built Totals	Year 1 Totals	Year 3 Totals	Year 5 Totals	Site Average Stems/acre
	1	2	3	4	5	6	7	8	9	10					
Betula nigra		1		1	5		2			5	14				
Acer rubrum	3	5		2							10				
Fraxinus pennsylvanica	2	3			4	8	2		4	3	26				
Juglans nigra	3	2		1			1	8			15				
Platanus occidentalis	3	4	7	10	4		3	3	10		44				
Liriodendron tulipfera			2			1		5		7	15				
Quercus phellos					1		1	7			9				
Quercus rubra			4	2	2	3		3			14				
Diospyros virginiana				1	5	8	2				16				
Shrub Species															
Alnus serrulata	1	1									2				
Calicanthus floridus	2	1	4	2							9				
Halesia carolina				3							3				
Cercis canadensis	2	1	2								5				
Asimina triloba					1	1					2				
Cornus florida	1	1									2				
Cornus amomum							1	3		1	5				
Stems/plot	17	19	19	22	22	21	12	29	14	16					
Stems/acre As-built	680	760	760	880	880	840	480	1160	560	640					764

2.5 Areas of Concern

There are two factors of concern at this project site. Neither have to do with specific sites on the channel. The first concern is the rate of overland flow that the site experiences above Interstate 26. Due to the buildings on this site and the high compaction of the soil from heavy use by horse show participants, the runoff from the land adjoining the stream is high. This has not affected the channel proper but is the source of some minor rutting along terrace slopes leading down to the floodplain. Baker is working with FENCE to seek grant funding to address this issue. The second concern is that two of the three box culverts under Interstate 26 are two thirds full of sand. During any high flow event this sand mobilizes into the channel downstream of the interstate. This is causing some pools to fill with sand and the loss of pool depth. The channel is moving this material and it will eventually correct the problem but it will affect the lower end of the project of the next several years. NCDOT has been contacted about this issue but they do not appear interested in addressing it.

The project area has received little precipitation in the time since ground cover and woody vegetation was planted in the riparian buffers. Considering the drought conditions that have persisted in the region where the project site is located, vegetation survival has been excellent. Mortality rates for woody vegetation planted appear to be low though some sections of the project have experienced higher rates of mortality as evidenced by the vegetative plot data listed in Table 9. Early observations indicate that the vegetation treatments have been effective at establishing herbaceous ground cover in the majority of the project site. Areas of sparser vegetation will be replanted if suitable cover is not found to be established during Year 1 monitoring.

Beyond these issues no areas of concern have been identified during the first months following completion of the project.

APPENDIX A

SELECTED PROJECT PHOTOGRAPHS

Blockhouse Creek Restoration Project
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 3: facing downstream

Photo Point 4: facing downstream

Photo Point 5: facing downstream

Photo Point 6: facing downstream

Photo Point 7: facing downstream

Photo Point 8: facing downstream

Photo Point 9: facing downstream

Photo Point 10: facing downstream

Photo Point 11: facing downstream

Photo Point 12: facing downstream

Photo Point 13: facing downstream

Photo Point 14: facing downstream

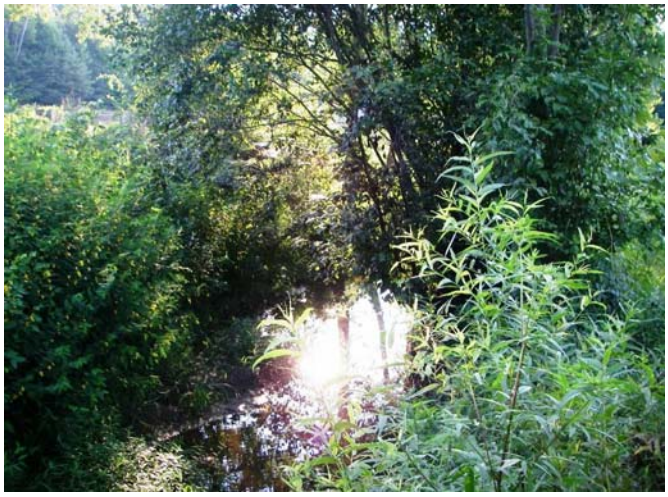


Photo Point 15: facing downstream

Photo Point 16: facing downstream

Photo Point 17: facing downstream

Photo Point 18: facing upstream

Photo Point 18: facing downstream

Photo Point 19: facing downstream

Photo Point 20: facing upstream

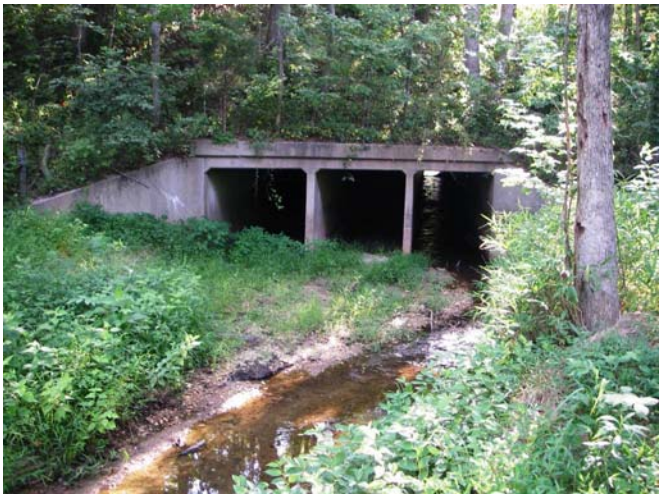


Photo Point 20: facing downstream

Photo Point 21: facing upstream

Photo Point 21: facing downstream

Photo Point 22: facing upstream

Photo Point 22: facing downstream

Photo Point 23: facing upstream

Photo Point 23: facing downstream

Photo Point 24: facing downstream

Photo Point 25: facing upstream

Photo Point 25: facing downstream

Photo Point 26: facing upstream

Photo Point 26: facing downstream

Photo Point 27: facing downstream

Photo Point 28: facing upstream

Photo Point 28: facing downstream

Photo Point 29: facing downstream

Photo Point 30: facing downstream

Photo Point 31: facing downstream

Photo Point 32: facing upstream

Photo Point 32: facing downstream

Blockhouse Creek Restoration Project: UT1
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 3: facing downstream

Photo Point 4: facing downstream

Photo Point 5: facing upstream

Photo Point 5: facing downstream

Photo Point 6: facing upstream

Photo Point 6: facing downstream

Blockhouse Creek Restoration Project: UT2
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing downstream

Photo Point 2: facing downstream

Photo Point 3: facing downstream

Photo Point 4: facing upstream

Photo Point 4: facing downstream

Photo Point 5: facingn downstream

Photo Point 6: facing upstream

Photo Point 6: facing downstream

Photo Point 7: facing upstream

Photo Point7: facing downstream

Photo Point 8: facing upstream

Photo Point 8: facing downstream

Photo Point 9: facing upstream

Photo Point 9: facing downstream

Photo Point 10: facing upstream

Photo Point: facing downstream

Photo Point 11: facing downstream

Blockhouse Creek Restoration Project: UT3
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

Photo Point 1: facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 4: facing downstream

Photo Point 5: facing downstream

Photo Point 6: facing upstream

Photo Point 7: facing upstream

Photo Point 8: facing upstream

Photo Point 9: facing downstream

Blockhouse Creek Restoration Project
Photo Log - Photo Points

Notes:

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and pink flagging tape.

7/8/2009

Photo Point 1: Veg Plot 1

7/8/2009

Photo Point 2: Veg Plot 2

7/8/2009

Photo Point 3: Veg Plot 3

7/8/2009

Photo Point 4: Veg Plot 4

7/8/2009

Photo Point 5: Veg Plot 5

7/8/2009

Photo Point 6: Veg Plot 6

7/8/2009

Photo Point 7: Veg Plot 7

7/8/2009

Photo Point 8: Veg Plot 8

7/8/2009

Photo Point 9: Veg Plot 9

7/8/2009

Photo Point 10: Veg Plot 10

APPENDIX B

AS-BUILT CROSS-SECTIONS AND LONGITUDINAL PROFILES

Morphology and Hydraulic Monitoring Summary - As-Built Monitoring

Blockhouse Creek Restoration Project

	Blockhouse Creek Reach 1 (1,070 ft)												**Blockhouse Creek Reach 2 (340ft)**											
Parameter	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Pool						Cross Section 4 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	21.69						23.48						23.01						22.57					
Floodprone Width (ft)	>54						>54						>48						>57					
BF Cross Sectional Area (ft2)	29.00						30.80						34.20						34.90					
BF Mean Depth (ft)	1.34						1.31						1.49						1.54					
BF Max Depth (ft)	2.29						2.81						3.45						2.92					
Width/Depth Ratio	16.20						17.89						15.49						14.62					
Entrenchment Ratio	2.50						2.30						2.10						2.50					
Wetted Perimeter (ft)	24.37						26.10						25.99						25.65					
Hydraulic Radius (ft)	1.19						1.18						1.32						1.36					
Substrate																								
d50 (mm)	10.75						----						----						----					
d84 (mm)	22.60						----						----						----					

	Blockhouse Creek Reach 3 (950ft)						**Blockhouse Creek Reach 4 (1,780 ft)**																	
Parameter	Cross Section 5 Riffle						Cross Section 6 Pool						Cross Section 7 Riffle						Cross Section 8 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	21.50						24.40						19.62						18.35					
Floodprone Width (ft)	>44						>36						>53						>61					
BF Cross Sectional Area (ft2)	33.00						35.40						34.80						35.80					
BF Mean Depth (ft)	1.54						1.45						1.77						1.95					
BF Max Depth (ft)	3.20						2.88						3.15						4.50					
Width/Depth Ratio	13.99						16.83						11.08						9.41					
Entrenchment Ratio	2.10						1.50						2.70						3.30					
Wetted Perimeter (ft)	24.58						27.30						23.16						22.25					
Hydraulic Radius (ft)	1.34						1.30						1.50						1.61					

	Blockhouse Creek Reach 4 (1,780 ft)					
Parameter	Cross Section 9 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5
Dimension						
BF Width (ft)	19.01					
Floodprone Width (ft)	>59					
BF Cross Sectional Area (ft2)	35.10					
BF Mean Depth (ft)	1.84					
BF Max Depth (ft)	2.98					
Width/Depth Ratio	10.30					
Entrenchment Ratio	3.10					
Wetted Perimeter (ft)	22.69					
Hydraulic Radius (ft)	1.55					
Substrate						
d50 (mm)	2.24					
d84 (mm)	26.23					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	55.00	144.00	99.50															
Radius of Curvature (ft)	15.50	36.00	25.75															
Meander Wavelength (ft)	109.00	216.00	162.50															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	15.00	80.00	47.50															
Riffle Slope (ft/ft)	0.00	0.04	0.02															
Pool Length (ft)	10.00	25.00	17.50															
Pool Spacing (ft)	30.00	122.00	76.00															
Substrate																		
d50 (mm)	2.24	10.75	6.50															
d84 (mm)	22.60	26.23	24.42															
Additional Reach Parameters																		
Valley Length (ft)	2939.00																	
Channel Length (ft)	4140.00																	
Sinuosity	1.12	1.19	1.16															
Water Surface Slope (ft/ft)	0.00	0.01	0.01															
BF Slope (ft/ft)	0.00	0.02	0.01															
Rosgen Classification	C4/Bc4/E4																	

UT1 Reach (580 ft)																		
Parameter	Cross Section 10 Riffle						Cross Section 11 Riffle						Cross Section 12 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	12.43						11.42						12.95					
Floodprone Width (ft)	>39						>41						>30					
BF Cross Sectional Area (ft2)	10.70						10.30						10.40					
BF Mean Depth (ft)	0.86						0.90						0.80					
BF Max Depth (ft)	1.76						1.66						1.58					
Width/Depth Ratio	14.48						12.66						16.16					
Entrenchment Ratio	3.10						3.60						2.30					
Wetted Perimeter (ft)	14.15						13.22						14.55					
Hydraulic Radius (ft)	0.76						0.78						0.71					
Substrate																		
d50 (mm)	----						----						----					
d84 (mm)	----						----						----					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	35.00	80.00	57.50															
Radius of Curvature (ft)	10.00	20.00	15.00															
Meander Wavelength (ft)	70.00	120.00	95.00															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	19.00	74.00	46.50															
Riffle Slope (ft/ft)	0.03	0.04	0.03															
Pool Length (ft)	7.00	15.00	11.00															
Pool Spacing (ft)	13.00	60.00	36.50															
Substrate																		
d50 (mm)	----	----	16.00															
d84 (mm)	----	----	26.89															
Additional Reach Parameters																		
Valley Length (ft)	525.00																	
Channel Length (ft)	580.00																	
Sinuosity	1.12	1.13	1.12															
Water Surface Slope (ft/ft)	----	----	0.02															
BF Slope (ft/ft)	----	----	0.02															
Rosgen Classification	C4																	

UT2 Reach (1,155 ft)																								
Parameter	Cross Section 13 Riffle						Cross Section 14 Pool						Cross Section 15 Riffle						Cross Section 16 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	10.93						6.21						8.55						6.87					
Floodprone Width (ft)	>24						>21						>29						>27					
BF Cross Sectional Area (ft2)	4.90						4.50						5.20						4.90					
BF Mean Depth (ft)	0.45						0.72						0.61						0.71					
BF Max Depth (ft)	1.07						1.24						1.00						1.05					
Width/Depth Ratio	24.52						8.59						14.00						9.63					
Entrenchment Ratio	2.20						3.40						3.40						3.90					
Wetted Perimeter (ft)	11.83						7.65						9.77						8.29					
Hydraulic Radius (ft)	0.41						0.59						0.53						0.59					
Substrate																								
d50 (mm)	----						----						----						----					
d84 (mm)	----						----						----						----					

Parameter	AB (2008)			MY-1 (2009)			MY-2 (2010)			MY-3 (2011)			MY-4 (2012)			MY-5 (2013)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	25.00	56.00	40.50															
Radius of Curvature (ft)	7.00	14.00	10.50															
Meander Wavelength (ft)	49.00	84.00	66.50															
Meander Width Ratio	3.50	8.00	5.75															
Profile																		
Riffle length (ft)	5.00	41.00	23.00															
Riffle Slope (ft/ft)	0.03	0.05	0.04															
Pool Length (ft)	3.00	15.00	9.00															
Pool Spacing (ft)	12.00	38.00	25.00															
Substrate																		
d50 (mm)	0.73	1.23	0.98															
d84 (mm)	1.90	4.47	3.19															
Additional Reach Parameters																		
Valley Length (ft)	946.00																	
Channel Length (ft)	1155.00																	
Sinuosity	1.14	1.28	1.21															
Water Surface Slope (ft/ft)	0.01	0.03	0.02															
BF Slope (ft/ft)	0.02	0.03	0.02															
Rosgen Classification	Bc5/Cb/E4																	

Baseline Stream Summary
Blockhouse Creek: Reach 1

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	16.48	-----	16.92	-----	18.50	20.00	21.50	18.50	20.00	21.50	21.69	22.59	23.48
Floodprone Width (ft)	-----	-----	33.00	-----	-----	-----	-----	-----	70+	-----	53.90	54.05	54.20
Bankfull Mean Depth (ft)	1.82	-----	1.80	-----	1.80	2.30	2.80	-----	1.9	-----	1.31	1.33	1.34
Bankfull Max Depth (ft)	-----	-----	3.00	-----	2.50	3.30	4.10	-----	2.5	-----	2.29	2.55	2.80
Bankfull Cross Sectional Area (ft2)	29.88	-----	30.60	-----	39.60	47.05	54.50	-----	29.4	-----	29.00	29.90	30.80
Width/Depth Ratio	-----	-----	9.40	-----	9.19	10.57	11.94	-----	8.2	-----	16.20	17.05	17.89
Entrenchment Ratio	-----	-----	1.90	-----	6.05	6.40	6.74	-----	>2.2	-----	2.30	2.40	2.50
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.05	-----	0.90	1.25	1.60
Bankfull Velocity (fps)	-----	-----	2.94	-----	3.50	4.25	5.00	-----	3.06	-----	3.10	3.01	2.92
Pattern													
Channel Beltwidth (ft)	-----	6.31	10.16	14.00	30.50	37.25	44.00	55.00	89.50	124.00	59.00	80.50	102.00
Radius of Curvature (ft)	-----	-----	----	-----	42.30	52.70	63.10	16.00	23.50	31.00	15.50	23.25	31.00
Meander Wavelength (ft)	-----	-----	----	-----	185.00	222.50	260.00	109.00	147.50	186.00	108.50	150.15	191.80
Meander Width Ratio	-----	-----	0.60	-----	1.50	1.83	2.16	2.97	4.37	5.77	2.72	3.53	4.34
Profile													
Riffle Length (ft)	-----	-----	----	-----	-----	-----	-----	25.00	70.00	115.00	18.76	36.50	73.00
Riffle Slope (ft/ft)	-----	-----	----	-----	0.0150	0.0170	0.0190	0.0081	0.00	0.0011	0.0030	0.0085	0.0140
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	8.00	21.50	35.00	13.00	17.0000	21.00
Pool Spacing (ft)	-----	-----	----	-----	97.50	138.65	179.80	62.00	85.50	109.00	65.00	77.50	90.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	0.3 / 0.58 /1.0/5.7/12.4			----			0.3 / 0.58 /1.0/5.7/12.4			NA/5.01/10.75/22.6/31.09		
Reach Shear Stress (competency) lb/f2	-----	-----	0.38	-----	-----	-----	-----	-----	0.33	-----	-----	0.32	-----
Stream Power (transport capacity) W/m2	-----	-----	1.13	-----	-----	-----	-----	-----	1.02	-----	-----	0.96	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	887.00	-----	-----	330.00	-----	-----	1070.00	-----	-----	1070.00	-----
Drainage Area (SM)	-----	-----	1.63	-----	0.20	1.90	2.30	-----	1.63	-----	-----	1.63	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4	-----
Bankfull Discharge (cfs)	126.72	-----	90.00	-----	-----	----	-----	-----	90.00	-----	-----	90.00	-----
Sinuosity	-----	-----	1.01	-----	-----	1.10	-----	-----	1.10	-----	-----	1.18	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0067	-----	-----	0.0054	-----

Baseline Stream Summary
Blockhouse Creek: Reach 2

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	17.71	----	25.6	----	18.50	20.00	21.50	18.50	20.00	21.50	22.57	22.79	23.01
Floodprone Width (ft)	-----	----	37.5	----	----	----	----	-----	70+	-----	47.70	52.50	57.30
Bankfull Mean Depth (ft)	1.92	----	1.94	----	1.80	2.30	2.80	-----	2.25	-----	1.49	1.52	1.54
Bankfull Max Depth (ft)	-----	----	3.3	----	2.50	3.30	4.10	-----	3.00	-----	2.92	3.19	3.45
Bankfull Cross Sectional Area (ft2)	33.98	----	49.7	----	39.60	47.05	54.50	-----	35.6	-----	34.20	34.55	34.90
Width/Depth Ratio	-----	----	13.2	----	9.19	10.57	11.94	-----	8.00	-----	14.62	15.06	15.49
Entrenchment Ratio	-----	----	1.5	----	6.05	6.40	6.74	-----	>2.2	-----	2.10	2.30	2.50
Bank Height Ratio	-----	----	2.0	----	1.00	1.05	1.10	-----	1.00	-----	0.90	0.90	0.90
Bankfull Velocity (fps)	-----	----	2.41	----	3.50	4.25	5.00	-----	3.37	-----	3.51	3.47	3.44
Pattern													
Channel Beltwidth (ft)	-----	5.09	8.70	12.30	30.50	37.25	44.00	63.00	103.50	144.00	57.30	78.70	100.10
Radius of Curvature (ft)	-----	----	----	----	42.30	52.70	63.10	18.00	27.00	36.00	30.79	34.06	37.32
Meander Wavelength (ft)	-----	----	----	----	185.00	63.60	260.00	126.00	171.00	216.00	145.67	165.94	186.21
Meander Width Ratio	-----	----	0.34	----	1.50	1.83	2.16	3.41	5.05	6.70	2.54	3.47	4.39
Profile													
Riffle Length (ft)	-----	----	----	----	-----	-----	-----	25.00	55.00	85.00	35.00	55.50	76.00
Riffle Slope (ft/ft)	-----	----	----	----	0.0150	0.0170	0.0190	0.0081	0.0046	0.0011	0.0109	0.02	0.0350
Pool Length (ft)	-----	----	----	----	-----	-----	-----	8.00	21.5000	35.00	15.00	20.00	25.00
Pool Spacing (ft)	-----	----	----	----	97.50	138.65	179.80	72.00	99.00	126.00	58.00	89.00	120.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.87/2.99/7.6/19/21.8			-----			.87/2.99/7.6/19/21.8			NA/5.01/10.75/22.6/31.09		
Reach Shear Stress (competency) lb/f2	-----	-----	0.45	-----	-----	-----	-----	-----	0.54	-----	-----	0.50	-----
Stream Power (transport capacity) W/m2	-----	-----	1.09	-----	-----	-----	-----	-----	1.83	-----	-----	1.74	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	340.00	-----	-----	330.00	-----	-----	340.00	-----	-----	340.00	-----
Drainage Area (SM)	-----	-----	1.97	-----	0.20	1.90	2.30	-----	1.97	-----	-----	1.97	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	C4	-----
Bankfull Discharge (cfs)	145.30	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.02	-----	-----	1.10	----	-----	1.10	-----	-----	0.38	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0121	-----	-----	0.0183	-----

Baseline Stream Summary
Blockhouse Creek: Reach 3

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	18.50	----	21.2	----	18.50	20.00	21.50	18.50	20.00	21.50	----	21.50	----
Floodprone Width (ft)	-----	----	>150	----	----	----	----	-----	45+	-----	----	44.20	----
Bankfull Mean Depth (ft)	1.99	----	2.31	----	1.80	2.30	2.80	-----	2.25	-----	----	1.54	----
Bankfull Max Depth (ft)	-----	----	3.3	----	2.50	3.30	4.10	-----	3.00	-----	----	3.20	----
Bankfull Cross Sectional Area (ft2)	36.75	----	49.1	----	39.60	47.05	54.50	-----	35.6	-----	----	33.00	----
Width/Depth Ratio	-----	----	9.2	----	9.19	10.57	11.94	-----	8.00	-----	----	13.99	----
Entrenchment Ratio	-----	----	>7	----	6.05	6.40	6.74	-----	>2.2	-----	----	2.10	----
Bank Height Ratio	-----	----	1.1	----	1.00	1.05	1.10	-----	1.00	-----	----	0.80	----
Bankfull Velocity (fps)	-----	----	2.44	----	3.50	4.25	5.00	-----	3.37	-----	-----	3.64	-----
Pattern													
Channel Beltwidth (ft)	-----	8.69	33.02	57.34	30.50	37.25	44.00	63.00	103.50	144.00	54.70	60.85	67.00
Radius of Curvature (ft)	-----	----	----	----	42.30	52.70	63.10	18.00	27.00	36.00	26.49	34.25	42.00
Meander Wavelength (ft)	-----	----	----	----	185.00	63.60	260.00	126.00	171.00	216.00	125.06	160.07	195.07
Meander Width Ratio	-----	----	1.56	----	1.50	1.83	2.16	3.15	5.18	7.20	2.54	2.83	3.12
Profile													
Riffle Length (ft)	-----	----	----	----	-----	-----	-----	25.00	60.00	95.00	35.00	52.50	70.00
Riffle Slope (ft/ft)	-----	----	----	----	0.0150	0.0170	0.0190	0.0038	0.00	0.0038	0.0120	0.03	0.0420
Pool Length (ft)	-----	----	----	----	-----	-----	-----	10.00	22.50	35.00	10.00	17.00	24.00
Pool Spacing (ft)	-----	----	----	----	97.50	138.65	179.80	72.00	99.00	126.00	30.00	76.00	122.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.5/2.12/6.1/18.1/21.1			-----			.5/2.12/6.1/18.1/21.1			NA/.31/2.24/26.23/55.59		
Reach Shear Stress (competency) lb/f2	-----	-----	0.54	-----	-----	-----	-----	-----	0.50	-----	-----	0.50	-----
Stream Power (transport capacity) W/m2	-----	-----	1.33	-----	-----	-----	-----	-----	1.69	-----	-----	1.82	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	950.00	-----	-----	330.00	-----	-----	950.00	-----	-----	950.00	-----
Drainage Area (SM)	-----	-----	2.21	-----	0.20	1.90	2.30	-----	2.21	-----	-----	2.21	-----
Rosgen Classification	-----	-----	C4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4/Bc4	-----
Bankfull Discharge (cfs)	157.88	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.06	-----	-----	1.10	----	-----	1.10	-----	-----	1.03	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0004	-----	-----	0.0032	-----

Baseline Stream Summary
Blockhouse Creek: Reach 4

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	19.21	18.2	18.85	19.5	18.50	20.00	21.50	18.50	20.00	21.50	18.35	20.35	24.40
Floodprone Width (ft)	-----	23.2	41.60	60	----	----	----	----	50+	-----	36.00	44.40	61.30
Bankfull Mean Depth (ft)	2.05	1.83	1.92	2.0	1.80	2.30	2.80	-----	2.25	-----	1.45	1.75	1.95
Bankfull Max Depth (ft)	-----	3.0	3.10	3.2	2.50	3.30	4.10	-----	3.00	-----	2.98	3.38	4.50
Bankfull Cross Sectional Area (ft2)	39.30	35.6	35.95	36.3	39.60	47.05	54.50	-----	35.6	-----	34.80	35.28	35.80
Width/Depth Ratio	-----	9.1	9.90	10.7	9.19	10.57	11.94	-----	8.00	-----	9.41	11.91	16.83
Entrenchment Ratio	-----	1.3	2.15	3	6.05	6.40	6.74	-----	>2.2	-----	1.50	2.65	3.30
Bank Height Ratio	-----	1.7	2.80	3.9	1.00	1.05	1.10	-----	1.00	-----	1.10	1.15	1.20
Bankfull Velocity (fps)	-----	-----	3.34	-----	3.50	4.25	5.00	-----	3.37	-----	3.45	3.40	3.35
Pattern													
Channel Beltwidth (ft)	-----	5.47	44.56	83.65	30.50	37.25	44.00	63.00	103.50	144.00	47.00	72.80	98.60
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	18.00	27.00	36.00	16.00	24.90	33.80
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	63.60	260.00	126.00	171.00	216.00	81.40	106.20	131.00
Meander Width Ratio	-----	-----	2.36	-----	1.50	1.83	2.16	3.15	5.18	7.20	2.31	3.58	4.85
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	25.00	65.00	105.00	27.00	53.50	80.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0075	0.01	0.0100	0.0110	0.01	0.0160
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	10.00	22.50	35.00	10.00	15.50	21.00
Pool Spacing (ft)	-----	-----	-----	-----	97.50	138.65	179.80	72.00	99.00	126.00	12.00	63.00	114.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.3/.58/1.0/5.7/12.4			-----			.3/.58/1.0/5.7/12.4			NA/.31/2.24/26.23/55.59		
Reach Shear Stress (competency) lb/f2	-----	-----	0.49	-----	-----	-----	-----	-----	0.54	-----	-----	0.56	-----
Stream Power (transport capacity) W/m2	-----	-----	1.64	-----	-----	-----	-----	-----	1.83	-----	-----	1.90	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	1821.00	-----	-----	330.00	-----	-----	1780.00	-----	-----	1780.00	-----
Drainage Area (SM)	-----	-----	2.44	-----	0.20	1.90	2.30	-----	2.44	-----	-----	2.44	-----
Rosgen Classification	-----	-----	E4	-----	-----	C/E4	-----	-----	E4	-----	-----	E4	-----
Bankfull Discharge (cfs)	169.59	-----	120.00	-----	----	----	----	----	120.00	----	-----	120.00	-----
Sinuosity	-----	-----	1.29	-----	-----	1.10	----	-----	1.10	-----	-----	1.19	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0047	-----	-----	0.0043	-----

Baseline Stream Summary
UT1

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	8.98	----	9.3	-----	18.50	20.00	21.50	-----	10.00	-----	11.42	12.27	12.95
Floodprone Width (ft)	-----	----	23.6	-----	----	----	----	30+	32.5+	35+	29.50	39.75	40.60
Bankfull Mean Depth (ft)	1.13	-----	.91	-----	1.80	2.30	2.80	-----	1.05	-----	0.80	0.85	0.90
Bankfull Max Depth (ft)	-----	-----	1.5	-----	2.50	3.30	4.10	-----	1.50	-----	1.58	1.67	1.76
Bankfull Cross Sectional Area (ft2)	10.08	-----	8.4	-----	39.60	47.05	54.50	-----	10.50	-----	10.30	10.47	10.70
Width/Depth Ratio	-----	-----	10.2	-----	9.19	10.57	11.94	-----	9.50	-----	12.66	14.43	16.16
Entrenchment Ratio	-----	-----	2.6	-----	6.05	6.40	6.74	-----	>2.2	-----	2.30	3.00	3.60
Bank Height Ratio	-----	-----	3.2	-----	1.00	1.05	1.10	-----	1.00	-----	0.90	0.97	1.00
Bankfull Velocity (fps)	-----	-----	3.57	-----	3.50	4.25	5.00	-----	2.86	-----	2.91	2.87	2.80
Pattern													
Channel Beltwidth (ft)	-----	5.30	9.47	13.63	30.50	37.25	44.00	35.00	57.50	80.00	22.60	33.64	44.68
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	10.00	15.00	20.00	10.78	15.20	19.62
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	63.60	260.00	70.00	95.00	120.00	32.86	38.77	44.68
Meander Width Ratio	-----	-----	1.02	-----	1.50	1.83	2.16	3.50	5.75	8.00	1.98	2.74	3.45
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	25.00	50.00	75.00	19.00	46.50	74.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0200	0.02	0.0270	0.0250	0.03	0.0370
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	8.00	14.00	20.00	7.00	11.00	15.00
Pool Spacing (ft)	-----	-----	-----	-----	97.50	138.65	179.80	40.00	55.00	70.00	13.00	36.50	60.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	9.68/13.27/16.00/25.97/31.45			----			9.68/13.27/16.00/25.97/31.45			1.68/11.71/16/26.89/34.85		
Reach Shear Stress (competency) lb/f2	-----	-----	0.94	-----	-----	-----	-----	-----	0.92	-----	-----	0.80	-----
Stream Power (transport capacity) lb/ft2	-----	-----	3.37	-----	-----	-----	-----	-----	2.62	-----	-----	3.40	-----
Additional Reach Parameters													
Channel length (ft)	-----	-----	523.00	-----	-----	330.00	-----	-----	580.00	-----	-----	580.00	-----
Drainage Area (SM)	-----	-----	0.33	-----	0.20	1.90	2.30	-----	0.33	-----	-----	0.33	-----
Rosgen Classification	-----	-----	E4	-----	-----	-----	-----	-----	E4	-----	-----	C4	-----
Bankfull Discharge (cfs)	39.98	-----	30.00	-----	----	----	----	----	30.00	----	-----	30.00	-----
Sinuosity	-----	-----	1.05	-----	-----	1.10	----	1.15	1.10	1.18	-----	1.12	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0142	-----	-----	0.0176	-----

Baseline Stream Summary
UT2

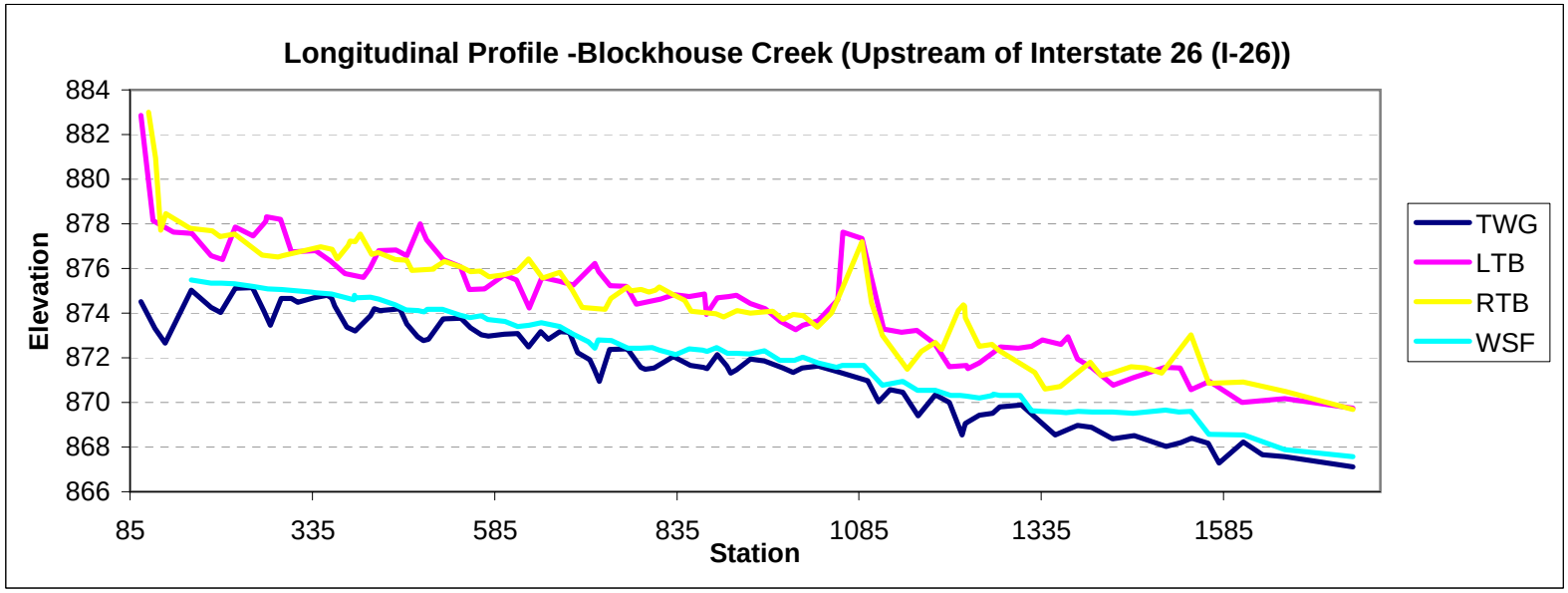
Parameter	Regional Curve	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built		
	Equation	(Upper Reach)						(Upper Reach)					
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Med	Max	Min	Mean	Max
Bankfull Width (ft)	5.48	-----	6.30	-----	18.50	20.00	21.50	-----	7.00	-----	6.21	8.57	10.93
Floodprone Width (ft)	-----	-----	22.60	-----	----	----	----	----	35+	----	21.20	22.65	24.10
Bankfull Mean Depth (ft)	0.76	-----	0.61	-----	1.80	2.30	2.80	-----	0.70	-----	0.45	0.59	0.72
Bankfull Max Depth (ft)	-----	-----	0.90	-----	2.50	3.30	4.10	-----	1.00	-----	1.07	1.16	1.24
Bankfull Cross Sectional Area (ft2)	4.17	-----	3.80	-----	39.60	47.05	54.50	-----	5.00	-----	4.50	4.70	4.90
Width/Depth Ratio	-----	-----	10.30	-----	9.19	10.57	11.94	-----	10.00	-----	8.59	16.56	24.52
Entrenchment Ratio	-----	-----	3.60	-----	6.05	6.40	6.74	----	>2.2	----	2.20	2.80	3.40
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.00	-----	0.70	0.85	1.00
Bankfull Velocity (fps)	-----	-----	3.42	-----	3.50	4.25	5.00	-----	2.60	-----	2.89	2.77	2.65
Pattern													
Channel Beltwidth (ft)	-----	6.80	29.55	52.30	30.50	37.25	44.00	25.00	40.50	56.00	20.34	31.67	43.00
Radius of Curvature (ft)	-----	-----	-----	-----	42.30	52.70	63.10	7.00	10.50	14.00	12.18	31.72	51.26
Meander Wavelength (ft)	-----	-----	-----	-----	185.00	222.50	260.00	49.00	66.50	84.00	46.87	74.30	101.72
Meander Width Ratio	-----	-----	4.69	-----	1.50	1.83	2.16	3.50	5.75	8.00	3.28	3.70	3.93
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	18.00	34.00	50.00	7.00	24.00	41.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0150	0.0170	0.0190	0.0270	0.03	0.0360	0.0270	0.03	0.0360
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3.50	9.25	15.00	4.00	9.50	15.00
Pool Spacing (ft)	----	-----	-----	-----	97.50	138.65	179.80	28.00	38.50	49.00	22.00	30.00	38.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.25 /.41 / .6 /1.7 /2.4			-----			.25 /.41 / .6 /1.7 /2.4			.13/.43/.73/1.9/2.97		
Reach Shear Stress (competency) lb/f2	-----	-----	0.40	-----	-----	-----	-----	-----	0.30	-----	-----*	-----*	-----*
Stream Power (transport capacity) W/m2	-----	-----	1.36	-----	-----	-----	-----	-----	0.78	-----	-----*	-----*	-----*
Additional Reach Parameters													
Channel length (ft)	-----	-----	1616.00	-----	-----	330.00	-----	-----	950.00	-----	-----	950.00	-----
Drainage Area (SM)	-----	-----	0.09	-----	0.20	1.90	2.30	-----	0.09	-----	-----	0.09	-----
Rosgen Classification	-----	-----	E5	-----	-----	B	-----	-----	E4	-----	-----	Bc5	-----
Bankfull Discharge (cfs)	15.64	-----	13.00	-----	----	-----	----	-----	13.00	-----	-----	13.00	-----
Sinuosity	-----	-----	1.34	-----	-----	1.10	----	-----	1.28	-----	-----	0.82	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0164	-----	-----	0.0292	-----

Notes: UT 2 was dry during the time as-built surveying was conducted. Therefore, water surface slope and transport parameters could not be calculated.

Baseline Stream Summary
UT2

Parameter	Regional Curve Equation	Pre-Existing Condition (Lower Reach)			Reference Reach(es) Data			Design (Lower Reach)			As-Built		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max				Min	Mean	Max
Bankfull Width (ft)	5.48	-----	6.30	-----	-----	7.00	-----	-----	7.00	-----	6.87	7.71	8.55
Floodprone Width (ft)	-----	-----	22.60	-----	-----	-----	-----	-----	35+	-----	26.90	28.20	29.50
Bankfull Mean Depth (ft)	0.76	-----	0.61	-----	-----	0.71	-----	-----	0.70	-----	0.61	0.66	0.71
Bankfull Max Depth (ft)	-----	-----	0.90	-----	-----	1.00	-----	-----	1.00	-----	1.00	1.03	1.05
Bankfull Cross Sectional Area (ft2)	4.17	-----	3.80	-----	-----	5.00	-----	-----	5.00	-----	4.90	5.05	5.20
Width/Depth Ratio	-----	-----	10.30	-----	12.00	15.00	18.00	-----	10.00	-----	9.63	11.82	14.00
Entrenchment Ratio	-----	-----	3.60	-----	-----	>2.2	-----	-----	>2.2	-----	3.40	3.65	3.90
Bank Height Ratio	-----	-----	2.80	-----	1.00	1.05	1.10	-----	1.00	-----	1.00	1.45	1.90
Bankfull Velocity (fps)	-----	-----	3.42	-----	4.00	5.00	6.00	-----	2.60	-----	2.65	2.57	2.50
Pattern													
Channel Beltwidth (ft)	-----	5.69	11.85	18.00	-----	-----	-----	25.00	40.50	56.00	34.28	43.54	52.80
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	23.72	25.92	28.12
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	120.46	-----
Meander Width Ratio	-----	-----	1.88	-----	2.00	5.00	8.00	-----	5.79	-----	4.99	5.65	6.18
Profile													
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	5.00	10.00	15.00	5.00	9.50	14.00
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.0320	0.0420	0.0520	0.0320	0.04	0.0520	0.0320	0.04	0.0520
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	4.00	6.50	9.00	3.00	4.00	5.00
Pool Spacing (ft)	-----	-----	-----	-----	10.50	22.75	35.00	10.50	22.75	35.00	12.00	15.50	19.00
Substrate and Transport Parameters													
d16 / d35 / d50 / d84 / d95	-----	.25 /.41 / .6 /1.7 /2.4			-----			.25 /.41 / .6 /1.7 /2.4			.11/.68/1.23/4.47/67.74		
Reach Shear Stress (competency) lb/f2	-----	-----	1.36	-----	-----	-----	-----	-----	1.15	-----	-----*	-----*	-----*
Stream Power (transport capacity) W/m2	-----	-----	4.66	-----	-----	-----	-----	-----	3.00	-----	-----*	-----*	-----*
Additional Reach Parameters													
Channel length (ft)	-----	-----	205.00	-----	-----	-----	-----	-----	205.00	-----	-----	205.00	-----
Drainage Area (SM)	-----	-----	0.09	-----	-----	-----	-----	-----	0.09	-----	-----	0.09	-----
Rosgen Classification	-----	-----	E5	-----	-----	B	-----	-----	B4	-----	-----	Cb/E4	-----
Bankfull Discharge (cfs)	15.64	-----	13.00	-----	-----	-----	-----	-----	13.00	-----	-----	13.00	-----
Sinuosity	-----	-----	1.34	-----	1.10	1.15	1.20	-----	1.14	-----	-----	1.11	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	0.0232	-----	-----	0.0173	-----

Notes: UT 2 was dry during the time as-built surveying was conducted. Therefore, water surface slope and transport parameters could not be calculated.


Longitudinal Profile -Blockhouse Creek (Upstream of Interstate 26 (I-26))
Elevation
884
882
880
878
876
874
872
870
868
866
85
335
585
835
1085
1335
1585
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	29	21.69	1.34	2.29	16.2	1.6	2.5	876.97	878.46

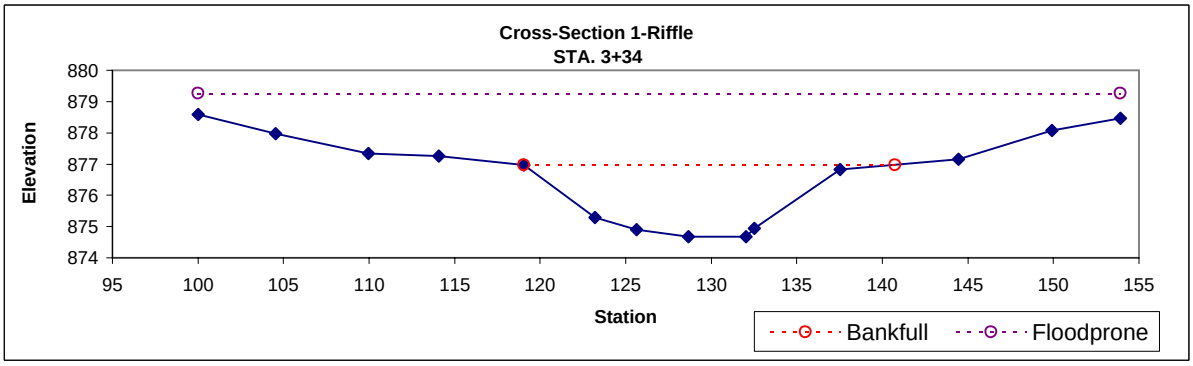


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	30.8	23.48	1.31	2.81	17.89	0.9	2.3	876	875.6

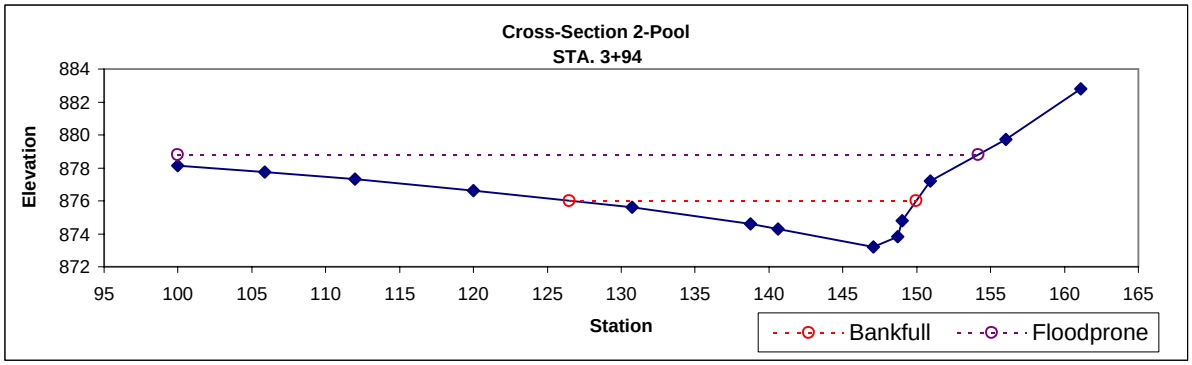


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Bc	34.2	23.01	1.49	3.45	15.49	0.9	2.1	872	871.66

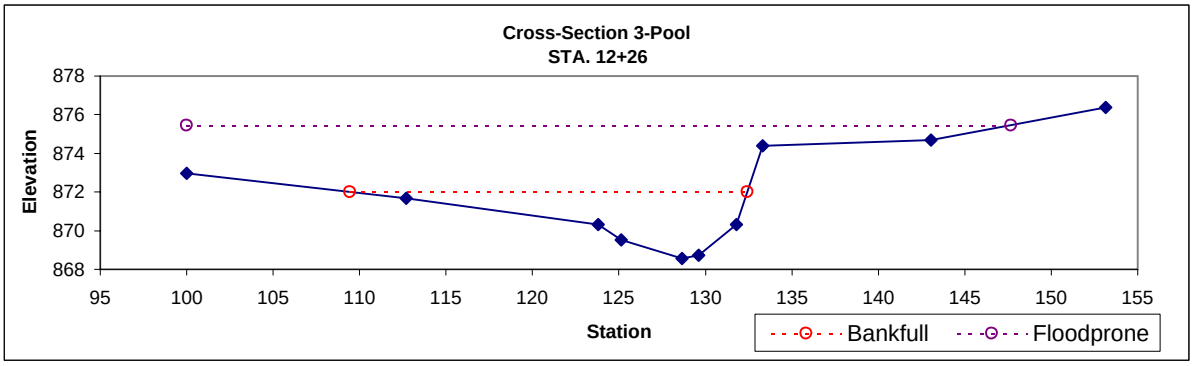


Photo 5: XS-3 facing right bank

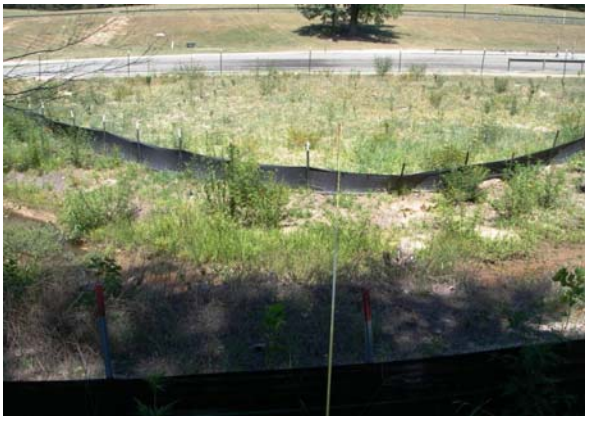


Photo 6: XS-3 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	34.9	22.57	1.54	2.92	14.62	0.9	2.5	872.4	872.25

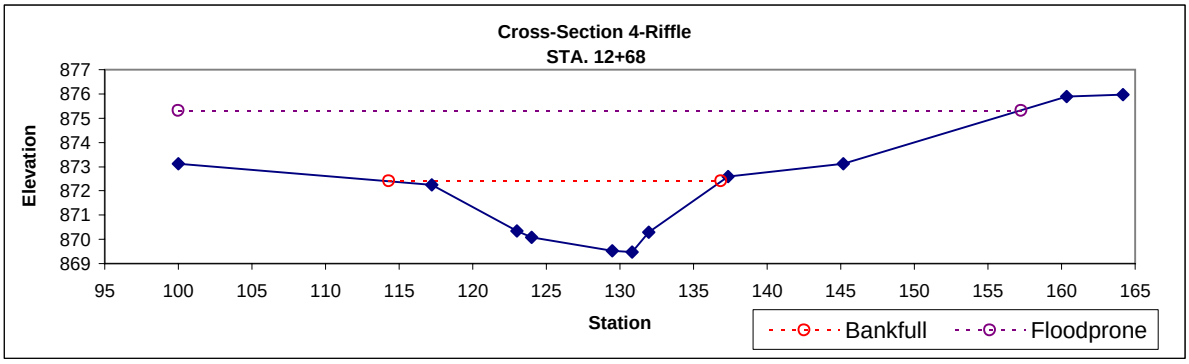


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	33	21.5	1.54	3.2	13.99	0.8	2.1	870.3	869.67

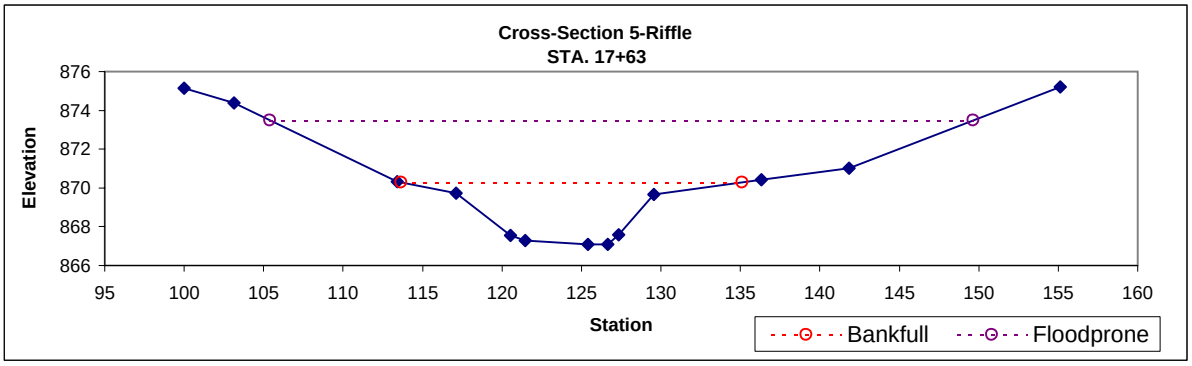
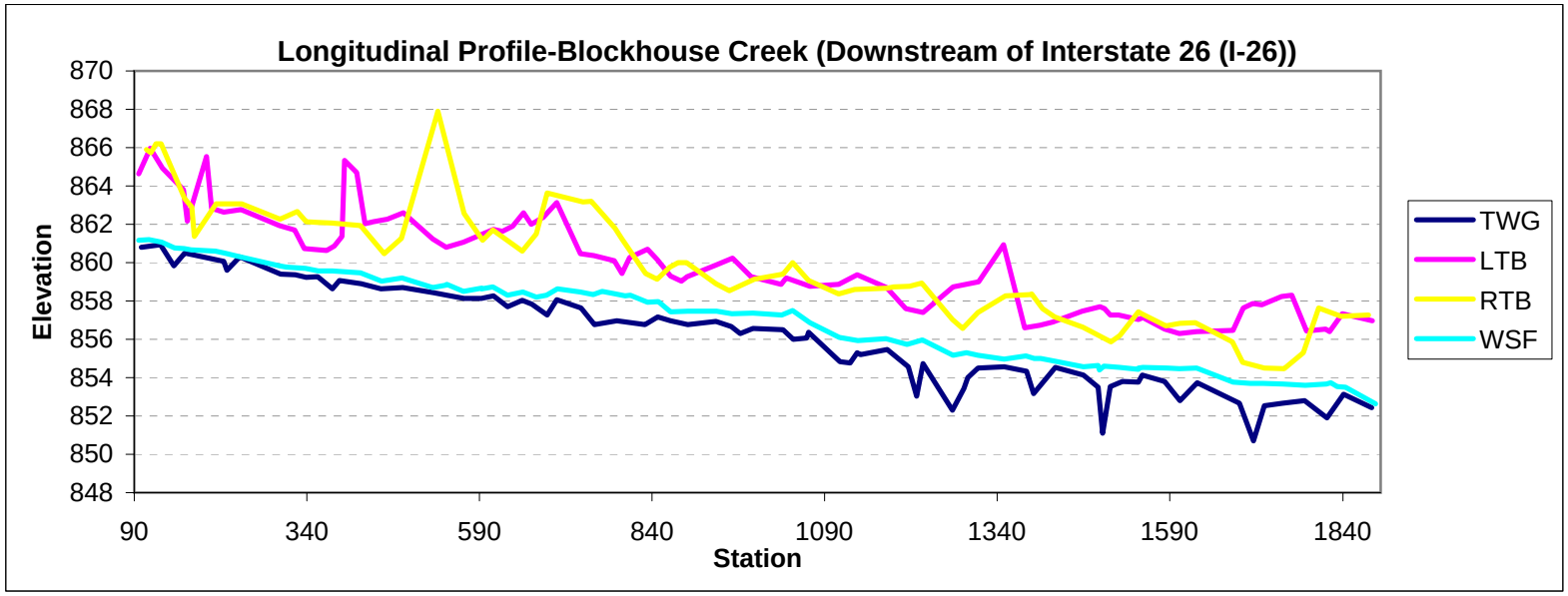


Photo 11: XS-5 facing right bank

Photo 12: XS-5 facing left bank


Longitudinal Profile-Blockhouse Creek (Downstream of Interstate 26 (I-26))
Elevation
870
868
866
864
862
860
858
856
854
852
850
848
90
340
590
840
1090
1340
1590
1840
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	35.4	24.4	1.45	2.88	16.83	1.2	1.5	861.17	861.62

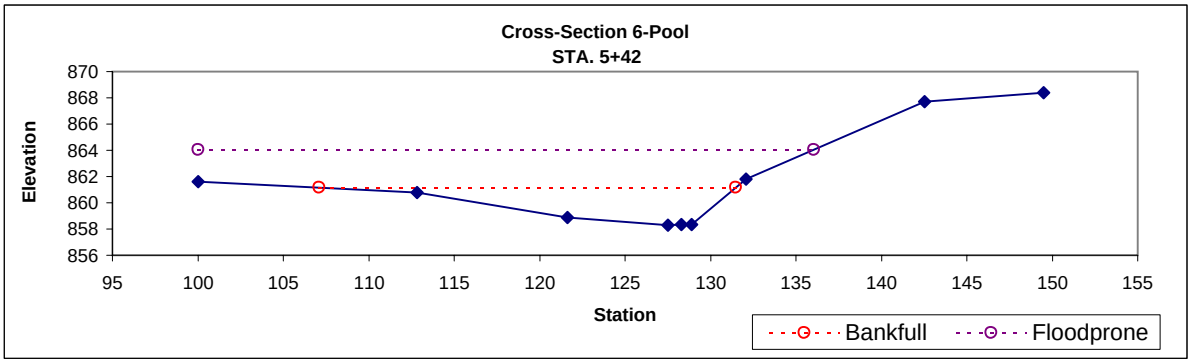


Photo 11: XS-6 facing right bank

Photo 12: XS-6 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	34.8	19.62	1.77	3.15	11.08	1.2	2.7	861.27	861.93

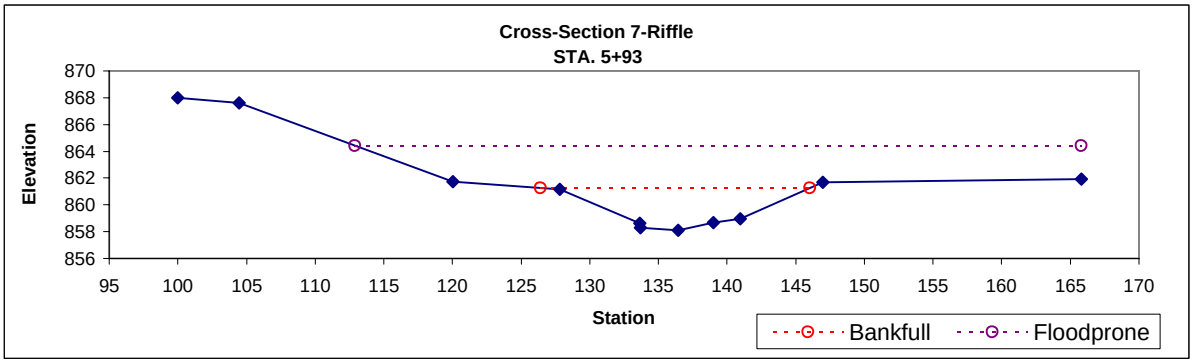


Photo 13: XS-7 facing right bank

Photo 14: XS-7 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E4	35.8	18.35	1.95	4.5	9.41	1.1	3.3	855.47	855.87

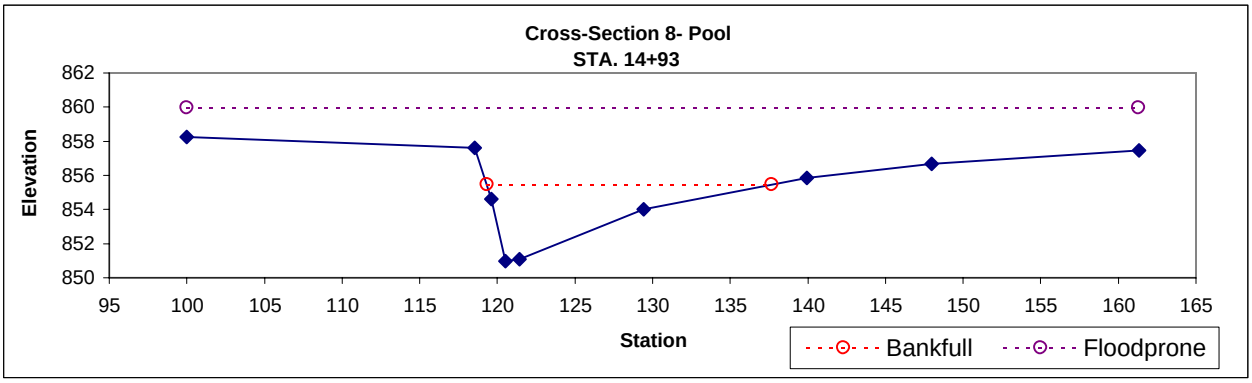


Photo 15: XS-8 facing right bank

Photo 16: XS-8 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E4	35.1	19.01	1.84	2.98	10.3	1.1	3.1	856.75	857.05

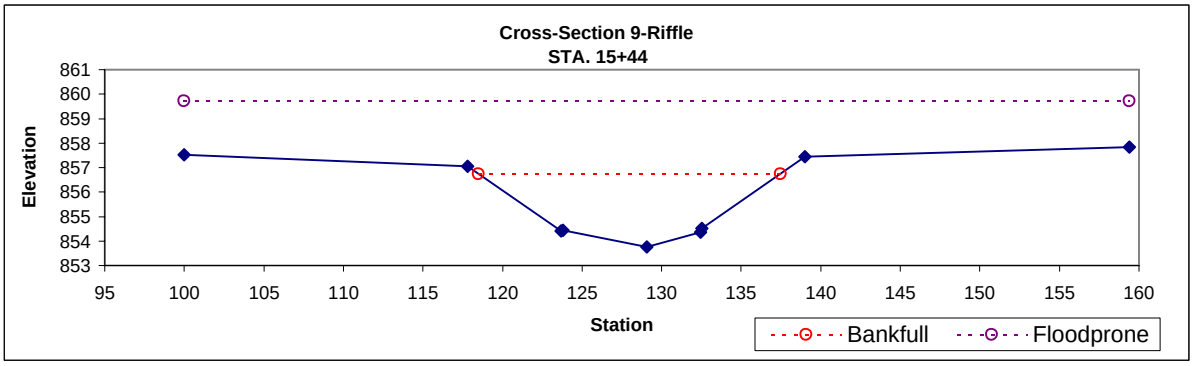
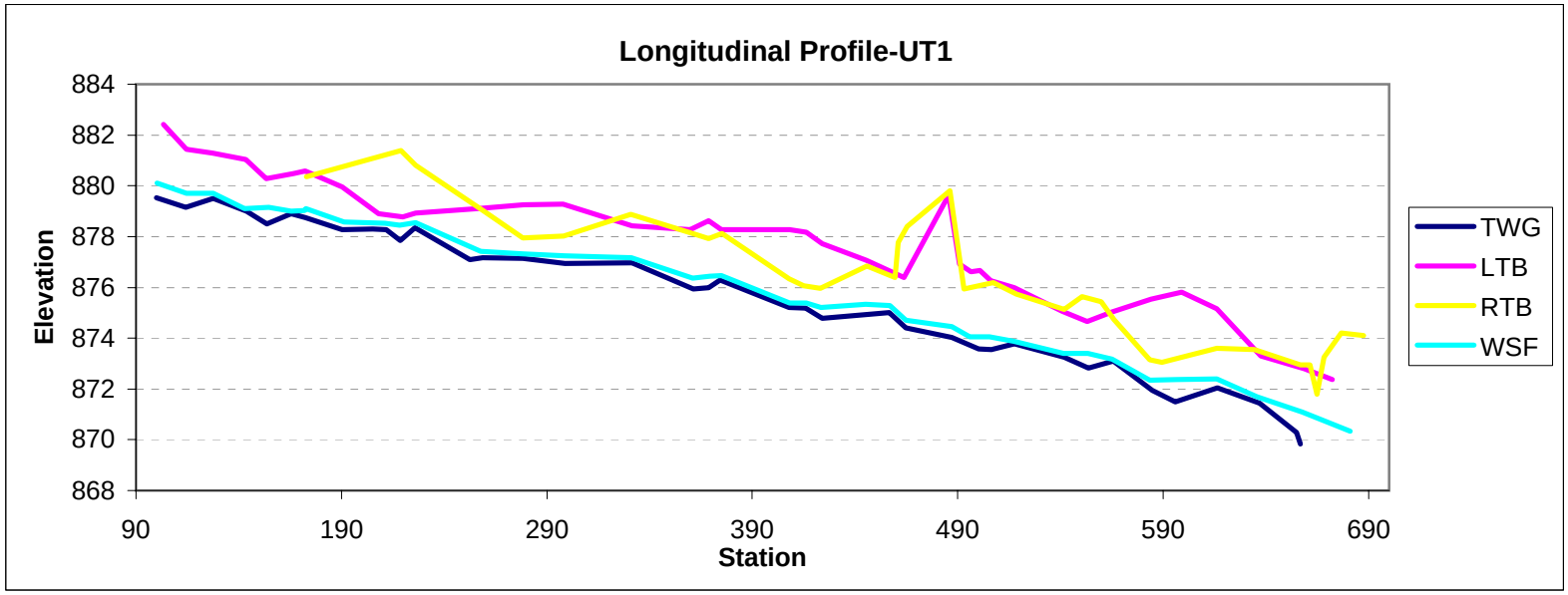


Photo 17: XS-9 facing right bank

Photo 18: XS-9 facing left bank


Longitudinal Profile-UT1
884
882
880
878
876
874
872
870
868
Elevation
90
190
290
390
490
590
690
Station
TWG
LTB
RTB
WSF

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	10.7	12.43	0.86	1.76	14.48	0.9	3.1	880.5	880.36

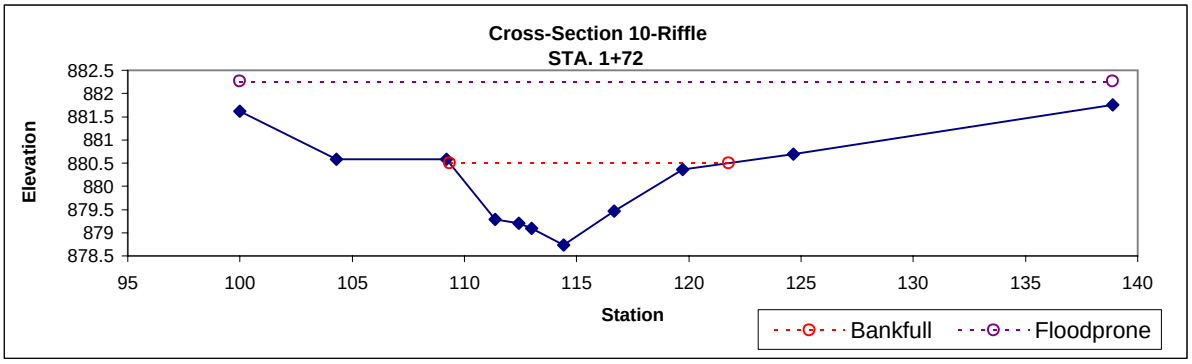


Photo 19: XS-10 facing right bank

Photo 20: XS-10 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C4	10.3	11.42	0.9	1.66	12.66	1	3.6	874.77	874.74

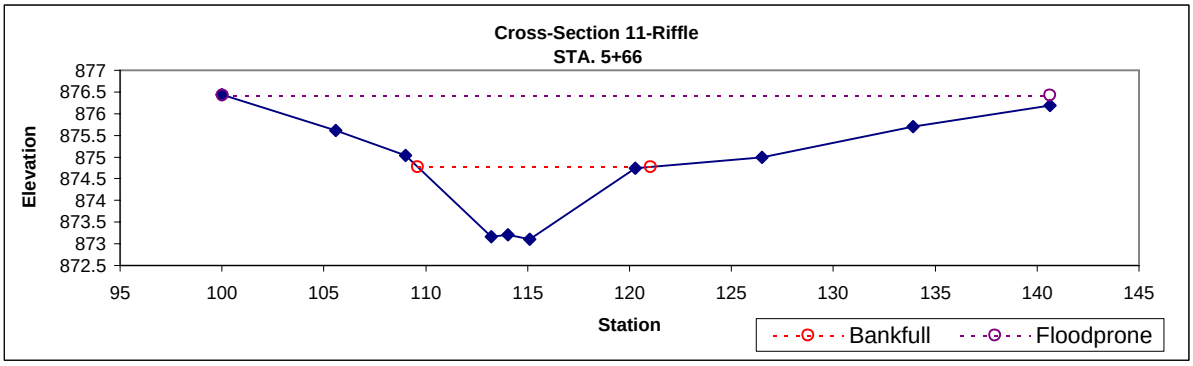


Photo 21: XS-11 facing right bank

Photo 22: XS-11 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C4	10.4	12.95	0.8	1.58	16.16	1	2.3	873.08	873.06

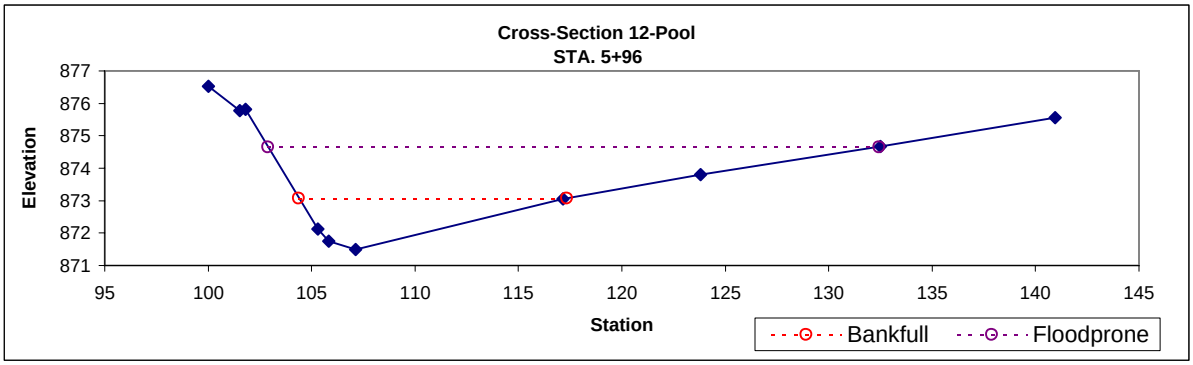
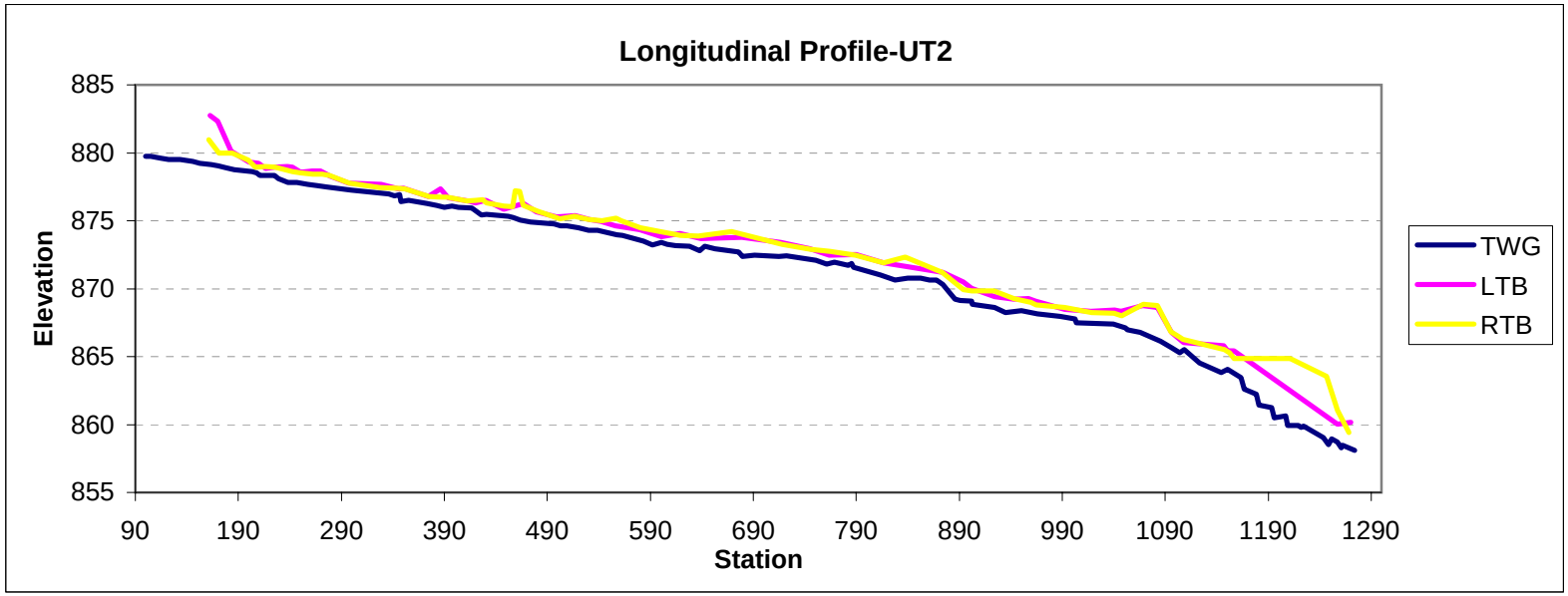


Photo 23: XS-12 facing right bank

Photo 24: XS-12 facing left bank


Longitudinal Profile-UT2
Elevation
885
880
875
870
865
860
855
90
190
290
390
490
590
690
790
890
990
1090
1190
1290
Station
TWG
LTB
RTB

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Bc	4.9	10.93	0.45	1.07	24.52	0.7	2.2	878.86	878.54

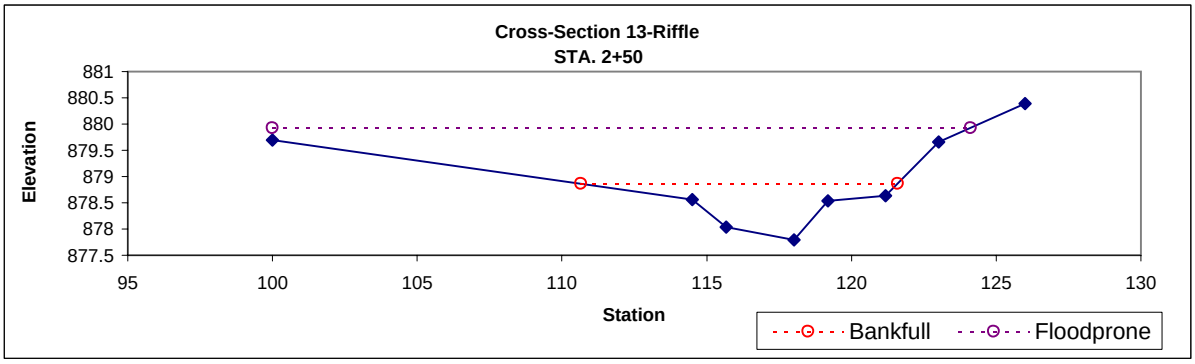


Photo 25: XS-13 facing right bank

Photo 26: XS-13 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E5	4.5	6.21	0.72	1.24	8.59	1	3.4	876.28	876.24

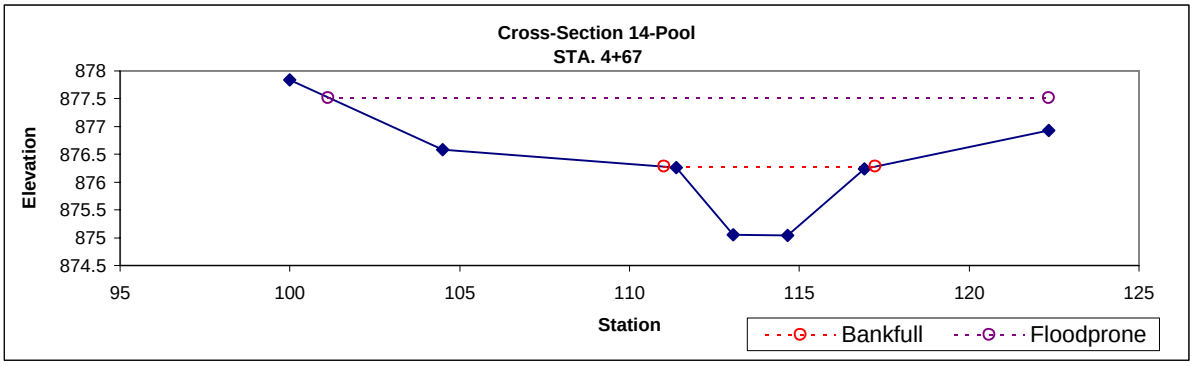


Photo 27: XS-14 facing right bank

Photo 28: XS-14 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb5	5.2	8.55	0.61	1	14	1	3.4	864.86	864.86

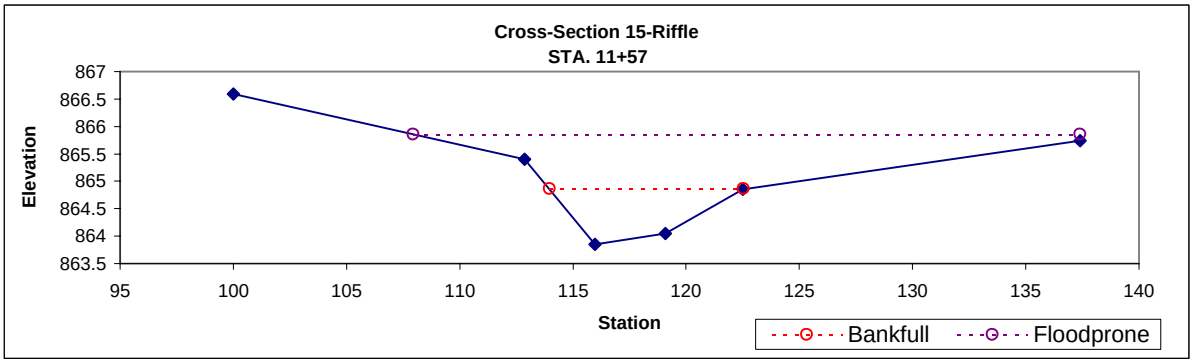


Photo 29: XS-15 facing right bank

Photo 30: XS-15 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E5	4.9	6.87	0.71	1.05	9.63	1.9	3.9	859.64	860.62

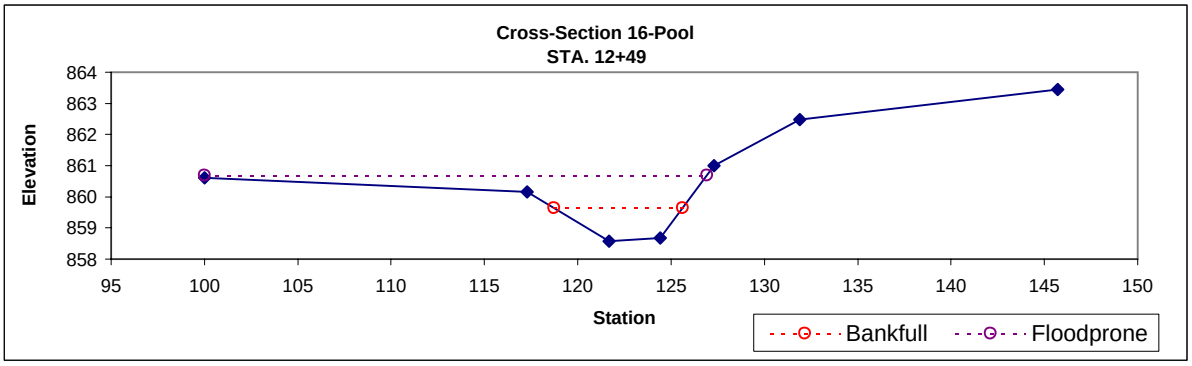


Photo 31: XS-16 facing right bank

Photo 32: XS-16 facing left bank

APPENDIX C

AS-BUILT PLAN SHEETS

APPENDIX C

AS-BUILT PLAN SHEETS