Puzzle Creek Mitigation Project

Year 4 Monitoring Report - Final

Rutherford County, North Carolina

Prepared for: NCDENR – Division of Mitigation Services
DMS Project Manager: Paul Wiesner
DMS Contract Number: D06027-C
DMS Project Number: 92522
Project Construction: April 2010
Year 4 Data Collection: March 2015
Report Submitted: April 2015

Report Prepared By:
Michael Baker Engineering, Inc.
797 Haywood Road, Suite 201
Asheville, NC 28806 NC
Engineering License F-1084

Monitoring Firm: Michael Baker Engineering, Inc. (Baker)
Monitoring Firm POC: Micky Clemmons

Table of Contents

EXECUTIVE SUMMARY **1**

1.0 PROJECT BACKGROUND AND ATTRIBUTES **2**

1.1 LOCATION AND SETTING 2
1.2 MITIGATION STRUCTURE AND OBJECTIVES 4
1.3 PROJECT HISTORY AND BACKGROUND 6
1.4 MONITORING PLAN VIEW 9

2.0 PROJECT CONDITION AND MONITORING RESULTS **15**

2.1 VEGETATION ASSESSMENT 15
2.1.1 Vegetation *15*
2.1.2 Soil Data *16*
2.1.3 Vegetative Problem Areas *16*
2.1.4 Stem Counts *17*
2.2 STREAM ASSESSMENT 17
2.2.1 Morphologic Parameters and Channel Stability *17*
2.2.2 Hydrology *19*
2.2.3 Photographic Documentation of Site *20*
2.2.4 Stream Stability Assessment *20*
2.3 AREAS OF CONCERN 21

3.0 REFERENCES **21**

Tables and Figures

Figure	**1**	Project Location Map
Table	**1**	Project Mitigation Structure and Objectives
Table	**2**	Project Activity and Reporting History
Table	**3**	Project Contacts
Table	**4**	Project Background
Figure	**2**	Restoration Approach by Project Reach
Table	**5**	Riparian Buffer Planting List
Table	**6**	Preliminary Soil Data
Table	**7&7b**	Stem Count Arranged by Plot
Table	**8**	Vegetative Problem Areas
Table	**9**	Hydrological (Bankfull) Verifications
Table	**10**	Stream Problem Areas
Table	**11**	Categorical Stream Feature Visual Stability Assessment
Table	**12**	Visual Morphological Stability Assessment
Table	**13**	Stream Reach Morphology and Hydraulic Data
Table	**14**	Cross-section Morphology and Hydraulic Data

Appendices

Exhibit	Vegetation Survey Data Tables	A
Exhibit	Vegetation Monitoring Plot Photos	A
Exhibit	Qualitative Visual Stability Assessment Tables	B
Exhibit	Cross-section Plots with Annual Overlays	B
Exhibit	Longitudinal Profiles with Annual Overlays	B
Exhibit	Stream Reach Morphology and Hydraulic Data	B
Exhibit	Cross-section Morphology and Hydraulic Data	B
Exhibit	Riffle Pebble Count Size Class Distribution (UT1)	B
Exhibit	Stream Reference Station Photologs	B

EXECUTIVE SUMMARY

The Puzzle Creek site was restored through a full delivery contract with the NCDENR – Division of Mitigation Services (DMS). This report documents Year 4 monitoring data for the five-year monitoring period. The goals for the restoration project are as follows:

- Improve hydrologic connectivity between creeks and floodplains;
- Reduce sediment and nutrient loading through restoration of riparian areas and stream banks;
- Create geomorphically stable conditions on the Puzzle Creek project site; and
- Improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Removal of anthropogenic impacts from the stream corridor and rehabilitation of incised and eroding streams by stabilizing stream channels and improving floodplain access;
- Improving impacted buffers to aid in nutrient removal from runoff and stabilizing stream banks to reduce bank erosion and sediment contribution to streams;
- Providing more stable and diverse channel features such as riffles , creating deeper pools and areas of water re-aeration, and providing woody debris to increase instream habitat quality and diversity;
- Establishment of riparian areas characterized by native vegetation, organic debris, and flooding which are protected by a permanent conservation easement. The establishment of native streambank and floodplain vegetation will improve bank stability, provide shade to decrease water temperature and improve terrestrial wildlife habitat.

Eight vegetation monitoring plots 100 square meters (m^2) (10m x 10m) in size were used to estimate survival of the woody vegetation planted on-site. The Year 4 vegetation monitoring indicated an average survival of 582 planted stems per acre and 2,524 volunteer stems per acre. When planted and volunteer stems are combined the site has an average density of 3,106 woody stems per acre. This data shows that the Site has met both the interim stem survival criteria for Year 3 (320 stems per acre) and is on track to meet the final success criteria of 260 trees per acre by the end of Year 5.

The design implemented at the Puzzle Creek mitigation site involved Priority Level I and II Restoration, and Enhancement Level I approaches. The resulting design will ultimately yield stable C-type channels for Puzzle Creek, and the project tributaries. Restoration and enhancement work were completed in accordance with the approved design approach provided in the mitigation plan for Puzzle Creek and its tributaries. Longitudinal profile and cross-section data indicate that the project streams have remained stable since baseline monitoring data were collected in February 2011. Additionally, as the photo logs included in this report show, the herbaceous cover at the project site is flourishing and is promoting bank stability, while planted woody vegetation grows and volunteer vegetation becomes more widespread. There are two areas of concern noted in this Year 4 monitoring period. The first area of concern is a bare bank area on Reach 1 of Puzzle Creek immediately downstream of the Piney Mountain Church Rd Bridge were erosion from station 0+15 to 0+30 has persisted from earlier years. This area is associated with a utility crossing under the stream that was not stabilized well. This area continues to be monitored and additional vegetation added. The second is an area of bank erosion at the lower end of the project in Reach 2 of Puzzle Creek that was destabilized during flooding in Year 3. We are monitoring this site to determine if it is improving or getting worse. This site does not appear to have changed over the last year. In previous reports a site on Reach 1 of Puzzle Creek upstream of the confluence with UT1has been identified as an area of concern. Based on this year's observations, this site appears to be stabilized with vegetation growing on the previously eroding surface and an extensive stand of trees is growing on the bank. It is expected that this area is becoming stable and will not require repair work. Based on geomorphic data presented in Appendix B, this Site is currently on track to meet the hydrologic and stream success criteria specified in the Puzzle Creek Mitigation Plan.

Summary information/data related to the occurrence of items such as beaver or encroachment and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report (formerly Mitigation Plan) and in the Mitigation Plan (formerly Restoration Plan) documents, which are available on EEP's website. All raw data supporting the tables and figures in the appendices is available from EEP upon request.

1.0 PROJECT BACKGROUND AND ATTRIBUTES

The Puzzle Creek Restoration site is located approximately three miles northeast of Bostic, in Rutherford 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 03-08-02 and United States Geologic Survey (USGS) hydrologic unit 03050105070050. The Puzzle Creek project area drains agricultural and forested land, as well as a small area occupied by residential development. The general area in which the project is located is rural in character, and is not likely to change significantly in the foreseeable future. The largest percentage of land use in the watershed currently is in forested cover for wildlife habitat and hunting as well as timber production. The percentage of land in the watershed available to agriculture is 27% with over 60% of the watershed remaining as forest land.

Orthophotography maps from the 1930's show residential and agricultural land use altering the Puzzle Creek watershed. Many streams were channelized to help mark property boundaries and to drain low lands for farming. Anthropogenic land use alteration and channelization of streams introduced instabilities from which the streams are still recovering. Incision, bank erosion, meander cutoffs, lateral bar formation, debris jams, and other ongoing stream processes typical of adjusting streams are found in the project reach. Segments of the unnamed tributary have achieved a degree of relative stability due to the presence of heavily wooded banks, developing floodplains which have been active in recent years, and bedrock that has prevented incision from becoming the driving factor in channel geomorphic development.

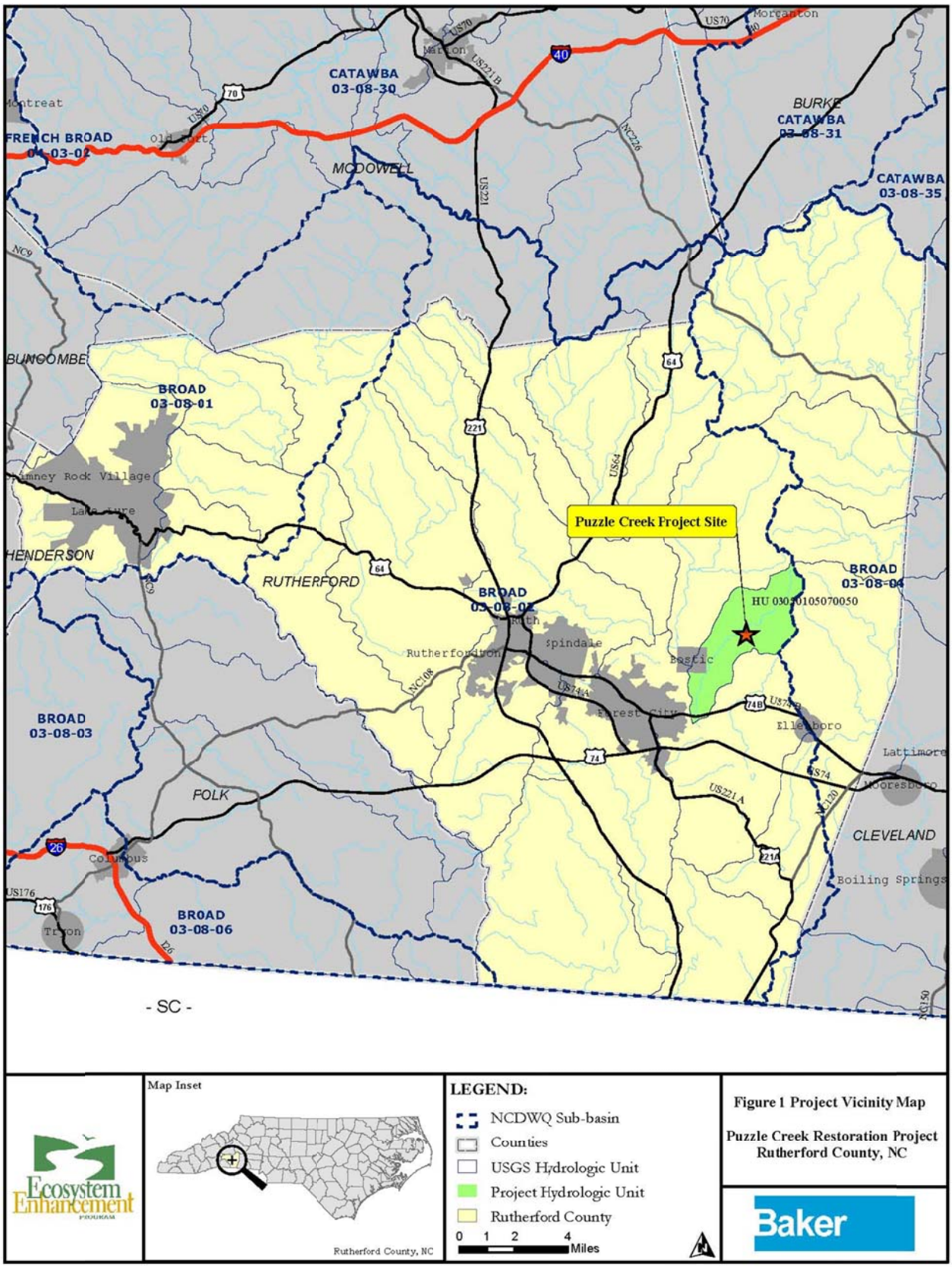
The project involved restoration or enhancement of four on-site streams: Puzzle Creek and three smaller unnamed tributaries (UT) identified in the project as UT1, UT2 and UT3. As noted in the Baseline Monitoring Report for Puzzle Creek, unnamed tributaries (UT2 and UT3) were added as short restored reaches as we recognized that work would be required on them within the easement area to facilitate connecting them to the mainstem. Total stream length across the project increased from approximately 4,849 LF to 5,073LF. The restoration and enhancement of 5,073 LF of stream within this project site has generated 4,966 stream mitigation units (SMUs).

1.1 Location and Setting

The Puzzle Creek restoration site is located approximately three miles northeast of Bostic in Rutherford County, NC (Figure 1). To access the site from Interstate 26, take the Hwy 74 East exit, Exit 67, toward NC-108/Columbus/Rutherford. Continue on Hwy 74 East for approximately 23 miles to Exit 182, turning left onto S. Broadway Street. Continue on S. Broadway Street to the stop light and take a right onto E. Main Street. Continue on E. Main for 1.43 miles and turn left on Bostic Sunshine Highway. Continue on Bostic Sunshine Road until reaching Piney Mountain Church Road (SR 1007). Take a hard right turn and continue 1.27 miles to 2321 Piney Mountain Church Road.

Unnamed tributary 1(UT 1) flows west then northwest from the east side of the Schafer property boundary to a break in the easement at the Shafer home. UT1 continues northwest from the break in the easement to its confluence with Puzzle Creek. Reach 1 of Puzzle Creek begins at Piney Mountain Church Rd (SR 1007) and continues southwest to the confluence with UT1. Reach 2 of Puzzle Creek begins at

the confluence with UT1 and continues northwest to the property boundary. The project site is accessible from Piney Mountain Church Rd.



1.2 Mitigation Structure and Objectives

Table 1 summarizes project data for each reach and restoration approaches used. The design implemented at the Puzzle Creek mitigation project site involved both Priority Level 1 and 2 approaches. The resulting design should ultimately yield primarily a C-type channel for Puzzle Creek and its tributaries within the project reach. Restoration and enhancement work on Puzzle Creek and UT1were completed in accordance with the approved design approach provided in the mitigation plan for Puzzle Creek.

Table 1. Project Mitigation Structure and Objectives
Puzzle Creek Mitigation Project-NCEEP Project#92522

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Puzzle Creek									
Reach 1	1,024LF	R	P1	C4/5	1,000 LF	1:1	1,000	0+00-10+00	Reroute channel through middle of valley, improve pattern, dimension and profile
Reach 2	600 LF	R	PII		634 LF	1:1	634	10+00-16+34	Pattern adjustment to address overly sinuous section, profile and dimension adjustments
UT1 (Reach 1)									
Subreach [A]	2,036 LF	R	PII		2,150 LF	1:1	2,150	00+00-21+50	Pattern and profile adjustments; improve floodplain benching
Subreach [A]	320 LF	E	LI	C4/5	320LF	1.5:1	213	21+50-24+70	Profile and dimension adjustments; improve floodplain access (narrow valley through this reach precluded pattern adjustments)
Subreach [A]	469 LF	R	PII		469 LF	1:1	469	24+70-29+39	Pattern and profile adjustments; improve floodplain benching
Subreach [A]	400LF	R	PII	C4/5	400 LF	1:1	400	32+12-36+12	Slight pattern and profile adjustments, lowering of bankfull elevation on right bank near confluence.
UT 2									
Reach 1	----	R	PII	-	52 LF	1:1	52	1+39-1+91	Bank grading and stabilization; invasives removal and re-planting with native riparian vegetation
UT 3									
Reach 1	----	R	PI	-	48 LF	1:1	48	0+63-1+11	Bank grading and stabilization; invasives removal and re-planting with native riparian vegetation

Mitigation Unit Summations

Stream (LF)	Total SMU	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)
5,073	4,966	NA	NA	NA	

Notes: [A] Sub-reaches are listed as they occur, going in a downstream direction as indicated by the stationing provided.

Prior to the mitigation project, riparian areas along Puzzle Creek were utilized for pasture and were frequently mowed. Today much of the site is wooded, with acreage being managed for timber production and also as a timberland used for hunting and quite enjoyment. The primary causes of impairment found within the project reaches included previous efforts to channelize the streams, logging activities, an abundance of unstable log jams resulting in erosion, and the presence of non-native vegetation.

The upper reach (reach 1) of the mainstem of Puzzle Creek had severe lateral instability resulting in self-perpetuating debris jams. Bank erosion, falling trees, incision, and impingement on the valley wall were considered significant and continuing trends present on the reach. A combination of Priority I and Priority II Restoration approaches were implemented along Reach 1 based on the need to excavate the floodplain in some areas while in other areas a new channel would be excavated that utilized the existing floodplain. As was the case with all project reaches, unforested sections of floodplain as well as areas of recently disturbed floodplain were seeded and replanted with trees and shrubs native to the area to provide stability and create an adequate riparian buffer.

The reach of Puzzle Creek downstream of the confluence with UT1 (Reach 2) was suffering from a cycle of debris jams, lateral instability, bank erosion, channel avulsion, and falling trees. This section of Puzzle Creek was incised, although some flood relief was available by the presence of a remnant channel in the left floodplain. A combination of Priority I and Priority II Restoration was applied in Reach 2 to create a meandering pattern with stable riffles and pools. This approach resulted in the channel being moved away from the right valley wall. This provided marked improvements in the profile, cross-section, and stability of the channel pattern.

Throughout UT1, a combination of Priority I and II Restoration approaches was implemented. Reach 1 of UT1 flows west then northwest from the upstream end of the Schafer property boundary to a break in the easement above a waterfall at the Schafer home. The primary issues addressed on UT1 were connectivity of the stream to the floodplain, localized erosion of streambanks and impingement on valley walls, sub-reaches with bed features that are inconsistent with the plan form of the stream, and non-native vegetation. At the uppermost end of the reach, floodplain connectivity was addressed by changing the bed profile, thereby raising the water surface. By creating backwater in meander bends, naturally-sustainable pools were created. Further downstream, a new channel was constructed to bring the stream away from the valley wall and to create more natural riffle-pool sequences. Below this offline section, banks were graded to improve stream stability and create the needed cross-sectional area while following the existing channel course. A riprap stream crossing was installed in this reach for land-owner and forest fire response access to both sides of the creek. Below the crossing, intact banks and bed diversity minimized the meandering needed and restoration consisted of making minor changes to the channel cross-section, pattern and profile as necessary to improve bank stability and sediment transport continuity.

In other less stable sections where the stream exhibited signs of channelization, the channel was taken offline to restore pattern and profile, creating a more stable channel with a more diverse channel bedform. A significant amount of bedrock is present throughout Reach 1. Consequently, the channel was brought back online where bedrock is present.

In other areas, where bedform is diverse, banks stable, and valley constraints present, modifications to the profile and cross-section were made, but the channel was kept in its existing alignment. For these reasons, an Enhancement Level I approach was taken in those sections of Reach 1.

In accordance with the approved mitigation plan for the site, construction activities began in September 2008. Toward the end of construction in October 2008 and shortly thereafter, the project site experienced a series of flood events. Post flooding conditions indicated that designed conditions in some areas needed to be reevaluated, particularly as they related to bank height and sinuosity. Baker evaluated the site to determine the appropriate course of action needed to stabilize the project area. It was determined that damage sustained on Puzzle Creek warranted re-mobilizing a construction crew to the site to repair

damage to the site and to make adjustments to the channel alignment. Minor areas of erosion were stabilized and vegetated geolifts were added. Just upstream of the confluence with UT1 one meander was removed to increase the meander length in this area. The last meander on Puzzle was determined to be excessively tight, so the radius was increased slightly by bringing the meander bend in slightly and a cross-vane was constructed at the head of the riffle to center the thalweg and hold elevation through the upstream pool.

During late fall and winter, a number of subsequent flood events impacted UT1, which had been completed by that time. In early 2009, Baker staff visited the site to assess channel and bank stability. Although there were no areas suffering from excessive erosion, there were some indications that the channel, as constructed, was not functioning to the level desired. Initially it appeared that meanders were attempting to elongate downstream and improper pattern was suspected; however, after some time passed and additional high flows passed through the channel it was determined that primarily the pattern of instability was due to the banks not being established at the proper elevation and the floodplain needing to be lower over a wider area. Channel pattern continued to be a concern and channel length was reduced by increasing meander length and reducing meander radius of curvature. In early 2010 the channel was modified by lowering the banks in some areas and lowering the floodplain elevation to accommodate bank flows; alignment modifications were also made. The repaired site has been observed for over 4 years and appears to be stabilized by the channel modifications. Further observation have not resulted in any additional design concerns.

Plan modifications during construction involved the location and selection of instream structures and bank stabilization practices as well as the lowering of the bankfull elevation in isolated reaches along Puzzle Creek and UT1. Meander length and radius of curvature was also increased along two reaches of UT1. Another modification made included applying Priority I and II measures on two additional tributaries to Puzzle Creek that are located within the project area. Unnamed Tributary 2 (UT2) is located above the confluence of Puzzle Creek and UT1. The third unnamed tributary to Puzzle Creek, UT3, is located just upstream of the only cross-vane on Puzzle Creek and downstream of the confluence with UT1. These tributaries are included in the total Restoration footage due to the need to reconstruct the confluences of these streams as the mainstem was modified. Invasive vegetation removal and replanting of these areas with native riparian vegetation was carried out along these tributaries. The total linear feet of UT2 and UT3 where Restoration measures were applied is 52 LF and 48 LF, respectively. Restoration measures applied to UT2 and UT3 actually extend beyond the conservation easement boundary, but footage beyond the easement was not considered in calculating the mitigation credit provided by this site. These changes are documented in the as-built drawings. The final as-built stream length for the project as indicated in Table 1 is 5,073 LF.

1.3 Project History and Background

The chronology of the Puzzle Creek mitigation project is presented in Table 2 while the contact information for designers, contractors and plant material suppliers is presented in Table 3. Relevant project background information is presented in Table 4. Total stream length across the project increased from approximately 4,849 LF to 5,073LF.

Table 2. Project Activity and Reporting History Puzzle Creek Mitigation Project-NCEEP Project#92522		
Activity or Report	**Data Collection**	**Completion or Delivery**
Restoration Plan	October 2007	December 2007
Final Design-90%	October 2007	December 2007
Construction	-	October 2008
Temporary S&E mix applied to entire project area	-	October 2008
Permanent seed mix applied to project site	-	October 2008
Containerized and B&B plantings set out	-	October 2008
Flood Events; Site Repairs	-	October-November 2008
Site Evaluation on UT1	January 2009	-
Site Modifications and Repairs	April 2010	-
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2010	January 2011
Year 1 Monitoring	November 2011; January-February 2012	May 2012
Year 2 Monitoring	October 2012, March 2013	June 2013
Year 3 Monitoring	October 2013, March 2014	June 2014
Year 4 Monitoring	March 2015	April 2015
Year 5 Monitoring		

Table 3. Project Contacts Table Puzzle Creek Mitigation Project-NCEEP Project#92522	
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: Bill Wright, Tel. 919.818.6686
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 4. Project Attribute Table Puzzle Creek Mitigation Project-NCEEP Project#92522	
Project County	Rutherford County, NC
Physiograhic Region	Piedmont Province. Borders Blue Ridge Escarpment
Ecoregion	Southern Inner Piedmont
Project River Basin	Broad
USGS HUC for Project	03050105070050
NCDWQ Sub-basin for Project	03-08-02
Within extent of EEP Watershed Plan?	No
WRC Class	Cool
% of Project Easement Fenced or Demarcated	~5% (goat pasture)
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles or Acres)	
Puzzle Creek Reach 1	2.58 mi^2
Puzzle Creek Reach 2	4.18 mi^2
UT1Reach 1	1.6 mi^2
UT1 Reach2	1.6 mi^2
UT2	<.5 mi^2
Stream Order	Puzzle-3rd Order, UT1-2nd Order, UT2-1st Order
Restored Length	
Puzzle Creek Reach 1	1,000 LF
Puzzle Creek Reach 2	634 LF
UT1Reach 1	3,339 LF
UT 2	52 LF
UT 3	48 LF
Perennial or Intermittent	Perennial (all project streams)
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	61%
Shrub	12%
Pasture	27%
Water	.45%
Drainage Impervious Cover Estimate (%)	<5%
NCDWQ AU/Index #	9-41-19
303d Listed	No
Upstream of 303d Listed Segment	No
Reasons for 303d Listing or Stressor	-
Total Acreage of Easement	11.64 Acres
Total Vegetated Acreage w/in Easement	n/a (Easement vegetated with exception of stream channel and access path)
Total Planted Acreage within the Easement	~10 Acres
Rosgen Classification (Pre-existing)	
Puzzle Creek Reach 1	C4

Table 4. Project Attribute Table Puzzle Creek Mitigation Project-NCEEP Project#92522				
Puzzle Creek Reach 2	E4			
UT1Reach 1	B4c/C4			
UT1 Reach2	B4c			
Rosgen Classification of As-built				
Puzzle Creek Reach 1	E4			
Puzzle Creek Reach 2	E4			
UT1Reach 1	E4/C4			
UT1 Reach2	E4			
Valley Type	VIII			
Valley Slope	.001 to .0106			
Valley Side Slope Range	n/a			
Valley Toe Slope Range	n/a			
Trout Waters Designation	No			
Species of Concern	No			
Dominant Soil Series and Characteristics	Chewacla/ Pacolet/Pacolet-Bethlehem			
	Depth (in.)	% Clay	K Factor	T Factor
Puzzle Creek Reach 1	61”	22.5	.32	5
Puzzle Creek Reach 2	61”	22.5	.32	5
UT1Reach 1	61”	22.5	.32	5
UT1 Reach2	62”	27.5	.2	3

1.4 Monitoring Plan View

The five-year monitoring plan for the Puzzle Creek Mitigation Site includes criteria to evaluate the success of the geomorphic and vegetative components of the project. A current condition plan view (CCPV) depicting the monitoring features for the Puzzle Creek Mitigation Project is provided below. The plan view provides a layout of channel pattern as well as the location of structures designed to aid in dimension and profile stability. Other features shown on the plan view include the location of crest gauges, vegetation monitoring plots, cross-sections, reference photo stations, and the location of maintenance and repair work completed. The plan view also provides call outs at the locations of problem areas. With the exception of intermittent areas of kudzu encroachment and patches of Chinese privet or multiflora rose scattered throughout the project reaches on Puzzle Creek and UT1, there are no additional problems present. These areas with invasive species are being treated to eradicate them if possible. Baker will continue to monitor the presence of invasives within the easement and treat them accordingly. Figure 2 illustrates the project as it is delineated by reach.

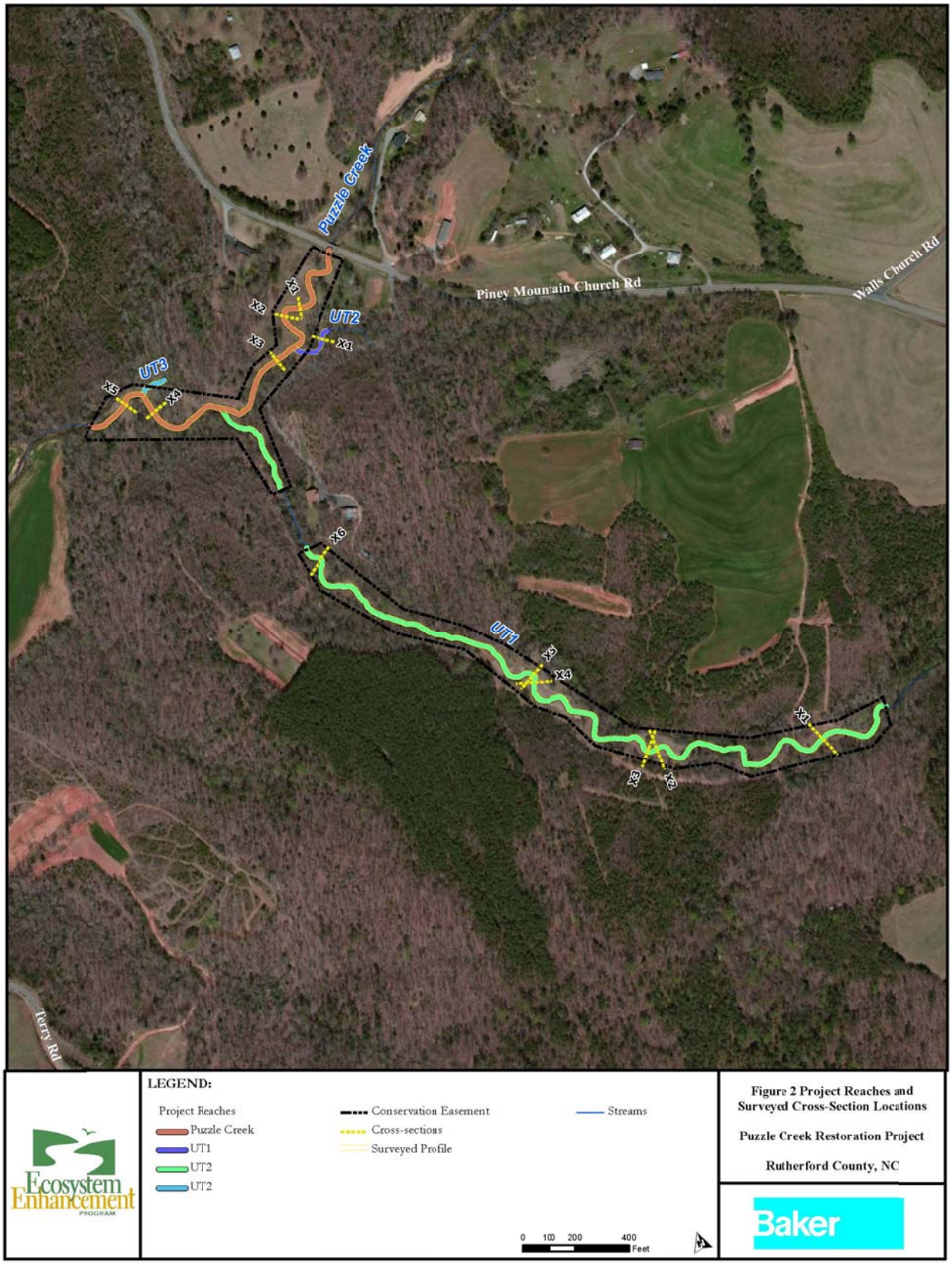


Figure 2 Project Reaches and Surveyed Cross-Section Locations

Puzzle Creek Restoration Project

Rutherford County, NC

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- FENCE
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET (NO PLOTS CURRENTLY MEETING THIS CRITERIA)
- STREAM PROBLEM AREA (SPA) BANKS WITH SCOUR/EROSION

PUZZLE CREEK
CURRENT CONDITION
PLAN VIEW
0+00–16+34
YEAR 4 MONITORING

40 0 40 80
SCALE: 1" = 80'

Michael Baker Engineering Inc.
NC Engineering License F-1084
797 Haywood Road, Suite 201
Asheville, North Carolina 28806
Phone: 828.350.1408
Fax: 828.350.1409

Baker

PUZZLE CREEK RESTORATION PROJECT
RUTHERFORD COUNTY, NORTH CAROLINA
YEAR 3 MONITORING
CURRENT CONDITION PLAN VIEW

Prepared for:
Division of Mitigation Services
2728 Capitol Blvd, Suite 1H 103
Raleigh, NC 27604
Phone 919-715-0476
Fax: 919-715-2219

EEP Project No. 92522
Baker Project No. 109277
Date: 4/5/2015
DESIGNED: JLR
DRAWN: MDR
APPROVED: MMC
Drawing Sheet No. 1 of 4
Monitoring Year 4 of 5

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET (NO PLOTS CURRENTLY MEETING THIS CRITERIA)
- STREAM PROBLEM AREA (SPA) BANKS WITH MINOR SCOUR/EROSION

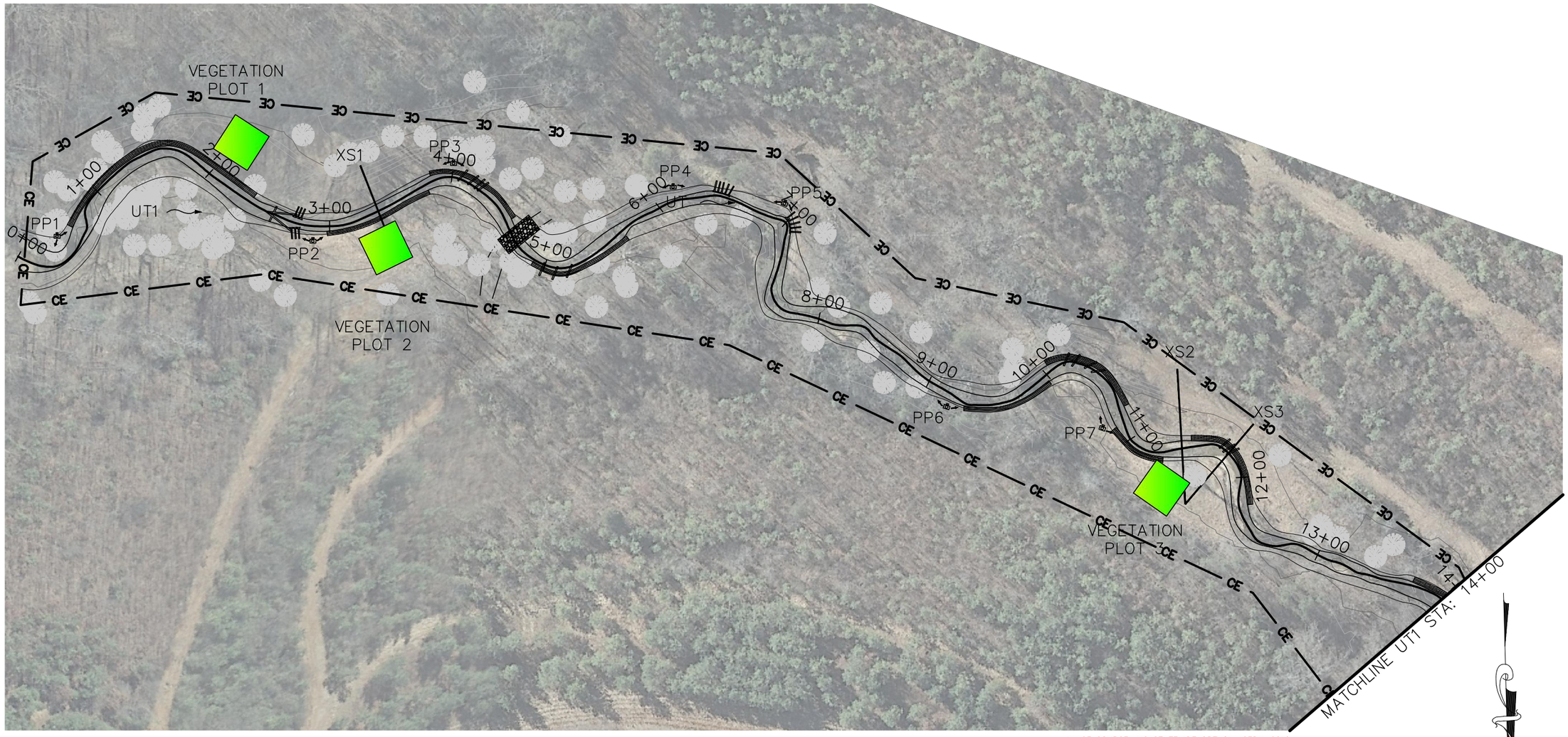


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

Note: the name or location for vegetation plots 3, 4 and 5 were incorrect in previous years, but have been corrected this year.

UT1
CURRENT CONDITION
PLAN VIEW
0+00–14+00
YEAR 4 MONITORING

40 0 40 80
SCALE: 1" = 80'

Michael Baker Engineering Inc.
NC Engineering License F-1084
797 Haywood Road, Suite 201
Asheville, North Carolina 28806
Phone: 828.350.1408
Fax: 828.350.1409

Baker

PUZZLE CREEK RESTORATION PROJECT
RUTHERFORD COUNTY, NORTH CAROLINA
YEAR 3 MONITORING
CURRENT CONDITION PLAN VIEW

Prepared for:
Division of Mitigation Services
2728 Capitol Blvd. Suite IH 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No.	92522
Baker Project No.	109277
Date:	4/5/2015
DESIGNED:	JLR
DRAWN:	MDR
APPROVED:	MMC
Drawing Sheet No.	2 of 4
Monitoring Year	4 of 5

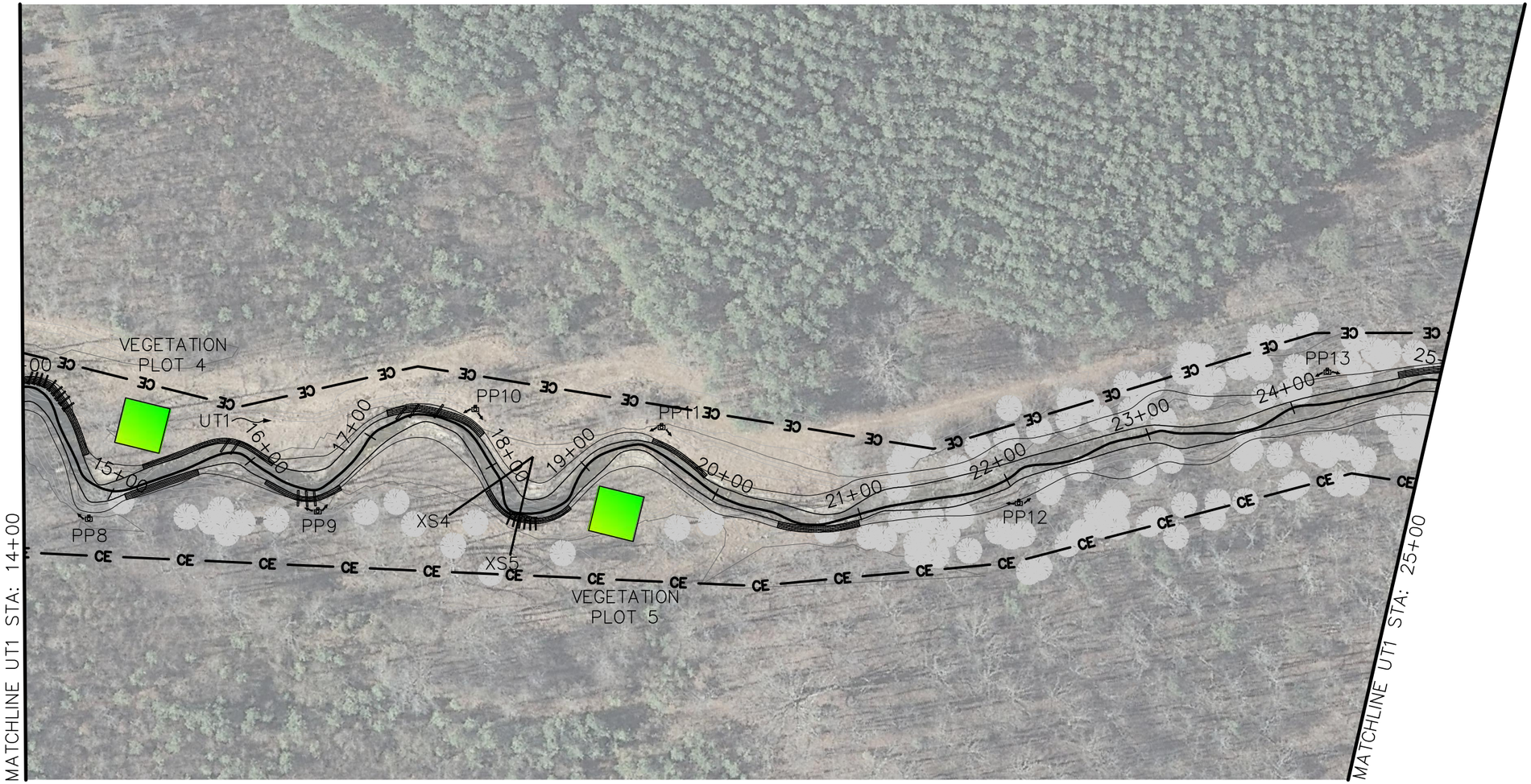


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

UT1
CURRENT CONDITION
PLAN VIEW
14+00–25+00
YEAR 4 MONITORING

Note: the name or location for vegetation plots 3, 4 and 5 were incorrect in previous years, but have been corrected this year.

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET (NO PLOTS CURRENTLY MEETING THIS CRITERIA)
- STREAM PROBLEM AREA (SPA) BANKS WITH MINOR SCOUR/EROSION

40 0 40 80
SCALE: 1" = 80'

Michael Baker Engineering Inc.
NC Engineering License F-1084
797 Haywood Road, Suite 201
Asheville, North Carolina 28806
Phone: 828.350.1408
Fax: 828.350.1409

Baker

PUZZLE CREEK RESTORATION PROJECT
RUTHERFORD COUNTY, NORTH CAROLINA
YEAR 3 MONITORING
CURRENT CONDITION PLAN VIEW

Prepared for:
Division of Mitigation Services
2728 Capitol Blvd, Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No. 92522
Baker Project No. 109277
Date: 4/5/2015
DESIGNED: JLR
DRAWN: MDR
APPROVED: MMC
Drawing Sheet No. 3 of 4
Monitoring Year 4 of 5

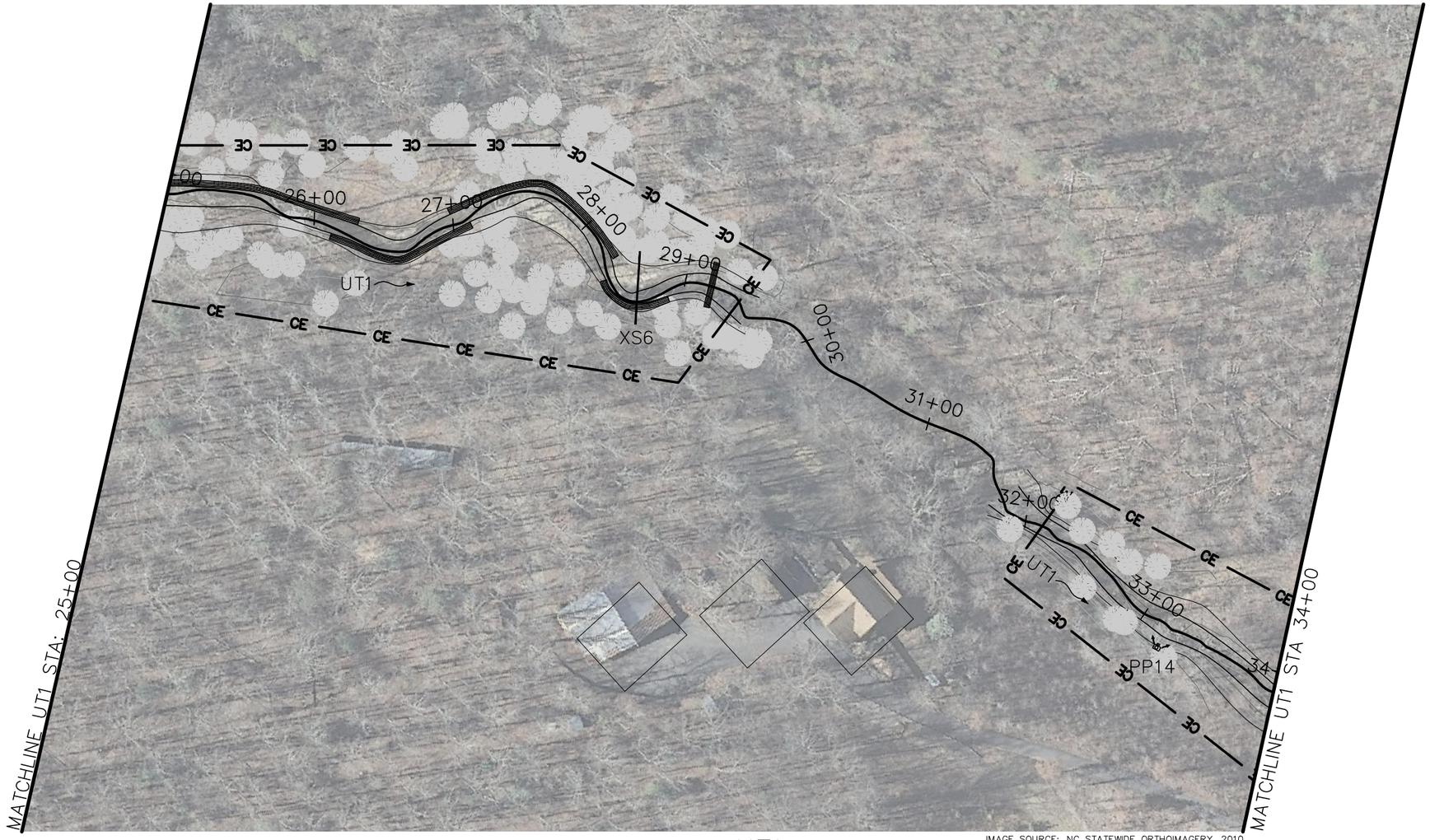


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

UT1
CURRENT CONDITION
PLAN VIEW
25+00–34+00
YEAR 4 MONITORING

LEGEND

- CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET (NO PLOTS CURRENTLY MEETING THIS CRITERIA)
- STREAM PROBLEM AREA (SPA) BANKS WITH MINOR SCOUR/EROSION

40 0 40 80
SCALE: 1" = 80'

Michael Baker Engineering Inc.
NC Engineering License F-1084
797 Haywood Road, Suite 201
Asheville, North Carolina 28806
Phone: 828.350.1408
Fax: 828.350.1409

Baker

PUZZLE CREEK RESTORATION PROJECT
RUTHERFORD COUNTY, NORTH CAROLINA
YEAR 3 MONITORING
CURRENT CONDITION PLAN VIEW

Prepared for:
Division of Mitigation Services
2728 Capitol Blvd. Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No. 92522
Baker Project No. 109277
Date: 4/5/2015
DESIGNED: JLR
DRAWN: MDR
APPROVED: MMC
Drawing Sheet No. 4 of 4
Monitoring Year 4 of 5

2.0 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the Puzzle Creek mitigation 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, reference photo stations and crest gauges are shown on the CCPV submitted with this report.

2.1 Vegetation Assessment

2.1.1 Vegetation

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, eight vegetation monitoring quadrants were installed across the restoration site. The size of individual quadrants varies from 100 square meters for tree species to 1 square meter for herbaceous vegetation. In the past Level 1 CVS vegetation monitoring was done, but this year we performed Level 2 CVS vegetation monitoring to access volunteer species as well as planted stems. Sampling normally occurs in spring, after leaf-out has occurred, or in the fall prior to leaf fall. Vegetation monitoring will evaluate, species composition, density, and survival. Individual seedlings were marked to ensure that they can be found in succeeding monitoring years.

Photographs are used to visually document vegetation success in sample plots. Reference photos of tree and herbaceous conditions within plots are taken at least once per year. Photos of the plots are included in Appendix A of this report.

The interim measure of vegetative success for the site is the survival of at least 320, 3-year old, planted trees per acre at the end of Year 3 of the monitoring period. The final vegetative success criteria is the survival of 260, 5-year old, planted trees per acre at the end of Year 5 of the monitoring period.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided excellent ground coverage. Live stakes and bare root trees planted are also flourishing and will increasingly contribute to streambank stability. Bare-root trees were planted throughout the conservation easement. A minimum 30-foot buffer was established along all restored stream reaches. 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 the winter of 2009-2010. Species planted are listed below.

Table 5. Riparian Buffer Planting List Puzzle Creek Mitigation Plan-NCEEP Project #92522			
Proposed Bare-Root and Live Stake Species (may also include seed or container species)			
Common Name	**Scientific Name**	**% Planted by Species**	**# of Stems**
Riparian Buffer Plantings			
Trees Overstory			
Sycamore	*Platanus occidentalis*	20%	136
Willow Oak	*Quercus phellos*	7%	48
River birch	*Betula nigra*	15%	102
Persimmon	*Diospyros virginiana*	10%	68
Tulip Poplar	*Liriodendron tulipifera*	20%	136
Green Ash	*Fraxinus pennsylvanica*	15%	102
Swamp Chestnut Oak	*Quercus michauxii*	8%	54
Black Cherry	*Prunus seritona*	5%	34
Understory Trees/Shrubs			
Pawpaw	*Asimina triloba*	15%	102
Witch-hazel	*Hamamelis virginiana*	15%	102
Spicebush	*Lindera benzoin*	20%	136
Sweet Shrub	*Calycanthus floridus*	15%	102
Redbud	*Cercis canadensis*	10%	68
Flowering Dogwood	*Cornus floridus*	15%	102
Arrowwood Viburnum	*Viburnum dentatum*	10%	68
Riparian Livestake Plantings			
Ninebark	*Physocarpus opulifolius*	na	
Elderberry	*Sambucus canadensis*	na	
Silky Willow	*Salix sericea*	na	
Silky Dogwood	*Cornus amomum*	na	
Note: Species selection may have changed due to refinement or availability at the time of planting.			

2.1.2 Soil Data

Table 6. Preliminary Soil Data Puzzle Creek Mitigation Project-NCEEP Project #92522					
Dominant Soil Series and Characteristics	Chewacla/ Pacolet/Pacolet-Bethlehem				
	Depth (in.)	% Clay	K Factor	T Factor	%OM
Puzzle Creek Reach 1	61”	22.5	.32	5	.75-2.5
Puzzle Creek Reach 2	61”	22.5	.32	5	.75-2.5
UT1Reach 1	61”	22.5	.32	5	2-2.5
UT1 Reach2	62”	27.5	.2	3	2-2.5

2.1.3 Vegetative Problem Areas

There are no major vegetation problem areas at this time. However, Chinese privet (*Ligustrum sinense*) and, to a lesser extent, Multiflora rose are scattered intermittently on-site. Kudzu, is encroaching upon the easement area, from outside of the area, on the lower end of Reach 2 of Puzzle Creek as well as at the upstream end of UT1 (Table 8, Appendix A). Baker continues to use a public herbicide applicator to treat areas where invasive vegetation is present.

2.1.4 Stem Counts

The mitigation plan for the Puzzle Creek Site specifies that the number of quadrants required will be based on the species/area curve method, as described in NCEEP monitoring guidance documents. The size of individual quadrants is 100 square meters for woody tree species, and 1 square meter for herbaceous vegetation. Eight vegetation plots, each 10 by 10 meters or, when constrained, 5 by 20 meters in size, were established across the restored site.

2.1.4.1 Results

Tables 7 and 7b in Appendix A presents information on the stem counts for each of the vegetation monitoring plots. Data from the Year 4 monitoring event shows a range of 324 - 769 planted stems per acre, with approximately 86% of the stems being in good to excellent condition. Nearly 9% of the stems planted are missing or have died; however a number of volunteers, namely river birch, sweet gum, poplar, pine and sycamore, have also begun populating the project area. This year, unlike past monitoring years, we estimated the number of volunteers per plot and utilized Level 2 analysis in the CVS entry tool to provide an estimate of volunteer stems per acre. This data indicates that the range of estimated volunteer stems per plot was 20 to 125 and this indicates a range of 809 to 5,059 (average = 2,524) volunteer stems per acre. The average density of planted stems, based on data collected from the eight monitoring plots during Year 4 monitoring is 575 stems per acre which indicates that the Site has met the interim minimum success criteria of 320 trees per acre by the end of Year 3 and is on track to meet the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the CCPV.

No discrete woody or herbaceous vegetation problem areas were identified during Year 4 monitoring. Although the density of herbaceous cover varies across the site, conditions observed on-site during the Year 4 monitoring survey found ground cover in the easement area to be sufficient for aiding in site stabilization. Survival rates of planted woody stems in the vegetation plots indicate that plantings across the easement area are of sufficient density to meet regulatory requirements, as well as the site stabilization and habitat enhancement goals originally set forth in the mitigation plan.

2.2 Stream Assessment

2.2.1 Morphologic Parameters and Channel Stability

Geomorphic monitoring of restored stream reaches is being conducted over a five year period to evaluate the effectiveness of the restoration practices installed. Monitored stream parameters include channel dimension (cross-sections), profile (longitudinal survey), pattern, bed composition, bank stability, bankfull flows, and stability of reference sites documented by photographs. Crest gauges, as well as wrack lines, may be used to document the occurrence of bankfull or greater events. The methods used and any related success criteria are described below for each parameter. For monitoring this site, twelve permanent cross-sections and two crest gauges were installed. Longitudinal profiles were also completed on Puzzle Creek, UT1 and UT2. Detailed channel morphology was surveyed with a total station by Baker; survey data is georeferenced.

2.2.1.1 Dimension

Twelve permanent cross-sections are installed to help evaluate the success of the mitigation project. Permanent cross-sections are established throughout the project site as follows: five cross-sections are located on Puzzle Creek, and six cross-sections are located on UT1. One cross-section is also located on UT2 to monitor restoration efforts associated with riparian improvements, pattern and profile adjustments made at the confluence of UT2 and Puzzle Creek. Data was not collected from UT2 during the YR4 monitoring period but will be

reexamined during the YR5 monitoring collection. Cross-sections selected for monitoring are located in representative riffle and pool reaches and each cross-section is marked on both banks with permanent pins to establish the exact transect used. A common benchmark is used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys include points measured at all breaks in slope, including top of bank, bankfull, edge of water, and thalweg, if the features are present. Riffle cross-sections are 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 movement toward a more unstable condition (e.g., down-cutting or erosion) or movement toward increased stability (e.g., settling, vegetative changes, or deposition along the banks).

2.2.1.1.1 Results

As-built cross-section monitoring data for stream stability was collected in January and February 2011. Eleven permanent cross-sections along the restored channels were re-surveyed in March 2015 to document stream dimension for Monitoring Year 4. Cross-section 1 on UT2 was not surveyed this year. Cross-sectional data is presented in Table 13 (Appendix B) and the location of cross-sections is shown on the plan sheets submitted with this report.

The cross-sections show that there has been little adjustment in stream dimension across the project reaches since construction. The small adjustments that do occur usually indicate a temporary response to flows during the preceding few months. When the year to year comparisons are evaluated we see minor deposition at some cross-sections or deepening but these changes remain within what is expected for a stable channel. Based on field observations, deposition and minor narrowing can be attributed to herbaceous vegetation that has become well established. In Yr3 some cross-sections showed minor deposition of sediment on the floodplain due to extensive overbank flooding the previous year or deposition within the channel as it is moving through the project reach. In Yr4 where deposition was higher in Yr3 it has been moved and is now more similar to the elevation that was there previous to these high flows. At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.2.1.2 Pattern and Longitudinal Profile

Longitudinal profiles for Year 4 were also surveyed during March 2015; profiles of the various project reaches are provided in Appendix B. A longitudinal profile was conducted for the entire project length on Puzzle Creek and 3,000 LF of UT1. In previous monitoring years, the entire length of UT2 was surveyed. For Year 4, the UT2 profile was not surveyed but will be surveyed again in Year 5. Longitudinal profiles of the mainstem and UT1 will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, and the low top of bank. The pools should remain relatively 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. Profile data collected reflect stable channel bedform and a diverse range of riffle and pool complexes.

All measurements were taken at the head of each feature (e.g., riffle, pool) and at the maximum pool depth. Elevations of grade control structures were also included in the longitudinal profiles surveyed. Surveys were tied to a permanent benchmark. Puzzle Creek and its tributaries are C-type streams primarily characterized by riffle-pool sequences. As the site is

monitored, reaches will be evaluated for significant changes in pattern. Any changes that warrant repair will be discussed in future monitoring reports.

2.2.1.2.1 Results

The longitudinal profiles show that the bed features are stable. As noted in the Stream Reach Morphology Data Tables in Appendix B (Table 14), riffle and pool characteristics do not appear to have changed much since construction; the measurements obtained for Year 4 are acceptable when compared to reference reach and design data provided for the project reaches. There was also little to no change in the profile of UT1 to Puzzle Creek. No areas of instability were noted during Year 4 monitoring.

2.2.1.3 Substrate and Sediment Transport

Bed material analysis consists of a pebble count taken in the same constructed riffle during annual geomorphic surveys of the project site. This sample, combined with evidence provided by changes in cross-sectional and profile data will reveal 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.

2.2.1.3.1 Results

For this project, a pebble count was collected on UT1. Visual observations and a review of pebble count data collected during Year 4 monitoring did not yield any signs that sediment transport functions have been hampered by the mitigation project; specifically, no significant areas of aggradation or degradation within the project area were observed. The pebble count data (Appendix B) indicates that the stream is moving fines through the system, and there is a marked trend in larger pebbles making up a greater percentage of the bed material. The Year 4 data show a marked change in bed composition when compared to the last two years and indicate significant sorting and transport of fines out of the sampled riffle. This is likely a function of the high flows that the stream has experienced over the last two years.

2.2.2 Hydrology

2.2.2.1 Streams

The occurrence of bankfull events within the monitoring period will be documented by the use of crest gauges and photographs. Crest gauges were installed on the floodplain at bankfull elevation. One crest gauge was set up near Vegetation Plot #3 on UT1 while another gauge was set up near the first two cross-sections in Reach 1 of Puzzle Creek. The crest gauges record the highest watermark between site visits and are checked at each site visit to determine if a bankfull event has occurred. Photographs are used to document the occurrence of wrack lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented on each crest gauge within the 5-year monitoring period. The two bankfull events must occur in separate years; otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years.

2.2.2.1.1 Results

Between October 29, 2012 and the conclusion of Year 4 monitoring in March 2015, the Site was found to have had at least two bankfull events based on crest gauge readings obtained on UT1 and Puzzle Creek and observed wrack lines. Crest gauges and physical observations only indicate how high flows have been since the last observation, so they only indicate that flows have exceeded bankfull; however, based on the record rainfall in this area over the last year we believe that this site had multiple bankfull or greater events. During monitoring YR4 Puzzle Creek appears to have had a flow that exceeded the height of the crest gauge based on all the cork being on the top of the gauge staff (see Photo 1 in Table 9). Based on our

documented observations, Puzzle Creek has had at least 5 bankfull events and UT1 has had 4 since construction ended. Information on these events is provided in Table 9 of Appendix B.

2.2.3 Photographic Documentation of Site

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

2.2.3.1 Lateral Reference Photos

Reference photo transects were taken of the right and left banks at each permanent cross-section. A survey tape was captured in most photographs which represents the cross-section line located perpendicular to the channel flow. The water line was located in the lower edge of the frame in order to document bank and riparian conditions. Photographers will make an effort to consistently maintain the same area in each photo over time.

2.2.3.2 Structure Photos

Photographs of primary grade control structures (i.e. vanes and weirs), along the restored streams 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.

Lateral and structure photographs are used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function, and stability, and effectiveness of erosion control measures subjectively. 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. Photo documentation of the site during Year 4 monitoring reflects stable site conditions in restored or enhanced areas as well as healthy stands of herbaceous and woody vegetation in the riparian corridors.

2.2.4 Stream Stability Assessment

In-stream structures installed within the restored streams included cover logs, rootwads, rock vanes, log vanes, and boulder toe protection. The Year 4 visual observations of these structures throughout the project site indicate that little or no changes have occurred since the baseline survey was performed; structures are functioning as designed and are holding their elevation and grade.

There are two stream problem areas identified. The first problem area is an area of bank erosion on Puzzle Creek Reach 1 immediately downstream of the Piney Mountain Church Rd Bridge from station 0+15 to 0+30. This area is associated with a utility crossing under the stream that was not well protected after utility work occurred. The area should stabilize over time and will be monitored to determine if corrective action should be taken. We will be reseeding this area during the spring of 2015. The second problem area is bank erosion that was identified on Puzzle Creek Reach 2 near station 16+00. This area is approximately ten feet in length, and is currently stable due to existing tree roots and vegetation. The area of erosion does not require repairs at this time and will likely become more stable over time. It does not appear to have gotten worse during YR4 but we will continue to monitor this condition. An area which has been noted in past monitoring reports is on Reach 1 of Puzzle Creek at station 9+25 and extending to the confluence of Puzzle Creek and UT1. This area is approximately 75 LF and had eroded due to the shear stress on the streambank caused by fast moving water during peak flows. The extent of erosion increased in Year 2 but slowed in Year 3. During Year 4 this are appears to have begun growing vegetation on the bank surface and a thick stand of volunteer and planted trees is now growing along the top of the bank. We believe it is becoming more stable and does not need intervention at this time. We will continue to observe this site to ensure the present trend continues.

The Categorical Stream Feature Visual Stability Assessment and Visual Morphological Stability Assessment tables in Appendix B (Tables 10 through 12), summarize the condition of project structures and bank conditions.

Quantitative reference reach and design data used to determine the restoration approach, as built data, as well as Year 4 monitoring data are summarized in Tables 13 and 14 of Appendix B.

2.3 Areas of Concern

At this time, there are two areas of concern. The streambanks of Reach 1 of Puzzle Creek immediately downstream of the Piney Mountain Church Rd Bridge are eroding from station 0+15 to 0+30. This area is associated with a utility crossing under the stream that was not stabilized after utility work. The area will be seeded and continue to be monitored. The second area of concern is the eroded bank area at station 16+00 at the end of the project. This area appears to be stable but we will continue to monitor it's condition.

Maintenance of the site for invasive vegetation control is ongoing and the two areas where bank erosion was noted will continue to be monitored and repaired as necessary. A public herbicide applicator will be notified of the need for invasives treatment, and a site visit to remove and/or spray the vegetation will be scheduled this spring. Given the presence of seed sources and proximity of invasive vegetation to the easement boundary, it is anticipated that invasives treatment will be ongoing in subsequent monitoring years.

There is limited evidence of beaver activity on UT1 but none was observed on the mainstem during monitoring year 4. Two beaver dams were removed on UT1 during the monitoring survey. The absence of the dams on the mainstem could be due to the high precipitation and flooding seen in this watershed during 2013 and 2014. Beaver removal along UT1 was discussed with the landowner and he was in agreement that they can be removed. We will be contacting the USDA APHIS group to have them trap the population that is impacting the two areas on UT1.

Mowing encroachment was noted during YR3; however, no additional mowing has been noted during the YR4 site visit. During February 2015, eastern red cedar trees were planted along the easement line in the field on the Shafer property. This will delineate the line and stop any further encroachment in this area, which is the only problem area on the Shafer property. The easement boundary was marked during the year and now should be clear to the landowners so no further encroachment happens. We will be sending a letter to these landowners to remind them of their commitments to observe the easements integrity.

3.0 REFERENCES

Leopold, L.B., M. Wolman, and J. Miller. 1964. "Fluvial Processes in Geomorphology." W. H. Freeman, San Francisco, CA.

Peet, R.K., T.R. Wentworth and P.S. White. 1998. "A flexible, multipurpose method for recording vegetation composition and structure." Castanea 63:262-274.

APPENDIX A

1. STEM COUNT ARRANGED BY PLOT (TABLES 7 AND 7B)
2. VEGETATION PROBLEM AREAS (TABLE 8)
3. VEGETATION PLOT PHOTOLOG

Table 7. Stem Count Arranged by Plot
Puzzle Creek Mitigation Site Project #92522

Tree Species	Common Name	Type	Current Data (Yr 2 2014)								AB (2010)	MY (2011)	MY2 (2012)	MY3 (2013)	MY4 (2014)	MY5 (2015)	Survival %	Probable Cause
			Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Totals	Totals	Totals	Totals	Totals	Totals		
Betula nigra	River Birch	Tree			2	4	1		5	2	2	5	5	4	14		700%	
Carpinus caroliniana	American hornbeam	Tree							1						1			
Diospyros virginiana	American Persimmon	Tree	1	2	2	1	2	1	1	3	19	19	19	16	13		68%	
Fraxinus pennsylvanica	Green Ash	Tree		4	4		3		1		17	14	14	13	12		71%	
Liriodendron tulipfera	Tulip Poplar	Tree		4	3	3				1	11	11	11	10	11		100%	
Platanus occidentalis	American Sycamore	Tree	1	1	1	9	1	3	5	4	27	25	25	25	25		93%	
Prunus serrulata	Black Cherry	Tree							1		5	4	4	3	1		20%	
Quercus sp.	Oak	Tree				1									1			
Quercus michauxii	Swamp Chestnut Oak	Tree	1					1	1	3	10	8	8	7	6		60%	
Quercus phellos	Willow Oak	Tree	5					3		2	18	13	13	11	10		56%	
Quercus rubra	Northern Red Oak	Tree	2	2				2	1	1	5	8	8	8	8		160%	
Salix nigra	Black Willow	Tree		1							3	2	2	2	1		33%	
Understory Species																		
Alnus serrulata	Tag Alder	Tree	2			1	1	3	2		12	10	10	10	9		75%	
Asimina triloba	Pawpaw	Tree									2	1	1	1	0		0%	misidentified
Cercis canadensis	Redbud	Tree									2	2	2	2	0		0%	misidentified
Cornus florida	Flowering Dogwood	Tree			1					2	7	3	3	3	3		43%	Damaged during over-bkf storm event
Volunteers																		
Acer rubrum	Red Maple	Tree											1	1				
Alnus serrulata	Tag Alder	Tree		1									2		1			
Betula nigra	River Birch	Tree	55	30	2	50	20	15	10	50	87+	87+	133+	80+	232			
Ilex opaca	American holly	Tree								1					1			
Juniperus virginiana	eastern redcedar	Tree		1											1			
Liriodendron tulipfera	Tulip Poplar	Tree	20	15	10			6		10	1+	3	10	15	61			
Liquidambar styraciflua	Sweet Gum	Tree	25	15	10	15			10	20		17	77	63+	95			
Pinus spp.	Pine	Tree	13	15		4	5		6				1	8	43			
Platanus occidentalis	American Sycamore	Tree	12			10			15	30	25+	56	16	26+	67			
Quercus rubra	Northern Red Oak	Tree									45+	45+	1					
	Plot area (acres)		0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247	0.0247							**Averages**	
	Species Count		10	11	7	8	6	8	11	10							9	
	Planted Stems/Plot		12	14	13	19	8	13	18	18							14	
	Stems/Plot		137	91	35	98	33	34	59	129							77	
	Planted Stems Per Acre		485.6	566.6	526.1	768.9	323.7	526.1	728.4	728.4							582	

Table 7b. Stem Count Arranged by Plot
Puzzle Creek Mitigation Project, DMS# 92522

			Current Plot Data (MY4 2015)																						Annual Means											
			E92522-01-0001			E92522-01-0002			E92522-01-0003			E92522-01-0004			E92522-01-0005			E92522-01-0006			E92522-01-0007			E92522-01-0008			MY4 (2014)			MY3 (2013)			MY2 (2012)			MY1 (2011)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Alnus serrulata	hazel alder		2	2	2			1				1	1	1	1	1	1	3	3	3	2	2	2				9	9	10	7	7	7	10	10	10	10	10	10
Asimina triloba	pawpaw	Tree																												1	1	1	1	1	1	1	1	1
Betula nigra	river birch	Tree			55			30	2	2	2	4	4	54	1	1	21			15	5	5	15	1	2	52	13	14	244	4	4	4	5	5	5	5	5	5
Carpinus caroliniana	American hornbeam	Tree																			1	1	1				1	1	1									
Cercis canadensis	eastern redbud	Tree																												2	2	2	2	2	2	2	2	2
Cornus florida	flowering dogwood	Tree							1	1	1													2	2	2	3	3	3	3	3	3	3	3	3	3	3	3
Diospyros virginiana	common persimmon	Tree	1	1	1	2	2	2	2	2	2	1	1	1	2	2	2	1	1	1	1	1	1	3	3	3	13	13	13	15	15	15	19	19	19	19	19	19
Fraxinus pennsylvanica	green ash	Tree				4	4	4	4	4	4				3	3	3				1	1	1				12	12	12	13	13	13	14	14	14	14	14	14
Ilex opaca	American holly	Tree																								1			1									
Juniperus virginiana	eastern redcedar	Tree						1																					1									
Liquidambar styraciflua	sweetgum	Tree			25			15			10			15									10			20			95									
Liriodendron tulipifera	tuliptree	Tree			20	4	4	19	3	3	13	3	3	3						6				1	1	11	11	11	72	10	10	10	11	11	11	11	11	11
Pinus sp.	pine	Tree			13			15						4			5						6						43									
Platanus occidentalis	American sycamore	Tree	1	1	13	1	1	1	1	1	1	9	9	19	1	1	1	3	3	3	5	5	20	4	4	34	25	25	92	22	22	22	25	25	25	25	25	25
Prunus serotina	black cherry	Tree																			1	1	1				1	1	1	3	3	3	4	4	4	4	4	4
Quercus sp.	oak	Tree										1	1	1													1	1	1									
Quercus michauxii	swamp chestnut oak	Tree	1	1	1													1	1	1	1	1	1	3	3	3	6	6	6	5	5	5	8	8	8	8	8	8
Quercus phellos	willow oak	Tree	5	5	5													3	3	3				2	2	2	10	10	10	7	7	7	13	13	13	13	13	13
Quercus rubra	northern red oak	Tree	2	2	2	2	2	2										2	2	2	1	1	1	1	1	1	8	8	8	6	6	6	8	8	8	8	8	8
Salix nigra	black willow	Tree					1	1																				1	1		2	2		2	2		2	2
		Stem count	12	12	137	13	14	91	13	13	33	19	19	98	8	8	33	13	13	34	18	18	59	17	18	129	113	115	614	98	100	100	123	125	125	123	125	125
		size (ares)	1			1			1			1			1			1			1			1			8			8			8			8		
		size (ACRES)	0.0247			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.20			0.20			0.20			0.20		
		Species count	6	6	10	5	6	11	6	6	7	6	6	8	5	5	6	6	6	8	9	9	11	8	8	10	13	14	18	13	14	14	13	14	14	13	14	14
		Stems per ACRE	485.6	485.6	5544	526.1	566.6	3683	526.1	526.1	1335	768.9	768.9	3966	323.7	323.7	1335	526.1	526.1	1376	728.4	728.4	2388	688	728.4	5220	571.6	581.7	3106	495.7	505.9	505.9	622.2	632.3	632.3	622.2	632.3	632.3

this color indicates that the number includes volunteer stems.

Table 8. Vegetation Problem Areas

Puzzle Creek Mitigation Project: Project No. 92522

Puzzle Creek Reach 1 (1,000 LF)			
Feature Issue	**Station No./Range**	**Suspected Cause**	**Number**
Other	N/A	N/A	N/A
Bare Bank	0+15-0+30	Utility crossing	1
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	Intermittently Scattered Throughout	Ligustrum sinense -source outside easement and persisting after treatment	N/A
Puzzle Creek Reach 2 (634 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	15+95-16+05	erosion during past flooding	2
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	Intermittently Scattered Throughout	Kudzu-source outside easement near Veg Plot 8, Ligustrum sinense -source outside easement and persisting after treatment	N/A
UT1 (3,339 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	Intermittently Scattered Throughout	Kudzu-source outside easement, Ligustrum sinense -source outside easement and persisting after treatment	N/A

Photo 1. Area of bare bank at utility crossing at top of project on mainstem.

Photo 3. View downstream at area listed last year as an unstable, bare bank near confluence with UT1. It is stabilized by many trees alongthe top and vegetation growing on the surface.

Photo 2. Bare area at Station 16+00 caused by past flooding, but appears stable at this time.

Photo 4. Upstream view of bend shown in Photo 3. No No recent instability noted.

Puzzle Creek Restoration Project
Photo Log - Vegetation Plot 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.
3. All photos were taken on March 25, 2015.

Photo 1: Veg Plot 1

Photo 2: Veg Plot 1: Herbaceous Plot

Photo 3: Veg Plot 2

Photo 4: Veg Plot 2: Herbaceous Plot

Photo 5: Veg Plot 3

Photo 6: Veg Plot 3: Herbaceous Plot

Puzzle Creek Restoration Project
Photo Log - Vegetation Plot 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.
3. All photos were taken on March 25, 2015.

Photo 7: Veg Plot 4

Photo 8: Veg Plot 4: Herbaceous Plot

Photo 9: Veg Plot 5

Photo 10: Veg Plot 5: Herbaceous Plot

Photo 11: Veg Plot 6

Photo 12: Veg Plot 6: Herbaceous Plot

Puzzle Creek Restoration Project
Photo Log - Vegetation Plot 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.
3. All photos were taken on March 25, 2015.

Photo 13: Veg Plot 7

Photo 14: Veg Plot 7: Herbaceous Plot

Photo 15: Veg Plot 8

Photo 16: Veg Plot 8: Herbaceous Plot

APPENDIX B

1. HYDROLOGICAL (BANKFULL) VERIFICATIONS (TABLE 9)
2. STREAM PROBLEM AREAS (TABLE 10)
3. CROSS-SECTION PLOTS WITH ANNUAL OVERLAYS
4. LONGITUDINAL PROFILES WITH ANNUAL OVERLAYS
5. CATEGORICAL STREAM FEATURE VISUAL STABILITY ASSESSMENT (TABLE 11)
6. VISUAL MORPHOLOGICAL STABILITY ASSESSMENT (TABLE 12)
7. STREAM REACH MORPHOLOGY AND HYDRAULIC DATA (TABLE 13)
8. CROSS-SECTION MORPHOLOGY AND HYDRAULIC DATA (TABLE 14)
9. RIFFLE PEBBLE COUNT SIZE CLASS DISTRIBUTIONS
10. STREAM REFERENCE STATION PHOTO LOGS

Table 9. Verification of Bankfull or Greater than Bankfull Events
Puzzle Creek Restoration Project No. 92522

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (inches above bankfull)	
			Puzzle Cr. Reach 1	UT1
2/3/2012	Between January 2011 and 2/2/12	Gauge measurement	2.52"	2.28"
10/29/2012	Between 2/2/12 and 10/29/12	Gauge measurement	2.75", 1.75"	2.25"
3/31/2014	Between 10/29/12 and 3/31/14	Gauge measurement	1.50"	2.50"
3/25/2015	Between 3/31/14 and 3/25/15	Gauge measurement	48"	5.88"

Photo 1. Crest gauge staff showing cork deposition at 5.87 inches above bankfull elevation, at the bottom of the gauge.

Photo 1. Crest gauge staff showing cork deposition on top of the staff indicating that flood waters were at or higher than 48 inches above

Table 10. Stream Problem Areas
Puzzle Creek Mitigation Project: Project No. 92522

Puzzle Creek Reach 1 (1,000 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Bank Erosion	0+15-0+30	Shear stress caused by high velocity flow against bank after utility work left banks vulnerable and they continue to be unstable.	Photo #1 under Table 8
Puzzle Creek Reach 2 (634 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Bank Erosion	15+95-16+05	Shear stress caused by high velocity flow against bank	Photo #2 under Table 8
UT1 (3,339 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
N/A	N/A	N/A	N/A

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	44.7	21.39	2.09	3.44	10.23	1	3.7	882.77	882.79

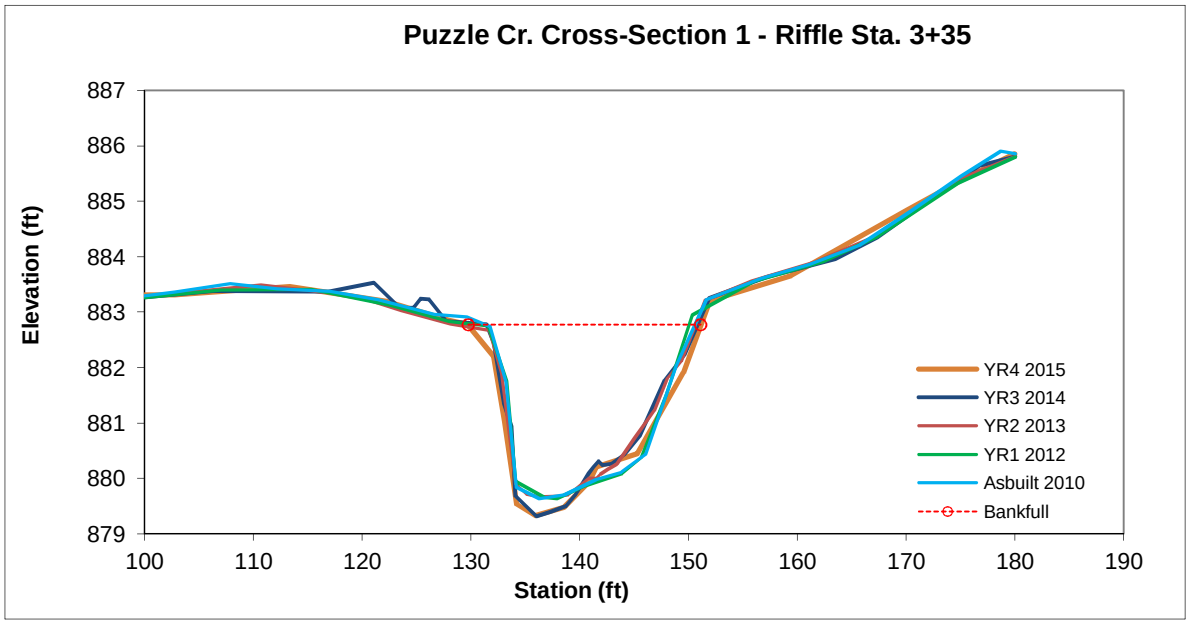


Photo1: XS-1 facing left bank

Photo 2: XS-1 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E	63.3	28.67	2.21	4.5	12.98	1.1	3.3	882.26	882.56

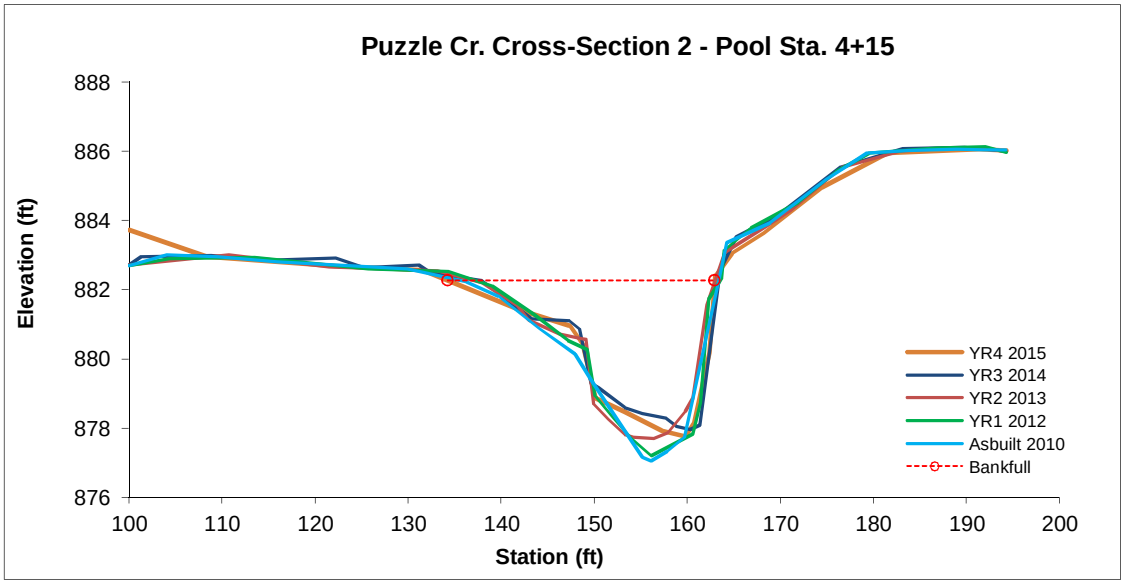


Photo 1: XS-2 facing left bank

Photo 2: XS-2 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	52.1	19.64	2.65	3.82	7.4	1	3.9	880.33	880.3

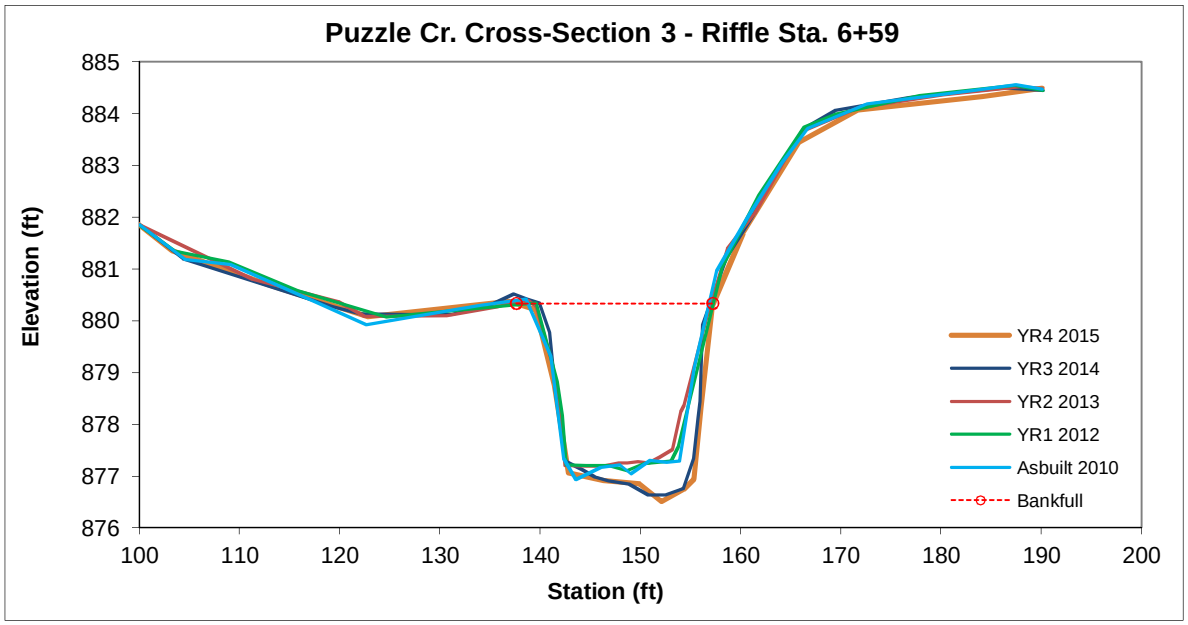


Photo 1: XS-3 facing left bank

Photo 2: XS-3 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	63.4	26.92	2.35	3.61	11.44	1	3.1	875.95	876.03

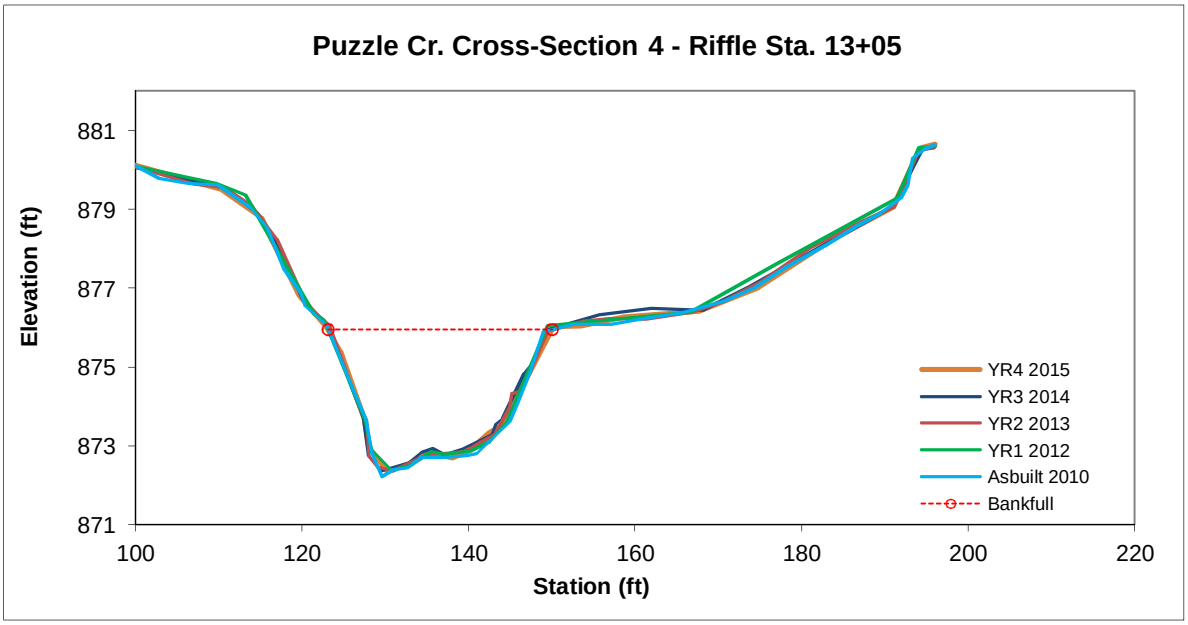


Photo 1: XS-4 facing left bank

Photo 2: XS-4 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	E	105.7	35.69	2.96	6.43	12.05	1.4	1.8	875.18	877.81

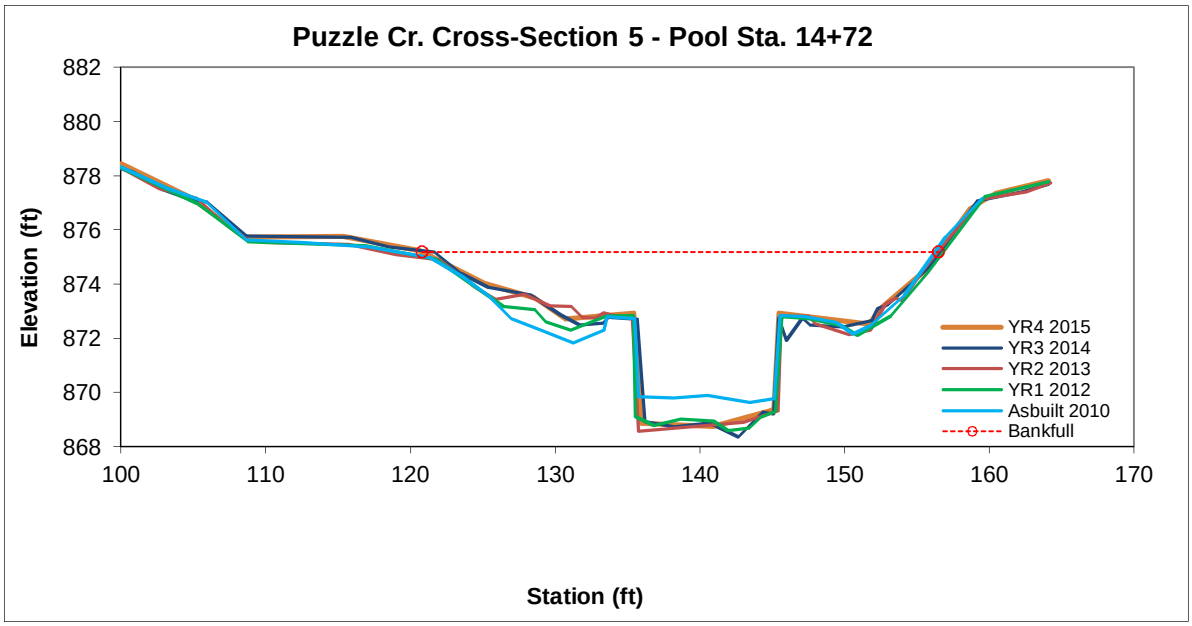


Photo 1: XS-5 facing left bank

Photo 2: XS-5 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	23.4	13.28	1.76	2.66	7.55	1	4.5	925.23	925.24

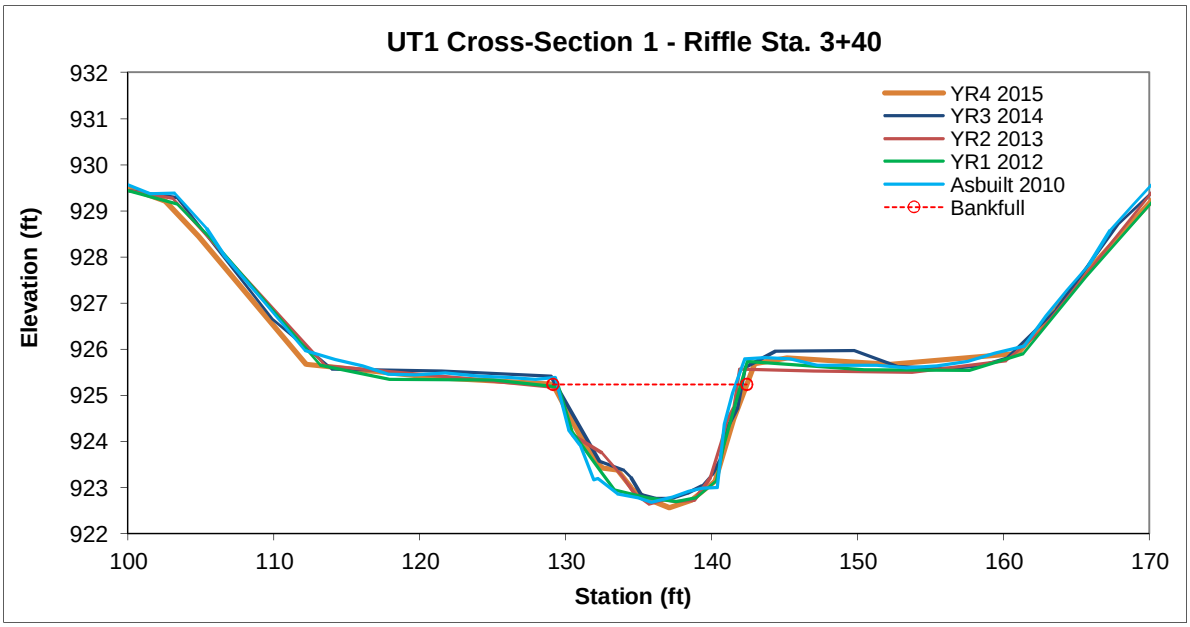


Photo 1: UT1 XS-1 facing left bank

Photo 2: UT1 XS-1 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	34.6	24.15	1.43	2.65	16.87	1	3.2	919.25	919.22

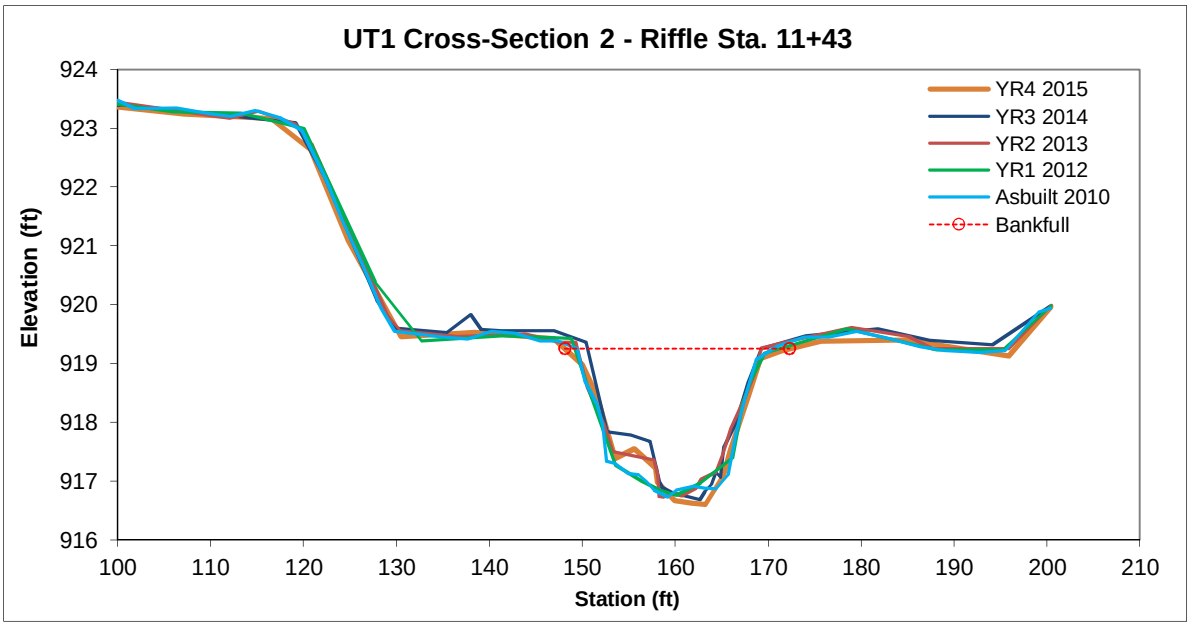


Photo 1: UT1 XS-2 facing left bank

Photo 2: UT1 XS-2 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	42.4	30.96	1.37	3.73	22.63	1	2.5	919	919.01

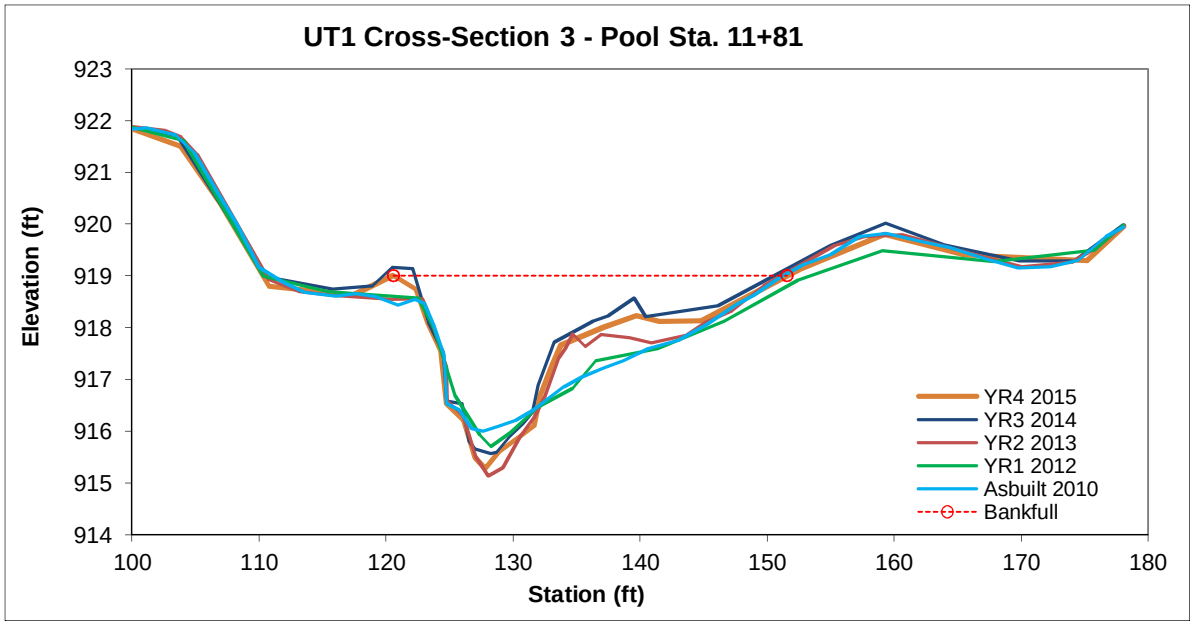


Photo 1: UT1 XS-3 facing left bank

Photo 2: UT1 XS-3 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	33.2	24.79	1.34	2.47	18.51	0.9	2.1	913.25	913.08

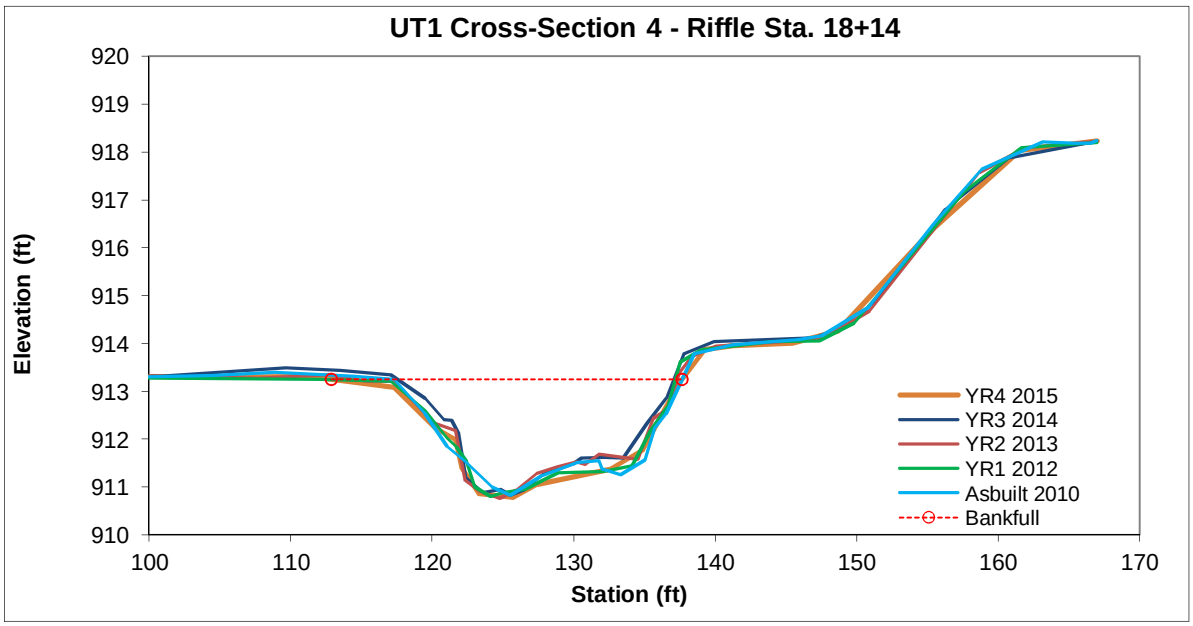


Photo 1: UT1 XS-4 facing left bank

Photo 2: UT1 XS-4 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	55.8	29.02	1.92	5.54	15.09	1	2.3	913.25	913.34

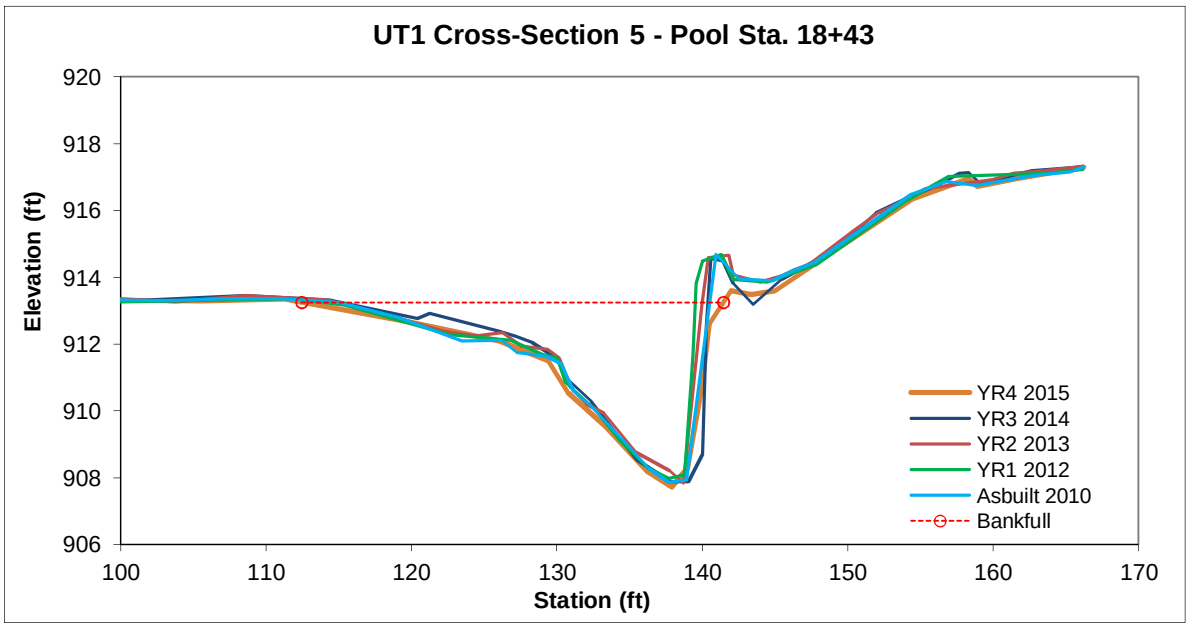


Photo 1: UT1 XS-5 facing left bank

Photo 2: UT1 XS-5 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	C	34.5	16.75	2.06	3.29	8.13	1.1	2.5	903.49	903.69

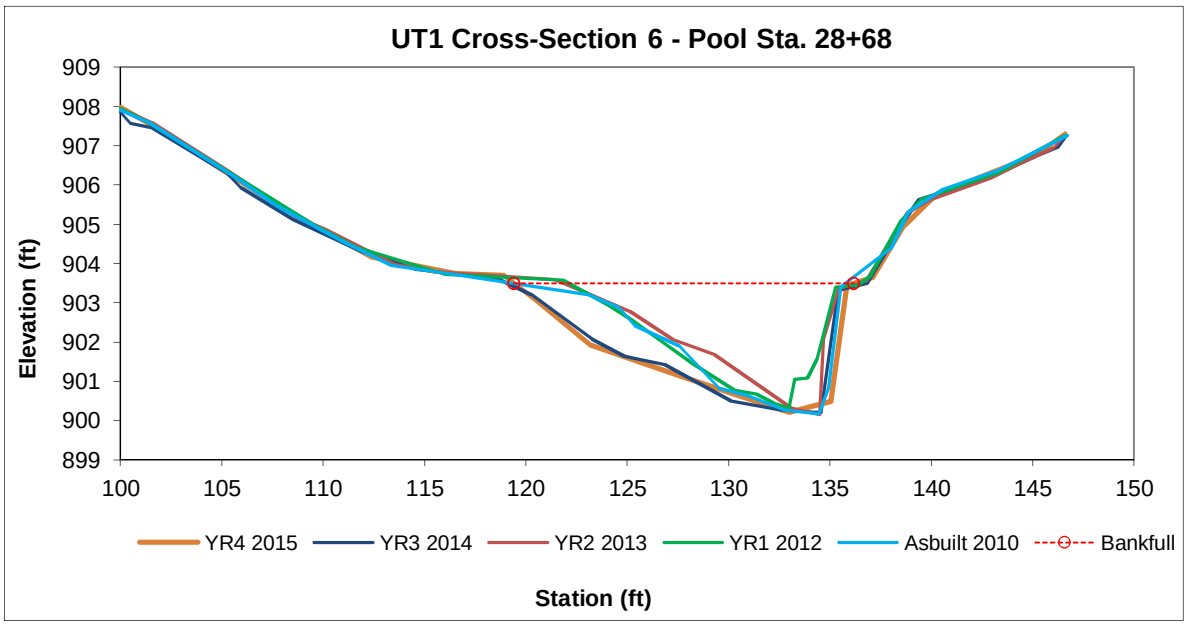
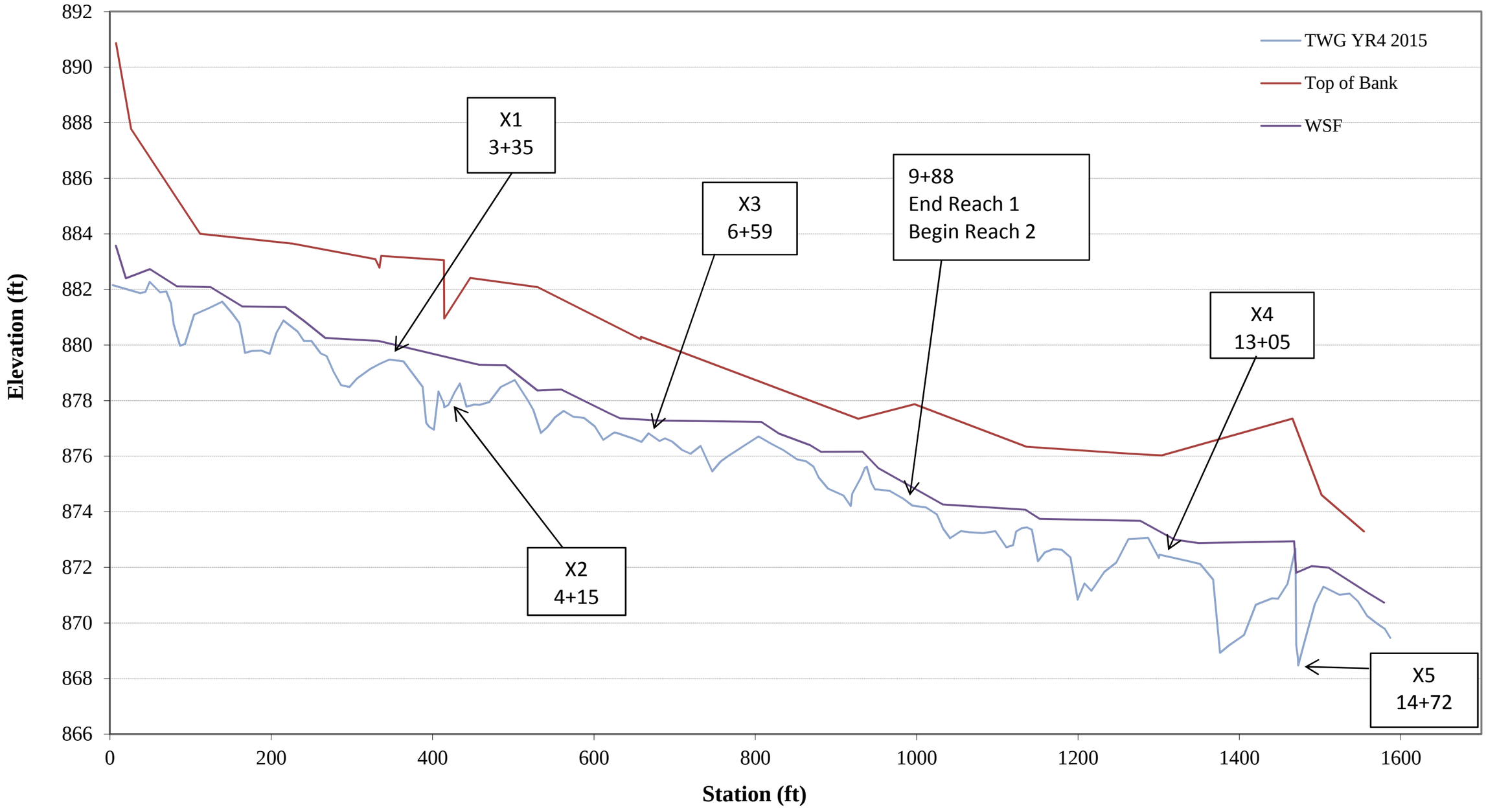


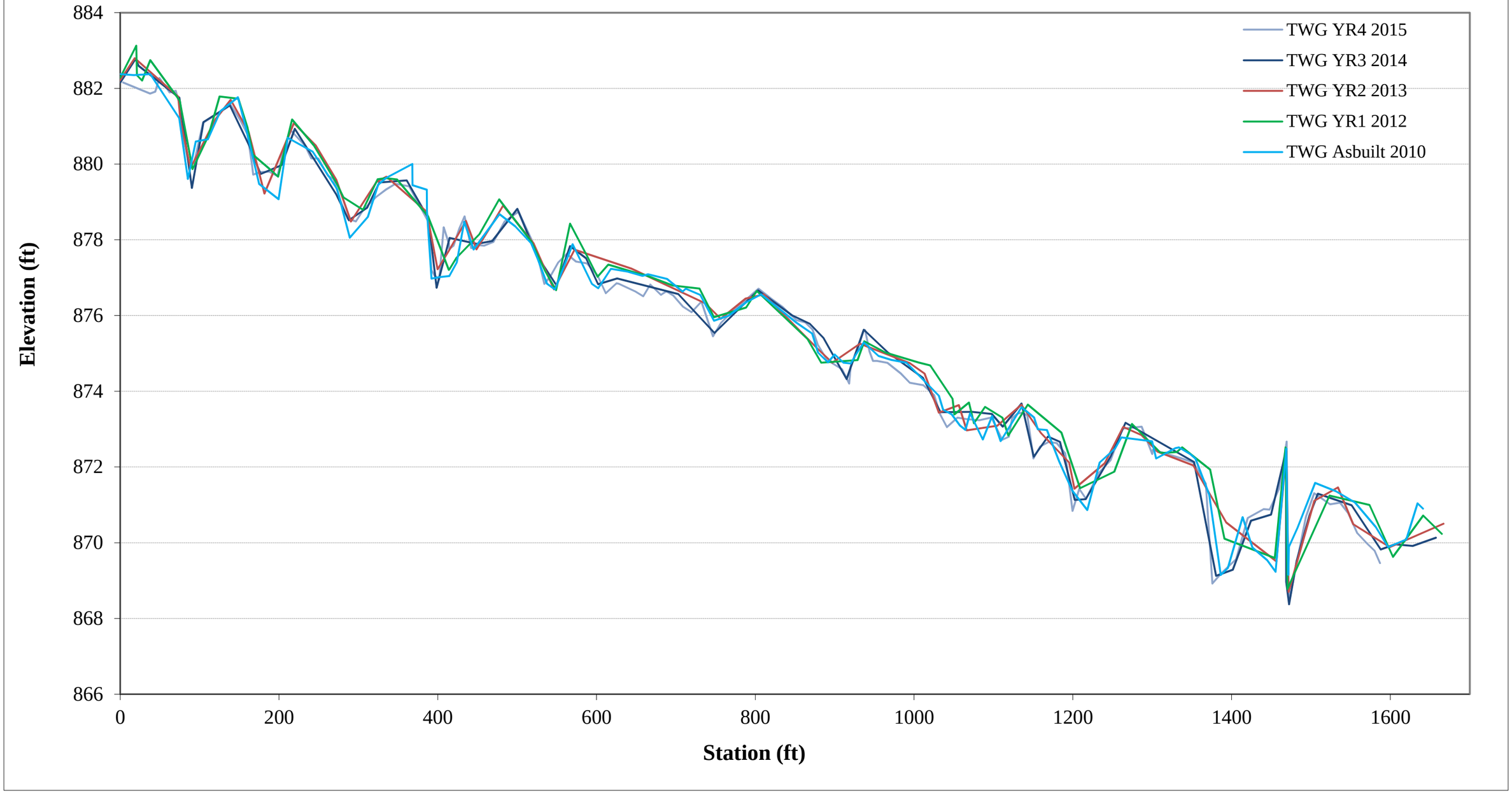
Photo 1: UT1 XS-6 facing left bank

Photo 2: UT1 XS-6 facing right bank

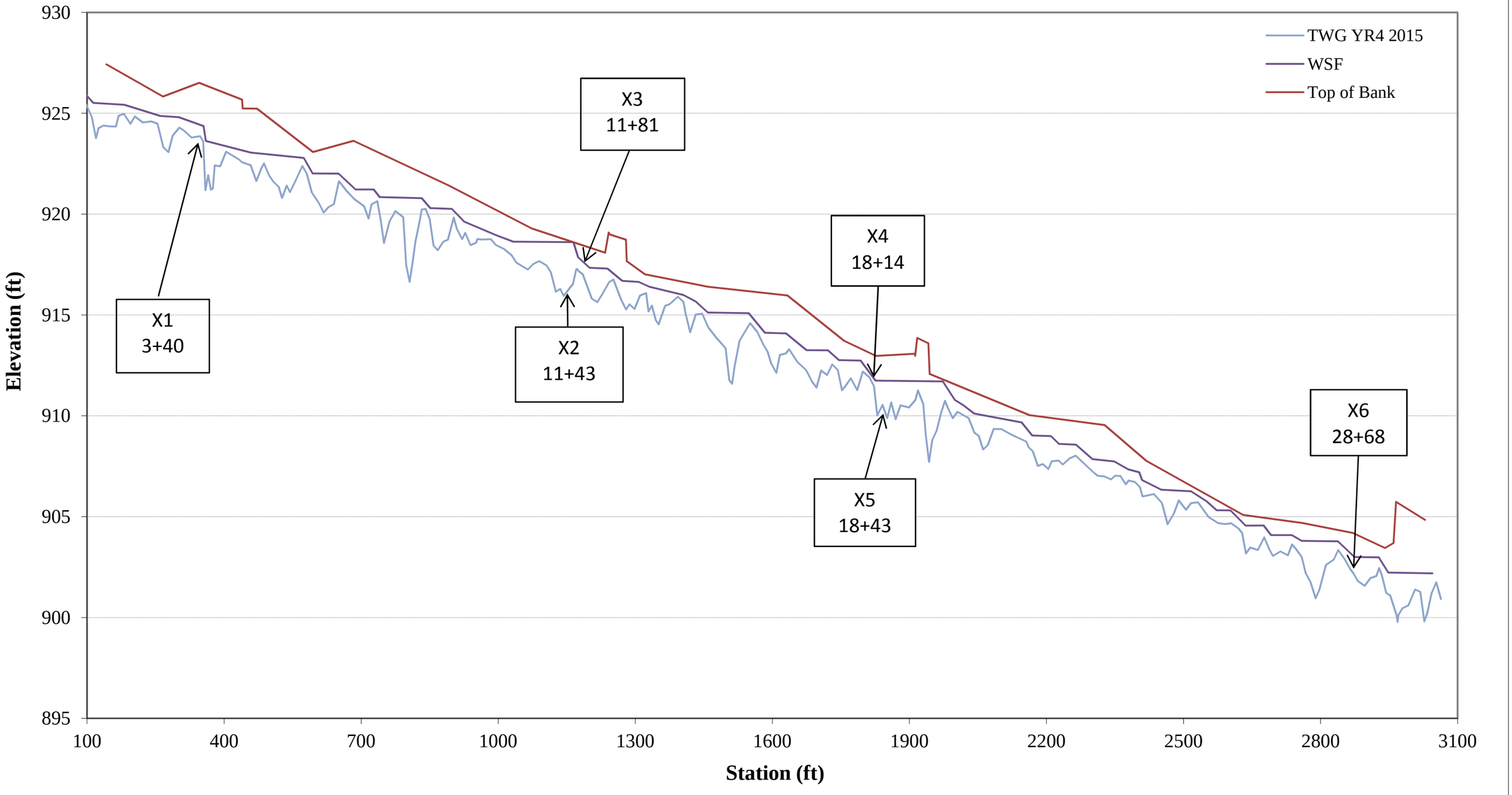
YR4 Longitudinal Profile - Puzzle Creek



Longitudinal Profile of Thalwag-Puzzle Creek
Year to Year Comparison



YR4 Longitudinal Profile - UT1



Longitudinal Profile of Thalwag - UT1
Year to Year Comparison

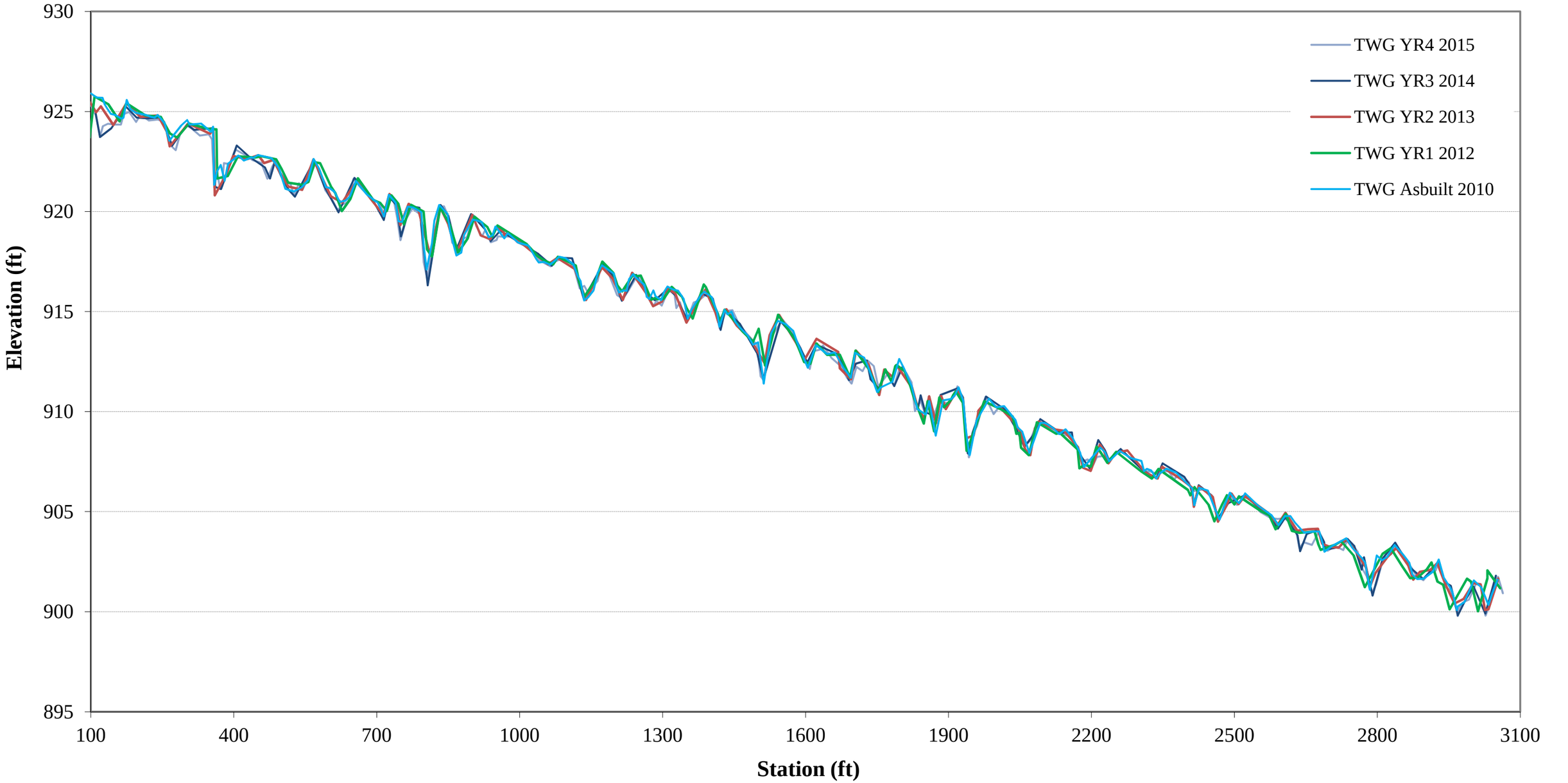


Table 11. Categorical Visual Morphological Stability Assessment						
Puzzle Creek Mitigation Project: Project No. 92522						
Puzzle Creek Reach 1 (1,000 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	100%	100%	100%	100%	100%	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	98%	95%	99%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	100%	100%	100%	100%	100%	
Wads and Boulders	100%	100%	100%	100%	100%	
Puzzle Creek Reach 2 (634 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	100%	100%	100%	100%	100%	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	99%	99%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	100%	100%	100%	100%	100%	
Wads and Boulders	100%	100%	100%	100%	100%	
UT1 (3,339 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	100%	100%	100%	100%	100%	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	100%	100%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	100%	100%	100%	100%	100%	
Wads and Boulders	100%	100%	100%	100%	100%	

Table 12. Visual Morphological Stability Assessment
Puzzle Creek Mitigation Project: Project No. 92522

Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
Puzzle Creek Reach 1 (1,000 LF)						
A. Riffles	1. Present?	9	9	N/A	100	
	2. Armor stable (e.g. no displacement)?	9	9	N/A	100	
	3. Facet grades appears stable?	9	9	N/A	100	
	4. Minimal evidence of embedding/fining?	9	9	N/A	100	
	5. Length appropriate?	9	9	N/A	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	10	10	N/A	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	10	10	N/A	100	
	3. Length appropriate?	10	10	N/A	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	N/A	100	
	2. Downstream of pool (structure) centering?	1	1	N/A	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	6	6	N/A	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	6	6	N/A	N/A	
	3. Apparent Rc within spec?	6	6	N/A	N/A	
	4. Sufficient floodplain access and relief?	6	6	N/A	N/A	**N/A**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	N/A	N/A	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	1	1	N/A	100	
	2. Height appropriate?	1	1	N/A	100	
	3. Angle and geometry appear appropriate?	1	1	N/A	100	
	4. Free of piping or other structural failures?	1	1	N/A	100	**100%**
G. Wads/ Boulders, Coverlogs	1. Free of scour?	5	5	N/A	N/A	
	2. Footing stable?	5	5	N/A	N/A	**100%**
Puzzle Creek Reach 2 (634 LF)						
Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
A. Riffles	1. Present?	5	5	N/A	100	
	2. Armor stable (e.g. no displacement)?	5	5	N/A	100	
	3. Facet grades appears stable?	5	5	N/A	100	
	4. Minimal evidence of embedding/fining?	5	5	N/A	100	
	5. Length appropriate?	5	5	N/A	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	6	6	N/A	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	6	6	N/A	100	
	3. Length appropriate?	6	6	N/A	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	N/A	100	
	2. Downstream of pool (structure) centering?	1	1	N/A	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	4	4	N/A	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	4	4	N/A	N/A	
	3. Apparent Rc within spec?	4	4	N/A	N/A	
	4. Sufficient floodplain access and relief?	4	4	N/A	N/A	**N/A**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	N/A	N/A	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	1	1	N/A	100	
	2. Height appropriate?	1	1	N/A	100	
	3. Angle and geometry appear appropriate?	1	1	N/A	100	
	4. Free of piping or other structural failures?	1	1	N/A	100	**100%**
G. Wads/ Boulders, Coverlogs	1. Free of scour?	2	2	N/A	N/A	
	2. Footing stable?	2	2	N/A	N/A	**100%**

UT1 (3,339 LF)						
Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
A. Riffles	1. Present?	26	26	N/A	100	
	2. Armor stable (e.g. no displacement)?	26	26	N/A	100	
	3. Facet grades appears stable?	26	26	N/A	100	
	4. Minimal evidence of embedding/fining?	26	26	N/A	100	
	5. Length appropriate?	26	26	N/A	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	24	24	N/A	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	24	24	N/A	100	
	3. Length appropriate?	24	24	N/A	100	**100%**
C. Thalweg	1. Upstream of pool (structure) centering?	1	1	N/A	100	
	2. Downstream of pool (structure) centering?	1	1	N/A	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	21	21	N/A	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	21	21	N/A	N/A	
	3. Apparent Rc within spec?	21	21	N/A	N/A	
	4. Sufficient floodplain access and relief?	21	21	N/A	N/A	**N/A**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	N/A	N/A	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	1	1	N/A	100	
	2. Height appropriate?	1	1	N/A	100	
	3. Angle and geometry appear appropriate?	1	1	N/A	100	
	4. Free of piping or other structural failures?	1	1	N/A	100	**100%**
G. Wads/ Boulders, Coverlogs	1. Free of scour?	13	13	N/A	N/A	
	2. Footing stable?	13	13	N/A	N/A	**N/A**

Table 13. Stream Reach Morphology and Hydraulic Data
Puzzle Creek Restoration Project #92522

Baseline Stream Summary
Puzzle Creek: Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	17.9	7.8	11.3	14.8	-----	22.0	-----	19.8	18.4	21.3	17.7	18.0	18.4	18.3	18.6	18.8	17.0	18.2	19.4	19.6	20.8	21.4			
Floodprone Width (ft)	-----	17	39	62	-----	100+	-----	69	74	80	66	73	80	66	72	78	69	75	80	76	83	94			
Bankfull Mean Depth (ft)	2.03	0.80	1.45	2.10	-----	1.90	-----	2.10	2.30	2.49	2.21	2.34	2.46	2.03	2.18	2.33	2.12	2.51	2.9	2.09	2.32	2.65			
Bankfull Max Depth (ft)	-----	1.30	1.95	2.60	-----	2.5	-----	3.28	3.38	3.47	3.12	3.18	3.24	3.00	3.10	3.20	3.45	3.58	3.7	3.44	3.92	4.5			
Bankfull Cross Sectional Area (ft2)	40.8	7.5	19.3	31.0	-----	42.5	-----	44.7	45.2	45.7	40.8	42.1	43.4	38.1	40.4	42.7	41.0	45.3	49.5	44.7	53.4	63.3			
Width/Depth Ratio	-----	5.4	8.3	11.1	-----	11.6	-----	7.4	8.8	10.1	7.2	7.8	8.3	7.9	8.5	9.2	5.9	7.5	9.1	7.4	10.2	13.0			
Entrenchment Ratio	-----	1.8	4.9	7.9	-----	>4.5	-----	3.7	3.8	3.8	3.7	4.0	4.4	3.6	3.9	4.2	4.1	4.1	4.1	3.3	3.6	3.9			
Bank Height Ratio	-----	1.3	1.4	1.4	-----	1.3	-----	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.2	1.3	1.4	1.0	1.0	1.1			
Bankfull Velocity (fps)	-----	3.1	9.9	3.3	-----	4.5	-----	----	4.2	----	----	4.5	----	----	4.7	----	----	4.2	----	----	3.6	----			
Pattern																									
Channel Beltwidth (ft)	-----	-----	62	-----	68	-----	156	75	92	117	75	92	117	75	92	117	75	92	117	75	92	117			
Radius of Curvature (ft)	-----	-----	13	-----	35	-----	68	20	39	81	20	39	81	20	39	81	20	39	81	20	39	81			
Meander Wavelength (ft)	-----	-----	64	-----	136	-----	160	137	155	173	137	155	173	137	155	173	137	155	173	137	155	173			
Meander Width Ratio	-----	6.0	7.0	8.0	3.1	-----	7.1	----	5.0	----	----	5.1	----	----	5.0	----	----	5.1	----	----	4.4	----			
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	25	-----	100	31	60	113	24	65	115	24	62	93	25	62	83	53	89	170			
Riffle Slope (ft/ft)	-----	0.001	0.029	0.058	-----	0.014	-----	0.005	0.012	0.019	0.003	0.013	0.028	0.006	0.015	0.028	0.004	0.020	0.045	0.002	0.010	0.024			
Pool Length (ft)	-----	-----	-----	-----	7	-----	60	34	57	86	14	35	63	56	79	106	57	86	110	29	49	64			
Pool Spacing (ft)	-----	24	33	42	58	-----	136	55	115	168	52	109	147	93	122	147	87	124	151	81	137	213			
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.5/.35/.92/30.04/56.91			----			----			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	0.90	-----	-----	0.90	-----	-----	0.94	-----	-----	0.83	-----	-----	0.83	-----	-----	0.83	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	4.0	-----	-----	3.8	-----	-----	4.2	-----	-----	3.9	-----	-----	3.5	-----	-----	3.0	-----			
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1000	-----	-----	1000	-----	-----	1000	-----	-----	1000	-----	-----	1000	-----	-----	1000	-----			
Drainage Area (SM)	-----	0.2	1.9	2.3	-----	2.6	-----	-----	2.6	-----	-----	2.6	-----	-----	2.6	-----	-----	2.6	-----	-----	2.6	-----			
Rosgen Classification	-----	-----	C/E4	-----	-----	C4-5	-----	-----	E4	-----	-----	E4	-----	-----	E4	-----	-----	E4	-----	-----	E4	-----			
Bankfull Discharge (cfs)	176.56	-----	190	-----	-----	190	-----	-----	190	-----	-----	190	-----	-----	190	-----	-----	190	-----	-----	190	-----			
Sinuosity	-----	-----	1.9	-----	-----	1.3	-----	-----	1.3	-----	-----	1.4	-----	-----	1.4	-----	-----	1.4	-----	-----	1.4	-----			
BF slope (ft/ft)	-----	-----	0.009	-----	0.009	0.009	0.009	-----	0.009	-----	-----	0.009	-----	-----	0.009	-----	-----	0.009	-----	-----	0.009	-----			

Table 13. Stream Reach Morphology and Hydraulic Data
Puzzle Creek Restoration Project #92522

Baseline Stream Summary
Puzzle Creek: Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	24.7	7.8	11.3	14.8	-----	25.0	-----	----	25.6	----	----	26.6	----	----	26.0	----	----	26.1	----	----	26.9	----			
Floodprone Width (ft)	-----	17	39	62	-----	100+	-----	----	82	----	----	84	----	----	81	----	----	81	----	----	73.4	----			
Bankfull Mean Depth (ft)	2.58	0.80	1.45	2.10	-----	2.10	-----	----	2.48	----	----	2.48	----	----	2.39	----	----	2.39	----	----	2.4	----			
Bankfull Max Depth (ft)	-----	1.30	1.95	2.60	-----	2.70	-----	----	3.66	----	----	3.66	----	----	3.54	----	----	3.58	----	----	3.6	----			
Bankfull Cross Sectional Area (ft2)	68.0	7.5	19.3	31.0	-----	52.6	-----	----	63.4	----	----	66.1	----	----	62.2	----	----	62.4	----	----	63.4	----			
Width/Depth Ratio	-----	5.4	8.3	11.1	-----	11.9	-----	----	10.4	----	----	10.7	----	----	10.9	----	----	11.0	----	----	11.4	----			
Entrenchment Ratio	-----	1.8	4.9	7.9	-----	>4.0	-----	----	3.2	----	----	3.2	----	----	3.1	----	----	3.1	----	----	3.1	----			
Bank Height Ratio	-----	1.3	1.4	1.4	1.0	-----	1.2	----	1.0	----	----	1.0	----	----	2.2	----	----	2.1	----	----	1.2	----			
Bankfull Velocity (fps)	-----	3.1	9.9	3.3	-----	4.8	-----	----	3.9	----	----	3.8	----	----	4.0	----	----	4.0	----	----	3.9	----			
Pattern																									
Channel Beltwidth (ft)	-----	-----	62	-----	87	-----	198	62	113	154	62	113	154	62	113	154	62	113	154	62	113	154			
Radius of Curvature (ft)	-----	-----	13	-----	45	-----	62	37	46	53	37	46	53	37	46	53	37	46	53	37	46	53			
Meander Wavelength (ft)	-----	-----	64	-----	174	-----	248	234	256	269	234	256	269	234	256	269	234	256	269	234	256	269			
Meander Width Ratio	-----	6.0	7.0	8.0	3.5	-----	8.0	----	4.4	----	----	4.3	----	----	4.3	----	----	4.3	----	----	4.2	----			
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	25	-----	100	32	56	87	42	64	98	60	76	85	48	70	86	67	86	105			
Riffle Slope (ft/ft)	-----	0.001	0.029	0.058	-----	0.016	-----	0.005	0.011	0.019	0.005	0.008	0.012	0.009	0.009	0.010	0.013	0.016	0.019	0.013	0.017	0.022			
Pool Length (ft)	-----	-----	-----	-----	7	-----	60	34	53	83	53	65	77	58	78	106	49	73	101	26	62	92			
Pool Spacing (ft)	-----	24	33	42	74	-----	174	85	121	168	79	121	182	104	133	165	92	125	164	132	156	176			
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.5/.35/.92/30.04/56.91			-----			-----			-----			-----			-----			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.1	-----	-----	1.1	-----	-----	1.0	-----	-----	1.1	-----	-----	1.1	-----	-----	1.1	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	5.1	-----	-----	4.2	-----	-----	3.7	-----	-----	4.3	-----	-----	4.3	-----	-----	4.2	-----			
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	634	-----	-----	634	-----	-----	634	-----	-----	634	-----	-----	634	-----	-----	634	-----			
Drainage Area (SM)	-----	0.2	1.9	2.3	-----	4.2	-----	-----	4.2	-----	-----	4.2	-----	-----	4.2	-----	-----	4.2	-----	-----	4.2	-----			
Rosgen Classification	-----	-----	C/E4	-----	-----	C4-5	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----			
Bankfull Discharge (cfs)	250	-----	190	-----	----	250	----	-----	250	-----	-----	250	-----	-----	250	-----	-----	250	-----	-----	250	-----			
Sinuosity	-----	-----	1.9	-----	-----	1.2	-----	-----	1.2	-----	-----	1.2	-----	-----	1.2	-----	-----	1.2	-----	-----	1.2	-----			
BF slope (ft/ft)	-----	-----	0.009	-----	-----	0.008	-----	-----	0.008	-----	-----	0.011	-----	-----	0.010	-----	-----	0.010	-----	-----	0.010	-----			

Table 13. Stream Reach Morphology and Hydraulic Data
Puzzle Creek Restoration Project #92522

Baseline Stream Summary: UT1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	14.6	7.8	11.3	14.8	14.0	----	18.0	12.4	17.8	20.4	12.5	16.9	20.2	12.3	16.9	20.0	13.2	14.4	20.1	16.8	25.1	31.0			
Floodprone Width (ft)	-----	16.7	39.1	61.5	----	50+	----	44.1	58.1	76.1	41.4	57.3	76.3	43.0	57.7	77.0	41.6	58.1	77.1	41.4	63.3	78.1			
Bankfull Mean Depth (ft)	1.74	0.80	1.45	2.10	1.50	----	1.70	1.53	1.69	1.99	1.54	1.67	1.85	1.47	1.60	1.74	1.5	1.7	1.9	1.3	1.6	2.1			
Bankfull Max Depth (ft)	-----	1.3	2.0	2.6	-----	----	-----	2.3	2.73	3.5	2.4	2.64	3.3	2.5	2.74	3.4	2.5	2.7	3.3	2.5	3.5	5.5			
Bankfull Cross Sectional Area (ft2)	29.5	7.5	19.3	31.0	24.0	----	28.0	24.6	29.5	31.9	23.1	28.0	33.8	21.3	26.7	32.9	23.7	29.3	33.2	33.2	40.1	55.8			
Width/Depth Ratio	-----	5.4	8.3	11.1	8.2	----	12.0	6.2	10.9	13.1	6.7	10.3	13.0	7.1	10.7	13.6	7.4	10.4	13.5	8.1	16.2	22.6			
Entrenchment Ratio	-----	1.8	4.9	7.9	-----	----	-----	2.3	3.4	4.8	2.7	3.5	4.7	2.7	3.5	4.7	2.3	3.4	4.5	1.0	2.1	2.5			
Bank Height Ratio	-----	1.3	1.4	1.4	1.0	----	1.2	0.9	1.0	1.0	1.0	1.0	1.0	1.1	1.8	2.7	1.1	1.8	2.5	0.9	1.0	1.1			
Bankfull Velocity (fps)	-----	3.1	1.3	3.3	-----	5.4	-----	4.4	4.8	5.7	4.1	5.0	6.1	4.3	5.2	6.6	4.2	4.8	5.9	2.5	3.5	4.2			
Pattern																									
Channel Beltwidth (ft)	-----	-----	62	-----	50	----	93	44	66	87	44	66	87	44	66	87	44	66	87	44	66	87			
Radius of Curvature (ft)	-----	-----	13	-----	28	----	52	23	39	54	23	39	54	23	39	54	23	39	54	23	39	54			
Meander Wavelength (ft)	-----	-----	64	-----	130	----	213	143	175	220	143	175	220	143	175	220	143	175	220	143	175	220			
Meander Width Ratio	-----	6	7	8	3	----	7	4	4	4	4	4	4	4	4	4	3	5	4	3	3	3			
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	22	----	100	25	46	55	23	51	85	22	51	90	21	41	66	12	51	154			
Riffle Slope (ft/ft)	-----	0.0006	0.0291	0.0576	0.0120	----	0.0200	0.0060	0.0122	0.0169	0.005	0.019	0.035	0.005	0.019	0.039	0.004	0.019	0.029	0.004	0.017	0.061			
Pool Length (ft)	-----	-----	-----	-----	25	----	50	17	33	52	13	22	38	35	43	57	34	46	64	27	52	96			
Pool Spacing (ft)	-----	24	33	42	50	----	90	56	91	127	55	92	131	55	91	135	61	94	136	55	92	168			
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.5/.4/.9/30/57			na/.4/1/30/57			.6/11/21/74/114			.3/6/14/60/98			.22/7/13/45/128			15/33/46/88/140			21/38/50/87/180					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.24	-----	-----	1.14	-----	-----	0.65	-----	-----	0.65	-----	-----	0.65	-----	-----	0.65	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	6.66	-----	-----	5.40	-----	-----	3.25	-----	-----	3.40	-----	-----	3.10	-----	-----	2.27	-----			
Additional Reach Parameters																									
Channel length (ft)	2975	-----	-----	-----	-----	3,246	-----	-----	3,339	-----		3,339			3,339			3,339			3,339				
Drainage Area (SM)	-----	0.20	1.25	2.30	-----	1.60	----	-----	1.60	-----	-----	1.60	-----	-----	1.60	-----	-----	1.60	-----	-----	1.60	-----			
Rosgen Classification	-----	-----	E5	-----	-----	C4-5	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----	-----	E/C4	-----			
Bankfull Discharge (cfs)	-----	23	26	29	----	140	----	-----	140	-----	-----	140	-----	-----	140	-----	-----	140	-----	-----	140	-----			
Sinuosity	1.2	-----	1.9	----	-----	1.3	-----	-----	1.3	-----	-----	1.3	-----	-----	1.3	-----	-----	1.3	-----	-----	1.3	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	0.016	-----	-----	0.016	-----	-----	0.009	-----	-----	0.010	-----	-----	0.010	-----	-----	0.010	-----			

Note: Although UT1 contains alternating restoration approaches, it was decided to leave UT1 as one reach for the purposes of this report as some of the reaches are less than 500 LF.

Table 14. Cross-section Morphology and Hydraulic Data
Puzzle Creek Restoration Project #92522

	Puzzle Creek Reach 1																	
Parameter	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	21.3	18.4	18.8	19.4	21.4		23.3	24.1	24.9	25.6	21.4		18.4	17.7	18.3	17.0	19.64	
Floodprone Width (ft)	80.1	80.1	78.3	80.0	80.0		94.3	94.3	94.3	94.2	94.3		68.7	65.9	66.0	69.3	76.00	
BF Cross Sectional Area (ft2)	44.7	40.8	38.1	41.0	44.7		56.8	62.1	60.2	60.2	63.3		45.7	43.4	42.7	49.5	52.10	
BF Mean Depth (ft)	2.10	2.21	2.03	2.12	2.09		2.44	2.58	2.42	2.35	2.21		2.49	2.46	2.33	2.90	2.65	
BF Max Depth (ft)	3.28	3.12	3.00	3.45	3.44		4.75	4.90	4.48	4.29	4.50		3.47	3.24	3.20	3.70	3.82	
Width/Depth Ratio	10.1	8.3	9.2	9.1	10.2		9.5	9.4	10.3	10.9	13.0		7.4	7.2	7.87	5.87	7.40	
Entrenchment Ratio	3.8	4.4	4.2	1.2	3.7		4.1	3.9	3.8	3.7	3.3		3.7	3.7	3.6	4.1	3.90	
Wetted Perimeter (ft)	25.5	22.9	22.8	23.6	25.6		28.1	29.3	29.7	30.3	25.8		23.4	22.6	23.0	22.8	24.9	
Hydraulic Radius (ft)	1.8	1.8	1.7	1.7	1.7		2.0	2.1	2.0	2.0	2.5		2.0	1.9	1.9	2.2	2.1	
Substrate																		
d50 (mm)	-	-	-	-			-	-	-	-			-	-	-	-		
d84 (mm)	-	-	-	-			-	-	-	-			-	-	-	-		

	Puzzle Creek Reach 2											
Parameter	Cross Section 4 Riffle						Cross Section 5 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	25.6	26.6	26.0	26.1	26.9		34.6	34.7	34.0	34.9	26.92	
Floodprone Width (ft)	82.2	83.8	80.5	81.3	82.6		59.5	64.1	64.3	64.1	64.10	
BF Cross Sectional Area (ft2)	63.4	66.1	62.2	62.4	63.4		99.9	105.8	100.7	108.30	63.40	
BF Mean Depth (ft)	2.48	2.49	2.39	2.39	2.35		2.89	3.05	2.96	3.10	2.35	
BF Max Depth (ft)	3.66	3.66	3.54	3.58	3.61		5.34	6.33	6.32	6.83	3.61	
Width/Depth Ratio	10.4	10.7	10.9	11.0	11.4		12.0	11.4	11.5	11.3	11.44	
Entrenchment Ratio	3.2	3.2	3.1	3.1	3.1		1.7	1.9	1.9	1.8	3.10	
Wetted Perimeter (ft)	30.6	31.5	30.8	30.9	31.6		40.3	40.8	39.9	41.1	31.6	
Hydraulic Radius (ft)	2.1	2.1	2.0	2.0	2.0		2.5	2.6	2.5	2.6	2.0	

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	62	154	103	62	154	103	62	154	103	62	154	103	62	154	103			
Radius of Curvature (ft)	20	81	42	20	81	42	20	81	42	20	81	42	20	81	42			
Meander Wavelength (ft)	137	269	206	137	269	206	137	269	206	137	269	206	137	269	206			
Meander Width Ratio	1.8	8.4	5.1	1.8	8.7	5.3	1.8	8.4	5.1	1.8	9.0	5.4	2.3	7.8	5.1			
Profile																		
Riffle length (ft)	31	113	60	24	115	64	24	93	67	25	83	74	53	170	86			
Riffle Slope (ft/ft)	0.005	0.019	0.013	0.003	0.028	0.010	0.006	0.028	0.016	0.004	0.045	0.016	0.002	0.024	0.012			
Pool Length (ft)	34	86	57	14	77	58	56	106	75	57	110	101	26	92	54			
Pool Spacing (ft)	55	168	115	52	182	115	93	147	122	87	151	124	81	213	142			
Substrate																		
d50 (mm)	----			----			----			----			----					
d84 (mm)	----			----			----			----			----					
Additional Reach Parameters																		
Valley Length (ft)	1,281			1,281			1,281			1,281			1,281					
Channel Length (ft)	1,634			1,634			1,634			1,634			1,634					
Sinuosity	1.3			1.4			1.4			1.4			1.4					
Water Surface Slope (ft/ft)	0.008			0.008			0.007			0.007			0.007					
BF Slope (ft/ft)	0.009			0.009			0.008			0.008			0.008					
Rosgen Classification	E/C4			E/C4			E/C4			E/C4			E/C4					

UT1																								
Parameter	Cross Section 1 Riffle						Cross Section 2 Riffle						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)	12.4	12.5	12.3	13.2	13.3		19.0	20.2	19.8	18.7	24.2		24.8	27.4	25.6	29.6	31.0		20.4	20.1	20.0	20.1	24.8	
Floodprone Width (ft)	59.1	58.2	57.3	59.9	60.0		76.1	76.3	77.0	77.1	77.7		72.1	73.7	78.1	78.0	78.1		53.3	53.2	53.5	53.8	53.3	
BF Cross Sectional Area (ft2)	24.6	23.1	21.3	23.7	23.4		31.9	33.8	32.9	30.3	34.6		32.9	36.4	33.5	41.2	42.4		31.7	30.8	29.4	30.0	33.2	
BF Mean Depth (ft)	1.99	1.85	1.74	1.80	1.76		1.68	1.67	1.66	1.62	1.43		1.33	1.33	1.31	1.39	1.4		1.55	1.54	1.47	1.49	1.34	
BF Max Depth (ft)	2.62	2.48	2.52	2.64	2.66		2.33	2.42	2.54	2.56	2.65		2.47	2.87	3.42	3.57	3.7		2.42	2.40	2.45	2.50	2.47	
Width/Depth Ratio	6.2	6.7	7.1	7.4	7.6		11.3	12.1	12.0	11.5	16.9		18.7	20.6	19.5	21.2	22.6		13.1	13.0	13.6	13.5	18.5	
Entrenchment Ratio	4.8	4.7	4.7	4.5	4.5		4.0	3.8	3.9	4.1	1.0		2.9	2.7	3.1	2.6	2.5		2.6	2.7	2.7	2.7	2.1	
Wetted Perimeter (ft)	16.4	16.2	15.8	16.8	16.8		22.4	23.6	23.1	21.9	27.0		27.5	30.0	28.2	32.4	33.7		23.5	23.1	22.9	23.1	27.5	
Hydraulic Radius (ft)	1.5	1.4	1.4	1.4	1.4		1.4	1.4	1.4	1.4	1.3		1.2	1.2	1.2	1.3	1.3		1.3	1.3	1.3	1.3	1.2	
Substrate																								
d50 (mm)	----	----	----	----			----	----	----	----			----	----	----	----			----	----	----	----		
d84 (mm)	----	----	----	----			----	----	----	----			----	----	----	----			----	----	----	----		

Parameter	Cross Section 5 Pool						Cross Section 6 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	25.5	27.6	25.8	26.0	29.0		19.6	14.9	15.5	17.7	16.8	
Floodprone Width (ft)	66.3	66.2	66.2	66.1	66.2		44.1	41.4	43.0	41.6	41.4	
BF Cross Sectional Area (ft2)	53.2	52.3	50.7	52.7	55.8		30.0	24.2	23.3	33.2	34.5	
BF Mean Depth (ft)	2.09	1.90	1.96	2.02	1.92		1.53	1.62	1.51	1.87	2.06	
BF Max Depth (ft)	5.39	5.38	5.49	5.45	5.54		3.53	3.26	3.44	3.29	3.29	
Width/Depth Ratio	12.2	14.6	13.2	12.9	15.1		12.8	9.2	10.3	9.5	8.1	
Entrenchment Ratio	2.6	2.4	2.6	2.5	2.3		2.3	2.8	2.8	2.1	2.5	
Wetted Perimeter (ft)	29.6	31.4	29.8	30.1	32.9		22.6	18.1	18.5	21.4	20.9	
Hydraulic Radius (ft)	1.8	1.7	1.7	1.8	1.7		1.3	1.3	1.3	1.5	1.7	
Substrate												
d50 (mm)	----	----	----	----			----	----	----	----		
d84 (mm)	----	----	----	----			----	----	----	----		

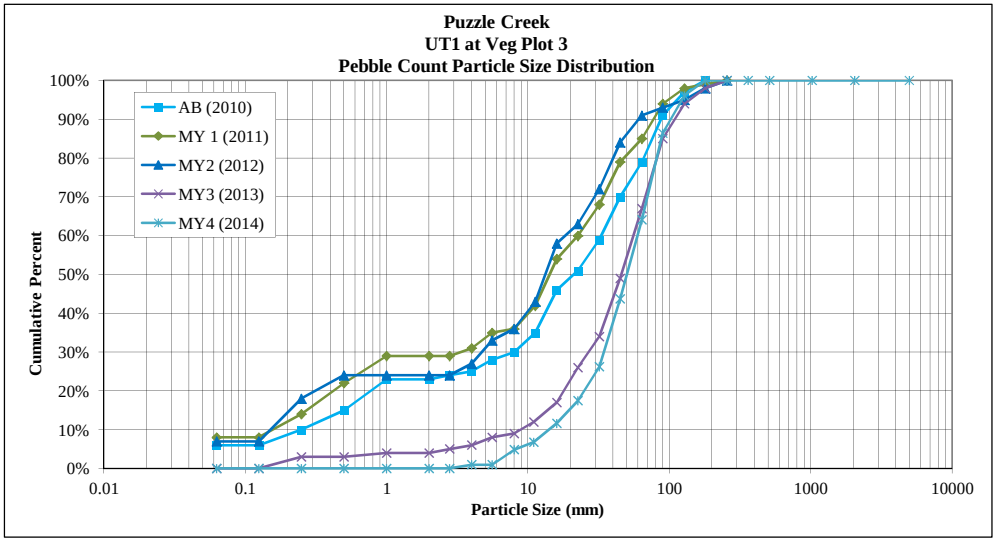
Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	44	87	66	44	87	66	44	87	66	44	87	66	44	87	66			
Radius of Curvature (ft)	23	54	39	23	54	39	23	54	39	23	54	39	23	54	39			
Meander Wavelength (ft)	143	220	175	143	220	175	143	220	175	143	220	175	143	220	175			
Meander Width Ratio	1.7	7.0	4.4	1.6	7.0	4.3	1.7	7.1	4.4	1.7	6.6	4.1	1.4	6.6	4.0			
Profile																		
Riffle length (ft)	25	55	52	23	85	58	22	90	44	21	66	42	12	154	39			
Riffle Slope (ft/ft)	0.006	0.017	0.011	0.005	0.035	0.016	0.005	0.039	0.018	0.004	0.029	0.020	0.004	0.061	0.013			
Pool Length (ft)	17	52	30	13	38	22	35	57	41	34	64	43	27	96	50			
Pool Spacing (ft)	56	127	95	55	131	89	55	135	84	61	136	92	55	168	91			
Substrate																		
d50 (mm)		21			14			13			46			50				
d84 (mm)		74			60			45			88			87				
Additional Reach Parameters																		
Valley Length (ft)		2,915			2,915			2,915			2,915			2,915				
Channel Length (ft)		3,339			3,339			3,339			3,339			3,339				
Sinuosity		1.3			1.3			1.3			1.3			1.3				
Water Surface Slope (ft/ft)		0.014			0.01			0.01			0.01			0.01				
BF Slope (ft/ft)		0.016			0.01			0.01			0.01			0.01				
Rosgen Classification		E/C4			E/C4			E/C4			E/C4			E/C4				

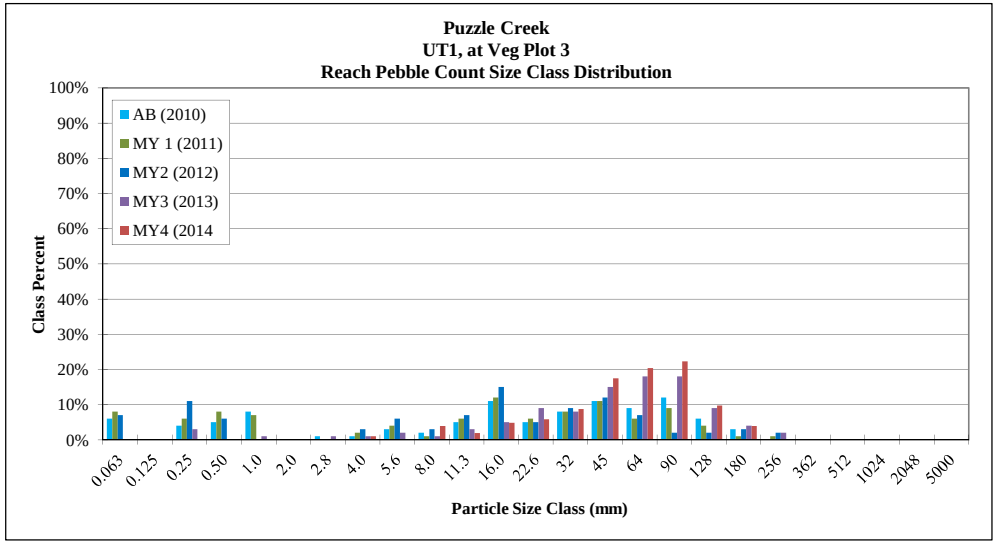
Cross-Section Pebble Count (UT1); Monitoring YR4
Puzzle Creek Mitigation Project, EEP# 92522

SITE OR PROJECT:	Puzzle Creek
REACH/LOCATION:	Riffle in front of Veg Plot 3
FEATURE:	Riffle

			2013		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt/Clay	Silt / Clay	< .063			0%
Sand	Very Fine	.063 - .125			0%
	Fine	.125 - .25			0%
	Medium	.25 - .50			0%
	Coarse	.50 - 1.0			0%
	Very Coarse	1.0 - 2.0			0%
Gravel	Very Fine	2.0 - 2.8			0%
	Very Fine	2.8 - 4.0	1	1%	1%
	Fine	4.0 - 5.6			1%
	Fine	5.6 - 8.0	4	4%	5%
	Medium	8.0 - 11.0	2	2%	7%
	Medium	11.0 - 16.0	5	5%	12%
	Coarse	16 - 22.6	6	6%	17%
	Coarse	22.6 - 32	9	9%	26%
	Very Coarse	32 - 45	18	17%	44%
	Very Coarse	45 - 64	21	20%	64%
Cobble	Small	64 - 90	23	22%	86%
	Small	90 - 128	10	10%	96%
	Large	128 - 180	4	4%	100%
	Large	180 - 256			100%
Boulder	Small	256 - 362			100%
	Small	362 - 512			100%
	Medium	512 - 1024			100%
	Large-Very Large	1024 - 2048			100%
Bedrock	Bedrock	> 2048			100%
Total % of whole count			103	100%	

Summary Data			
Channel materials			
D16 =	20.7	D84 =	86.8
D35 =	38.0	D95 =	122.9
D50 =	50.2	D100 =	128-180





Puzzle Creek Mitigation Project
Puzzle Creek 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 flagging tape.
3. Photos taken March 2015.

Photo Point 1: facing upstream

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 upstream

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

Photo Point 7: facing upstream

Photo Point 7: facing downstream

Puzzle Creek Mitigation Project
Photo Log - UT 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 flagging tape.
3. Photos taken March 2015.

Intentionally Blank

Photo Point 1: UT facing downstream

Photo Point 2: UT facing upstream

Photo Point 2: facing downstream

Photo Point 3: facing upstream

Photo Point 3: facing downstream

Photo Point 4: facing upstream

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

Photo Point 7: facing upstream

Photo Point 7: facing downstream

Photo Point 8: facing upstream

Intentionally Blank

Photo Point 9: facing upstream

Photo Point 9: facing downstream

Photo Point 10: facing upstream

Photo Point 10: facing downstream

Photo Point 11: facing upstream

Photo Point 11: facing downstream

Photo Point 12: facing upstream

Photo Point 12: facing downstream

Photo Point 13: facing upstream

Photo Point 13: facing downstream

Photo Point 14: facing upstream

Photo Point 14: facing downstream

Photo Point 15: facing upstream

Photo Point 15: facing downstream

Photo Point 16: facing upstream

Photo Point 16: facing downstream