Elk Branch Restoration Project

Year 2 Monitoring Report

Mitchell County, North Carolina

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Monitoring Firm POC: Matthew Reid

Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Harry Tsomides

Report Prepared By: Michael Baker Engineering, Inc., NC Professional Engineering License #F-1084

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Asheville, NC 28806

Contract Number: D06125-C, EEP Project Number: 92665

Project Construction: 2011

Data Collection Period: November 2013

Date Submitted: February 2014

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EXECUTIVE SUMMARY

The Elk Branch site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report presents Year 2 monitoring data for the five-year monitoring period. The goals for the restoration project were as follows:

- Restore or enhance headwater tributaries to Cane Creek and the French Broad Basin;
- Reduce sediment and nutrient loading through restoration of riparian areas and streambanks;
- Improve and restore hydrologic connections between the project streams and the floodplain;
- Create geomorphically stable conditions on the Elk Branch project site; and
- Improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restore the existing trampled, straightened and relocated streams by creating stable channels with adequate grade control and access to the floodplain;
- Establish buffers for nutrient removal from runoff and stabilization of streambanks to reduce bank erosion;
- Improve in-stream habitat by reducing fine sediment loading from the watershed, provide a more diverse bedform with riffles and pools, create deeper pools, develop areas that increase oxygenation, provide woody debris for habitat, and reduce bank erosion; and
- Improve terrestrial habitat by planting riparian areas with native vegetation and protect these areas with a permanent conservation easement and fencing, so that the riparian area will increase storm water runoff filtering capacity, improve bank stability, provide shading to decrease water temperature and improve wildlife habitat.

A total of six vegetation monitoring plots 100 square meters (m^2) (10m x 10m) in size were installed to evaluate survival of the woody vegetation planted on-site. The Year 2 vegetation monitoring indicated an average survival rate of 405 planted stems per acre, no volunteers were observed. The data shows that the Site is on track to meet both the interim stem survival criteria for Year 3 (320 stems per acre) and the final success criteria of 260 trees per acre by the end of Year 5.

The design proposed for the Elk Branch mitigation project involved Restoration (Priority 1 & 2) and Enhancement approaches and this was completed as described in the baseline monitoring report for this site. The project should ultimately result in stable Cb and Eb-type channels for Elk Branch, UT1 and UT2. Longitudinal profile and cross-section data indicate that the project streams have remained stable since baseline monitoring data were collected in 2011. Additionally, as the photo logs included in this report show, herbaceous cover at the project site is dense, and in conjunction with other erosion control measures like matting, is promoting bank stability on-site while planted, woody vegetation becomes more established. Based on data collected and presented in this report, this site is currently on track to meet the other success criteria specified in the Elk Branch Mitigation Plan.

Summary information and data related to the occurrence of items such as beaver impacts 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. Site conditions were evaluated in comparison to project success criteria; there are no project issues or concerns to report at this time. Although flow in UT2 went subsurface at one location for 20 linear feet total, Baker feels this is a large improvement over Year 1 when 103 linear feet of UT2 was observed to go subsurface. Baker will continue to monitor the status of continuous flow in the channel and EEP will be contacted should it be determined that corrective measures are needed. 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 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

The Elk Branch mitigation site is situated in the French Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 04-03-06 and United States Geologic Survey (USGS) hydrologic unit 06010108040010. The watershed in which the Elk Branch mitigation project is located is dominated by forested land, but also contains pastures and residences. Slightly less than two-thirds of the watershed is in forested cover, leaving about one-third of the drainage in some form of pasture land or other agricultural or residential use. Elk Branch and its tributaries have been impaired by historical and recent land management practices that include timber harvesting, pasture conversion, channelization, and livestock grazing. Prior to restoration, stream channelization and dredging were evident through much of the project site, as were the impacts of open stream access by cattle and horses. A significant loss of woody streambank vegetation also occurred during the development of the land for agricultural use. Over time, these practices have contributed excessive sediment and nutrient loading to Elk Branch, Cane Creek and ultimately to the North Toe River, home to the endangered Appalachian elktoe mussel.

The project involved restoration or enhancement of 3,159 linear feet (LF) primarily along three on-site streams: Elk Branch and two unnamed tributaries (UT1 and UT2). In addition, a third tributary (UT3) segment was also restored by day-lighting the tributary from the easement boundary to its confluence with Elk Branch. UT3 was impounded sometime in the past to create a small pond which flows to the easement boundary through a pipe. Elk Branch is shown as a solid blue-line stream while spring-fed tributaries UT1 and UT2 are apparent from the topography, but are not displayed on the USGS topographic quadrangle map for the site. Elk Branch, UT1 and UT2 were confirmed as being perennial and UT3 was considered intermittent based on field evaluations using the NCDWQ stream assessment protocol.

1.1 Location and Setting

The Elk Branch project site is located about one mile northeast of Bakersville in Mitchell County, North Carolina (Figure 1). To reach the project site, follow I-26 North from Asheville for approximately 20 miles and take U.S. Highway 19N Exit 9, towards Burnsville and Spruce Pine. Continue along U.S. Highway 19 (which becomes 19-E), for 25 miles. Turn left onto N.C. Highway 226 and continue until you reach the Town of Bakersville. Once in Bakersville, turn right (northeast) onto North Mitchell Avenue and after approximately a half mile, North Mitchell Avenue turns into Cane Creek Road. Continue another 0.7 miles, then turn left off of Cane Creek Road onto Nora Lane (SR 1219). The project site begins just below a spring head at the head of the valley, approximately 1,500 feet beyond the end of Nora Road (paved).

1.2 Mitigation Structure and Objectives

Table 1 summarizes project data for each reach and restoration approach used. The design proposed for the Elk Branch mitigation project involved Restoration (Priority 1 & 2) and Enhancement approaches. Beyond a few minor changes, restoration and enhancement were completed in accordance with the approved design approach provided in the mitigation plan for this site. Field changes made were implemented in order to minimize impacts to existing resources and adapt to unmapped or changed field conditions including micro-topography, vegetation, and existing in-stream grade control. The project should ultimately result in stable Cb and Eb-type channels for Elk Branch, UT1 and UT2.

Table 1. Project Mitigation Structure and Objectives
Elk Branch Mitigation Project-NCEEP Project #92665

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Elk Branch									
Reach 1	2,020 LF	R	P1	Cb4	951 LF	1.0:1	951	0+76-10+50	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore step-pool channel via grade control and constructed riffles.
Reach A		E	LI		592 LF	1.5:1	395	10+50-16+42	Restore stable dimension to halt erosion and add grade control to improve pools. Grade control structures will provide long-term channel stability and improve instream habitat.
Reach B		R	P1/2		403 LF	1.0:1	403	16+42-20+60	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore step-pool channel via grade control and constructed riffles.
Reach 2	279 LF	E	LI		279 LF	1.5:1	186	20+60-23+39	Restore stable dimension to halt erosion and add grade control to improve pools. Grade control structures will provide long-term channel stability and improve instream habitat.
UT1									
Reach 1	685 LF	R	P1	Cb4	656 LF	1.0:1	656	0+06-6+83	Restore channel-floodplain connectivity of previously channelized tributary. Adjustments also made to pattern and profile to eliminate eroding streambanks and improve habitat diversity. Invasive vegetation also removed; riparian buffer restored.
UT 2									
Reach 1	185* LF	R	P1	Eb4	242 LF	1.0:1	242	0+92-3+34	Excavate previously buried section of UT2. New channel constructed with stable dimension, pattern, and profile. Priority 1 approach also applied to existing segment of UT2 to improve channel and bank stability, as well as increased access to the floodplain. Trash and debris were removed. *buried portion not included in existing length
UT 3 (New component, not in restoration plan)									
Reach 1	0 LF	R	P1	Cb4	36 LF	1.0:1	36	0+00-0+36	Daylight previously piped section of UT3 at the easement boundary and run into Elk Branch Reach B with bank sloping and matting and structure for grade control.

Mitigation Unit Summations

Stream	Riparian Wetland	Nonriparian Wetland	Total Wetland	Buffer	Comment
2,869	NA	NA	NA		

Notes: Elk Branch Reach 1 was broken out into smaller reaches subsequent to the submittal and approval of the restoration plan.

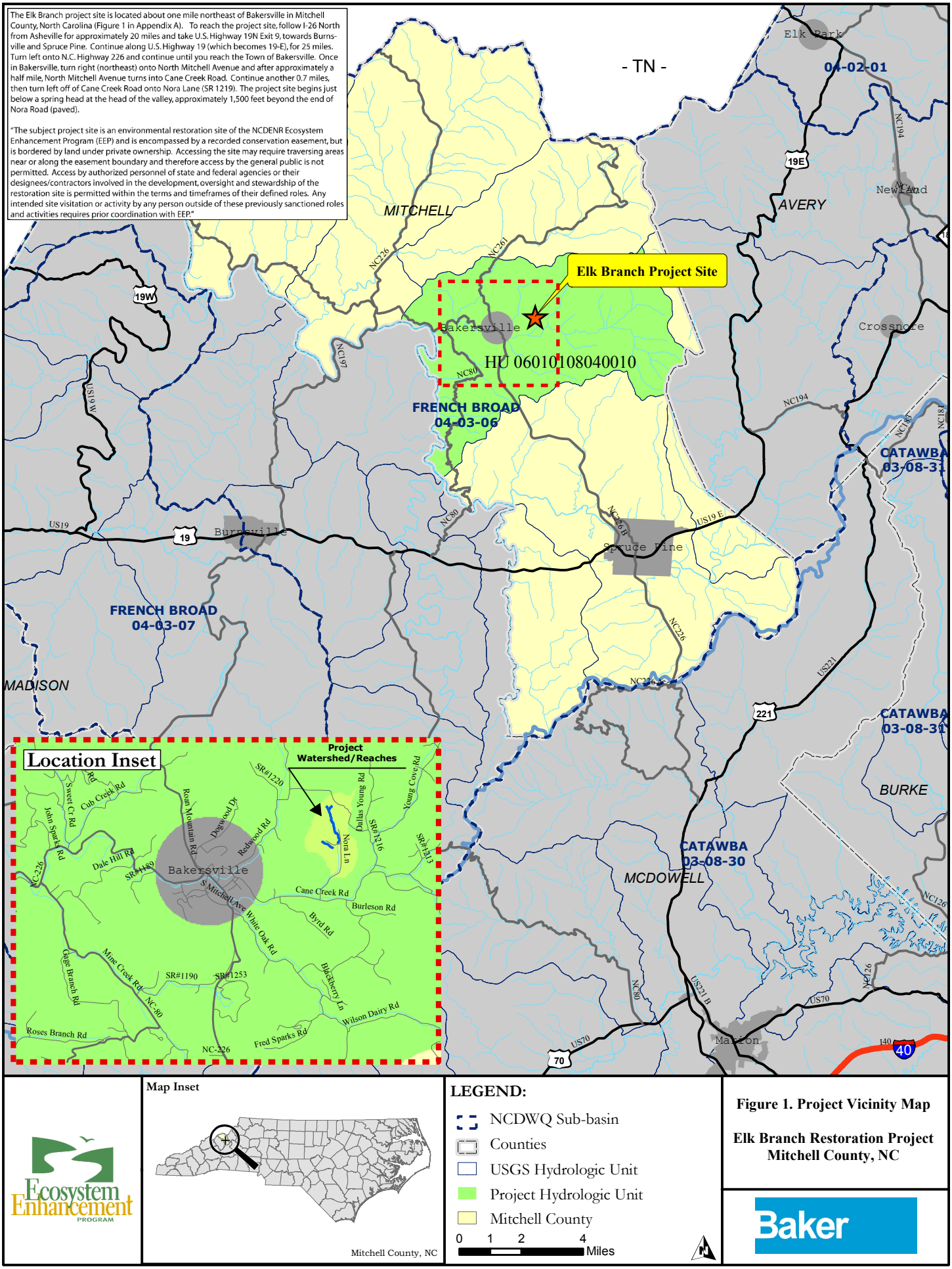

Figure 1. Project Vicinity Map

Elk Branch Restoration Project
Mitchell County, NC

Figure 1. Notes

The Elk Branch project site is located about one mile northeast of Bakersville in Mitchell County, North Carolina, North Carolina. To reach the project site, follow I-26 north from Asheville for approximately 20 miles and take U.S. Highway 19N Exit 9, towards Burnsville and Spruce Pine. Continue along U.S. Highway 19 (which becomes 19-E), for 25 miles. Turn left onto N.C. Highway 226 and continue until you reach the Town of Bakersville. Once in Bakersville, turn right (northeast) onto North Mitchell Avenue and after approximately a half mile, North Mitchell Avenue turns into Cane Creek Road. Continue another 0.7 miles, then turn left, off of Cane Creek Road onto Nora Lane (SR 1219). The project site begins just below a spring head at the head of the valley, approximately 1,500 feet beyond the end of Nora Lane (paved).

The subject project site is an environmental restoration site of the NCDENR Ecosystem Enhancement Program (EEP) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with EEP.

Anthropogenic land use alteration, such as deforestation, channelization of streams for agricultural purposes, and prolonged open stream access to livestock has resulted in various stream corridor impairments. Stream channel incision, bank destabilization and erosion, loss of in-stream and riparian habitat, and loss of shading and buffering capacity functions were present throughout the project area.

In accordance with the approved mitigation plan for the site, construction activities began in May 2011. Project activity on Elk Branch Reach 1, Reach B, UT1, UT2, and UT3 consisted of making adjustments to channel dimension, pattern, and profile typically using a Priority 1 Restoration approach. A Level I Enhancement approach was used on Elk Branch Reaches A and 2 to re-establish adequate channel dimension for bank stability and floodplain access, while recreating a stable channel profile and bedform using a step-pool restoration approach that features grade control structures and constructed riffles.

The creation of a step-pool channel profile was used to achieve vertical stability and eliminate self-propagating headcuts previously found within the site. This was the primary method for promoting improved stability, water quality, and habitat goals. In-stream structures (constructed riffles, boulder steps, log vanes, log drops, and log rollers) were used to control streambed grade, reduce stresses on streambanks, and promote diversity of bedform and habitat. Structures were spaced at a distance that replicated natural pool to pool spacing and allowed downstream headers to protect the upstream structure footer to create long term vertical stability.

Stream dimensions were adjusted to eliminate vertical banks and erosion resulting from excessive shear stress and lack of floodplain relief. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, transplants, and live staking. Transplants will provide living root mass quickly to increase streambank stability and create shaded holding areas for fish and aquatic biota. Where feasible, plan form adjustments were made to correct prior channelization by making slight adjustments to channel pattern (step-pool channels have a low sinuosity). These modifications will allow flows larger than bankfull to spread onto the restored floodplain, dissipating flow energies and reducing streambank stress. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

1.3 Project History and Background

The chronology of the Elk Branch 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. The total as-built stream length across the project is 3,159 LF.

Table 2. Project Activity and Reporting History
Elk Branch Mitigation Project-NCEEP Project #92665

Activity or Report	Data Collection Complete	Completion or Delivery
Restoration Plan		December 2009
Final Design-90%		December 2009
Construction		June 2011
Temporary S&E mix applied to entire project area		June 2011
Permanent seed mix applied to project site		June 2011
Installation of crest gauges		July 2011
Plantings set out	January 2012	January 2012
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	July 2011/January 2012	April 2012
Year 1 Monitoring	October 2012	December 2012
Year 2 Monitoring	November 2013	February 2014

Table 2. Project Activity and Reporting History Elk Branch Mitigation Project-NCEEP Project #92665		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contacts Elk Branch Mitigation Project-NCEEP Project #92665	
Principal-In-Charge	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Matthew Reid, Tel. 828.350.1408 x2006
Construction Contractor	
River Works, Inc.	6105 Chapel Hill Road; Raleigh, NC 27607 Contact: Bill Wright, Tel. 919.818.6686
Planting & Seeding Contractor	
River Works, Inc.	6105 Chapel Hill Road; Raleigh, NC 27607 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: Matthew Reid, Tel. 828.350.1408 x2006

Table 4. Project Attribute Elk Branch Mitigation Project-NCEEP Project #92665	
Project County	Mitchell County, NC
Physiograhic Region	Blue Ridge
Ecoregion	Blue Ridge Mountains-Southern Crystalline Ridges and Mountains
Project River Basin	French Broad
USGS HUC for Project	6010108040010
NCDWQ Sub-basin for Project	04-03-06
Within extent of EEP Watershed Plan?	In a TLW (French Broad River Basin Priorities Report-2009)
WRC Class	Cold
% of Project Easement Fenced or Demarcated	100% (~60% fenced, 40% demarcated)
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles)	
Elk Branch Reach 1	.07 mi^2

Table 4. Project Attribute **Elk Branch Mitigation Project-NCEEP Project #92665**	
Reach A	
Reach B	
Elk Branch Reach 2	.14 mi^2
UT1	.06 mi^2
UT2	.01 mi^2
Stream Order	Elk Branch-1st, UT1-Zero, UT2-Zero, UT3-Zero
Restored Length	
Elk Branch Reach 1	951 LF
Reach A	592 LF
Reach B	403 LF
Elk Branch Reach 2	279 LF
UT1	656 LF
UT2	242 LF
UT3	36 LF
Perennial or Intermittent	Perennial
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	57%
Shrub	6%
Pasture/Crops	33%
Developed Open Space	4%
Drainage Impervious Cover Estimate (%)	<10%
NCDWQ AU/Index #	7-2-59-8
303d Listed	No
Upstream of 303d Listed Segment	No
Reasons for 303d Listing or Stressor	-
Total Acreage of Easement	9.46
Total Vegetated Acreage w/in Easement	Easement vegetated with exception of stream channel and a ford crossings within an easement breaks
Total Planted Acreage within the Easement	~4 Acres (remainder already forested)
Rosgen Classification (Pre-existing)	
Elk Branch	Cb/B/G/Eb
UT1	Fb
UT2	B
UT3	Piped
Rosgen Classification of As-built	
Elk Branch-Reach 1	Cb4
Reach A	Cb4
Reach B	Cb4
Elk Branch-Reach 2	Cb4
UT1	Cb4

Table 4. Project Attribute Elk Branch Mitigation Project-NCEEP Project #92665	
UT2	Eb4
UT3	Cb4
Valley Type	II
Valley Slope	.03 (Elk Branch), .04 (UT1), .04 (UT2)
Valley Side Slope Range	n/a
Valley Toe Slope Range	n/a
Trout Waters Designation	Yes (Elk Branch is a tributary to designated trout waters)
Species of Concern	No

1.4 Monitoring Plan View

The current conditions plan view depicts the monitoring features for the Elk Branch mitigation project. The plan set will also be used to identify locations where stream and vegetation problem areas are present. At this time, no problems areas are present. Figure 2 illustrates the project as it is delineated by reach.

2.0 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the Elk Branch 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 Year 2 Current Condition Plan View 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, six vegetation monitoring quadrants were installed across the restoration site. The size of individual quadrants vary from 100 square meters for tree species to 1 square meter for herbaceous vegetation. Vegetation monitoring will occur in spring, after leaf-out has occurred, or in the fall prior to leaf fall. Individual quadrant data provided during subsequent monitoring events will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

Photographs are used to visually document vegetation success in sample plots. Reference photos of tree and herbaceous condition 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 the Year 3 monitoring period. The final vegetative success criteria is the survival of 260, 5-year old, planted trees per acre at the end of the Year 5 monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant

CE — CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA

ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING
STA. 0+00–8+00

30 0 30 60
SCALE (FT)

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Phone: 828.350.1408
Fax: 828.350.1409

Baker

ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING

Ecosystem Enhancement Program

Prepared for:
Ecosystem Enhancement Program
2728 Capitol Blvd, Suite 1H 103
Raleigh, NC 27604
Phone: 919-715-0476
Fax: 919-715-2219

EEP Project No.	92665
Baker Project No.	111085
Date:	1/31/2014
DESIGNED:	JPM
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	2 of 5
Sheet:	1 of 4

CE CE — CONSERVATION EASEMENT
ASBUILT CENTERLINE
ASBUILT TOP OF BANK

XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA

ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING
STA. 8+00–16+00

30 0 30 60
SCALE (FT)

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ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING

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CE CE — CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

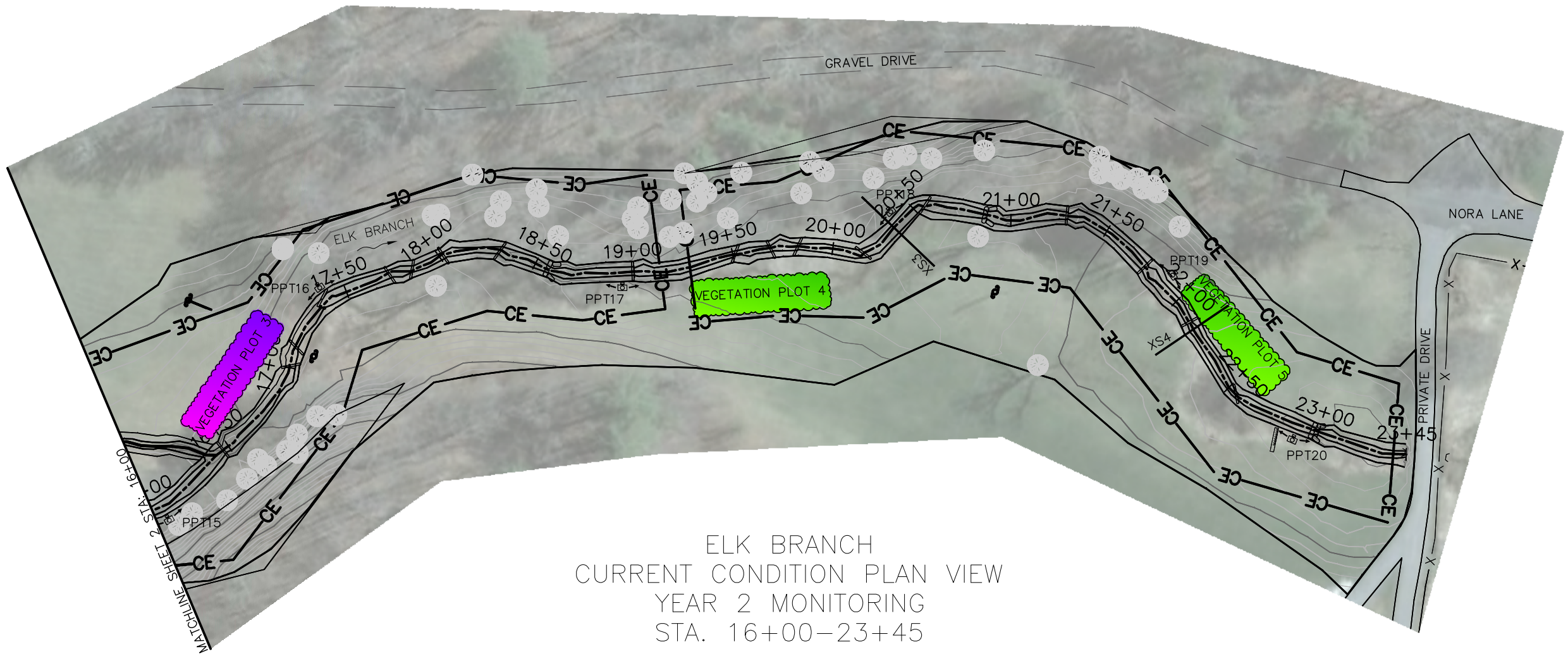
XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA



ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING
STA. 16+00–23+45

30 0 30 60
SCALE (FT)

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ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

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YEAR 2 MONITORING

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Sheet:	3 of 4

CE CE — CONSERVATION EASEMENT
ASBUILT CENTERLINE
ASBUILT TOP OF BANK

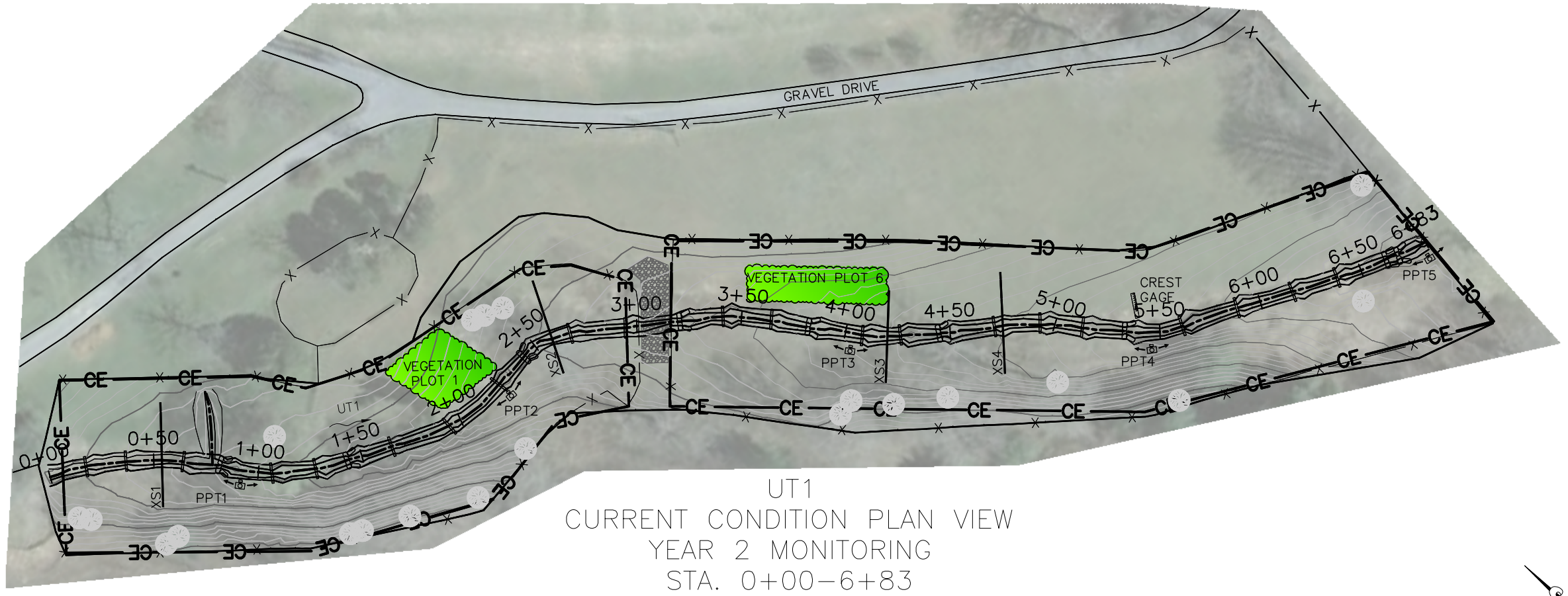
XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA



UT1
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING
STA. 0+00–6+83

30 0 30 60
SCALE (FT)

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ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION PLAN VIEW
YEAR 2 MONITORING

Ecosystem Enhancement Program

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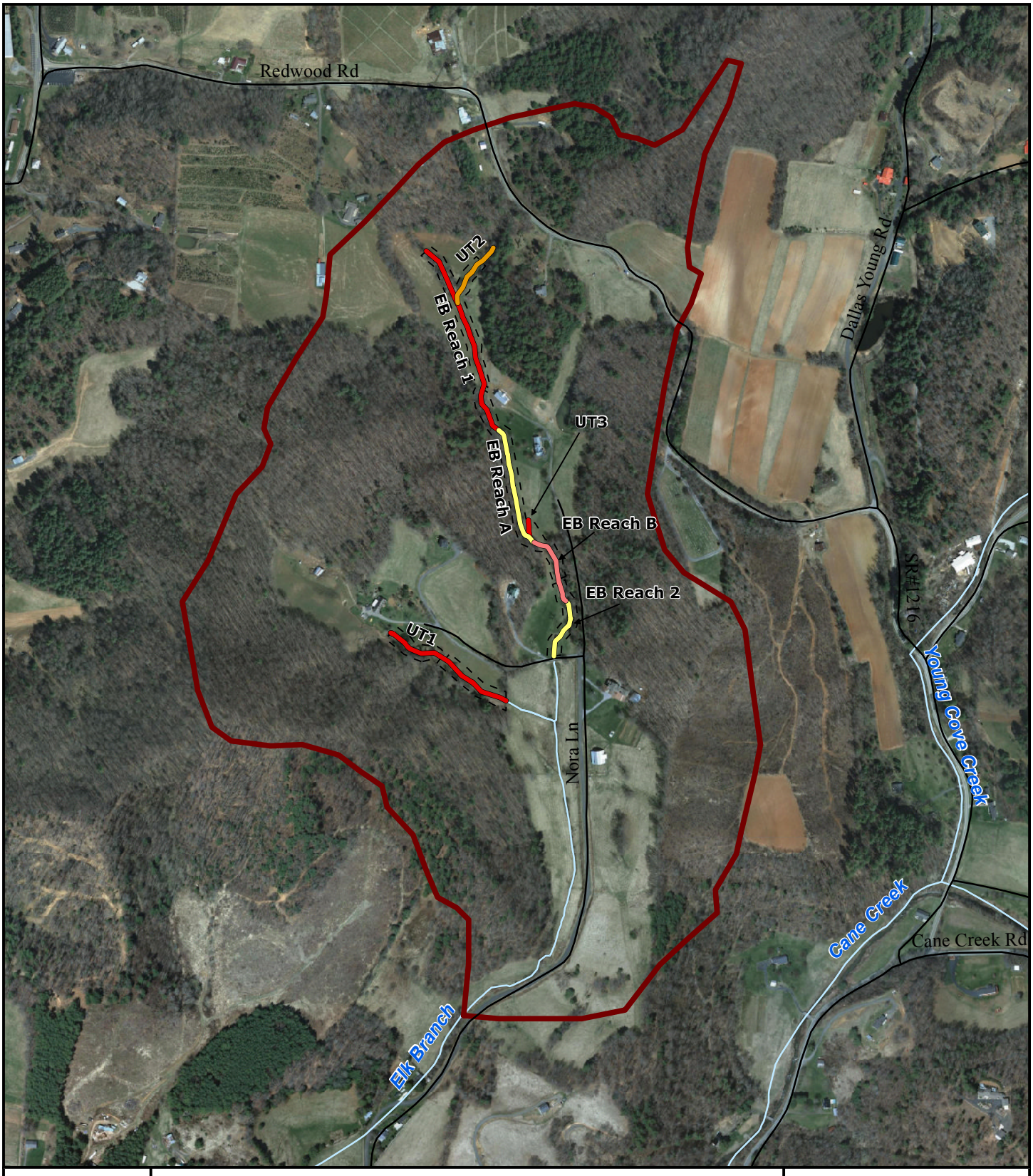
Sheet:	4 of 4



LEGEND:

Proposed Project Component
- Enhancement 1
- Priority 1 Restoration
- Priority 2 Restoration
- Priority I & 2 Restoration

- Proposed Easement Boundary
- Streams
- Watershed Boundary

0 200 400 800 Feet

Ecosystem Enhancement Program

Figure 2. Project Approach

Elk Branch Restoration Project
Mitchell County, NC

Baker

community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCEEP.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided good ground coverage. Live stakes and bare root trees planted are also providing streambank stability. Bare-root trees were planted throughout the conservation easement. A minimum 60-foot-wide conservation easement was established along the project streams during initial design (this is in addition to the stream width). After final design, a buffer width of 30 feet on either side of the stream was achieved in most areas. In some areas, regulatory comments or ultimate field design changes resulted in varying buffer widths. In general, bare-root vegetation was planted at a target density of 537 stems per acre, in a 9-foot by 9-foot grid pattern. Planting of bare-root trees was completed in January 2012. Species planted are listed below.

Table 5. Riparian Buffer Plantings
Elk Branch Mitigation Project- NCEEP Project #92665

Common Name	Scientific Name	% Planted by Species	Planting Density
Acer rubrum	Red Maple	10%	54
Betula nigra	River Birch	7%	38
Carpinus caroliniaun	Ironwood	7%	38
Carya ovata	Shagbark Hickory	5%	27
Cornus florida	Flowering Dogwood	5%	27
Diospyros virginiana	Persimmon	5%	27
Lindera benzoin	Spicebush	5%	27
Liriodendron tulipfera	Tulip Poplar	5%	27
Nyssa sylvatica	Blackgum	5%	27
Platanus occidentalis	Sycamore	8%	43
Quercus alba	White Oak	5%	27
Quercus rubra	Red Oak	5%	27
Understory/Shrub Species			
Alnus serrulata	Tag Alder	10%	54
Calycanthus floridus	Sweetshrub	13%	70
Sambucus canadensis	Elderberry	5%	27
Riparian Livestake Plantings			
Cornus amomum	Silky Dogwood	40%	215
Salix sericea	Silky Willow	30%	161
Salix nigra	Black Willow	10%	54
Sambucus canadensis	Elderberry	20%	108

2.1.2 Soil Data

Table 6. Preliminary Soil Data Elk Branch Mitigation Project-NCEEP Project #92665					
Dominant Soil Series and Characteristics	Bandana/ Fannin/Saunook-Thunder/Saunook				
	Depth (in.)	% Clay	K Factor	T Factor	% OM
Elk Branch Reach 1	>60"	7-20/12-27, 5-35	.24/.05, .32	5	4-10
Reach A	>60"	7-20/12-27, 5-35	.24/.05, .32	5	0-10
Reach B	>60"	7-20/12-27, 5-35	.24/.05, .32	5	4-10
Elk Branch Reach 2	>60"	7-20/12-27, 10-20	.24/.05, .2	5,4	4-10
UT1	>60"	7-20/12-27	.24/.05	5	0-10
UT2	>60"	7-20/12-27, 12-35	.24/.05, .15-.32	5	4-10

2.1.3 Vegetative Problem Areas

Currently, there are no vegetative problem areas.

2.1.4 Stem Counts

The mitigation plan for the Elk Branch 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. A total of six vegetation plots, each 10 by 10 meters or 5 by 20 meters in size, were established across the restored site.

2.1.4.1.1.1 Results

Table 7 in Appendix A presents information on the stem counts for each of the vegetation monitoring plots. Data from the Year 2 monitoring event showed a range of 202-607 planted stems per acre, with approximately 86% of the stems showing no signs of damage. The average density of planted bare root or livestake stems, based on data collected from the six monitoring plots during Year 2 monitoring, is 405 stems per acre which indicates that the Site is on track to meet the minimum interim success criteria of 320 trees per acre by the end of Year 3 and 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 Year 2 Current Condition Plan View.

As shown in Table 8 (Appendix A), no woody or herbaceous vegetation problem areas were identified during Year 2 monitoring. Although the density of herbaceous cover varies across the site, conditions observed during the Year 2 monitoring survey found ground cover in the easement area to be sufficient for aiding in site stabilization. Based on the plot data collected, plots 2 and 3 are not currently meeting the success criteria with 202 and 283 trees per acre respectively. The lower density recorded is likely attributed to the orientation in which bare roots were planted in relation to the layout of these 5x20' vegetation plots, and the measurement of stem offsets (9'x9') as described in the Baseline Monitoring Document. Wet conditions from ground water near the surface may also be the cause of vegetation mortality in plot 2. In other instances, lower densities can be attributed to damage brought about by animals and competition with dense herbaceous cover. EEP expressed concerns of low planting density throughout the easement area. This perception of low planting densities can be attributed to the slow growth of trees and the thick herbaceous vegetation that makes it difficult to identify the individual trees. 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. The eventual onset of volunteer trees will

further aid in site stabilization and habitat improvements. Additional trees will be planted in areas not meeting the success criteria in Fall 2014. A photo log of the vegetation plots is provided in Appendix A.

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 high flow marks, will be used to document the occurrence of bankfull events. The methods used and any related success criteria are described below for each parameter. To monitor stream success criteria, eleven permanent cross-sections, six longitudinal profile sections and two crest gauges were installed.

2.2.1.1 Dimension

Eleven permanent cross-sections were installed to help evaluate the success of the mitigation project and measured data are provided in Appendix B. Permanent cross-sections were established throughout the project site as follows: five cross-sections were located on Elk Branch, four cross-sections were located on UT1 and two cross-sections were located on UT2. Cross-sections selected for monitoring were located in representative riffle and pool reaches, and each cross-section was marked on both banks with permanent pins to establish the exact transect to be used year-to-year. A common horizontal and vertical reference will be used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys will include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if the features are present. Riffle cross-sections are classified using the Rosgen Stream Classification System.

Although minor changes are not uncommon, there should not be any significant changes in the as-built cross-sections. If changes do take place, they will be evaluated to determine if they represent a movement toward a more unstable condition (e.g., down-cutting or erosion) or a movement toward increased stability (e.g., settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). At this time, cross-sectional measurements do not indicate any streambank or channel stability issues.

2.2.1.1.1 Results

As-built cross-section monitoring data for stream stability was collected in July 2011. The eleven permanent cross-sections along the restored channels were resurveyed in November 2013 to document stream dimension for Monitoring Year 2. Cross- sectional data is presented in 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 to no adjustment to stream dimension across the project reaches since construction. What adjustment that has occurred has primarily been observed in riffle cross-sections that are exhibiting signs of narrowing. Based on field observation, this narrowing can be attributed to herbaceous vegetation becoming well established. 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 2 were surveyed during November 2013; profiles of the various project reaches are provided in Appendix B. A longitudinal profile was completed

for the entire project length of Elk Branch, UT1 and UT2 to evaluate changes in channel bed conditions since the as-built survey was completed. Longitudinal profiles will be replicated annually during the five year monitoring period.

Measurements taken during longitudinal profiles include thalweg, water surface, and top of low 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, run, pool, or glide) and at the maximum pool depth. Elevations of grade control structures were also included in longitudinal profiles surveyed. Surveys were tied to permanent horizontal and vertical control. The longitudinal profiles show that the bed features are stable. Where the channel slopes are steeper, closely-spaced grade control structures should help maintain the overall profile desired and there was no notable bank erosion observed as a result of the channel profile adjustments.

Although pattern adjustments were made, Elk Branch and its tributaries are primarily Cb-type streams characterized by step-pool sequences, and increased sinuosity is not a design goal, nor a typical characteristic of this channel type. Pattern information is not provided in Appendix B, as this information is generally only provided for meandering, alluvial channels. Nevertheless, as the site is monitored, reaches will be evaluated for significant changes in pattern and any changes warranting repair work will be discussed in future monitoring reports.

2.2.1.2.1 Results

The longitudinal profiles show that the bed features are also stable across the project site. As noted in the Stream Reach Morphology Data Tables in Appendix B (Tables 13 and 14), riffle and pool characteristics do not appear to have changed much and are acceptable when compared to reference reach and design data provided for the project reaches. Higher rainfall this year has resulted in increased flows that have resulted in increased depth of pools on all profiles during this year. This is a positive change that has provided improved pool habitat for aquatic organisms. Given the location of these project reaches in the valley and the spacing of structures in these streams, it is expected that the profiles will display little change over the course of the monitoring period.

As the profile for UT2 demonstrates, there was one section where the flow went subsurface for 20 linear feet. This is a considerable improvement from the Year 1 Monitoring survey data that indicated UT2 flow was subsurface for 103 linear feet. Record precipitation was received during the 2013 monitoring year which provided flows that helped to move sediment and fines through the system. These increased flows helped seal any structures where water was discovering a subsurface path to follow. The area where flow goes subsurface is noted in Appendix B (Table 10). Other than the lack of continuous surface flow, UT2 appears stable. No other areas of instability were noted in the project area during Year 2 monitoring.

2.2.1.3 Substrate and Sediment Transport

Bed material analysis consists of conducting a pebble count in the same constructed riffle during annual geomorphic surveys of the project site. This sample will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loading and transport out of the study reaches. 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 in Reach A of Elk Branch. As noted in pebble count exhibit in Appendix B, the pebble count for Reach A of Elk Branch indicates a general coarsening of the bedload. Visual observations of Elk Branch and its tributaries and a review of pebble count data collected 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 during the Year 2 monitoring survey.

2.2.2 Hydrology

2.2.2.1 Streams

The occurrence of bankfull events within the monitoring period is being documented by the use of crest gauges and photographs. Crest gauges were installed on the floodplain at bankfull elevation. One crest gauge was placed near the end of Reach 2 of Elk Branch while another gauge was set up near the end of the project area on UT1 to Elk Branch. The crest gauges will record the highest watermark between site visits and will be checked at each site visit to determine if a bankfull event has occurred. Photographs will be used to document the occurrence of debris lines and sediment deposition on the floodplain during monitoring site visits.

Two bankfull flow events must be documented 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

Since the time of the As-built survey, the Site was found to have had at least two bankfull events based on crest gauge readings obtained on the mainstem and UT1. 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 a subjective

judgment of the effectiveness of erosion control measures. Lateral photos should not indicate excessive erosion or degradation of the banks. A series of photos over time should indicate successive maturation of riparian vegetation and consistent structure function.

2.2.3.2.1 Results

Photographs of the restoration project were taken in November 2013. The photographs illustrate stable conditions across the project site. Vegetative growth along the streambanks and riparian buffers has become dense and improved since construction was completed in 2011. Structures are functioning as designed.

2.2.4 Stream Stability Assessment

In-stream structures installed within the restored streams included constructed riffles, log drops, log sequences, and boulder steps. The Year 2 visual observations of these structures 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. Frequent spacing of log drops, log sequences and boulder drops have greatly enhanced bedform diversity as well as promoting more stable C and B-type channels. The Categorical Stream Feature Visual Stability Assessment and Visual Morphological Stability Assessment tables in Appendix B (Tables 11 and 12), summarize the condition of project structures.

Quantitative reference reach and design data used to determine the restoration approach, as built data, as well as Year 2 monitoring data are summarized in Tables 13 and 14 of Appendix B.

2.3 Areas of Concern

At this time, there are no areas of concern. As previously noted in the As-built report, additional planting was proposed if further evaluation of the site indicated stem density was insufficient to meet the vegetation success criteria set forth in this report across the entire site. Based on Year 2 monitoring data, increasing stem density by planting additional trees is unnecessary at this time.

APPENDIX A

1. VEGETATION SURVEY DATA TABLES
2. VEGETATION MONITORING PLOT PHOTOS

Table 7. Stem Count Arranged by Plot
Elk Branch Mitigation Project-#92665

Tree Species	Plots						As-built Totals	MY 1 Totals	MY 2 Totals	MY 3 Totals	MY 4 Totals	MY 5 Totals	Survival %	Probable Cause
	1	2	3	4	5	6								
Acer rubrum	6	3	1	1		6	19	19	17				89%	
Betula nigra	2		1	1	1		3	5	5				100%	
Carya ovata	5		1	1		4	17	15	11				65%	
Diospyros virginiana	1	1			1		3	3	3				100%	
Juglans nigra				1			1	1	1				100%	
Liriodendron tulipifera	1				1		4	2	2				50%	
Platanus occidentalis				4	1	1	8	7	6				75%	
Quercus rubra			1		3		5	5	4				80%	
Salix nigra		1			1		0	2	2				100%	
Shrub Species														
Alnus serrulata			3		3	1	0	7	7				100%	
Lindera benzoin					2		4	2	2				50%	
Vaccinium							1	1	0				0%	
Stems/plot	15	5	7	8	13	12							10	
Stems/acre Year 2	607	202	283	324	526	486							405	

Table 7b. Stem Count Arranged by Plot
Elk Branch Mitigation Project-#92665

Scientific Name	Common Name	Species Type	Current Plot Data (MY2 2013)																		Annual Means								
			E92665-01-0001			E92665-01-0002			E92665-01-0003			E92665-01-0004			E92665-01-0005			E92665-01-0006			MY2 (2013)			MY1 (2012)			MY0 (2012)		
			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
Acer rubrum	red maple	Tree	6	6	6	3	3	3	1	1	1	1	1	1				6	6	6	3	3	3	4	4	4	4	4	4
Alnus serrulata	hazel alder	Tree							3	3	3				3	3	3	1	1	1	2	2	2	2	2	2			
Betula nigra	river birch	Tree	2	2	2				1	1	1	1	1	1	1	1	1				1	1	1	1	1	1	2	2	2
Carya ovata	shagbark hickory	Tree	5	5	5				1	1	1	1	1	1				4	4	4	3	3	3	3	3	3	3	3	3
Catalpa ovata	Chinese catalpa	Shrub																									1	1	1
Corylus americana	American hazelnut	Shrub																									1	1	1
Diospyros virginiana	common persimmon	Tree	1	1	1	1	1	1							1	1	1				1	1	1	1	1	1	3	3	3
Juglans nigra	black walnut	Tree										1	1	1							1	1	1	1	1	1			
Lindera benzoin	northern spicebush	Shrub													2	2	2				2	2	2	2	2	2	4	4	4
Liriodendron tulipifera	tuliptree	Tree	1	1	1										1	1	1				1	1	1	1	1	1	4	4	4
Platanus occidentalis	American sycamore	Tree										4	4	4	1	1	1	1	1	1	2	2	2	2	2	2	8	8	8
Quercus rubra	northern red oak	Tree							1	1	1				3	3	3				2	2	2	2	2	2	5	5	5
Salix nigra	black willow	Tree				1	1	1							1	1	1				1	1	1	1	1	1			
Vaccinium	blueberry	Shrub																						1	1	1	1	1	1
		Stem count	15	15	15	5	5	5	7	7	7	8	8	8	13	13	13	12	12	12	10	10	10	12	12	12	11	11	11
		size (ares)		1			1			1			1			1			1			6			1			6	
		size (ACRES)		0.02			0.02			0.02			0.02			0.02			0.02			0.20			0.20			0.20	
		Species count	5	5	5	3	3	3	5	5	5	5	5	5	8	8	8	4	4	4	5	5	5	6	6	6	5	5	5
		Stems per ACRE	607	607	607	202	202	202	283	283	283	324	324	324	526	526	526	486	486	486	405	405	405	465	465	465	432	432	432

Table 8. Vegetation Problem Areas
Elk Branch Mitigation Project: Project No. 92665

Elk Branch Reach 1 (951 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	N/A	N/A	N/A
Elk Branch Reach A (592 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	N/A	N/A	N/A
Elk Branch Reach B (403 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	N/A	N/A	N/A
Elk Branch Reach 2 (186 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	N/A	N/A	N/A
UT1 to Elk Branch (656 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	N/A	N/A	N/A
UT2 to Elk Branch (242 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	N/A	N/A	N/A
UT3 to Elk Branch (36 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	N/A	N/A	N/A

Elk Branch Mitigation Project
Photo Log - Vegetation Plot Photo Points (Year 2)

Notes:

1. Vegetation plots marked by t-posts at corners; herbaceous plot marked by stake within larger plot.
2. Planted vegetation flagged and tagged for future identification.

10/24/2013

Photo 1: Veg Plot 1

10/24/2013

Photo 2: Veg Plot 1: Herbaceous Plot

10/24/2013

Photo 3: Veg Plot 2

10/24/2013

Photo 4: Veg Plot 2: Herbaceous Plot

10/24/2013

Photo 5: Veg Plot 3

10/24/2013

Photo 6: Veg Plot 3: Herbaceous Plot

10/24/2013

Photo 7: Veg Plot 4

10/24/2013

Photo 8: Veg Plot 4: Herbaceous Plot

10/24/2013

Photo 9: Veg Plot 5

10/24/2013

Photo 10: Veg Plot 5: Herbaceous Plot

10/24/2013

Photo 11: Veg Plot 6

10/24/2013

Photo 12: Veg Plot 6: 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

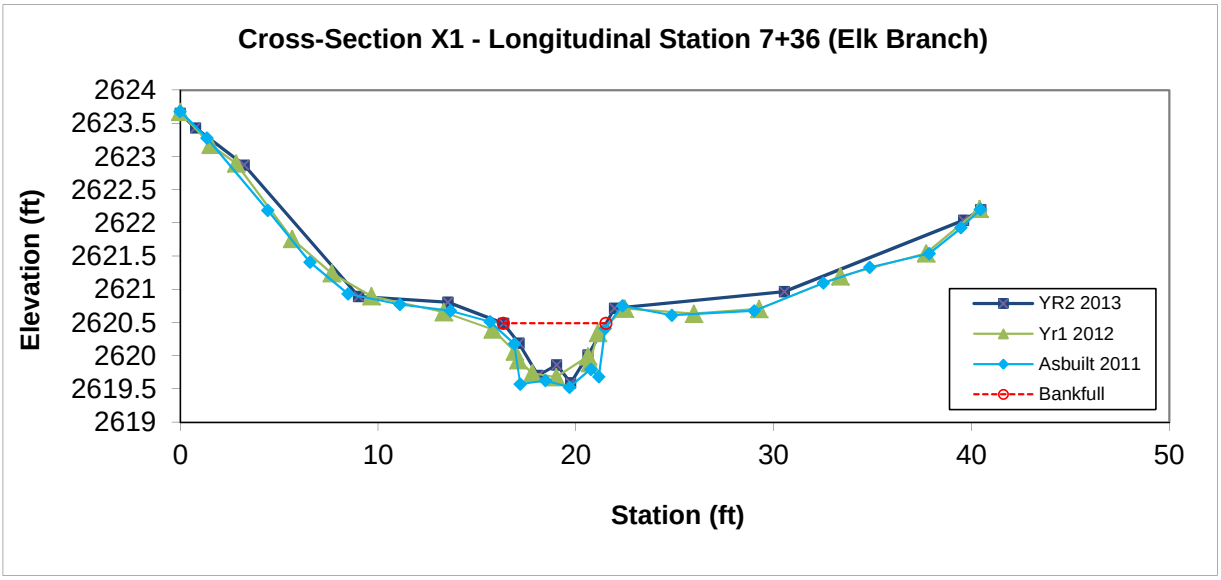
Table 9. Hydrological (Bankfull) Verifications
Elk Branch Mitigation Project-#92665

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (inches)	
			Elk Branch Reach 2	UT1
10/25/2012	Between July 2011 and 10/25/12	Gauge measurement.	6", 2.4"	3"
11/27/2013	Between 10/25/12 and 11/27/13	Gauge measurement.	1.6"	4.12"

Table 10. Stream Problem Areas
Elk Branch Mitigation Project-#92665

MY	Feature Issue	Station No.	Suspected Cause	Photo Number
1	Lack of continuous flow (UT2)	1+07-1+19	Survey conducted in summer during time with lack of significant rainfall	---
		1+25-1+42		---
		1+48-2+06		---
		2+16-2+32		---
2	Lack of continuous flow (UT2)	1+43-1+63	Structure may not be completely sealed on upstream end	---

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	2.7	5.19	0.51	0.89	10.13	1.3	5.1	2620.49	2620.71



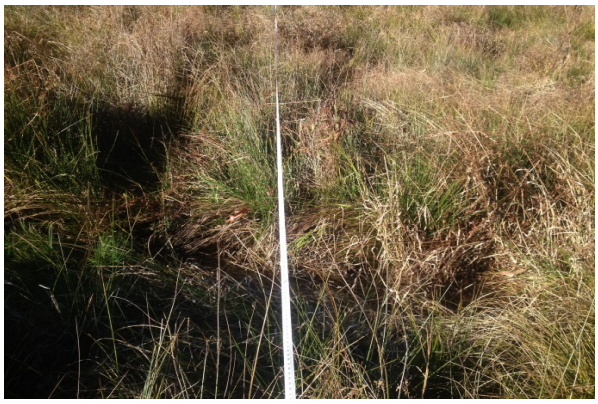


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	-	4.8	5.1	0.93	1.48	5.46	1.3	6.4	2604.32	2604.76

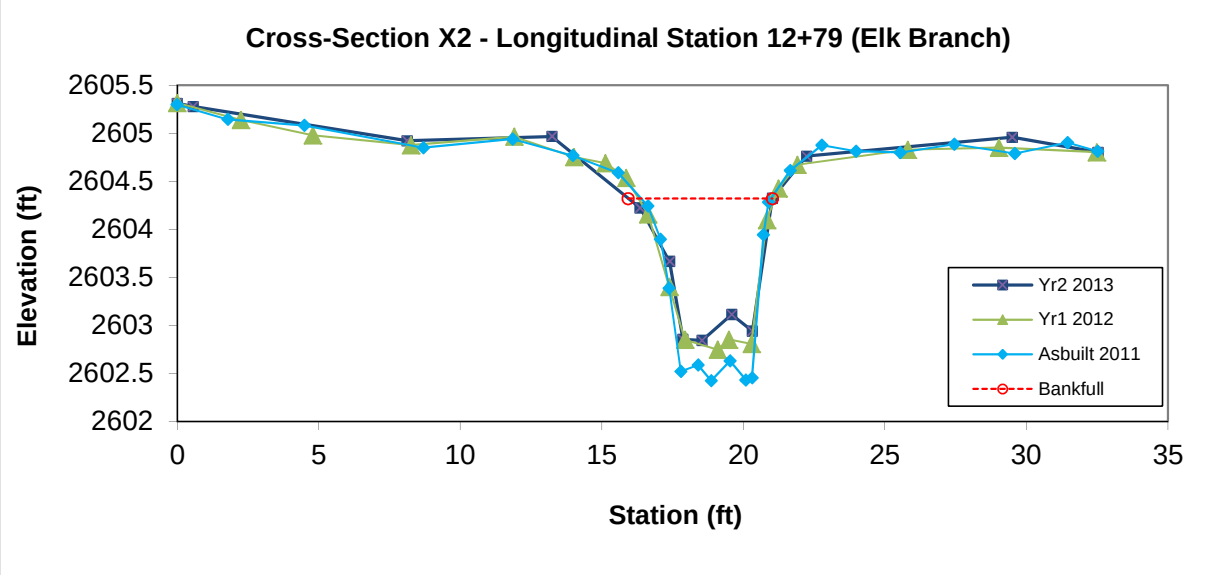


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	3.4	8.21	0.42	0.95	19.59	1	4.3	2599.51	2599.51

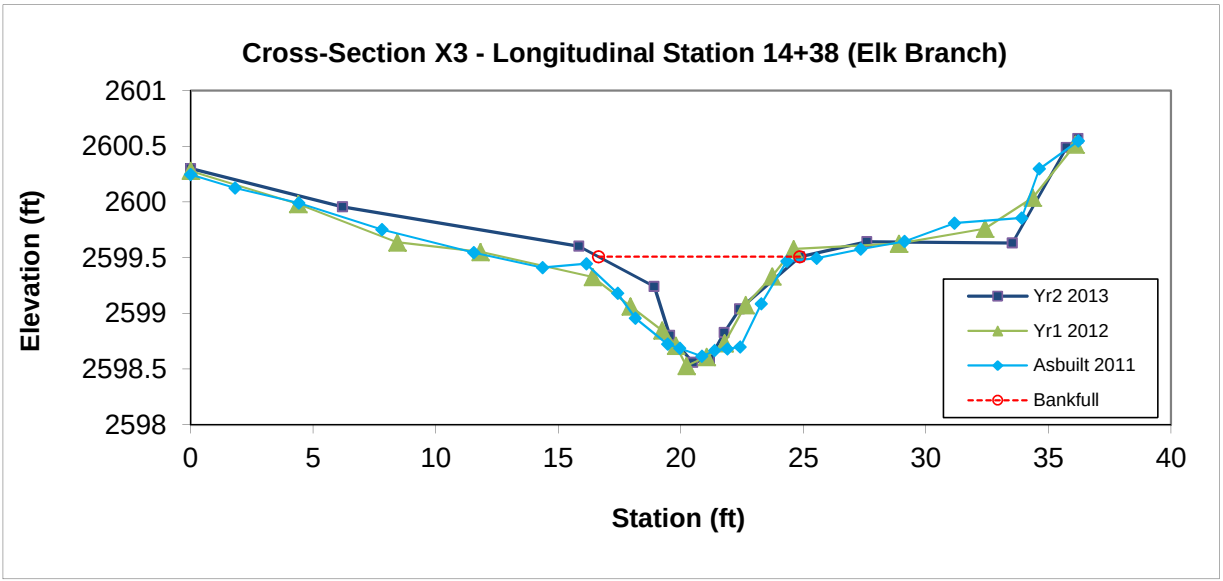


Photo 9: XS-3 facing right bank

Photo 10: XS-3 facing left bank

Photo 11: XS-3 facing upstream

Photo 12: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	4.9	9.44	0.52	0.98	18	1	4.8	2587.66	2587.66

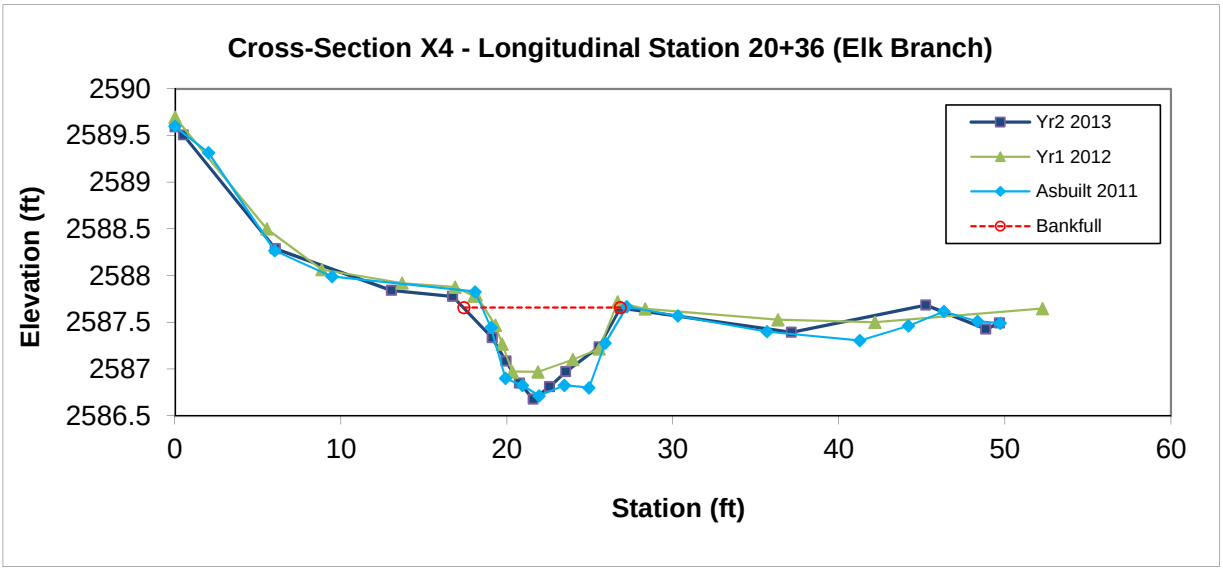


Photo 13: XS-4 facing right bank

Photo 14: XS-4 facing left bank

Photo 15: XS-4 facing upstream

Photo 16: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	-	10.4	10.29	1.01	2.49	10.21	1	4.3	2583.4	2583.4

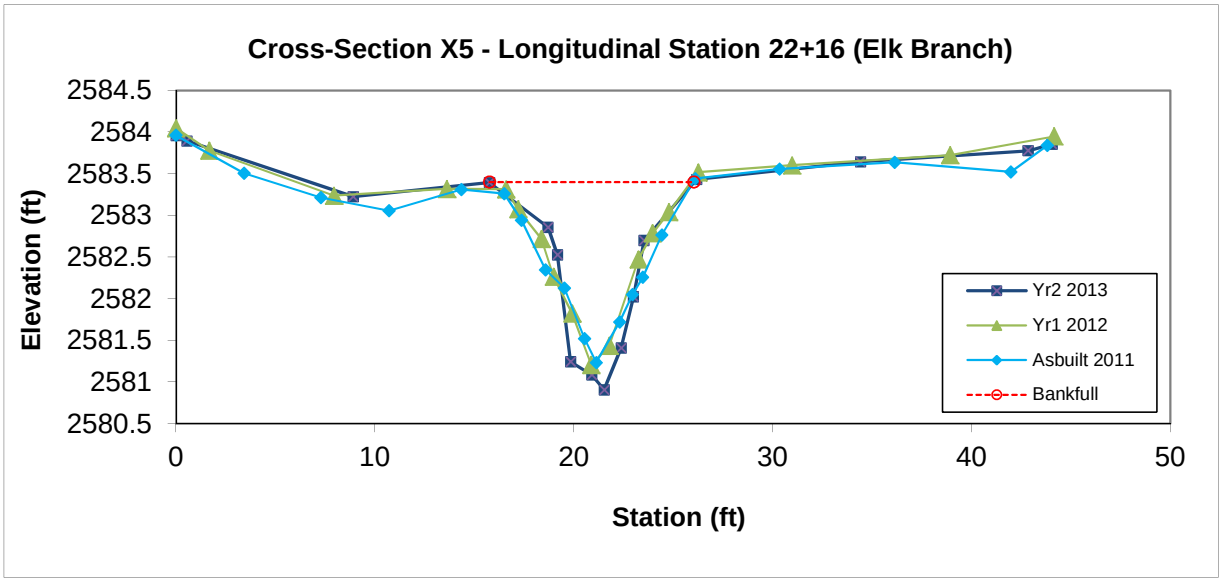


Photo 17: XS-5 facing right bank

Photo 18: XS-5 facing left bank

Photo 19: XS-5 facing upstream

Photo 20: XS-5 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	2.7	7.31	0.37	0.79	19.72	1	5.1	2608.18	2608.18

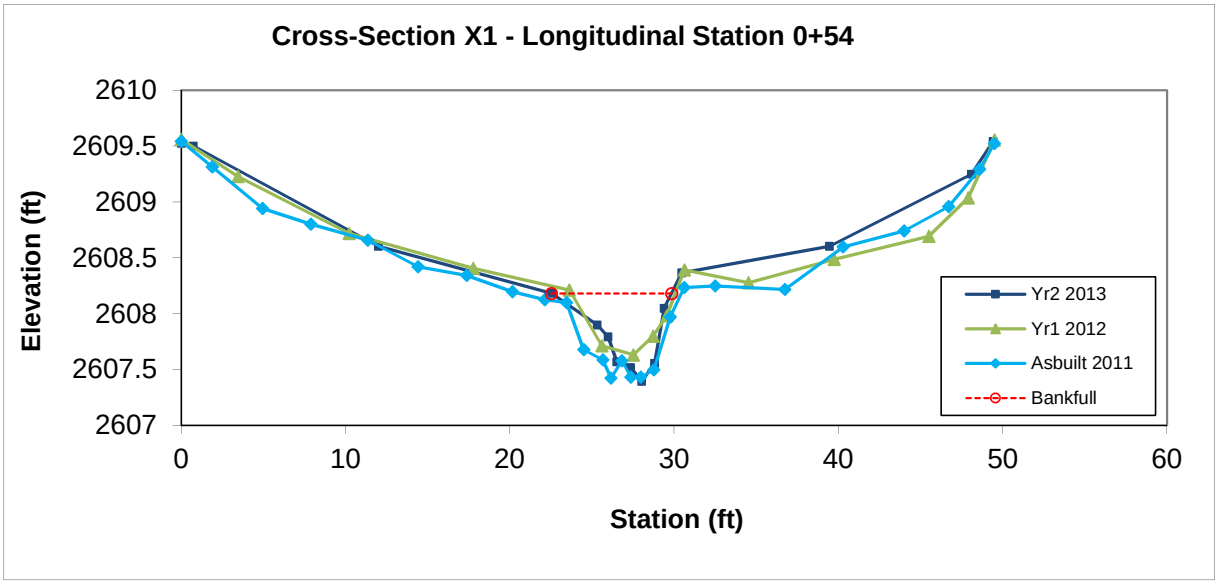


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	3.6	7.02	0.52	0.93	13.61	1	5.8	2599.9	2599.9

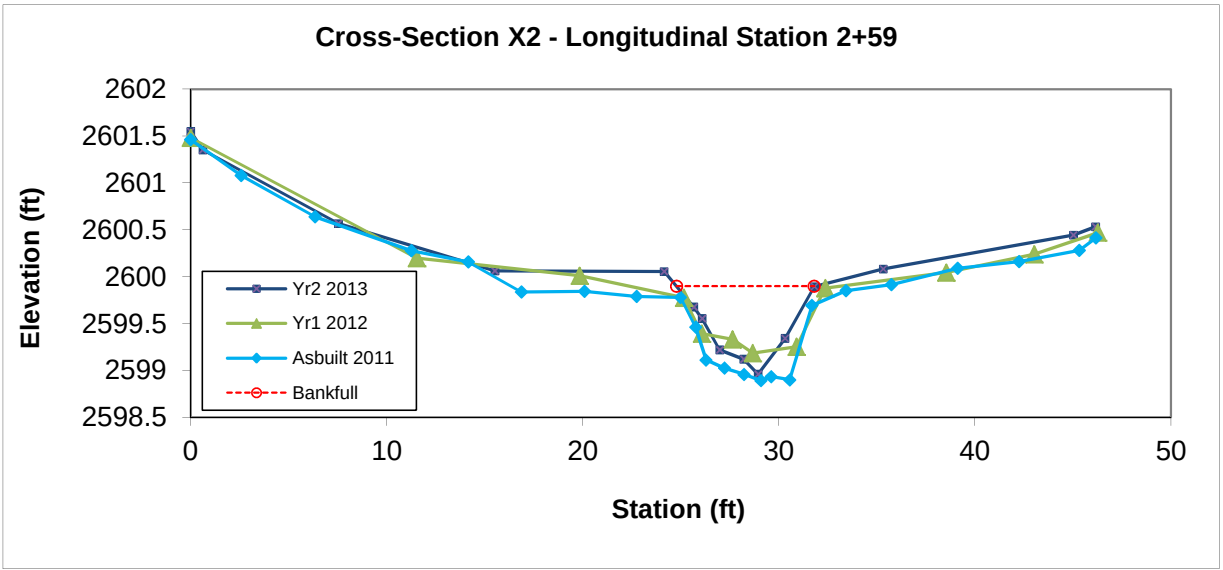


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	3.7	8.25	0.45	1.04	18.33	1	4.6	2592.25	2592.25

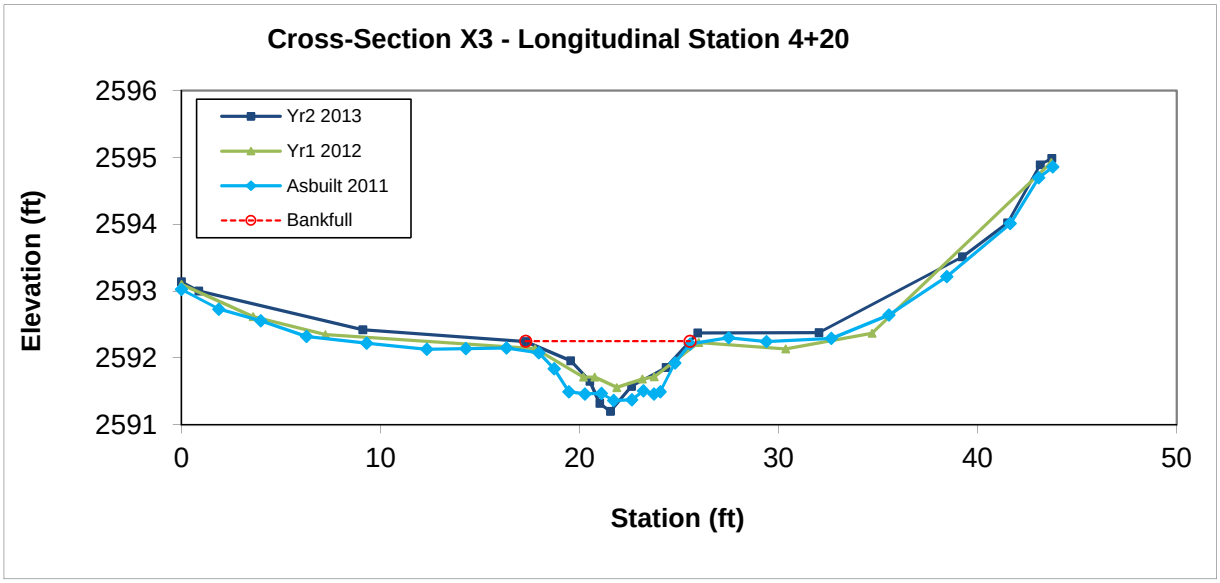


Photo 9: XS-3 facing right bank

Photo 10: XS-3 facing left bank

Photo 11: XS-3 facing upstream

Photo 12: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	-	11.7	9.85	1.19	2.28	8.28	1	4.7	2590.09	2590.09

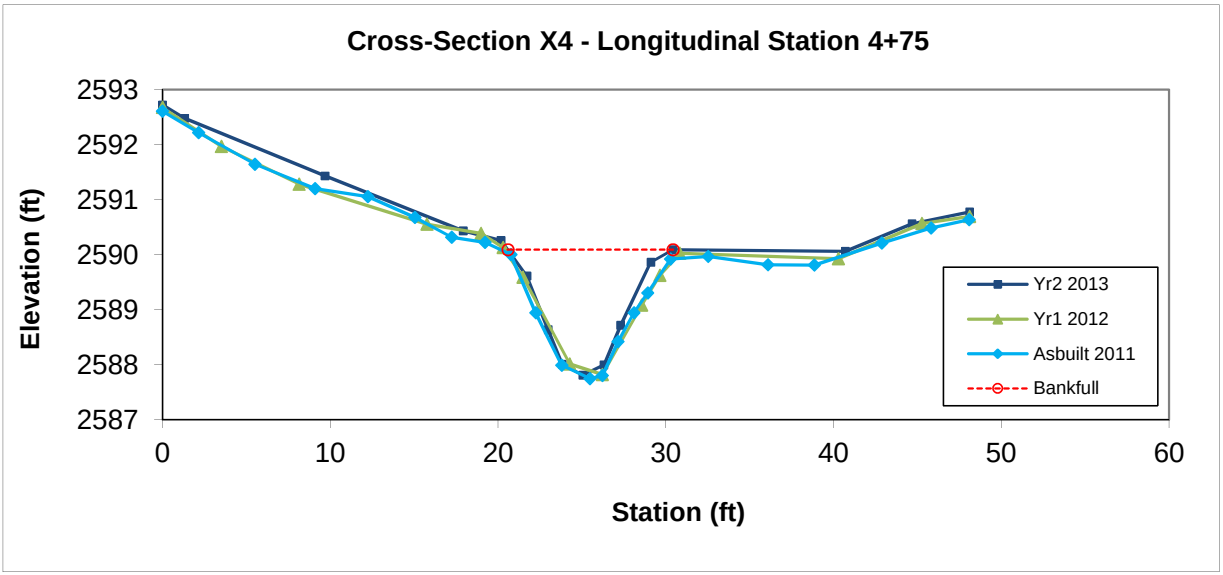


Photo 13: XS-4 facing right bank

Photo 14: XS-4 facing left bank

Photo 15: XS-4 facing upstream

Photo 16: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	2.9	5.23	0.55	0.84	9.5	1	7.6	2639.18	2639.18

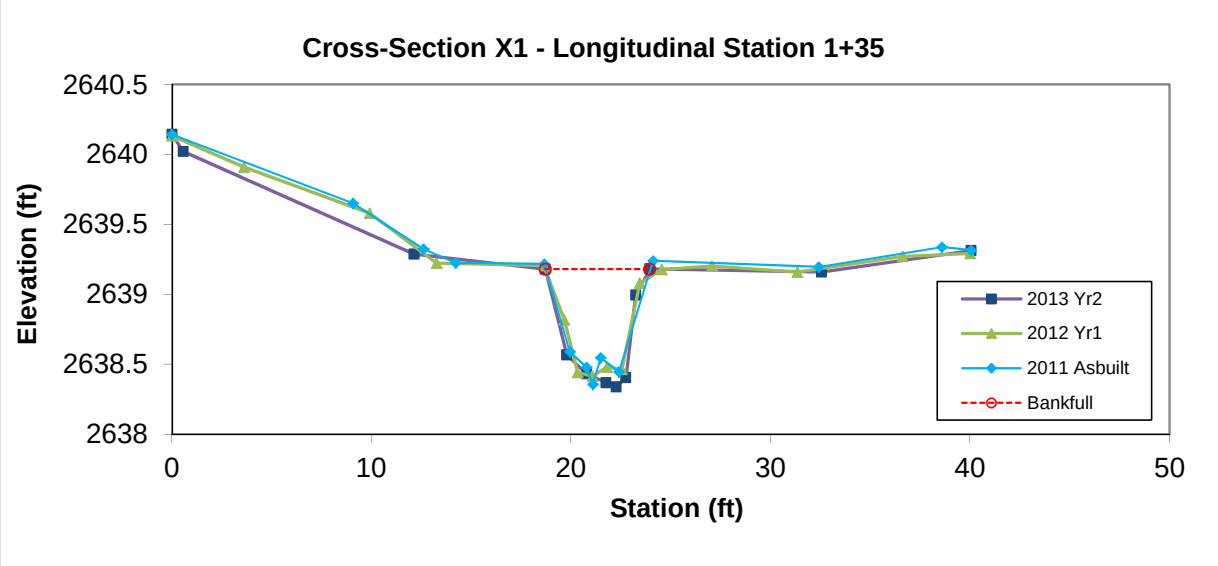


Photo 1: XS-1 facing right bank

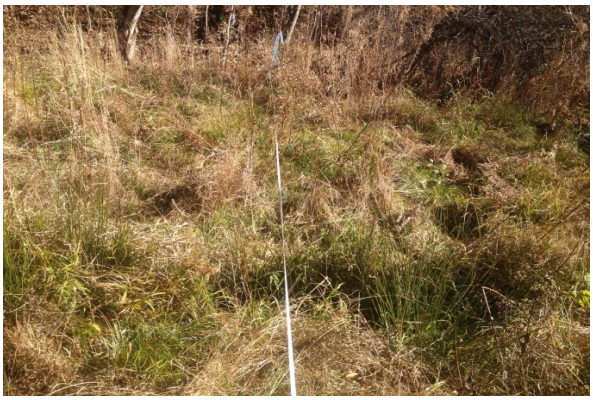
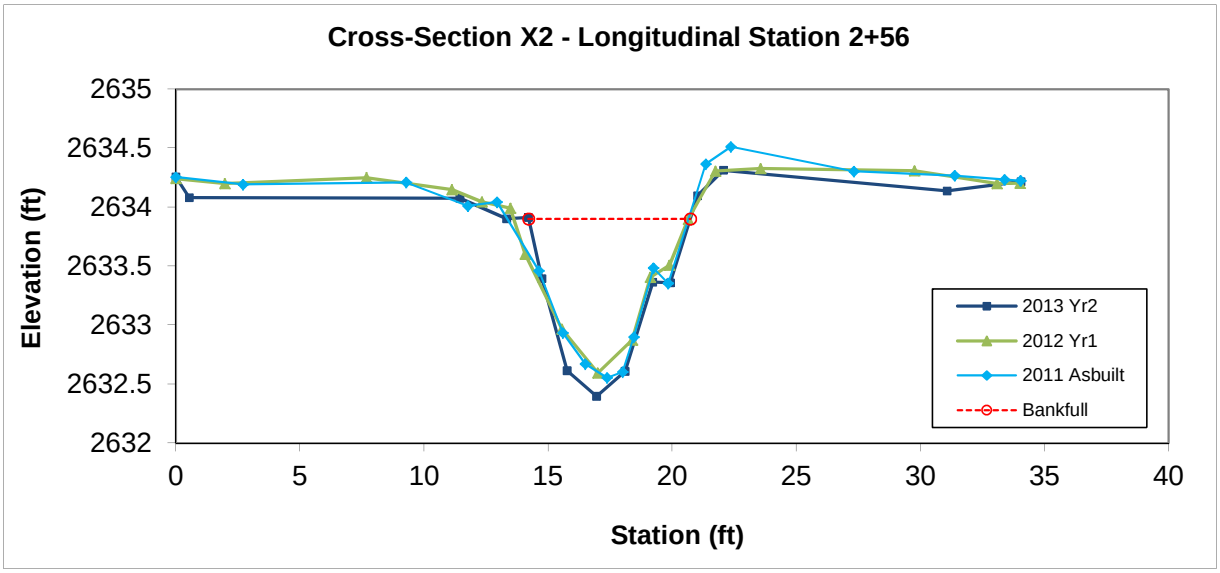


Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Eb	5.9	6.51	0.91	1.5	7.15	1	5.2	2633.9	2633.9



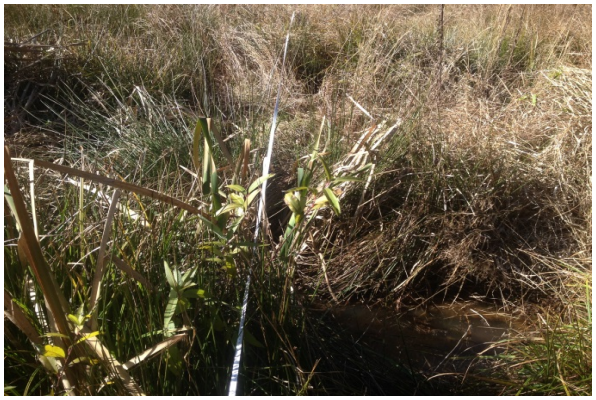


Photo 5: XS-2 facing right bank

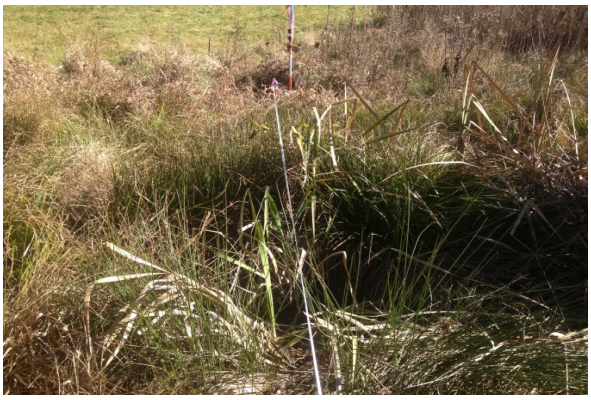
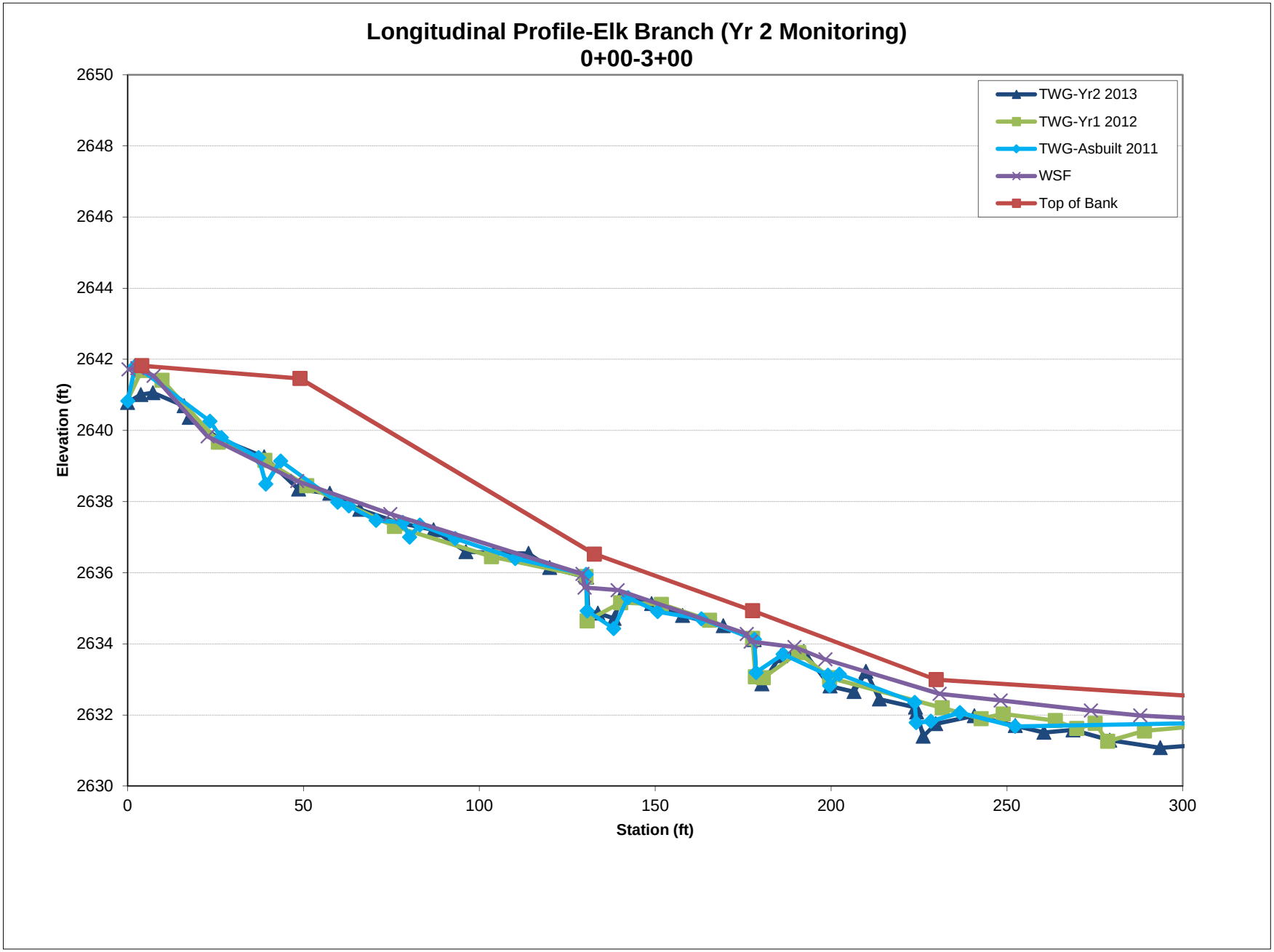
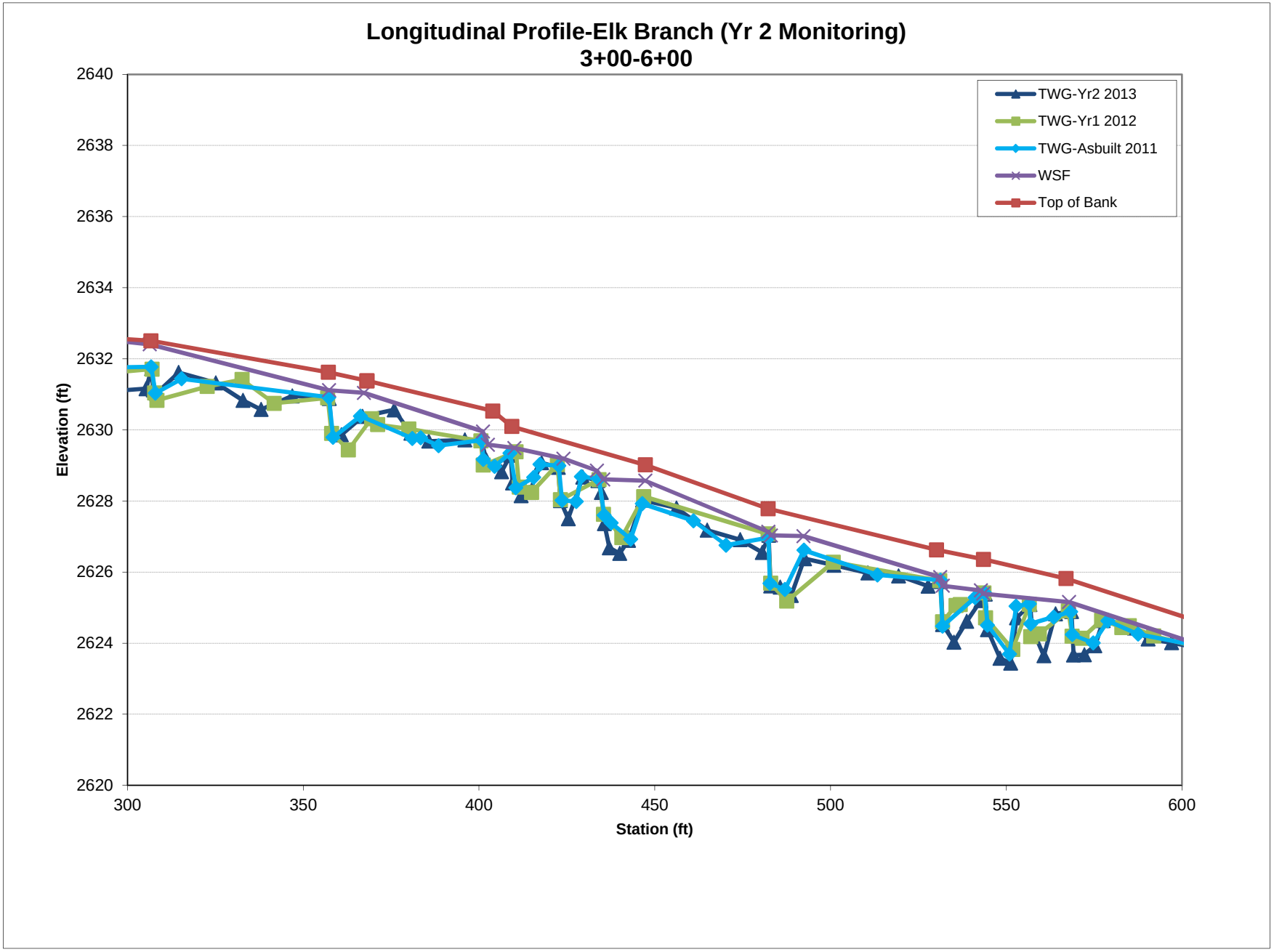


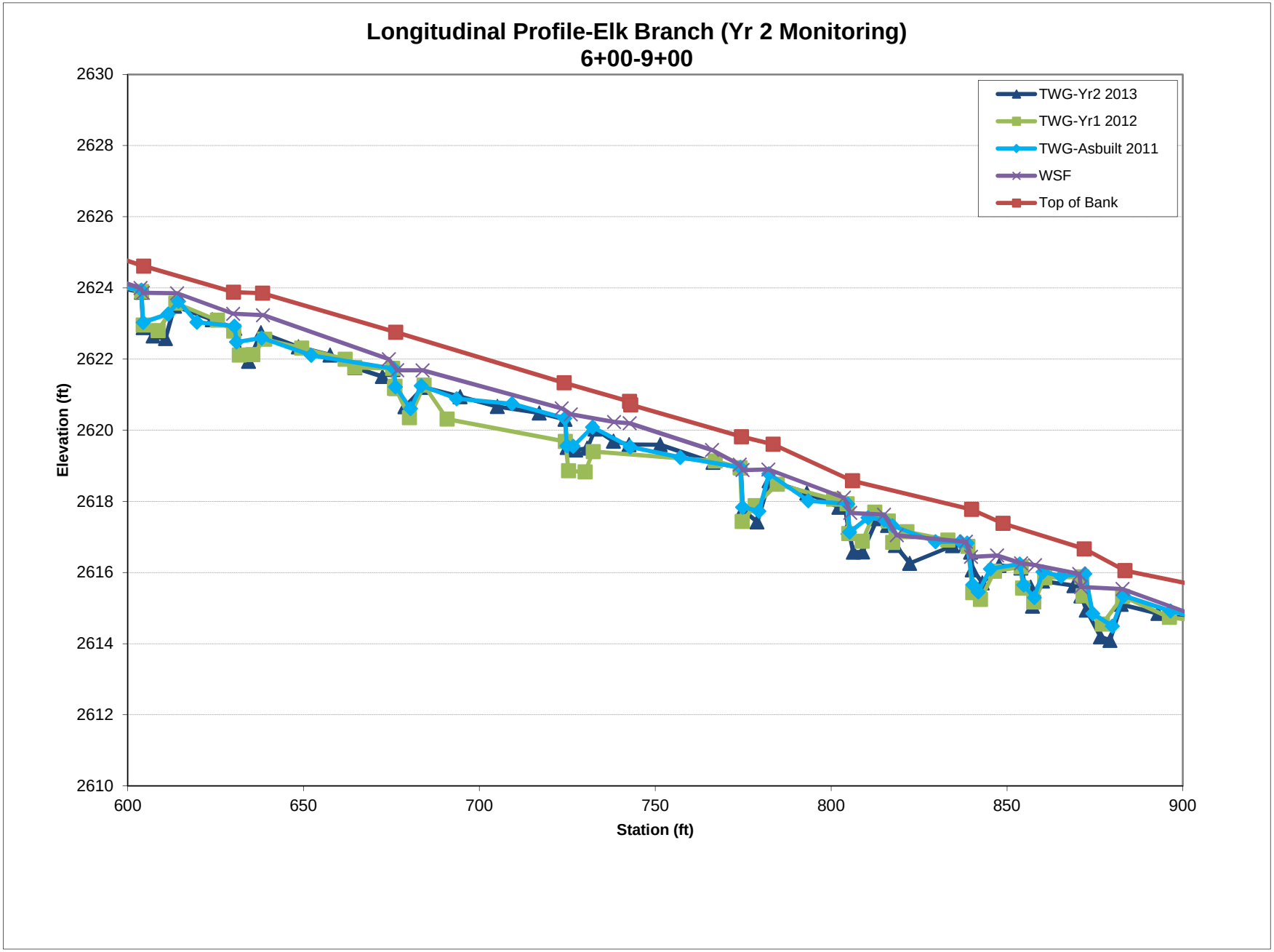
Photo 6: XS-2 facing left bank

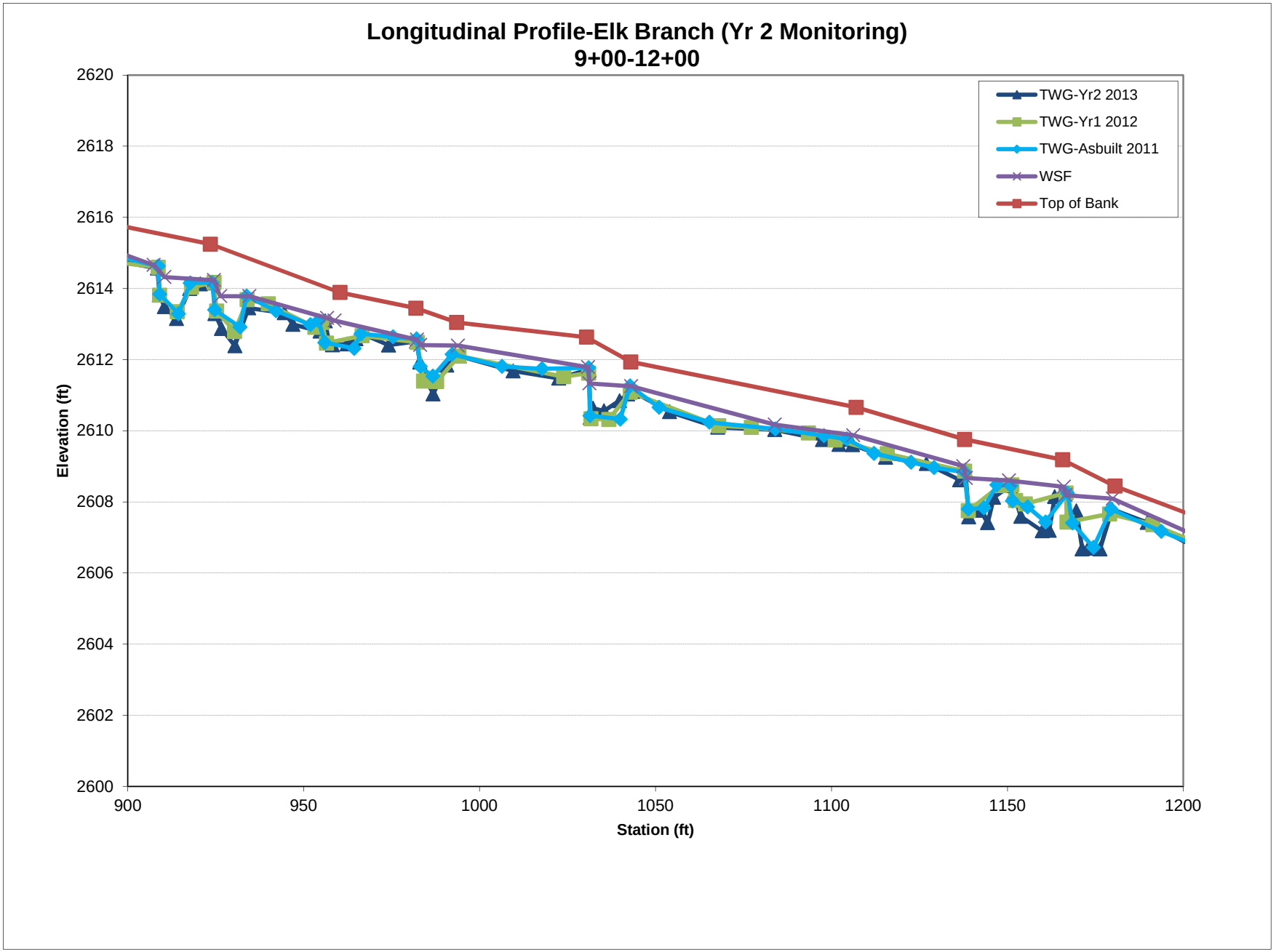
Photo 7: XS-2 facing upstream

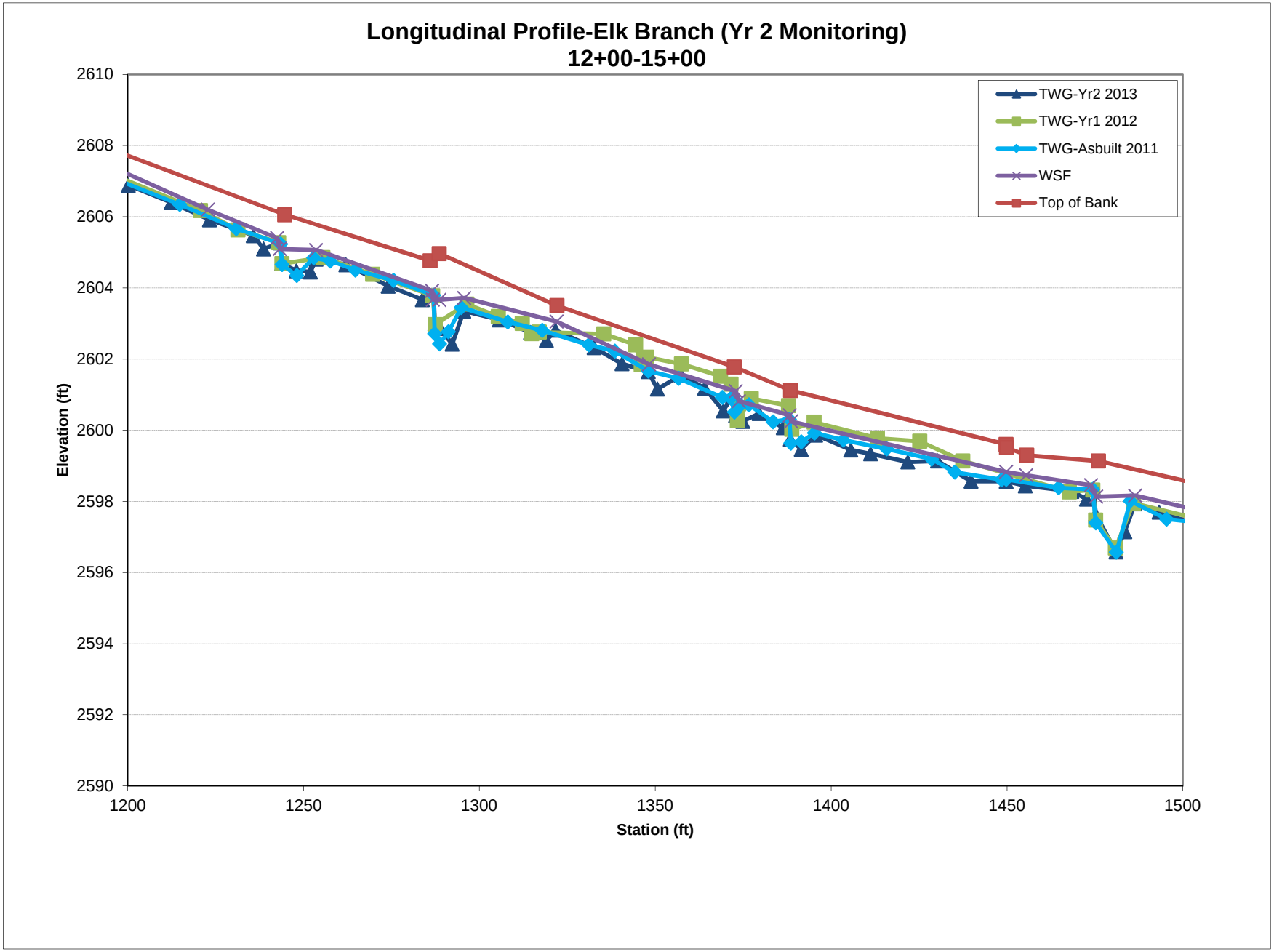
Photo 8: XS-2 facing downstream

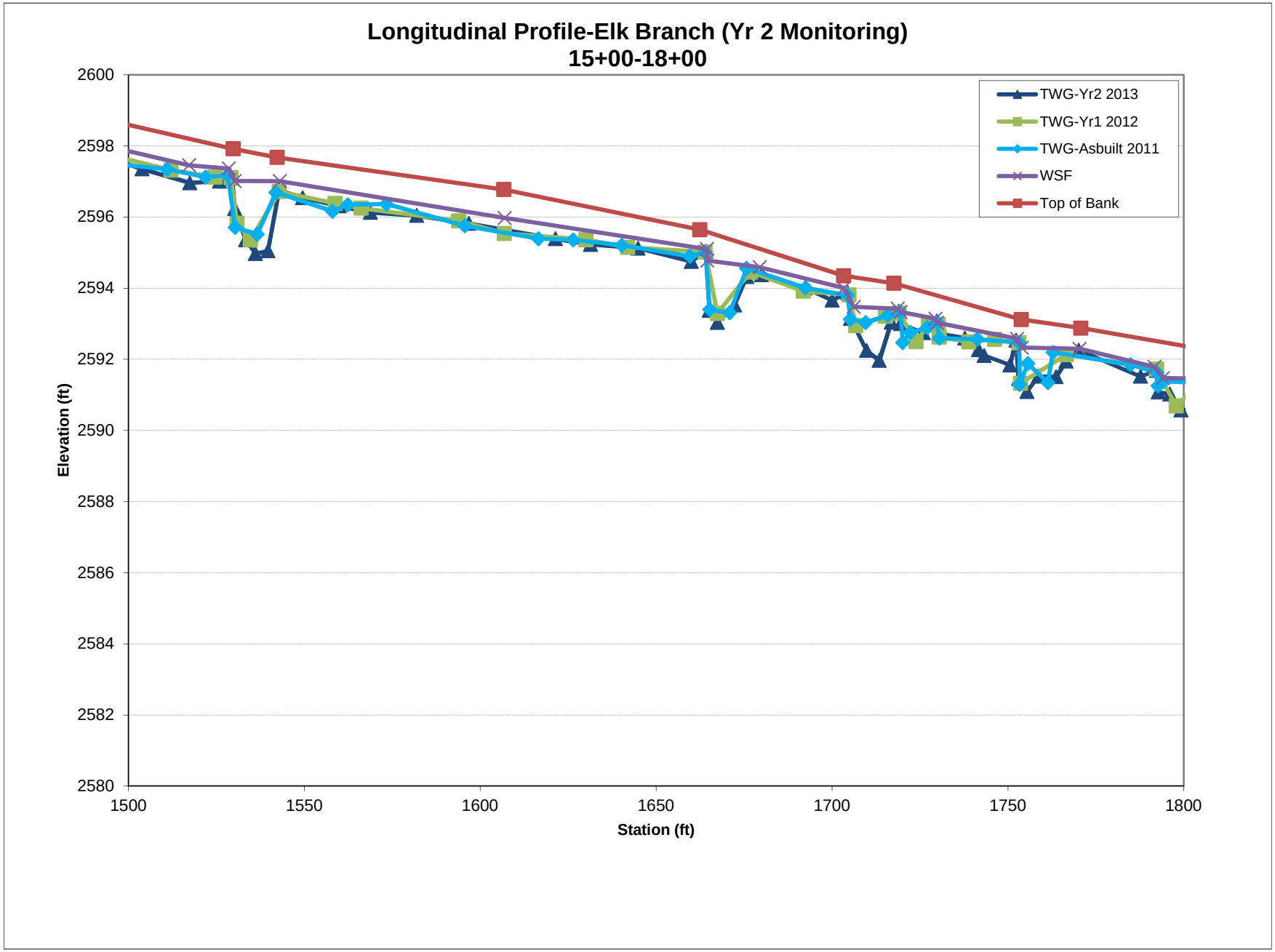

Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
0+00-3+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2650
2648
2646
2644
2642
2640
2638
2636
2634
2632
2630
0
50
100
150
200
250
300

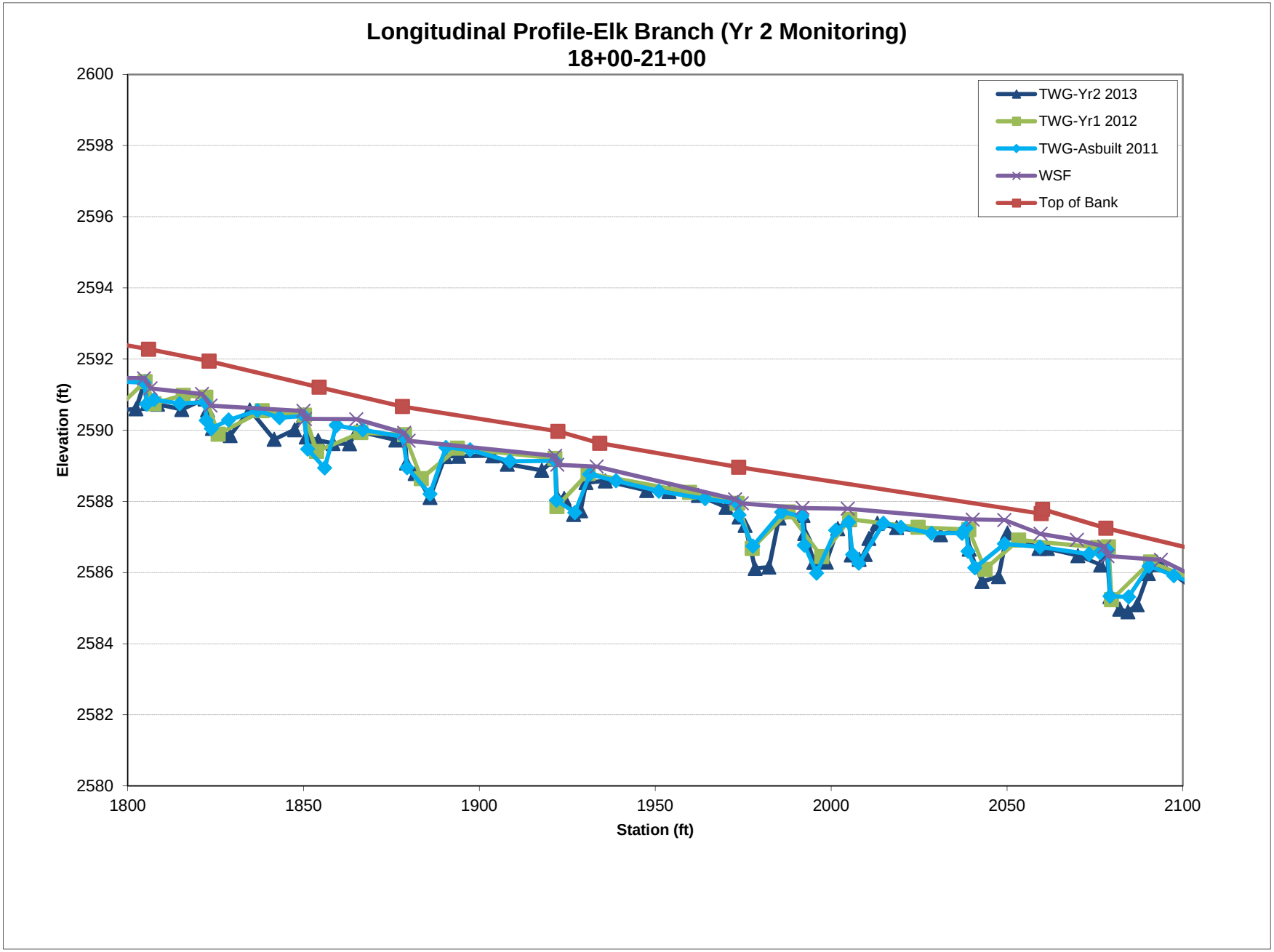

Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
3+00-6+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
2640
2638
2636
2634
2632
2630
2628
2626
2624
2622
2620
300
350
400
450
500
550
600
Station (ft)

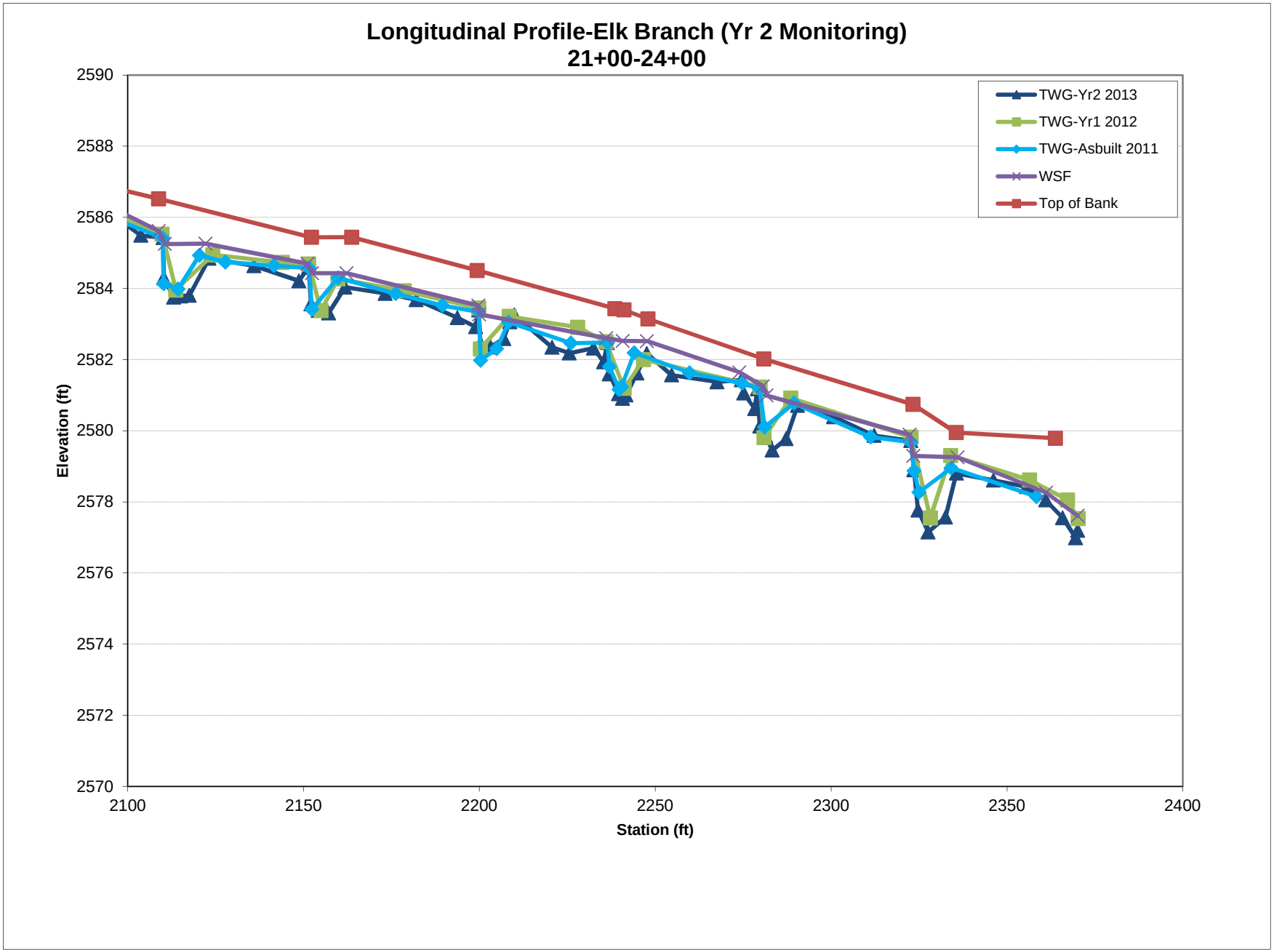

Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
6+00-9+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2630
2628
2626
2624
2622
2620
2618
2616
2614
2612
2610
600
650
700
750
800
850
900

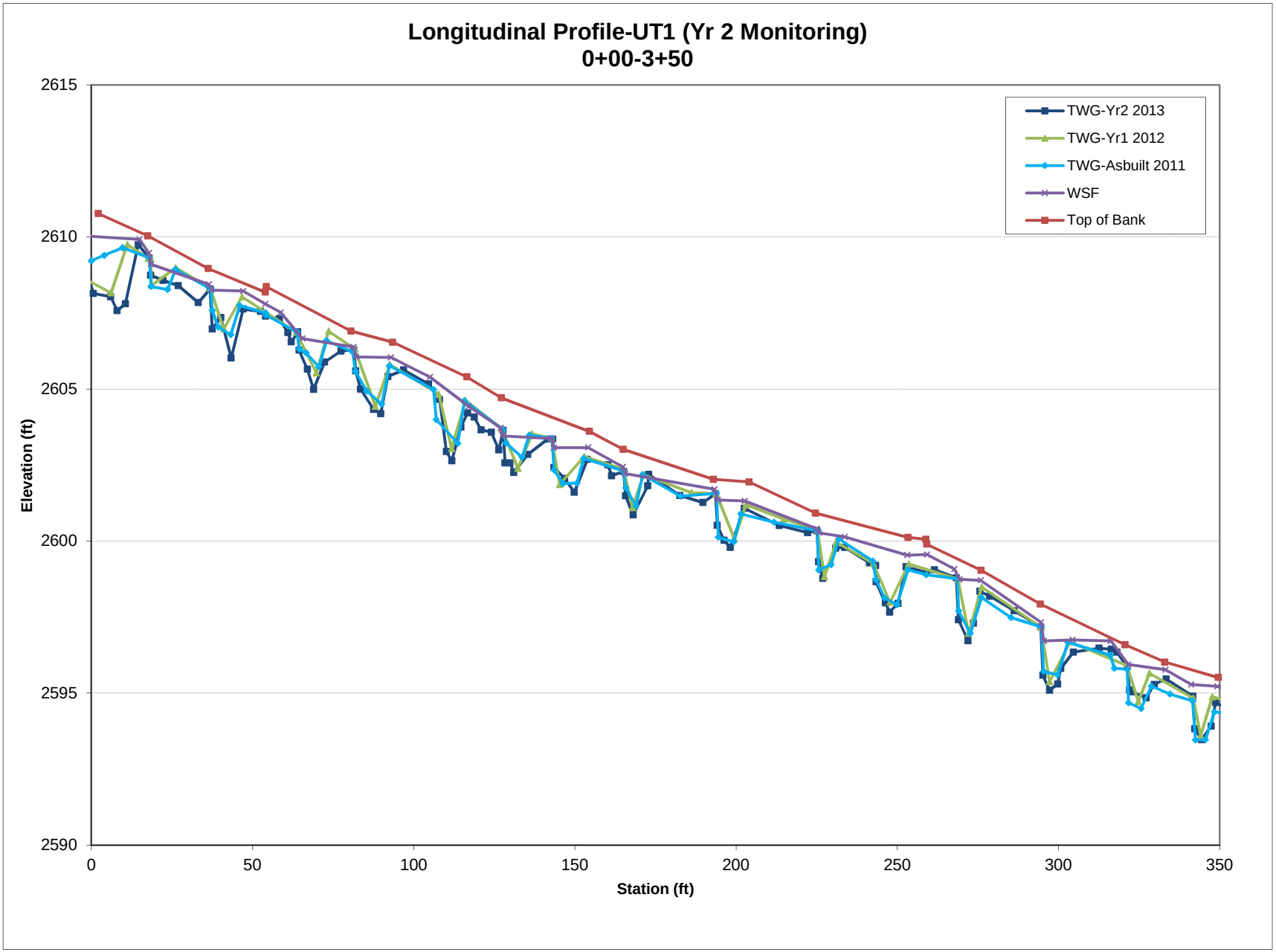

Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
9+00-12+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2620
2618
2616
2614
2612
2610
2608
2606
2604
2602
2600
900
950
1000
1050
1100
1150
1200

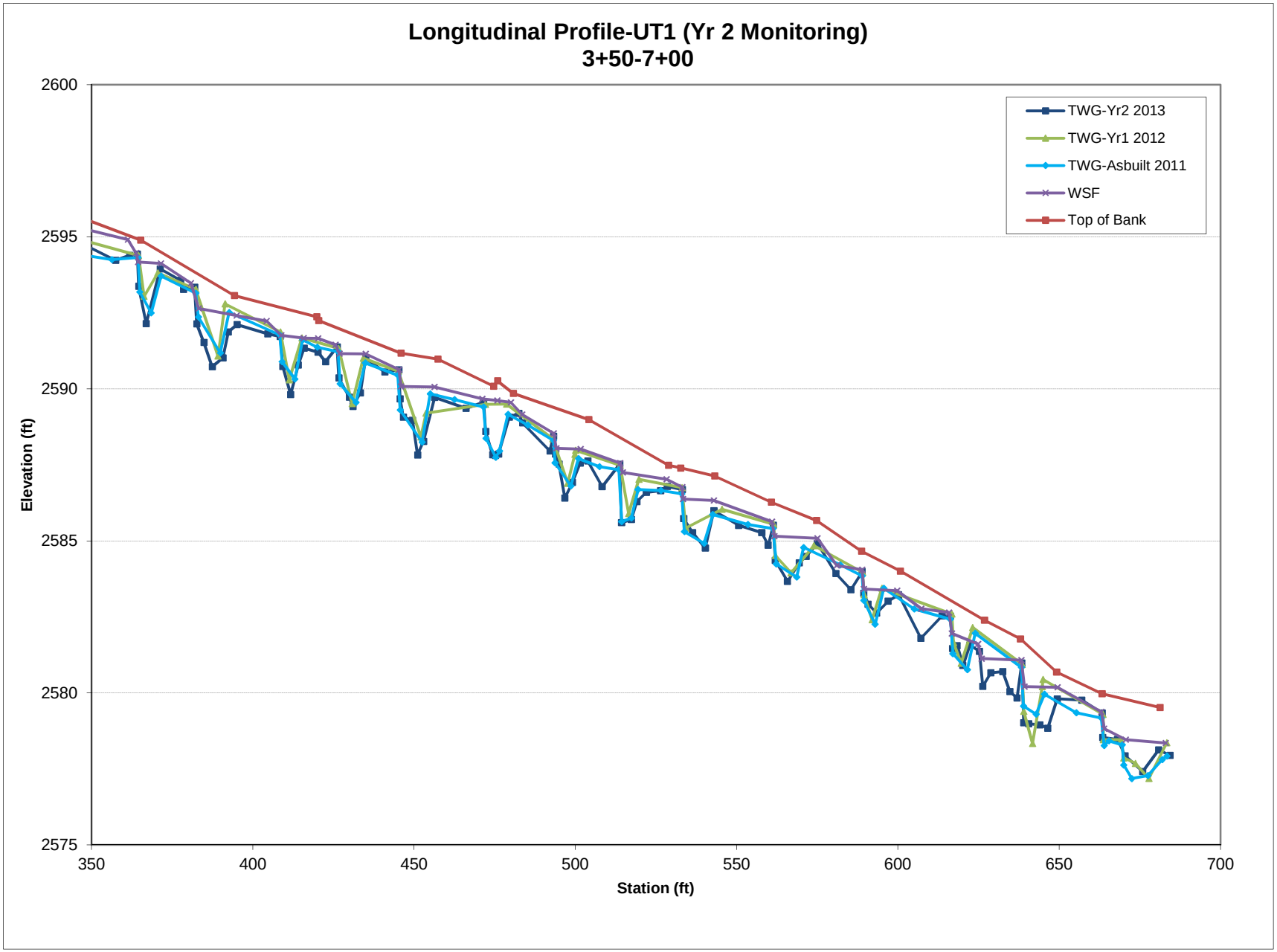

Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
12+00-15+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
2610
2608
2606
2604
2602
2600
2598
2596
2594
2592
2590
1200
1250
1300
1350
1400
1450
1500
Station (ft)


Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
15+00-18+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2600
2598
2596
2594
2592
2590
2588
2586
2584
2582
2580
1500
1550
1600
1650
1700
1750
1800


Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
18+00-21+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
2600
2598
2596
2594
2592
2590
2588
2586
2584
2582
2580
1800
1850
1900
1950
2000
2050
2100
Station (ft)


Longitudinal Profile-Elk Branch (Yr 2 Monitoring)
21+00-24+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2590
2588
2586
2584
2582
2580
2578
2576
2574
2572
2570
2100
2150
2200
2250
2300
2350
2400


Longitudinal Profile-UT1 (Yr 2 Monitoring)
0+00-3+50
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
2615
2610
2605
2600
2595
2590
0
50
100
150
200
250
300
350
Station (ft)


Longitudinal Profile-UT1 (Yr 2 Monitoring)
3+50-7+00
TWG-Yr2 2013
TWG-Yr1 2012
TWG-Asbuilt 2011
WSF
Top of Bank
Elevation (ft)
Station (ft)
2600
2595
2590
2585
2580
2575
350
400
450
500
550
600
650
700

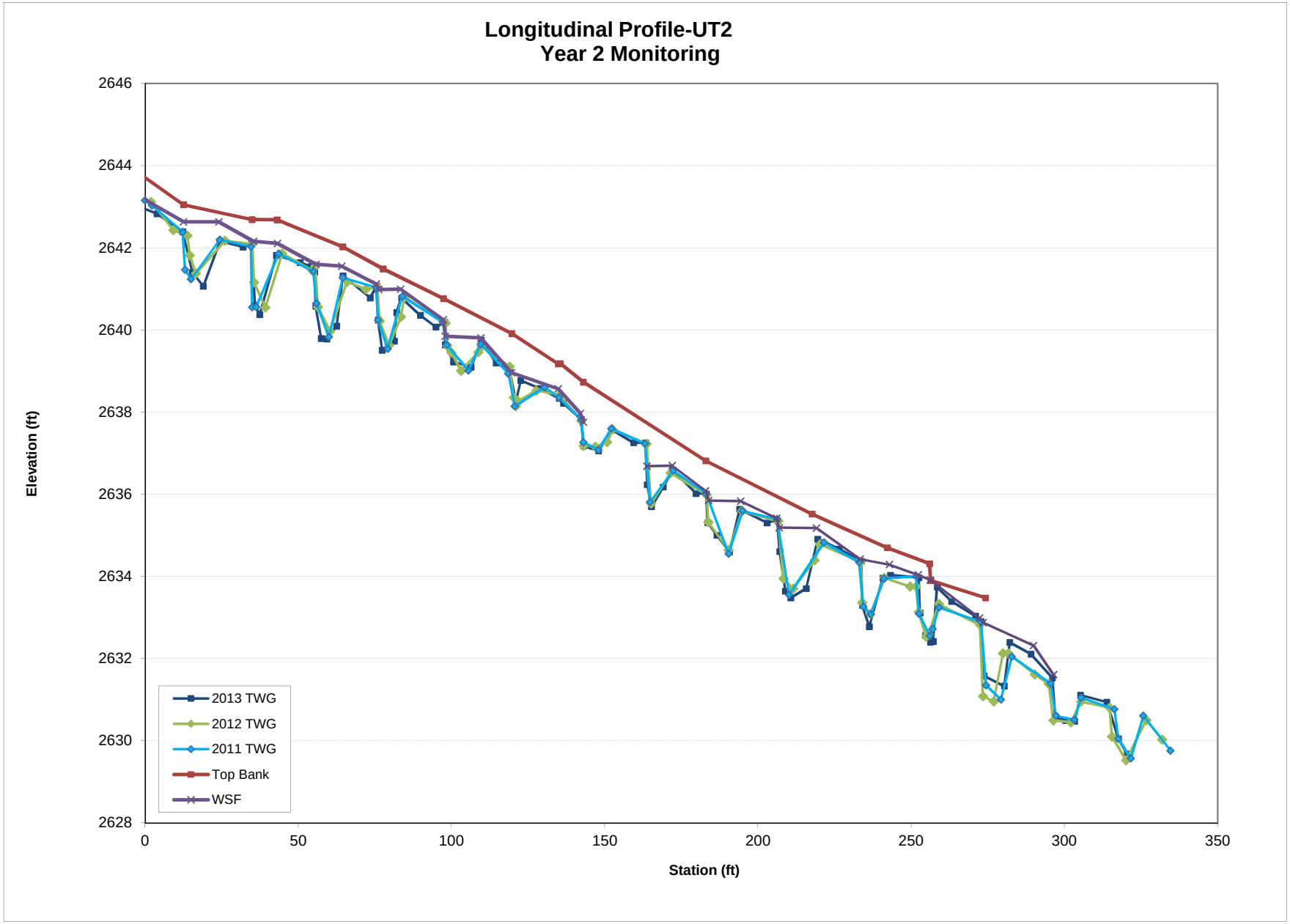

Longitudinal Profile-UT2
Year 2 Monitoring
Elevation (ft)
2646
2644
2642
2640
2638
2636
2634
2632
2630
2628
0
50
100
150
200
250
300
350
Station (ft)
2013 TWG
2012 TWG
2011 TWG
Top Bank
WSF

Table 11. Categorical Visual Morphological Stability Assessment						
Elk Branch Mitigation Project - Project No. 92665						
Elk Branch Reach 1 (951 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	100%	100%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	100%	100%			
Vanes / J Hooks etc.	-----	-----	-----			
Wads and Boulders	-----	-----	-----			
Elk Branch Reach A (592 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	100%	100%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	100%	100%			
Vanes / J Hooks etc.	-----	-----	-----			
Wads and Boulders	-----	-----	-----			
Elk Branch Reach B (403 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	100%	100%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	100%	100%			
Vanes / J Hooks etc.	100%	100%	100%			
Wads and Boulders	-----	-----	-----			

Elk Branch Reach 2 (186 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	100%	100%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	100%	100%			
Vanes / J Hooks etc.	-----	-----	-----			
Wads and Boulders	-----	-----	-----			
UT1 (656LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	94%	100%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	99%	100%			
Vanes / J Hooks etc.	-----	-----	-----			
Wads and Boulders	-----	-----	-----			
UT2 (242 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%			
Pools	100%	100%	100%			
Thalweg	100%	100%	100%			
Meanders	-----	-----	-----			
Bed General	100%	79%	96%			
Bank Condition	100%	100%	100%			
Rock/Log Drops	100%	100%	98%			
Vanes / J Hooks etc.	100%	100%	100%			
Wads and Boulders	-----	-----	-----			

Table 12. Visual Morphological Stability Assessment
Elk Branch Mitigation Project -Project No. 92665

Elk Branch Reach 1 (951 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?	23	23	0/0	100	
	2. Armor stable (e.g. no displacement)?	23	23	0/0	100	
	3. Facet grades appears stable?	23	23	0/0	100	
	4. Minimal evidence of embedding/fining?	23	23	0/0	100	
	5. Length appropriate?	23	23	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	30	30	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	30	30	0/0	100	
	3. Length appropriate?	30	30	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%** [2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A** [3]
E. Bed General	1. General channel bed aggradation areas (bar formation)	951	951	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	951	951	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	30	30	0/0	100	
	2. Height appropriate?	30	30	0/0	100	
	3. Angle and geometry appear appropriate?	30	30	0/0	100	
	4. Free of piping or other structural failures?	30	30	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

Elk Branch Reach A (592 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?	15	15	0/0	100	
	2. Armor stable (e.g. no displacement)?	15	15	0/0	100	
	3. Facet grades appears stable?	15	15	0/0	100	
	4. Minimal evidence of embedding/fining?	15	15	0/0	100	
	5. Length appropriate?	15	15	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	15	15	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	15	15	0/0	100	
	3. Length appropriate?	15	15	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%** [2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A** [3]
E. Bed General	1. General channel bed aggradation areas (bar formation)	592	592	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	592	592	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	9	9	0/0	100	
	2. Height appropriate?	9	9	0/0	100	
	3. Angle and geometry appear appropriate?	9	9	0/0	100	
	4. Free of piping or other structural failures?	9	9	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

Elk Branch Reach B (403 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?	14	14	0/0	100	
	2. Armor stable (e.g. no displacement)?	14	14	0/0	100	
	3. Facet grades appears stable?	14	14	0/0	100	
	4. Minimal evidence of embedding/fining?	14	14	0/0	100	
	5. Length appropriate?	14	14	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	14	14	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	14	14	0/0	100	
	3. Length appropriate?	14	14	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%** [2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A** [3]
E. Bed General	1. General channel bed aggradation areas (bar formation)	403	403	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	403	403	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	14	14	0/0	100	
	2. Height appropriate?	14	14	0/0	100	
	3. Angle and geometry appear appropriate?	14	14	0/0	100	
	4. Free of piping or other structural failures?	14	14	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

Elk Branch Reach 2 (186 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?	7	7	0/0	100	
	2. Armor stable (e.g. no displacement)?	7	7	0/0	100	
	3. Facet grades appears stable?	7	7	0/0	100	
	4. Minimal evidence of embedding/fining?	7	7	0/0	100	
	5. Length appropriate?	7	7	0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	7	7	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	7	7	0/0	100	
	3. Length appropriate?	7	7	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%** [2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A** [3]
E. Bed General	1. General channel bed aggradation areas (bar formation)	186	186	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	186	186	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	7	7	0/0	100	
	2. Height appropriate?	7	7	0/0	100	
	3. Angle and geometry appear appropriate?	7	7	0/0	100	
	4. Free of piping or other structural failures?	7	7	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT1 (656 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?	29	29	0/0	100	
	2. Armor stable (e.g. no displacement)?	29	29	0/0	100	
	3. Facet grades appears stable?	29	29	0/0	100	
	4. Minimal evidence of embedding/fining?	29	29	0/0	100	
	5. Length appropriate?	29	29	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	30	30	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	30	30	0/0	100	
	3. Length appropriate?	30	30	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**[2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A**[3]
E. Bed General[4]	1. General channel bed aggradation areas (bar formation)	656	656	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	656	656	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	29	29	0/0	100	
	2. Height appropriate?	29	29	0/0	100	
	3. Angle and geometry appear appropriate?	29	29	0/0	100	
	4. Free of piping or other structural failures?	29	29	0/0	100	**100%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT2 (242 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?	10	10	0/0	100	
	2. Armor stable (e.g. no displacement)?	10	10	0/0	100	
	3. Facet grades appears stable?	10	10	0/0	100	
	4. Minimal evidence of embedding/fining?	10	10	0/0	100	
	5. Length appropriate?	10	10	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	10	10	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	10	10	0/0	100	
	3. Length appropriate?	10	10	0/0	100	**100%**
C. Thalweg[1]	1. Upstream of pool (structure) centering?	1	1	0/0	100	
	2. Downstream of pool (structure) centering?	1	1	0/0	100	**100%**[2]
D. Meanders	1. Outer bend in state of limited/controlled erosion?	0	0	0/0	N/A	
	2. Of those eroding, # w/concomitant point bar formation?	0	0	0/0	N/A	
	3. Apparent Rc within spec?	0	0	0/0	N/A	
	4. Sufficient floodplain access and relief?	0	0	0/0	N/A	**N/A**[3]
E. Bed General[4]	1. General channel bed aggradation areas (bar formation)	242	242	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	222	242	20	92	**96%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	11	11	0/0	100	
	2. Height appropriate?	11	11	0/0	100	
	3. Angle and geometry appear appropriate?	11	11	0/0	100	
	4. Free of piping or other structural failures?	10	11	0/0	91	**98%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

[1] Thalweg feature is scored according to the centering of the thalweg over inverts of drop structures above pools and through the constructed riffle below pools since this reach is a step-pool channel without meander bends.

[2] Of the structures and riffles that contained flow, 100% had a centered thalweg. Centering of the thalweg for all remaining structures and riffles lacking baseflow that are located within the 'dry' portion of the reach will be re-assessed in the Year 2 monitoring report.

[3] Given the stream types present within the project area, stream flow energy was primarily managed vertically through drop control structures. Pattern adjustments were not designed to increase sinuosity on-site. As a result, the features addressed in Section D. 1-3 are not as common to the project site as they are on C or E-type channels in more gently sloping terrain. Pattern adjustments were limited to maintaining channel in low point of the valley.

[4] The channel bed is stable; the linear feet provided in Column F represents the total linear feet of subsurface flow.

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
Elk Branch: Reach 1

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	6.3-9.3	3.9	5.9	7.8	11.7	19.7	27.6	4.0	7.3	10.5	----	6.1	----	----	5.5	----	----	5.2	----			
Floodprone Width (ft)	-----	5.2	30.1	55.0	20.0	-----	41.0	9.0	44.5	80.0	----	30.9	----	----	24.3	----	----	26.4	----			
Bankfull Mean Depth (ft)	.44-.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.67	----	----	0.46	----	----	0.51	----			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.50	0.75	1.00	----	0.98	----	----	0.72	----	----	0.89	----			
Bankfull Cross Sectional Area (ft2)	3.6-6.8	2.9	8.7	14.5	10.2	21.6	33.0	3.0	5.0	7.0	----	4.1	----	----	2.6	----	----	2.7	----			
Width/Depth Ratio	-----	5.0	9.5	14.0	10.7	18.9	27.0	10.0	12.0	14.0	----	9.0	----	----	12.0	----	----	10.1	----			
Entrenchment Ratio	-----	1.6	4.3	7.0	1.3	2.3	3.2	3.0	5.3	7.6	----	5.1	----	----	4.4	----	----	5.1	----			
Bank Height Ratio	-----	1.4	2.3	3.1	1.0	1.0	1.0	1.0	1.1	1.1	----	1.0	----	----	1.0	----	----	1.3	----			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.6	----	----	4.1	----	----	3.9	----			
Pattern																						
Channel Beltwidth (ft)	-----	2	3	4	16	36	55	11	45	80	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	2	4	7	28	38	47	5	15	25	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	9	23	38	70	165	260	21	52	82	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	0.4	0.6	0.8	1.1	2.6	4.1	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	18	34	51	21	29	37	20.4	30.8	38.0			
Riffle Slope (ft/ft)	-----	0.02	0.03	0.03	0.200	0.480	0.760	0.022	0.037	0.051	0.021	0.029	0.045	0.017	0.026	0.031	0.018	0.026	0.034			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	3	6	9	2	7	13	9	10	13			
Pool Spacing (ft)	-----	42	-----	157	42	137	231	9	30	50	17	40	55	15	39	54	17	40	53			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----	1.2/6.6/13/65/130			1-6/14/31-39/51-88/110-210			.6-1.5/2-7/6.2-19/19-65/ 26-130			---			---			---					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	-----	-----	0.7	-----	-----	0.7	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.6	-----	-----	2.8	-----	-----	2.6	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	901	-----	-----	901	-----	-----	901	-----	-----	901	-----			
Drainage Area (SM)	-----	0.03	0.05	0.07	0.45	1.03	1.60	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14			
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	7-13	-----	-----	-----	-----	-----	-----	7	11	14	7	11	14	7	11	14	7	11	14			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	1.02	1.07	1.11	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.033	-----	-----	0.032	-----	-----	0.029	-----			

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
Elk Branch: Reach A

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	6.3-9.3	3.9	5.9	7.8	11.7	19.7	27.6	4.0	7.3	10.5	----	8.1	----	----	7.3	----	----	8.2	----			
Floodprone Width (ft)	-----	5.2	30.1	55.0	20.0	-----	41.0	9.0	44.5	80.0	----	34.6	----	----	32.5	----	----	35.6	----			
Bankfull Mean Depth (ft)	.44-.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.51	----	----	0.40	----	----	0.42	----			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.50	0.75	1.00	----	0.83	----	----	0.80	----	----	0.95	----			
Bankfull Cross Sectional Area (ft2)	3.6-6.8	2.9	8.7	14.5	10.2	21.6	33.0	3.0	5.0	7.0	----	4.2	----	----	2.9	----	----	3.4	----			
Width/Depth Ratio	-----	5.0	9.5	14.0	10.7	18.9	27.0	10.0	12.0	14.0	----	15.8	----	----	18.4	----	----	19.6	----			
Entrenchment Ratio	-----	1.6	4.3	7.0	1.3	2.3	3.2	3.0	5.3	7.6	----	4.3	----	----	4.4	----	----	4.3	----			
Bank Height Ratio	-----	1.4	2.3	3.1	1.0	1.0	1.0	1.0	1.1	1.1	----	1.0	----	----	1.0	----	----	1.0	----			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.5	----	----	3.6	----	----	3.1	----			
Pattern																						
Channel Beltwidth (ft)	-----	2	3	4	16	36	55	11	45	80	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	2	4	7	28	38	47	5	15	25	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	9	23	38	70	165	260	21	52	82	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	0.40	0.60	0.80	1.10	2.60	4.10	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	34	45	64	31	44	64	35	44	64			
Riffle Slope (ft/ft)	-----	0.02	0.03	0.03	0.200	0.480	0.760	0.022	0.037	0.051	0.010	0.025	0.040	0.013	0.026	0.037	0.008	0.022	0.039			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	4	5	6	5	9	12	9	12	14			
Pool Spacing (ft)	-----	42	-----	157	42	137	231	9	30	50	22	43	57	28	44	54	21	41	55			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----	1.2/6.6/13/65/130			1-6/14/31-39/51-88/110-210			.6-1.5/2-7/6.2-19/19-65/26-130			3.2/12/17/37/69			0.2/17/27/69/117			9.4/24/30/72/152					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.7	-----	-----	0.7	-----	-----	0.7	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.7	-----	-----	2.5	-----	-----	2.1	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	642	-----	-----	642	-----	-----	642	-----	-----	642	-----			
Drainage Area (SM)	-----	-----	.03-.07	-----	0.45	1.03	1.60	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14			
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	7-13	-----	-----	-----	-----	-----	-----	7	11	14	7	11	14	7	11	14	7	11	14			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.027	-----	-----	0.028	-----	-----	0.028	-----			

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
Elk Branch: Reach B

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	6.3-9.3	3.9	5.9	7.8	11.7	19.7	27.6	4.0	7.3	10.5	----	8.7	----	----	8.3	----	----	9.4	----			
Floodprone Width (ft)	-----	5.2	30.1	55.0	20.0	-----	41.0	9.0	44.5	80.0	----	45.0	----	----	46.5	----	----	45.2	----			
Bankfull Mean Depth (ft)	.44-.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.65	----	----	0.53	----	----	0.52	----			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.50	0.75	1.00	----	0.95	----	----	0.75	----	----	0.98	----			
Bankfull Cross Sectional Area (ft2)	3.6-6.8	2.9	8.7	14.5	10.2	21.6	33.0	3.0	5.0	7.0	----	5.7	----	----	4.4	----	----	4.9	----			
Width/Depth Ratio	-----	5.0	9.5	14.0	10.7	18.9	27.0	10.0	12.0	14.0	----	13.3	----	----	15.6	----	----	18.0	----			
Entrenchment Ratio	-----	1.6	4.3	7.0	1.3	2.3	3.2	3.0	5.3	7.6	----	5.2	----	----	5.6	----	----	4.8	----			
Bank Height Ratio	-----	1.4	2.3	3.1	1.0	1.0	1.0	1.0	1.1	1.1	----	1.0	----	----	1.0	----	----	1.0	----			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	-----	1.8	-----	-----	2.4	-----	-----	2.1	-----			
Pattern																						
Channel Beltwidth (ft)	-----	2	3	4	16	36	55	11	45	80	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	2	4	7	28	38	47	5	15	25	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	9	23	38	70	165	260	21	52	82	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	0.40	0.60	0.80	1.10	2.60	4.10	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5	23	42	12	25	42	11	24	40			
Riffle Slope (ft/ft)	-----	0.02	0.03	0.03	0.200	0.480	0.760	0.022	0.037	0.051	0.018	0.025	0.039	0.005	0.021	0.041	0.017	0.018	0.022			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	4	8	14	8	9	11	8	11	13			
Pool Spacing (ft)	-----	42	-----	157	42	137	231	9	30	50	10	29	50	17	31	55	17	33	56			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----	1.2/6.6/13/65/130			-6/14/31-39/51-88/110-2			.6-1.5/2-7/6.2-19/19-65/26-130			---			---			---					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	-----	-----	0.9	-----	-----	0.9	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.9	-----	-----	2.0	-----	-----	1.8	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	403	-----	-----	403	-----	-----	403	-----	-----	403	-----			
Drainage Area (SM)	-----	-----	.03-.07	-----	0.45	1.03	1.60	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14			
Rosgen Classification	-----	-----	Cb/B/G/Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	7-13	-----	-----	-----	----	----	----	7	11	14	7	11	14	7	11	14	7	11	14			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.021	-----	-----	0.023	-----	-----	0.021	-----			

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
Elk Branch: Reach 2

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			(As-Built)			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	9.30	3.9	5.9	7.8	11.7	19.7	27.6	4.0	7.3	10.5	----	9.2	----	----	9.0	----	----	10.3	----			
Floodprone Width (ft)	-----	5.2	30.1	55.0	20.0	-----	41.0	9.0	44.5	80.0	----	43.8	----	----	44.2	----	----	44.1	----			
Bankfull Mean Depth (ft)	0.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.98	----	----	0.96	----	----	1.01	----			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.50	0.75	1.00	----	2.02	----	----	2.11	----	----	2.49	----			
Bankfull Cross Sectional Area (ft2)	6.80	2.9	8.7	14.5	10.2	21.6	33.0	3.0	5.0	7.0	----	9.0	----	----	8.7	----	----	10.4	----			
Width/Depth Ratio	-----	5.0	9.5	14.0	10.7	18.9	27.0	10.0	12.0	14.0	----	9.3	----	----	9.4	----	----	10.2	----			
Entrenchment Ratio	-----	1.6	4.3	7.0	1.3	2.3	3.2	3.0	5.3	7.6	----	4.8	----	----	4.9	----	----	4.3	----			
Bank Height Ratio	-----	1.4	2.3	3.1	1.0	1.0	1.0	1.0	1.1	1.1	----	1.0	----	----	1.0	----	----	1.0	----			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	-----	1.2	-----	-----	1.2	-----	-----	1.0	-----			
Pattern																						
Channel Beltwidth (ft)	-----	2	3	4	16	36	55	11	45	80	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	2	4	7	28	38	47	5	15	25	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	9	23	38	70	165	260	21	52	82	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	0.40	0.60	0.80	1.10	2.60	4.10	3.50	5.75	8.00	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	19	30	40	19	30	40	17	27	38			
Riffle Slope (ft/ft)	-----	0.02	0.03	0.03	0.200	0.480	0.760	0.022	0.037	0.051	0.021	0.028	0.039	0.021	0.028	0.041	0.018	0.029	0.049			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	7	9	11	5	9	14	9	10	12			
Pool Spacing (ft)	-----	42	-----	157	42	137	231	9	30	50	31	39	48	33	39	45	39	43	48			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----	1.2/6.6/13/65/130			1-6/14/31-39/51-88/110-210			.6-1.5/2-7/6.2-19/19-65/26-130			---			---			---					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.3	-----	-----	1.4	-----	-----	1.4	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.6	-----	-----	1.7	-----	-----	1.4	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	279	-----	-----	279	-----	-----	279	-----	-----	279	-----			
Drainage Area (SM)	-----	0.07	-----	0.14	0.45	1.03	1.60	0.07	0.11	0.14	0.05	0.10	0.14	0.05	0.10	0.14	0.05	0.10	0.14			
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	13-23	-----	-----	-----	----	----	----	7	11	14	7	11	14	7	11	14	7	11	14			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----	-----	1.09	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.024	-----	-----	0.023	-----	-----	0.023	-----			

Note: Dimension information based on pool cross-section

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
UT1 to Elk Branch

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Mean
Bankfull Width (ft)	6.90	3.5	7.7	11.9	11.7	19.7	27.6	3.0	6.9	8.4	6.5	6.9	7.3	6.5	7.2	7.8	7.0	7.7	8.3			
Floodprone Width (ft)	-----	6.8	29.4	52.0	20.0	30.5	41.0	9.0	17.0	25.0	34.8	36.3	37.9	33.0	35.0	36.9	36.9	38.9	40.9			
Bankfull Mean Depth (ft)	0.47	0.34	0.53	0.72	0.60	0.85	1.10	0.30	0.45	0.60	0.46	0.53	0.59	0.34	0.38	0.42	0.37	0.4	0.52			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.40	0.70	1.00	0.68	0.74	0.80	0.58	0.59	0.59	0.79	0.9	1.04			
Bankfull Cross Sectional Area (ft2)	4.10	5.5	7.7	9.9	10.2	21.6	33.0	3.0	4.5	6.0	3.1	3.5	3.8	2.5	2.7	2.9	2.7	3.2	3.7			
Width/Depth Ratio	-----	2.1	5.1	8.1	10.7	18.9	27.0	10.0	12.0	14.0	11.0	12.8	14.5	16.7	20.0	23.2	13.6	16.7	19.7			
Entrenchment Ratio	-----	1.9	4.8	7.7	1.3	2.3	3.2	-----	3.0	-----	4.8	5.3	5.8	4.2	5.0	5.7	4.6	5.2	5.8			
Bank Height Ratio	-----	1.0	1.5	1.9	1.0	1.0	1.0	1.0	1.1	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	2.6	2.9	3.2	3.4	3.8	4.1	2.7	3.2	3.7			
Pattern																						
Channel Beltwidth (ft)	-----	-----	-----	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	-----	-----	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	-----	-----	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	-----	-----	-----	1.10	2.60	4.10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	11	17	24	11	15	22	11	15	19			
Riffle Slope (ft/ft)	-----	0.022	0.030	0.038	0.200	0.138	0.076	0.023	0.042	0.061	0.018	0.066	0.104	0.037	0.061	0.080	0.022	0.042	0.063			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	2	4	6	2	5	8	7	9	11			
Pool Spacing (ft)	-----	-----	-----	-----	42	137	231	9	13	17	20	23	26	18	21	24	19	23	24			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----		----		-6/14/31-39/51-88/110-21				----			---			---			---					
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.53	-----	-----	0.53	-----	-----	0.53	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.54	-----	-----	1.98	-----	-----	1.69	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	685	-----	-----	-----	-----	-----	654	-----	-----	656	-----	-----	656	-----	-----	656	-----			
Drainage Area (SM)	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----			
Rosgen Classification	-----	-----	B4/G	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	10-12	-----	-----	-----	----	----	----	3	7	10	-----	10	-----	-----	10	-----	-----	10	-----			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	----	1.04	----	-----	1.04	-----	-----	1.04	-----	-----	1.04	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.046	-----	-----	0.046	-----	-----	0.048	-----			

Table 13. Stream Reach Morphology and Hydraulic Data

Elk Branch Mitigation Project #92665

Stream Reach Data Summary
UT2 to Elk Branch

Parameter	Regional Curve Equation	Pre-Existing Condition			Reference Reach(es) Data			Design			As-Built			Monitoring Year 1			Monitoring Year 2			Monitoring Year 3		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	3.70	3.5	7.7	11.9	11.7	19.7	27.6	3.0	5.7	8.4	----	5.4	----	----	5.8	----	----	5.2	----			
Floodprone Width (ft)	-----	6.8	29.4	52.0	20.0	30.5	41.0	9.0	17.0	25.0	----	38.9	----	----	36.9	----	----	39.5	----			
Bankfull Mean Depth (ft)	0.28	0.34	0.53	0.72	0.60	0.85	1.10	0.30	0.45	0.60	----	0.52	----	----	0.44	----	----	0.55	----			
Bankfull Max Depth (ft)	-----	0.90	1.30	1.70	0.90	1.70	2.50	0.40	0.70	1.00	----	0.86	----	----	0.76	----	----	0.84	----			
Bankfull Cross Sectional Area (ft2)	1.50	5.5	7.7	9.9	10.2	21.6	33.0	3.0	4.5	6.0	----	2.8	----	----	2.6	----	----	2.9	----			
Width/Depth Ratio	-----	2.1	5.1	8.1	10.7	18.9	27.0	10.0	12.0	14.0	----	10.3	----	----	13.3	----	----	9.5	----			
Entrenchment Ratio	-----	1.9	4.8	7.7	1.3	2.3	3.2	-----	3.0	-----	----	7.2	----	----	6.3	----	----	7.6	----			
Bank Height Ratio	-----	1.0	1.5	1.9	1.0	1.0	1.0	1.0	1.1	1.1	----	1.0	----	----	1.0	----	----	1.0	----			
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.1	----	----	2.3	----	----	2.1	----			
Pattern																						
Channel Beltwidth (ft)	-----	-----	-----	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Radius of Curvature (ft)	-----	-----	-----	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Wavelength (ft)	-----	-----	-----	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Meander Width Ratio	-----	-----	-----	-----	1.1	2.6	4.1	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----			
Profile																						
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	9	12	14	9	13	15	10	13	15			
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.190	0.475	0.760	0.023	0.042	0.061	0.026	0.050	0.080	0.038	0.048	0.056	0.042	0.054	0.065			
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	3	7	11	4	7	9	8	10	12			
Pool Spacing (ft)	----	-----	-----	-----	42	137	231	9	26	42	15	22	27	18	21	24	19	21	23			
Substrate and Transport Parameters																						
d16 / d35 / d50 / d84 / d95	-----		----		1-6/14/31-39/51-88/110				---			---			---			---				
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.1	-----	-----	0.9	-----	-----	0.9	-----			
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.3	-----	-----	2.1	-----	-----	1.9	-----			
Additional Reach Parameters																						
Channel length (ft)	-----	-----	185	-----	-----	-----	-----	-----	244	-----	-----	241	-----	-----	241	-----	-----	241	-----			
Drainage Area (SM)	-----	-----	0.01	-----	0.45	1.025	1.60	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----			
Rosgen Classification	-----	-----	B4/G	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----			
Bankfull Discharge (cfs)	2-3	-----	-----	-----	----	-----	----	-----	6	-----	-----	6	-----	-----	6	-----	-----	6	-----			
Sinuosity	-----	1.02	1.06	1.10	1.10	1.15	1.19	-----	1.04	-----	-----	1.04	-----	-----	1.04	-----	-----	1.04	-----			
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.039	-----	-----	0.039	-----	-----	0.040	-----			

Table 14. Cross-Section Morphology and Hydraulic Data
Elk Branch Mitigation Project #92665

	Elk Branch - Reach 1						Elk Branch - Reach A											
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)	6.1	5.5	5.2				6.0	5.7	5.1				8.1	7.3	8.2			
Floodprone Width (ft)	30.9	24.3	26.4				32.5	32.5	32.5				34.6	32.5	35.6			
BF Cross Sectional Area (ft2)	4.1	2.6	2.7				7.3	6.3	4.8				4.2	2.9	3.4			
BF Mean Depth (ft)	0.67	0.46	0.51				1.22	1.1	0.93				0.51	0.4	0.42			
BF Max Depth (ft)	0.98	0.72	0.89				2.16	1.79	1.48				0.83	0.8	0.95			
Width/Depth Ratio	9.0	12.0	10.1				4.9	5.1	5.5				15.8	18.4	19.6			
Entrenchment Ratio	5.1	4.4	5.1				5.4	5.7	6.4				4.3	4.4	4.3			
Wetted Perimeter (ft)	7.4	6.5	6.2				8.5	7.9	7.0				9.1	8.1	9.1			
Hydraulic Radius (ft)	0.6	0.4	0.4				0.9	0.8	0.7				0.5	0.4	0.4			
Substrate																		
d50 (mm)																		
d84 (mm)																		

	Elk Branch - Reach B					
Parameter	Cross Section 4 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5
Dimension						
BF Width (ft)	8.7	8.3	9.44			
Floodprone Width (ft)	45.0	46.5	45.20			
BF Cross Sectional Area (ft2)	5.7	4.4	4.90			
BF Mean Depth (ft)	0.65	0.53	0.52			
BF Max Depth (ft)	0.95	0.75	0.98			
Width/Depth Ratio	13.3	15.6	18.0			
Entrenchment Ratio	5.2	5.6	4.8			
Wetted Perimeter (ft)	10.0	9.3	10.5			
Hydraulic Radius (ft)	0.6	0.5	0.5			

Parameter	AB (2011)			MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	5	64	36	12	64	29	11	64	34									
Riffle Slope (ft/ft)	0.010	0.045	0.025	0.005	0.041	0.027	0.008	0.039	0.021									
Pool Length (ft)	3	14	7	2	13	9	8.1	13.8	11.8									
Pool Spacing (ft)	10	57	44	15	55	45	16.6	56.2	43.9									
Substrate																		
d50 (mm)		17			27			30										
d84 (mm)		38			69			72										
Additional Reach Parameters																		
Valley Length (ft)		2121			2121			2121										
Channel Length (ft)		1946			1946			1946										
Sinuosity		1.09			1.09			1.09										
Water Surface Slope (ft/ft)		0.027			0.027			0.029										
BF Slope (ft/ft)	0.021	0.033	0.027	0.023	0.032	0.028	0.021	0.029	0.025									
Rosgen Classification		B4			B4			B4										

Table 14. Cross-Section Morphology and Hydraulic Data
Elk Branch Mitigation Project #D06125-B

Parameter	Elk Branch - Reach 2					
	Cross Section 5 Pool					
	AB	MY1	MY2	MY3	MY4	MY5
Dimension						
BF Width (ft)	9.2	9.0	10.29			
Floodprone Width (ft)	43.8	44.2	44.1			
BF Cross Sectional Area (ft2)	9.0	8.7	10.40			
BF Mean Depth (ft)	0.98	0.96	1.01			
BF Max Depth (ft)	2.02	2.11	2.49			
Width/Depth Ratio	9.3	9.4	10.2			
Entrenchment Ratio	4.8	4.9	4.3			
Wetted Perimeter (ft)	11.1	11.0	12.3			
Hydraulic Radius (ft)	0.8	0.8	0.8			
Substrate						
d50 (mm)						
d84 (mm)						

Parameter	AB (2011)			MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	19	40	31	19	40	30	17	38	27									
Riffle Slope (ft/ft)	0.021	0.039	0.026	0.021	0.041	0.025	0.018	0.049	0.024									
Pool Length (ft)	7	11	9	5	14	10	9	12	11									
Pool Spacing (ft)	31	48	40	33	45	40	39	48	42									
Substrate																		
d50 (mm)	---			---			---											
d84 (mm)	---			---			---											
Additional Reach Parameters																		
Valley Length (ft)	304			304			304											
Channel Length (ft)	279			279			279											
Sinuosity	1.09			1.09			1.09											
Water Surface Slope (ft/ft)	0.027			0.027			0.028											
BF Slope (ft/ft)	0.017	0.024	0.021	0.023			0.023											
Rosgen Classification	B4/Eb4			B4/Eb4			B4/Eb4											

Table 14. Cross-Section Morphology and Hydraulic Data
Elk Branch Mitigation Project #D06125-B

UT1

Parameter	Cross Section 1 Riffle						Cross Section 2 Riffle						Cross Section 3 Riffle						Cross Section 4 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																								
BF Width (ft)	6.7	6.5	7.3				6.5	6.96	7.0				7.3	7.79	8.3				9.4	10.3	9.9			
Floodprone Width (ft)	35.7	36.89	36.9				37.6	34.75	40.9				34.8	33.03	37.8				45.2	45.88	45.9			
BF Cross Sectional Area (ft2)	3.1	2.45	2.7				3.8	2.91	3.6				3.6	2.61	3.7				11.9	12.36	11.7			
BF Mean Depth (ft)	0.46	0.38	0.37				0.59	0.42	0.52				0.5	0.34	0.45				1.3	1.2	1.2			
BF Max Depth (ft)	0.68	0.58	0.79				0.8	0.59	0.93				0.71	0.91	1.04				2.2	2.2	2.3			
Width/Depth Ratio	14.7	17.3	19.7				11.0	16.67	13.6				14.5	23.2	18.3				7.5	8.58	8.3			
Entrenchment Ratio	5.3	5.7	5.1				5.8	5.0	5.8				4.8	4.2	4.6				4.8	4.45	4.7			
Wetted Perimeter (ft)	7.7	7.3	8.0				7.7	7.8	8.1				8.3	8.5	9.2				11.9	12.7	12.2			
Hydraulic Radius (ft)	0.41	0.34	0.34				0.50	0.37	0.45				0.44	0.31	0.40				1.00	0.97	0.96			
Substrate																								
d50 (mm)																								
d84 (mm)																								

Parameter	AB (2011)			MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	11	24	15	11	22	14	11	19	16									
Riffle Slope (ft/ft)	0.018	0.104	0.080	0.037	0.080	0.063	0.022	0.064	0.044									
Pool Length (ft)	2	6	4	2	8	5	7	11	10									
Pool Spacing (ft)	31	26	23	18	24	22	19	24	23									
Substrate																		
d50 (mm)	----			----			----											
d84 (mm)	----			----			----											
Additional Reach Parameters																		
Valley Length (ft)	662			662			662											
Channel Length (ft)	683			683			683											
Sinuosity	1.04			1.04			1.04											
Water Surface Slope (ft/ft)	0.049			0.046			0.046											
BF Slope (ft/ft)	0.046			0.046			0.048											
Rosgen Classification	B			B			B											

Table 14. Cross-Section Morphology and Hydraulic Data
Elk Branch Mitigation Project #D06125-B

UT2

Parameter	Cross Section 1 Riffle						Cross Section 2 Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	5.4	5.8	5.2				7.9	7.4	6.5			
Floodprone Width (ft)	38.9	36.9	39.5				34.0	34.0	34.1			
BF Cross Sectional Area (ft2)	2.8	2.6	2.9				6.6	5.9	5.9			
BF Mean Depth (ft)	0.52	0.44	0.55				0.83	0.80	0.91			
BF Max Depth (ft)	0.86	0.76	0.84				1.49	1.40	1.50			
Width/Depth Ratio	10.3	13.3	9.5				9.5	9.3	7.2			
Entrenchment Ratio	7.2	6.3	7.6				4.3	4.6	5.2			
Wetted Perimeter (ft)	6.4	6.7	6.3				9.6	9.0	8.3			
Hydraulic Radius (ft)	0.4	0.4	0.5				0.7	0.7	0.7			
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2011)			MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	9	14	13	9	15	13	10.00	14.90	14.20									
Riffle Slope (ft/ft)	0.026	0.080	0.047	0.038	0.056	0.050	0.042	0.065	0.054									
Pool Length (ft)	3	11	5	4	9	7	8	12	9									
Pool Spacing (ft)	15	27	23	18	24	22	19	23	20									
Substrate																		
d50 (mm)		----			----			----			----			----			----	
d84 (mm)		----			----			----			----			----			----	
Additional Reach Parameters																		
Valley Length (ft)		320			320			320										
Channel Length (ft)		241			241			241										
Sinuosity	----	1.04	----	----	1.04	----	----	1.04	----									
Water Surface Slope (ft/ft)	----	0.038	----	----	0.038	----	----	0.039	----									
BF Slope (ft/ft)	0.039	0.049	0.044		0.039			0.040										
Rosgen Classification		B4			B4			B4										

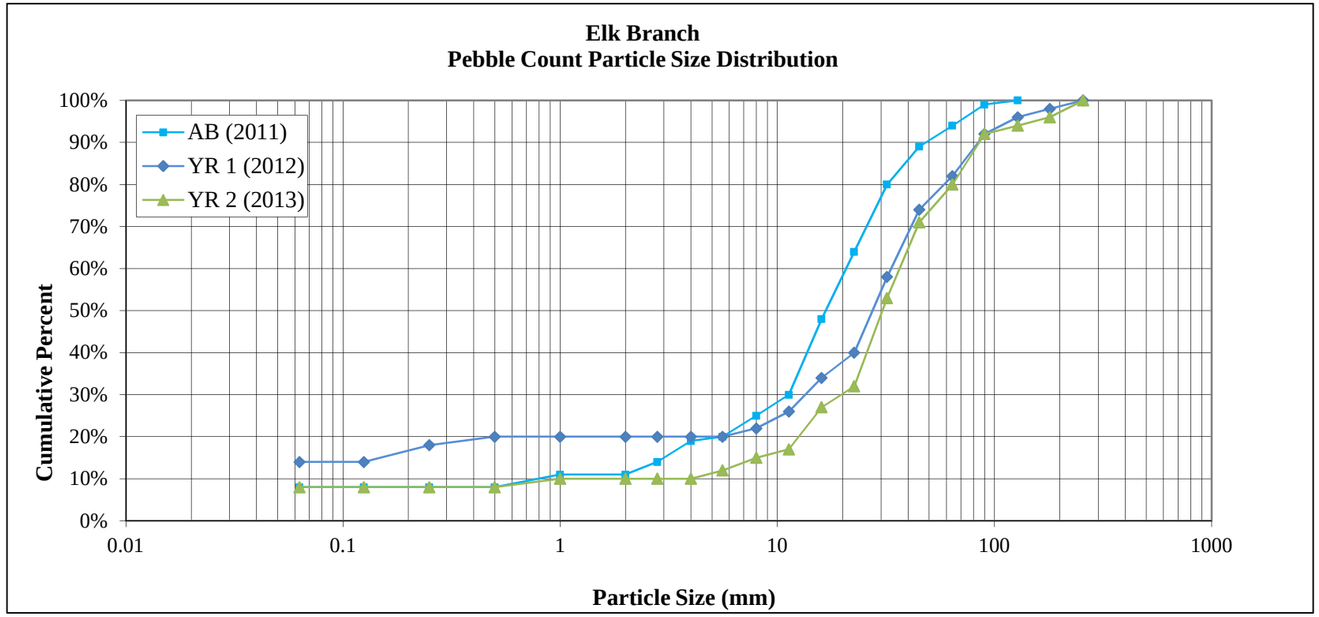
Notes:

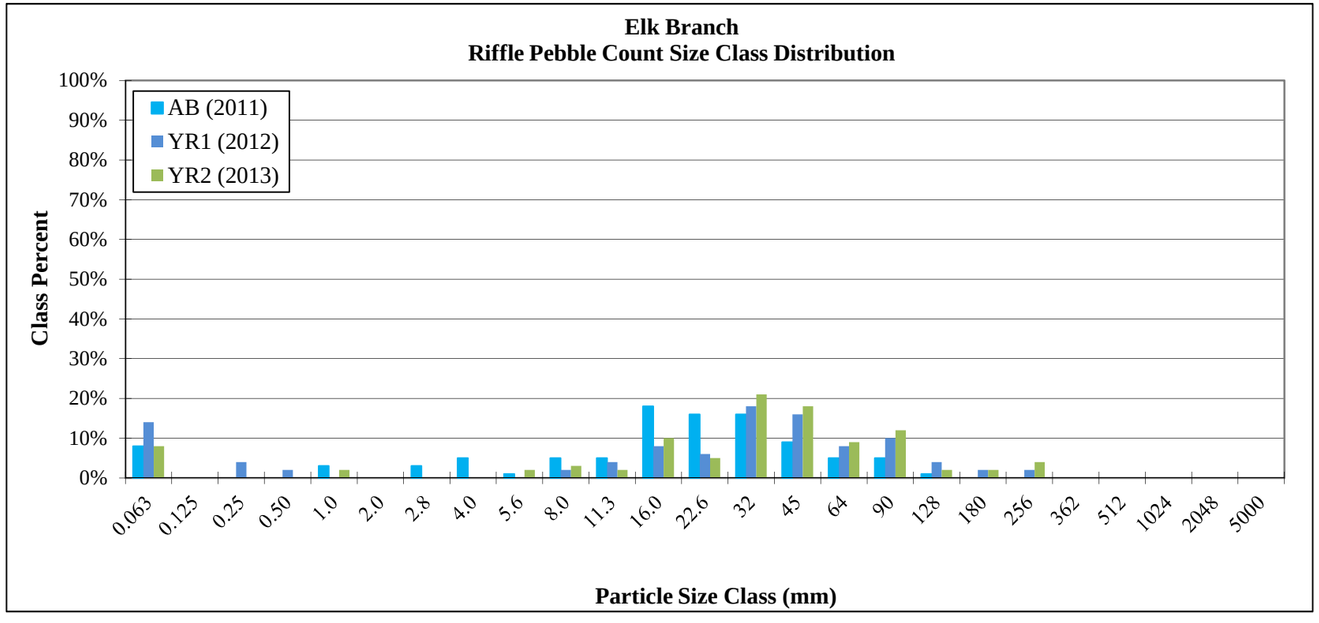
Figure B1. Elk Branch Pebble Count
Elk Branch Mitigation Project, EEP# 92665

SITE OR PROJECT:	Elk Branch
REACH/LOCATION:	Mainstem, Riffle below PPT16
FEATURE:	Riffle

			2013		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt / Clay	Silt / Clay	< .063	8	14%	14%
Sand	Very Fine	.063 - .125			14%
	Fine	.125 - .25		4%	18%
	Medium	.25 - .50		2%	20%
	Coarse	.50 - 1.0	2		20%
	Very Coarse	1.0 - 2.0			20%
Gravel	Very Fine	2.0 - 2.8			20%
	Very Fine	2.8 - 4.0			20%
	Fine	4.0 - 5.6	2		20%
	Fine	5.6 - 8.0	3	2%	22%
	Medium	8.0 - 11.0	2	4%	26%
	Medium	11.0 - 16.0	10	8%	34%
	Coarse	16 - 22.6	5	6%	40%
	Coarse	22.6 - 32	21	18%	58%
	Very Coarse	32 - 45	18	16%	74%
	Very Coarse	45 - 64	9	8%	82%
Cobble	Small	64 - 90	12	10%	92%
	Small	90 - 128	2	4%	96%
	Large	128 - 180	2	2%	98%
	Large	180 - 256	4	2%	100%
Boulder	Small	256 - 362			
	Small	362 - 512			
	Medium	512 - 1024			
	Large-Very Large	1024 - 2048			
Bedrock	Bedrock	> 2048			
Total% of Whole Count			100	100	100

Summary Data	
Channel Materials	
D_{50} =	30.45
D_{84} =	71.70
D_{95} =	151.79





Elk Branch
Photo Log - Reference Photo Points

Notes: Photos for Elk Branch were taken November 2013.

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. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

Photo Point 5: looking downstream

Photo Point 6: looking upstream

Photo Point 6: looking downstream

Photo Point 7: looking upstream

Photo Point 7: looking downstream

Photo Point 8: looking upstream

Photo Point 8: looking downstream

Photo Point 9: looking upstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

Photo Point 11: looking downstream

Photo Point 12: looking upstream

Photo Point 13: looking upstream

Photo Point 13: looking downstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Photo Point 15: looking upstream

Photo Point 15: looking downstream

Photo Point 16: looking upstream

Photo Point 16: looking downstream

Photo Point 17: looking upstream

Photo Point 17: looking downstream

Photo Point 18: looking upstream

Photo Point 18: looking downstream

Photo Point 19: looking upstream

Photo Point 19: looking downstream

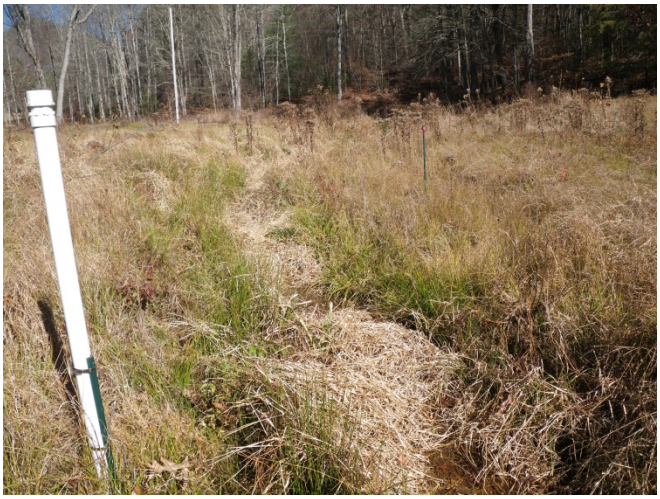


Photo Point 20: looking upstream

Photo Point 20: looking downstream

UT1 to Elk Branch
Photo Log - Reference Photo Points

Notes: Photos for UT1 to Elk Branch were taken November 2013

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. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream

UT2 to Elk Branch
Photo Log - Reference Photo Points

Notes: Photos for UT2 to Elk Branch were taken November 2013.

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. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 4: looking downstream

Photo Point 5: looking upstream