Elk Branch Restoration Project

Year 4 Monitoring Report

Mitchell County, North Carolina

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

Monitoring Firm POC: Micky Clemmons

Prepared for: North Carolina Division of Mitigation Services (NCDMS)

NCDMS Project Manager: Matthew Reid

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

797 Haywood Road, Suite 201

Asheville, NC 28806

Contract Number: D06125-C,

DMS Project Number: 92665

Project Construction: 2011

Data Collection Period: October 2015

Date Submitted: November 2015

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EXECUTIVE SUMMARY

The Elk Branch site was restored through a full delivery contract with the North Carolina Division of Mitigation Services (NCDMS). This report presents Year 4 monitoring data as part of the five-year monitoring period. The goals for the restoration project are 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 4 vegetation monitoring indicated an average survival rate of 493 planted stems per acre with an additional four volunteers observed. The data shows that the Site has met the interim stem survival criteria for Year 3 (320 stems per acre) and should meet the final success criteria of 260 trees per acre by the end of Year 5. Due to the low survival of trees in some of the riparian zone during Year 3 monitoring, supplemental plantings were established by RiverWorks.

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 having 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 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 is one minor area of encroachment but no major project issues or concerns to report at this time. Narrative background and supporting information can be found in previous reports that are available on DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS 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 Resources (NCDWR) 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 nutrients 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) of channel, 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 flowed 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 becomes Cane Creek Road. Continue on Cane Creek Road another 0.7 miles, then turn left off of Cane Creek Road onto Nora Lane (SR 1219). Continue on Nora Lane for .65 miles where Nora Lane ends in a turn around with a private drive continuing north onto the Wylie property (and the upstream point of the project) and to the west of the turnaround Annies Cove (a dead end) diverges. The Hall property (UT1 is on the Hall property) is accessed from Annies Cove. The project site begins just below a spring head at the top of the valley on the Wylie property, approximately 1,500 feet beyond the end of Nora Road (unpaved) and the project along the mainstem ends where it crosses under Annies Cove.

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.

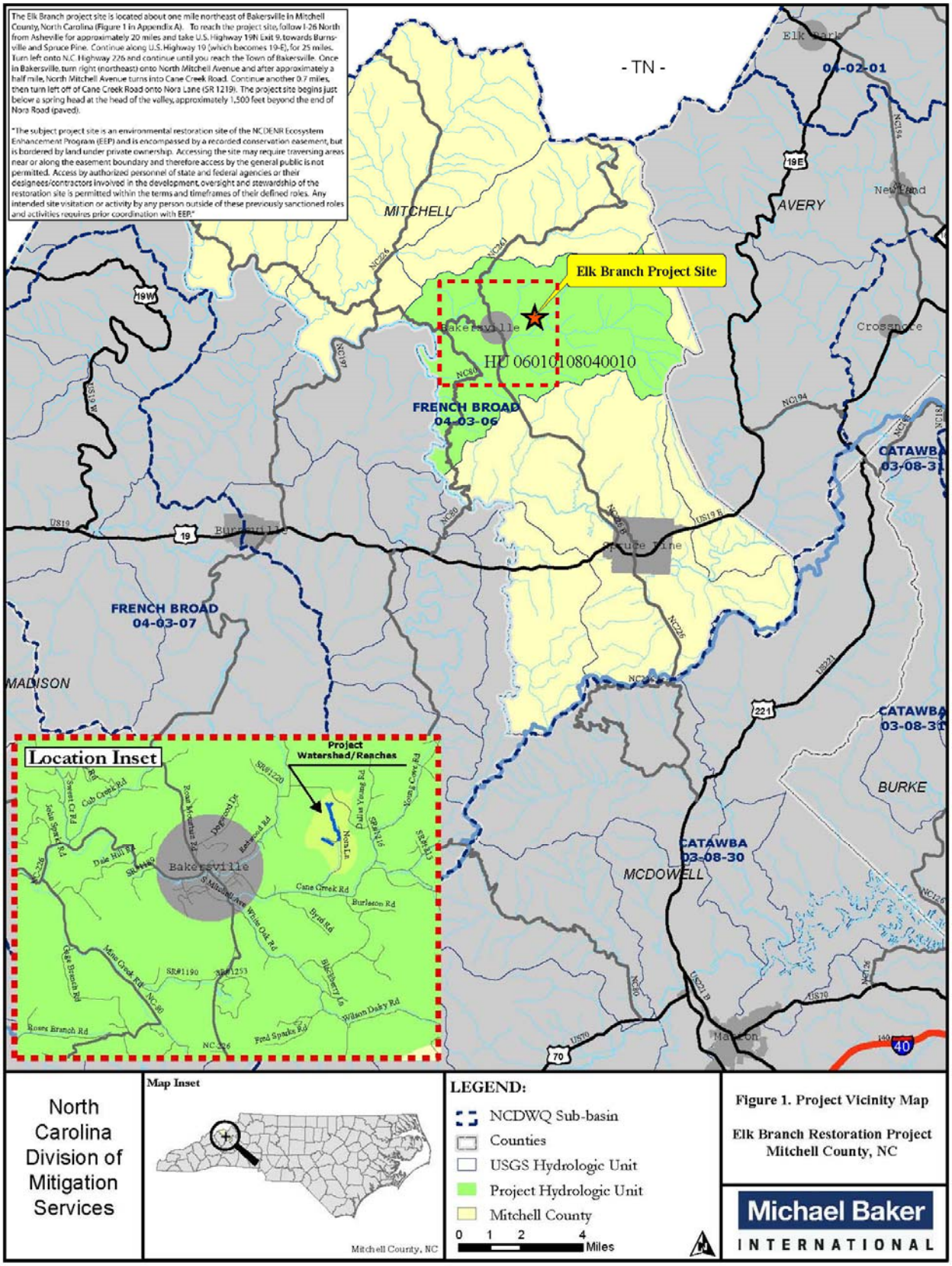

The Elk Branch project site is located about one mile northeast of Bakersville in Mitchell County, North Carolina (Figure 1 in Appendix A). To reach the project site, follow I-26 North from Asheville for approximately 20 miles and take U.S. Highway 19N Exit 9, towards Burnsville and Spruce Pine. Continue 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).
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.
- TN -
MITCHELL
AVERY
MADISON
BURKE
MCDOWELL
Elk Branch Project Site
HU 060101080400 10
FRENCH BROAD 04-03-06
FRENCH BROAD 04-03-07
CATAWBA 03-08-30
CATAWBA 03-08-31
04-02-01
Bakersville
Burnsville
Spruce Pine
Crossnore
Newland
Marion
Location Inset
Project Watershed/Ranches
Cane Creek Rd
Burleson Rd
Byrd Rd
White Oak Rd
Wilson Dairy Rd
Fred Sparks Rd
Rogers Branch Rd
Mine Creek Rd
Bike Berry Ln
Nora Ln
Young Cow Ln
Dale Hill Rd
Cobb Creek Rd
Redwood Rd
Deerwood Dr
Rose Mountain Rd
SR#1220
SR#1253
SR#1190
NC 80
NC 226
Map Inset
Mitchell County, NC
LEGEND:
NCDWQ Sub-basin
Counties
USGS Hydrologic Unit
Project Hydrologic Unit
Mitchell County
0 1 2 4 Miles
North Carolina Division of Mitigation Services
Figure 1. Project Vicinity Map
Elk Branch Restoration Project
Mitchell County, NC
Michael Baker INTERNATIONAL

Table 1. Project Mitigation Structure and Objectives Elk Branch Mitigation Project-NCDMS 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	PI	Cb4	951 LF	1:1	951	0+76 to 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 to 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 in-stream habitat.
Reach B		R	P1/2		403 LF	1:1	403	16+42 to 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 to 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 in-stream habitat.
UT 1									
Reach 1	685 LF	R	P1	Cb4	656 LF	1:1	656	0+06 to 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	279 LF	R	PI	Eb4	242 LF	1:1	242	0+92 to 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	PI	Cb4	36 LF	1:1	36	0+00 to 0+36	Minor pattern adjustment, extensive improvements to dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via multiple grade control structures and constructed riffles.

Mitigation Unit Summations					
Stream (SMU)	Riparian Wetland (WMU)	Nonriparian Wetland (WMU)	Total Wetland (WMU)	Buffer (BMU)	Comment
2,869	NA	NA	NA		

Notes:
1. Elk Branch R1 was broken into smaller reaches subsequent to the submittal and approval of the restoration plan, following regulatory comments.
2. Mitigation units have been calculated by excluding easement exception on Elk Branch Reach I, Elk Branch Reach B and UT1.

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 a stable channel cross-section that provides 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.

Channel 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. The entire mitigation site is protected through a permanent conservation easement and native vegetation was planted throughout the easement area.

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-NCDMS 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

Table 2. Project Activity and Reporting History Elk Branch Mitigation Project-NCDMS Project #92665		
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
Easement boundary was marked by DMS.		October 2014
Year 3 Monitoring	November /December 2014	February 2015
Supplemental Tree Planting		February 2015
Year 4 Monitoring	October 2015	November 2015
Year 5 Monitoring	--	--

Table 3. Project Contacts Elk Branch Mitigation Project-NCDMS Project #92665	
Principal-In-Charge	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.412.6100
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.412.6100
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
Supplemental Container Trees	Southern Roots Tree Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.412.6100

Table 4. Project Attribute Elk Branch Mitigation Project-NCDMS 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

Table 4. Project Attribute **Elk Branch Mitigation Project-NCDMS Project #92665**	
Within extent of DMS 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
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 break
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

Table 4. Project Attribute Elk Branch Mitigation Project-NCDMS Project #92665	
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
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 major problems areas are present. One minor area of mowing encroachment is shown. Figure 2 illustrates the project as it is delineated by reach.

CE CE — CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

XS — CROSS SECTION

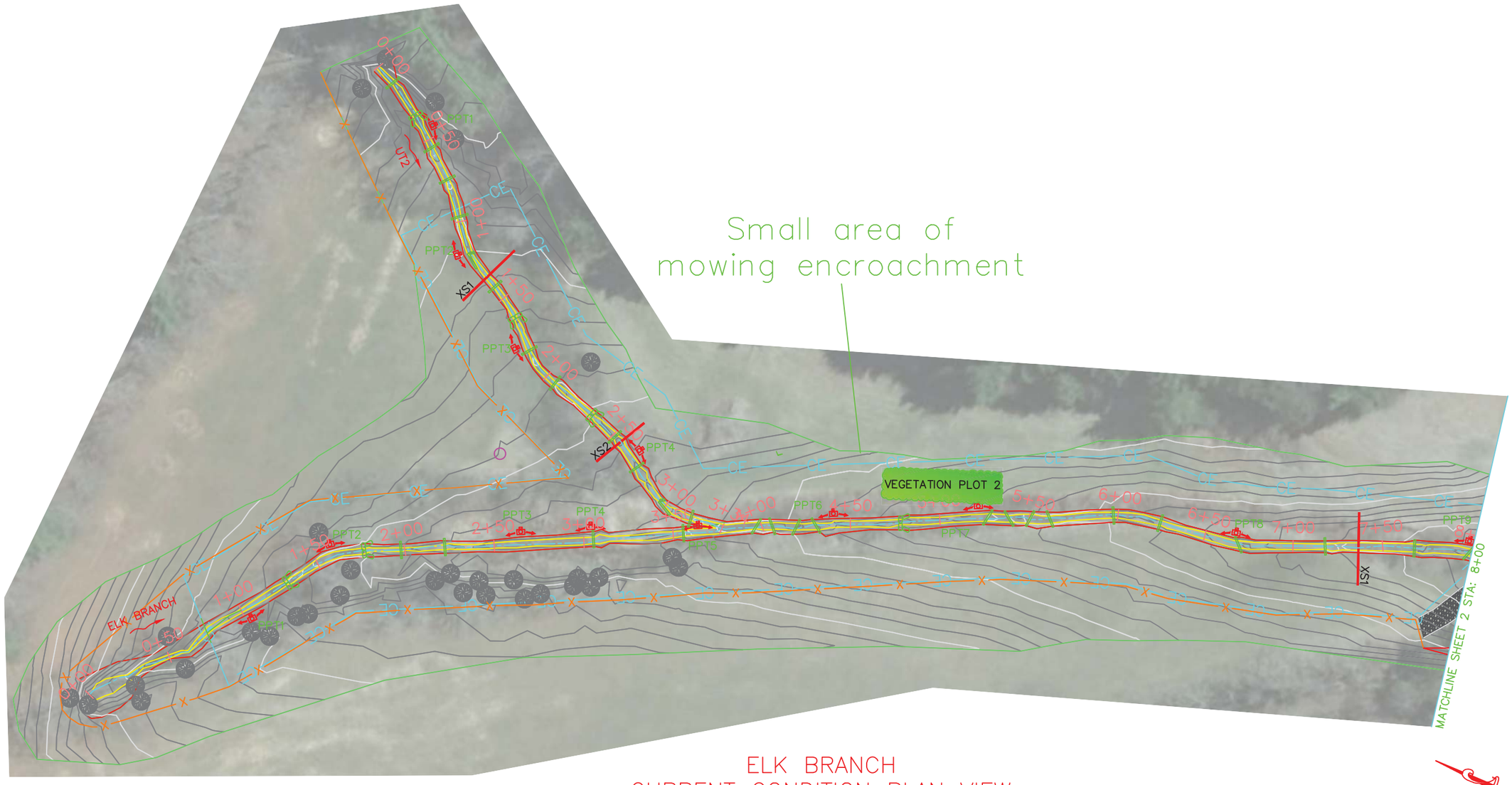
PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA

STREAM PROBLEM AREA (NO AREAS EXHIBITING PROBLEM)



ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING
STA. 0+00–8+00

30 0 30 60
SCALE (FT)

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

Michael Baker INTERNATIONAL

ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING

NORTH CAROLINA DIVISION OF MITIGATION SERVICES

Prepared for:
Division of Mitigation Services
217 West Jones St. Suite 3000A
Raleigh, NC 27603
Phone: 919-707-8976
Fax: 828-232-4420

DMS Project No.	92665
Baker Project No.	111085
Date:	11/09/2015
DESIGNED:	JPM
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	4 of 5
Sheet:	1 of 4

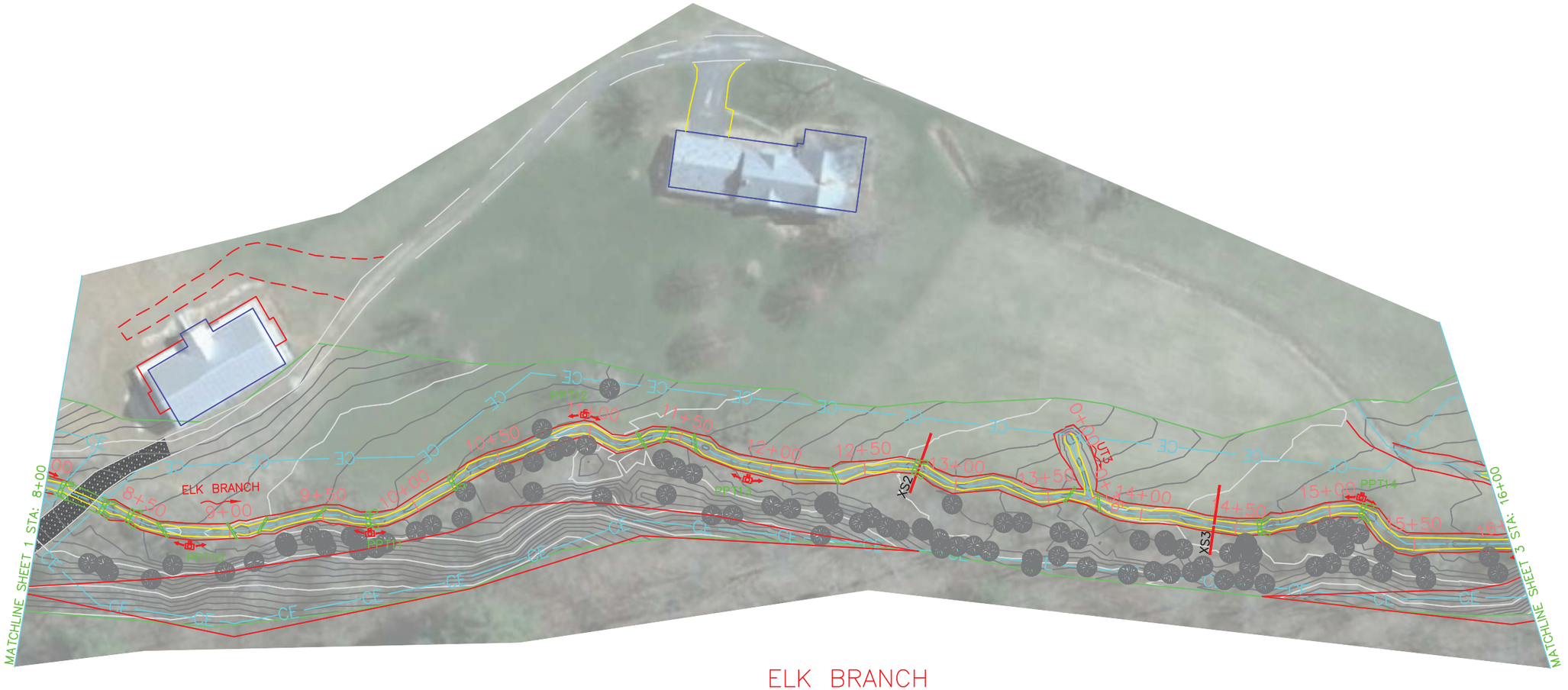
CE CE — CONSERVATION EASEMENT

— — — ASBUILT CENTERLINE

— — — ASBUILT TOP OF BANK

XS — CROSS SECTION

PHOTO ID POINT



ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING
STA. 8+00–16+00

30 0 30 60
SCALE (FT)

Michael Baker Engineering Inc.
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Michael Baker INTERNATIONAL

ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING

NORTH CAROLINA DIVISION OF MITIGATION SERVICES

Prepared for:
Division of Mitigation Services
217 West Jones St. Suite 3000A
Raleigh, NC 27603
Phone 919-707-8976
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APPROVED:	MMC
Monitoring Year:	4 of 5
Sheet:	2 of 4

CE CE — CONSERVATION EASEMENT

ASBUILT CENTERLINE

ASBUILT TOP OF BANK

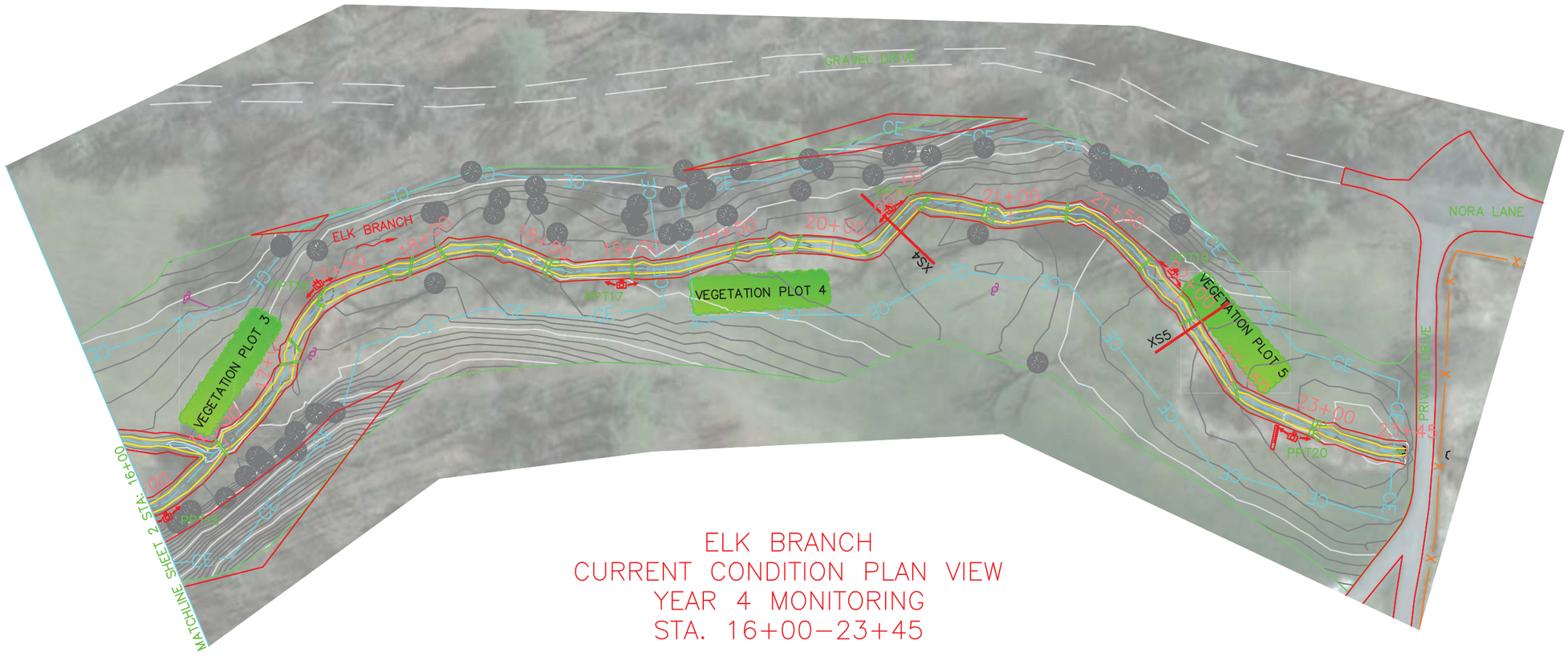
XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA



ELK BRANCH
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING
STA. 16+00–23+45

30 0 30 60
SCALE (FT)

Michael Baker Engineering Inc.
NC Engineering License F-1084
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Michael Baker INTERNATIONAL

ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING

NORTH CAROLINA DIVISION OF MITIGATION SERVICES

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Monitoring Year:	4 of 5
Sheet:	3 of 4

CE CE — CONSERVATION EASEMENT
ASBUILT CENTERLINE
ASBUILT TOP OF BANK

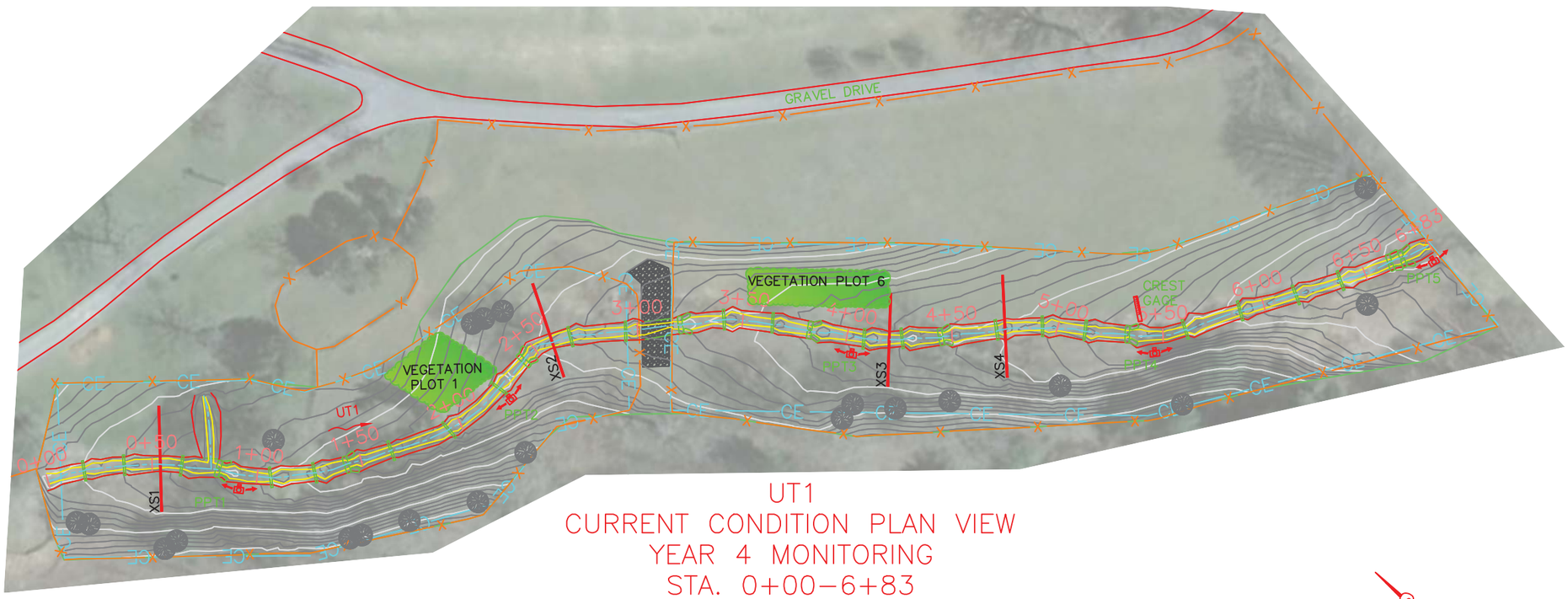
XS — CROSS SECTION

PHOTO ID POINT

VEGETATION PLOT

VEGETATION PLOT MEETING CRITERIA

VEGETATION PLOT NOT MEETING CRITERIA



UT1
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING
STA. 0+00–6+83

30 0 30 60
SCALE (FT)

Michael Baker Engineering Inc.
NC Engineering License F-1084
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Fax: 828.350.1409

Michael Baker INTERNATIONAL

ELK BRANCH RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION PLAN VIEW
YEAR 4 MONITORING

NORTH CAROLINA DIVISION OF MITIGATION SERVICES

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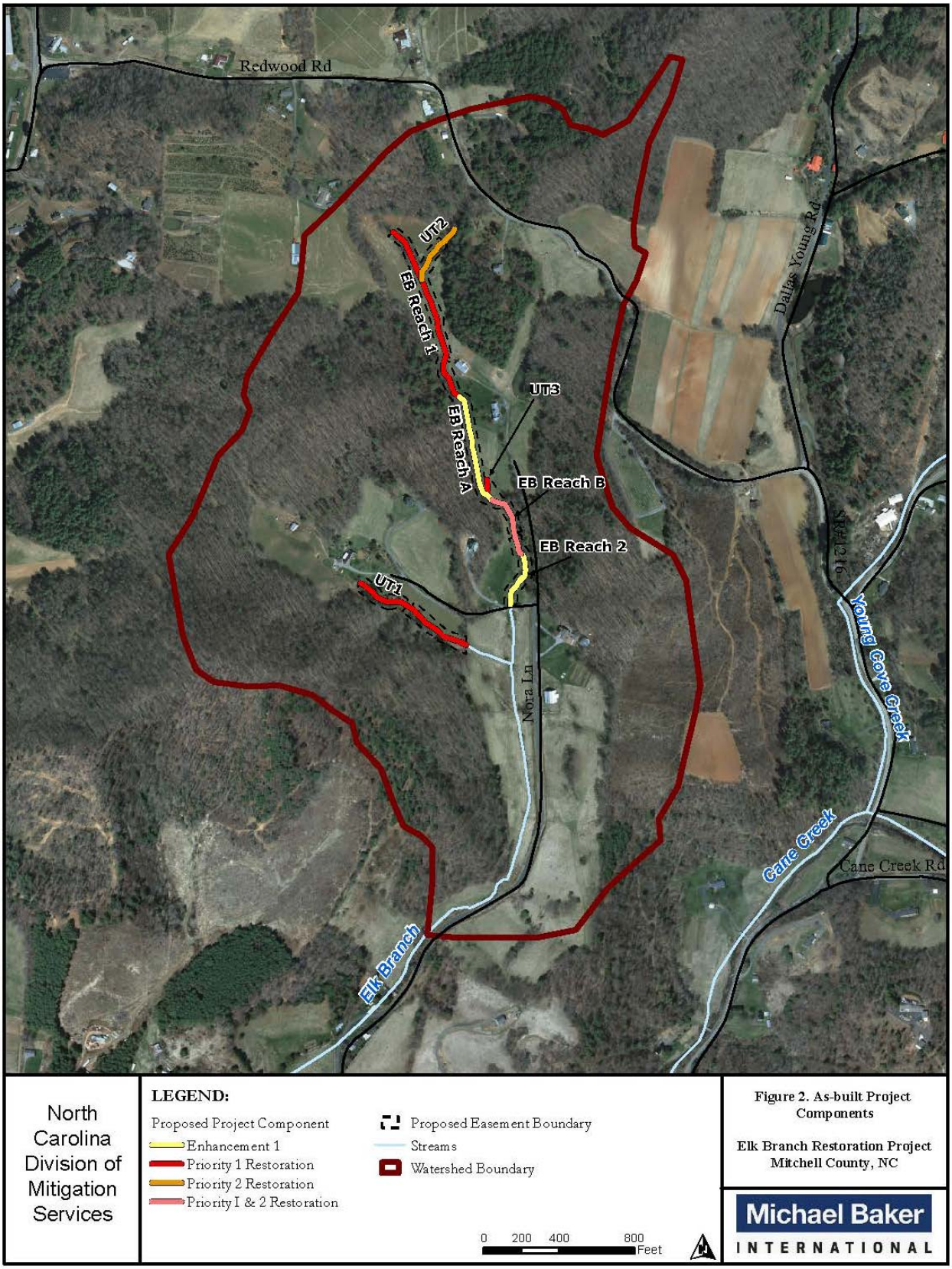
Monitoring Year:	4 of 5
Sheet:	4 of 4


Redwood Rd
UT2
EB Reach 1
EB Reach A
UT3
EB Reach B
EB Reach 2
UT1
Nora Ln
Dallas Young Rd
NC 226
Young Cove Creek
Cane Creek
Cane Creek Rd
Elk Branch
North Carolina Division of Mitigation Services
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
Figure 2. As-built Project Components
Elk Branch Restoration Project
Mitchell County, NC
Michael Baker INTERNATIONAL

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 channel components of the project. The specific locations of vegetation plots, permanent cross-sections, reference photo stations and crest gauges are shown on the Year 4 Current Condition Plan View shown above.

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. Individual quadrant data provided during subsequent monitoring events will include diameter, height, density, and coverage quantities. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Survival 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 plots are taken at least once per year to indicate vegetation condition within the plots. 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 community health, additional plant community indices may be incorporated into the vegetation monitoring plan as requested by the NCDMS.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided excellent ground coverage. Live stakes and bare root trees planted are also 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- NCDMS Project #92665

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Riparian Buffer Plantings				
Trees				
Red Maple	*Acer rubrum*	5	100	FAC
River Birch	*Betula nigra*	5	100	FACW
Shagbark hickory	*Carya ovata*	5	100	FACU
Persimmon	*Diospyros virginiana*	5	100	FAC
Tulip Poplar	*Liriodendron tulipifera*	5	100	FAC
Black gum	*Nyssa sylvatica*	5	100	FAC
Sycamore	*Platanus occidentalis*	5	100	FACW-
White Oak	*Quercus alba*	5	100	FACU
Northern Red Oak	*Quercus rubra*	5	100	FACU
Shrubs				
Tag Alder	*Alnus serrulata*	10	200	OBL
Sweet shrub	*Calycanthus floridus*	10	300	FACU
Ironwood	*Carpinus caroliniana*	5	300	FAC
Flowering Dogwood	*Cornus florida*	5	400	FACU
Hazelnut	*Corylus americana*	5	50	FACU
Witch Hazel	*Hamamelis virginiana*	5	400	FACU
Spicebush	*Lindera benzoin*	5	100	FACW
Elderberry	*Sambucus canadensis*	5	200	FAC
Highbush Blueberry	*Vaccinium sp*	5	200	FACU
Riparian Livestake Plantings *				
Ninebark	*Physocarpus opulifolius*	10	---	FAC-
Elderberry	*Sambucus canadensis*	20	---	FACW-
Black Willow	*Salix nigra*	10 or less	---	OBL
Silky Willow	*Salix sericea*	35	---	OBL
Silky Dogwood	*Cornus amomum*	25	---	FACW+

*Note: Total numbers of livestakes installed was not recorded by the planter.

Table 5a. Supplemental Riparian Buffer Plantings added in February 2015
Elk Branch Mitigation Project- NCDMS Project #92665

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Riparian Buffer Plantings				
Trees				
Red Maple	*Acer rubrum*	8%	50	FAC
Sycamore	*Platanus occidentalis*	23%	150	FACW-
Shrubs				
Tag Alder	*Alnus serrulata*	30%	200	OBL
Button Bush	*Cephalanthus occidentalis*	8%	50	FAC
Silky Dogwood	*Cornus amomum*	8%	50	FACW
Hazelnut	*Corylus americana*	15%	100	FACU
Ninebark	*Physocarpus opulifolius*	8%	50	FAC
Riparian Livestake Plantings				
Silky Dogwood	*Cornus amomum*	30%	150	FACW+
Black Willow	*Salix nigra*	40%	200	OBL
Silky Willow	*Salix sericea*	30%	150	OBL
An additional 25, 3 Gal containerized trees were planted at this time but specific species was not noted. There would have been 3-4 from a mix of River Birch, Red Maple, Sycamore, Green Ash, White Oak, Persimmon, American Elm or American hornbeam planted randomly at the site.				

2.1.2 Soil Data

Table 6. Preliminary Soil Data
Elk Branch Mitigation Project-NCDMS 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 NCDMS 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 Results

Table 7 in Appendix A presents information on the stem counts for each of the vegetation monitoring plots. Data for Year 4 monitoring shows a range of 400 - 680 planted stems per acre, with approximately 98.6% of the stems showing no significant damage. The average density of planted bare root stems, based on data collected from the six monitoring plots during Year 4 monitoring, is 493 stems per acre which indicates that the Site has met the minimum interim success criteria of 320 trees per acre at the end of Year 3 and is on track to meet the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the Year 4 Current Condition Plan View.

As shown in Table 8 (Appendix A), no woody or herbaceous vegetation problem areas were identified during Year 4 monitoring. Although the density of herbaceous cover varies across the site, conditions observed during the Year 4 monitoring found ground cover in the easement area to be sufficient for providing site stabilization. Based on the plot data collected, plots 2, 3 and 4 did not meet the success criteria with 202, 243 and 243 trees per acre, respectively, during Year 3 monitoring, thus there reaches where these plots are located were supplemented with additional trees and shrubs as described in Table 5a. The eventual onset of volunteer trees will further aid in site stabilization and habitat improvements. 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 site stability 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; data and graphics 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 is used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge

of water, and thalweg, if the features are discernible. 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 October of 2015 to document stream dimension for Monitoring Year 4. Cross- sectional data is presented in Appendix B and the location of cross-sections is shown on the Year 4 Current Condition Plan View submitted with this report.

The cross-sections show that there has been little 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, or depending on flow during the year, deepening of pools may also be observed. Based on field observation, the narrowing can be attributed to thick 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 4 were surveyed during October of 2015; 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 baseline survey was completed. Longitudinal profiles are being 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.

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 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. Pool depths have reduced to a minor degree during the 2015 monitoring period. 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 significant change over the course of the monitoring period.

It was noted in the Year 1 monitoring survey data that UT2 had subsurface flow for 103 linear feet. In Year 2 this subsurface flow decreased to one section where the flow was subsurface for 20 linear feet. In Year 3 sampling did not indicate any areas of subsurface flow. In Year 4 we found that water was present in the pools but was not flowing across the riffles. This indicates that the water table has dropped lower than the elevation that supports flow across the riffles. Continuous flow began at Station 2+73 on the profile. This area of the state suffered from draught conditions for much of the spring and summer of 2015 and this is a typical pattern for a headwater, intermittent stream under these conditions. Sediment and fines have moved through the system in that last four years and have helped seal any areas within the bed or around structures where water was discovering a subsurface path to follow. Under normal rainfall conditions this channel carries flow as demonstrated last year. No areas of instability were noted in the project area during Year 4 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 the pebble count exhibit in Appendix B, the pebble count for Reach A of Elk Branch indicates a general coarsening of the bedload and the particle size distribution was very similar to has been seen the last two years. 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 4 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, during different years based on crest gauge readings obtained on the mainstem and

UT1. Information on these events is provided in Table 9 of Appendix B. To date, a bankfull event has been recorded each monitoring year.

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 October 2015. The photographs illustrate stable conditions across the project site. Vegetative growth along the streambanks and riparian buffers has become dense and has improved since construction was completed in 2011. Structures are functioning as designed. While the same photo stations have been maintained, the ability to observe structures is limited at this site due to the thick herbaceous vegetation that overhangs the channel and most of the structures.

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 4 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 4 monitoring data are summarized in Tables 13 and 14 of Appendix B.

2.3 Areas of Concern

There is only one small area of concern due to a mowing encroachment, as shown on page 1 of the current condition plan view. This is at an area along the easement line where the marking posts cannot be seen very well due to a small hill and thick vegetation. We believe this was an accidental encroachment as there are no other similar areas. We plan to add two additional posts to more visibly mark the line in this area.

As previously noted in this report, additional planting was carried out because of our concern that stem density may be insufficient to meet vegetation success criteria at some locations within the project site. Based on Year 3 monitoring data, increasing stem density by additional plantings was unnecessary based on the guidelines and our estimated average density; however, there were some individual veg plots not meeting the criteria and we desire to exceed the average guideline density at closeout. Because wet conditions appear to be the main issue, we supplemented plantings with more wet tolerant species in the areas showing a need.

APPENDIX A

VEGETATION RAW DATA

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

Table 7. Stem Count Arranged by Plot - Year 4

Project Name: Elk Branch Mitigation Project, NCDMS Project Code 92665.

			Current Plot Data (MY4 2015)																		Annual Means											
			E92665-01-0001			E92665-01-0002			E92665-01-0003			E92665-01-0004			E92665-01-0005			E92665-01-0006			MY4 (2015)			MY3 (2014)			MY2 (1714)			MY1 (2012)			MY0 (2012)		
Scientific Name	Common Name	Species Type	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T
Acer rubrum	red maple	Tree	4		4	4		4	1		1	1		1				6		6	16		16	17		17	17		17	19		19	19		19
Alnus serrulata	hazel alder					3		3	3		3	3		3	3		3	1		1	13		13	7		7	7		7	7		7			
Amelanchier arborea	common serviceberry	Tree													1		1				1		1											
Betula nigra	river birch	Tree	1		1				1		1	1		1	1		1				4		4	5		5	5		5	5		5	3		3
Carpinus caroliniana	American hornbeam	Tree							2		2										2		2											
Carya ovata	shagbark hickory	Tree	3		3				1		1	1		1				3		3	8		8	7		7	11		11	15		15	16		16
Catalpa ovata	Chinese catalpa																															1		1
Cornus florida	flowering dogwood	Tree	1		1	2		2													3		3											
Corylus americana	American hazelnut	Shrub																														1		1
Diospyros virginiana	common persimmon	Tree	1		1	1		1													2		2	3		3	3		3	3		3	3		3
Juglans nigra	black walnut	Tree																									1		1	1		1			
Lindera benzoin	northern spicebush	Shrub													2		2				2		2	2		2	2		2	2		2	4		4
Liriodendron tulipifera	tuliptree	Tree	2	3	5							1		1	1		1				4	3	7	2		2	2		2	2		2	4		4
Nyssa sylvatica	blackgum	Tree							1		1										1		1											
Platanus occidentalis	American sycamore	Tree		1	1	4		4				4		4	1		1	1		1	10	1	11	6		6	6		6	7		7	8		8
Quercus rubra	northern red oak	Tree													2		2				2		2	2		2	4		4	5		5	5		5
Salix nigra	black willow	Tree							1		1				1		1				2		2	2		2	2		2	2		2			
Unknown		Shrub or Tree				3		3				1		1							4		4											
Vaccinium	blueberry	Shrub																												1		1	1		1
		Stem count	12	4	16	17	0	17	10	0	10	12	0	12	12	0	12	11	0	11	74	4	78	53		53	60		60	69		69	65		65
		size (ares)	1			1			1			1			1			1			6			6			6			6			6		
		size (ACRES)	0.025			0.025			0.025			0.025			0.025			0.025			0.15			0.15			0.15			0.15			0.15		
		Species count	6	2	7	6	0	6	7	0	7	7	0	7	8	0	8	4	0	4	15	2	15	10	0	10	11	0	11	12	0	12	11	0	11
		Stems per ACRE	480	160	640	680	0	680	400	0	400	480	0	480	480	0	480	440	0	440	493	27	520	353	0	353	400	0	400	460	0	460	433	0	433

P = Planted

V = Volunteer

T = Total

Exceeds requirements by 10%

Includes volunteer stems

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

Feature Issue	Station No.	Suspected Cause	Photo Number
Elk Branch Reach 1 (951 LF)			
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)			
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)			
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 (279 LF)			
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)			
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)			
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)			
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 Projects
Photo Log – Vegetation Plot Photo Points (Year 4)

Notes: Photos for Elk Branch vegetation plots were taken October 20, 2015

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.

Photo 1: Veg. Plot 1

Photo 2: Veg Plot 1, Herbaceous Plot

.

Photo 3: Veg Plot 2

Photo 4: Veg Plot 2: Herbaceous Plot

Photo 5: Veg Plot 3

Photo 6: Veg Plot 3: Herbaceous Plot

Photo 7: Veg Plot 4

Photo 8: Veg Plot 4: Herbaceous Plot

Photo 9: Veg Plot 5

Photo 10: Veg Plot 5: Herbaceous Plot

Photo 11: Veg Plot 6

Photo 12: Veg Plot 6: Herbaceous Plot

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"
11/25/2014	Between 11/27/13 and 11/25/14	Gauge measurement.	1.5"	25.5"*
10/20/2015	Between 11/25/14 and 10/20/2015	Gauge measurement.	11.4"	7.8"

*Cork in the crest gauge was this high on staff but we question accuracy, do believe a banfull flow was recorded.

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	---
3	NONE			---
4	NONE			---

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	2.5	5	0.49	0.86	10.12	1	5.7	2620.5	2620.52

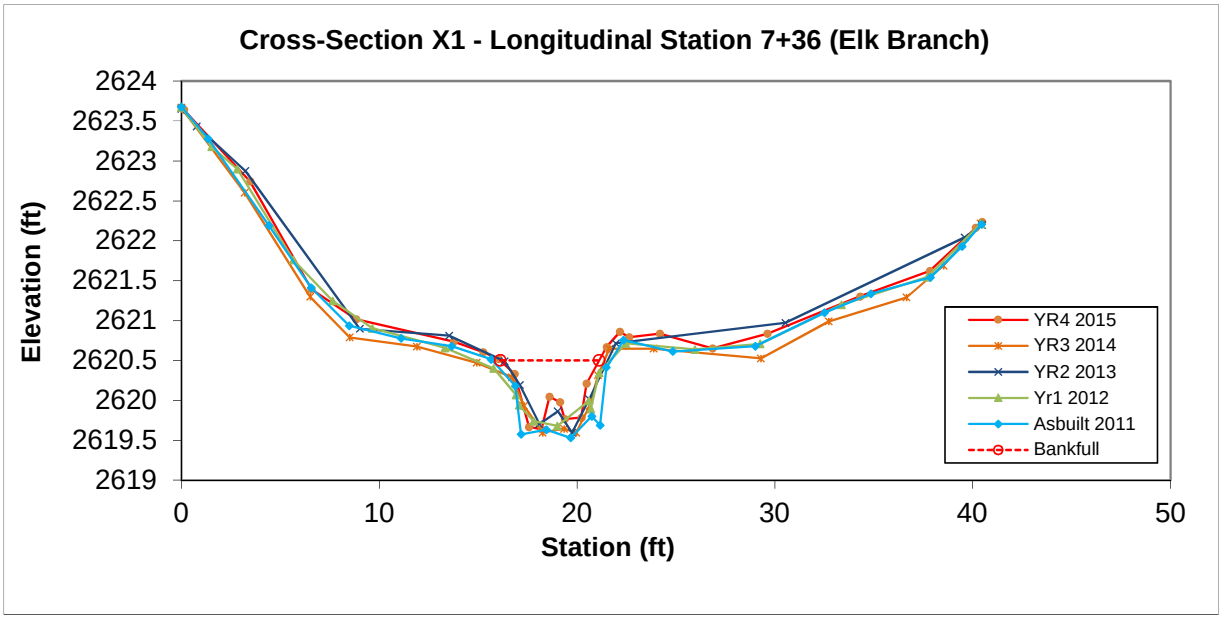


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		7.5	8.51	0.88	2.08	9.69	1	3.8	2604.78	2604.79

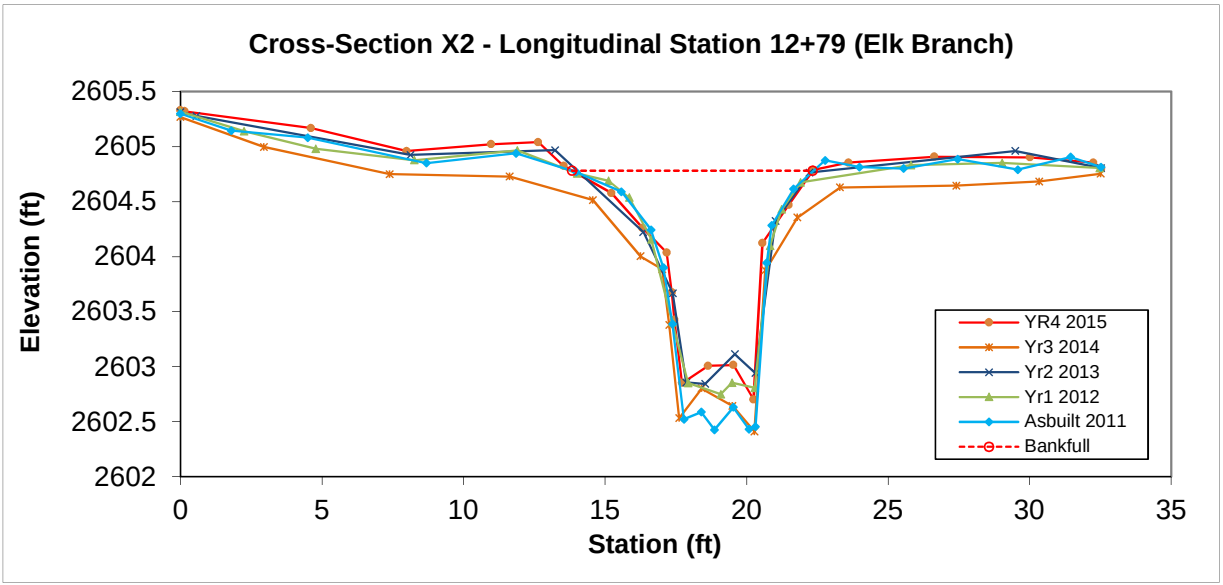


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	2.9	8.11	0.36	0.77	22.44	1.2	4	2599.36	2599.5

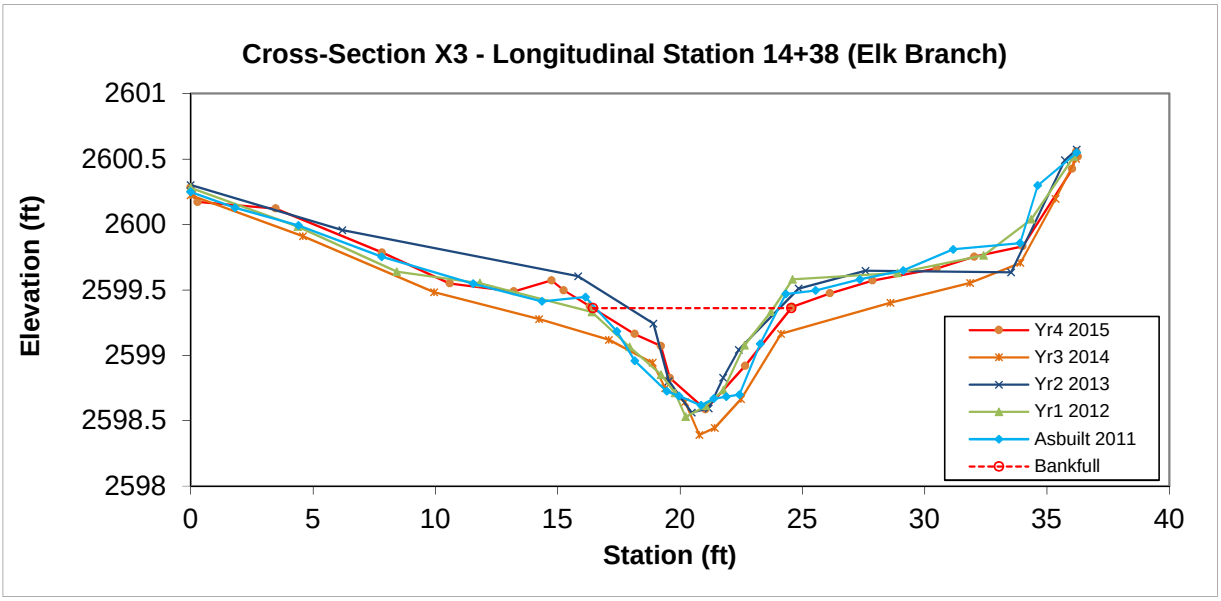


Photo 5: XS-3 facing right bank

Photo 6: XS-3 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	3.8	9.58	0.39	0.64	24.34	1.1	4.4	2587.53	2587.57

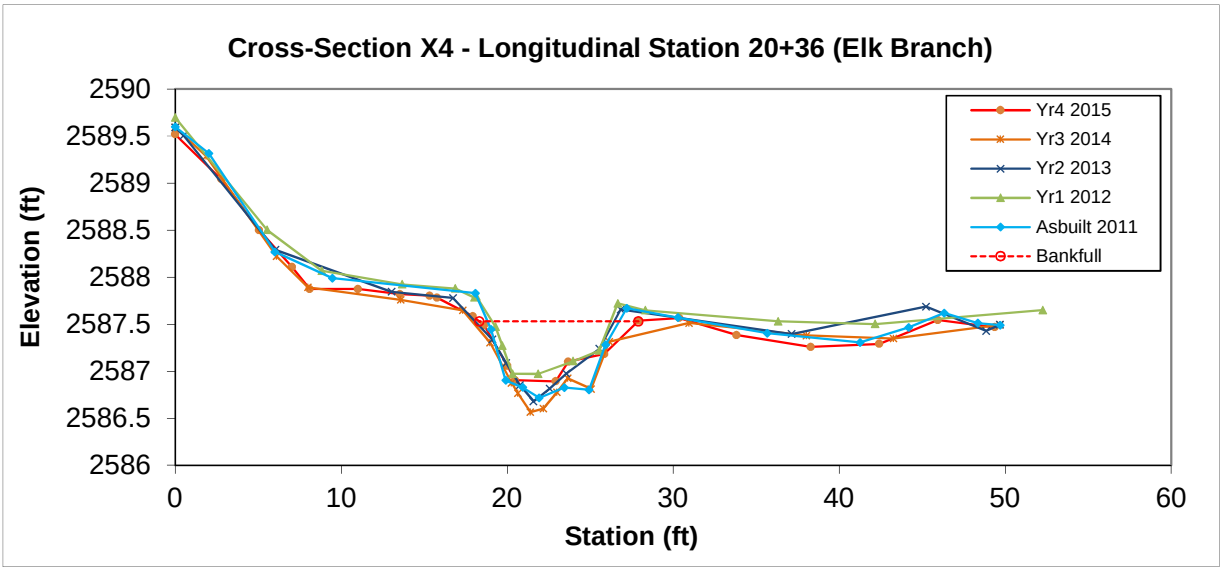


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		6.8	11.44	0.6	1.1	19.19	1	3.8	2583.4	2583.38

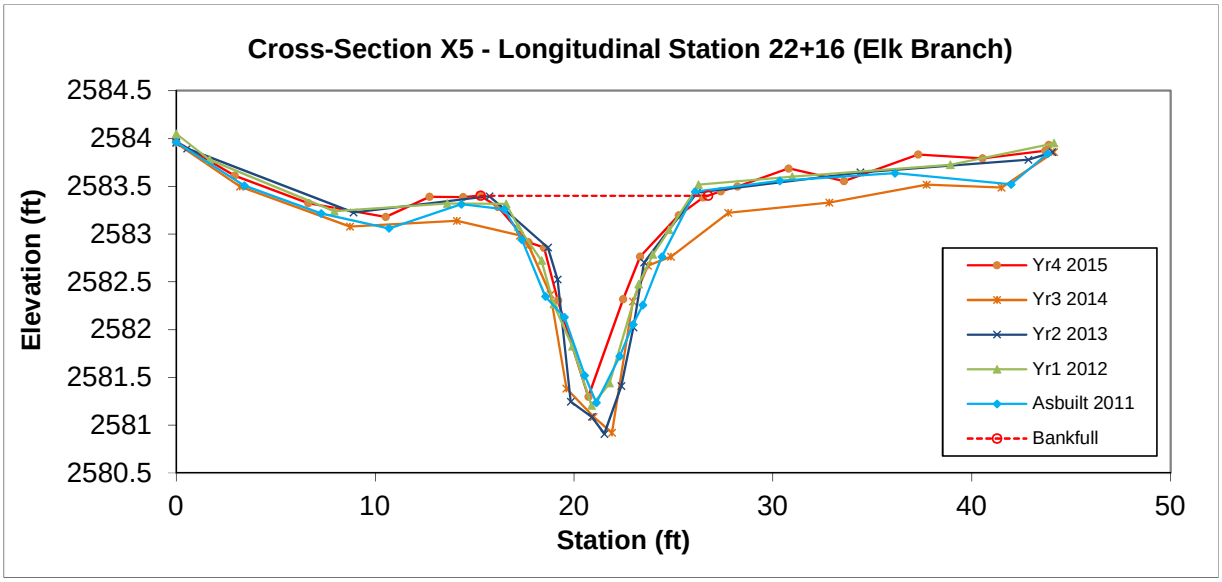


Photo 9: XS-5 facing right bank

Photo 10: XS-5 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B4	2.5	7.88	0.31	0.53	25.31	1	4.3	2608.24	2608.25

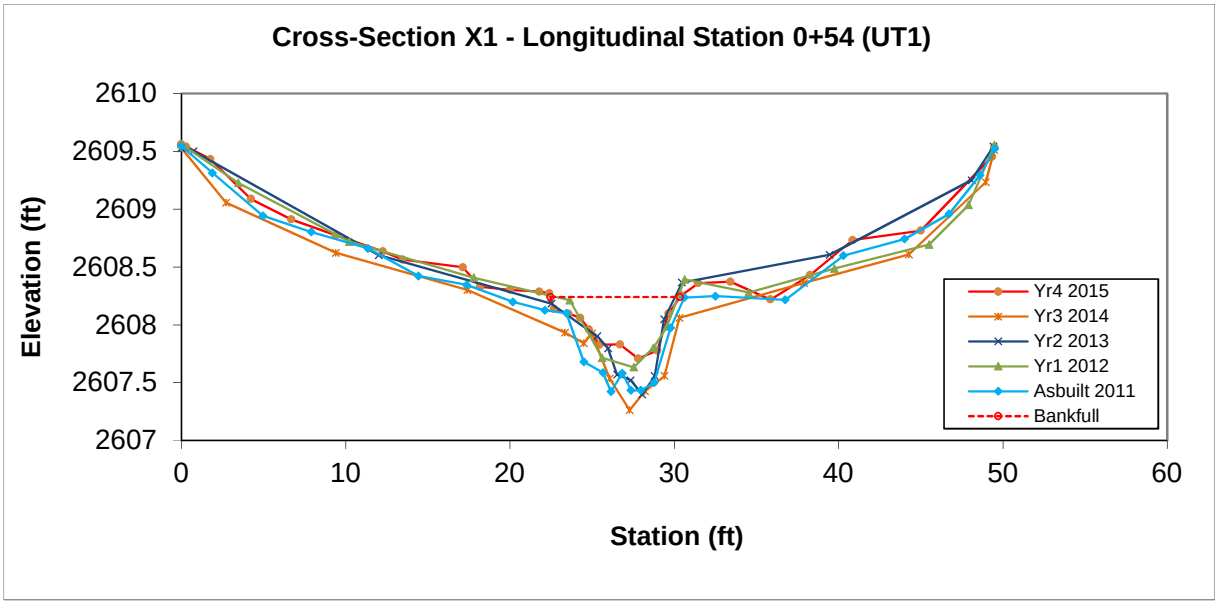


Photo 1: XS-1 facing left bank

Photo 2: XS-1 facing the right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B4	3.5	7.05	0.5	0.9	14.05	1	5.7	2599.86	2599.88

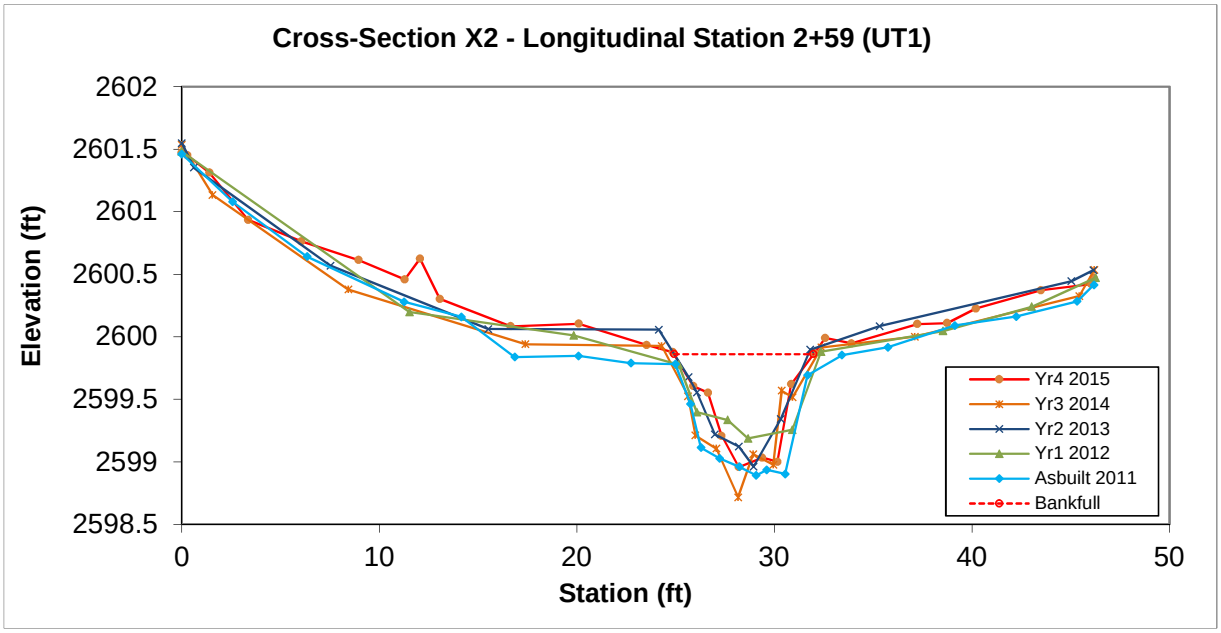


Photo 3: XS-2 facing right bank

Photo 4: XS-2 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B4	3.9	7.73	0.51	1.09	15.29	1	5	2592.17	2592.18

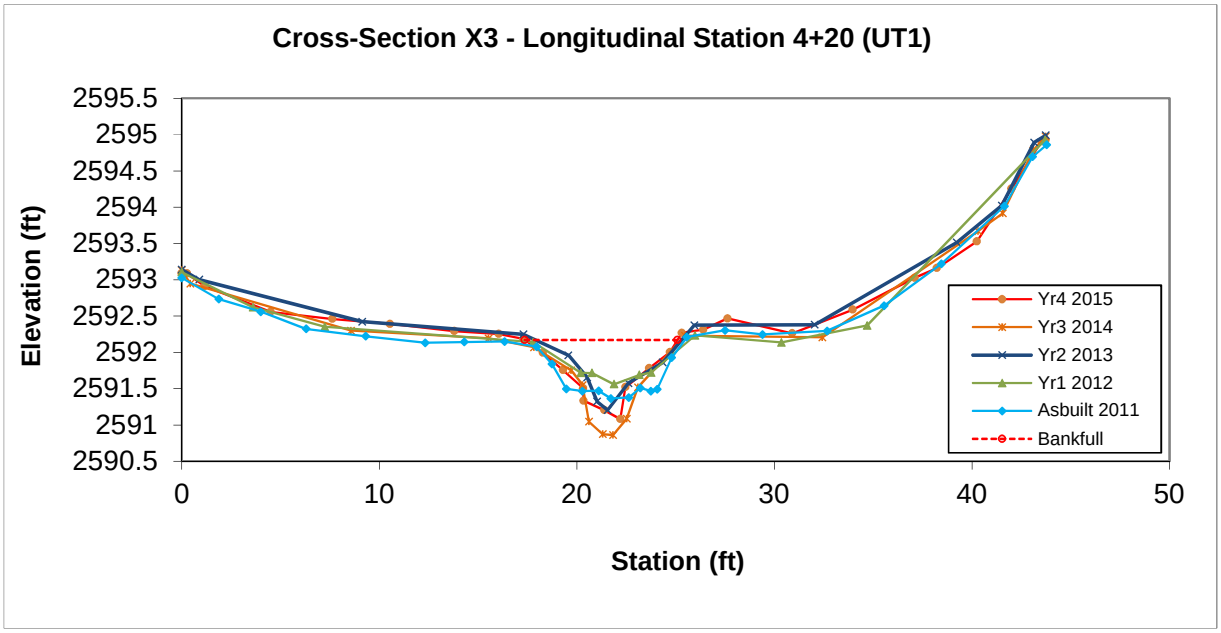


Photo 5: XS-3 facing left bank

Photo 6: XS-3 facing right bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		9.4	9.81	0.96	1.88	10.21	1	4.5	2590.03	2590.05

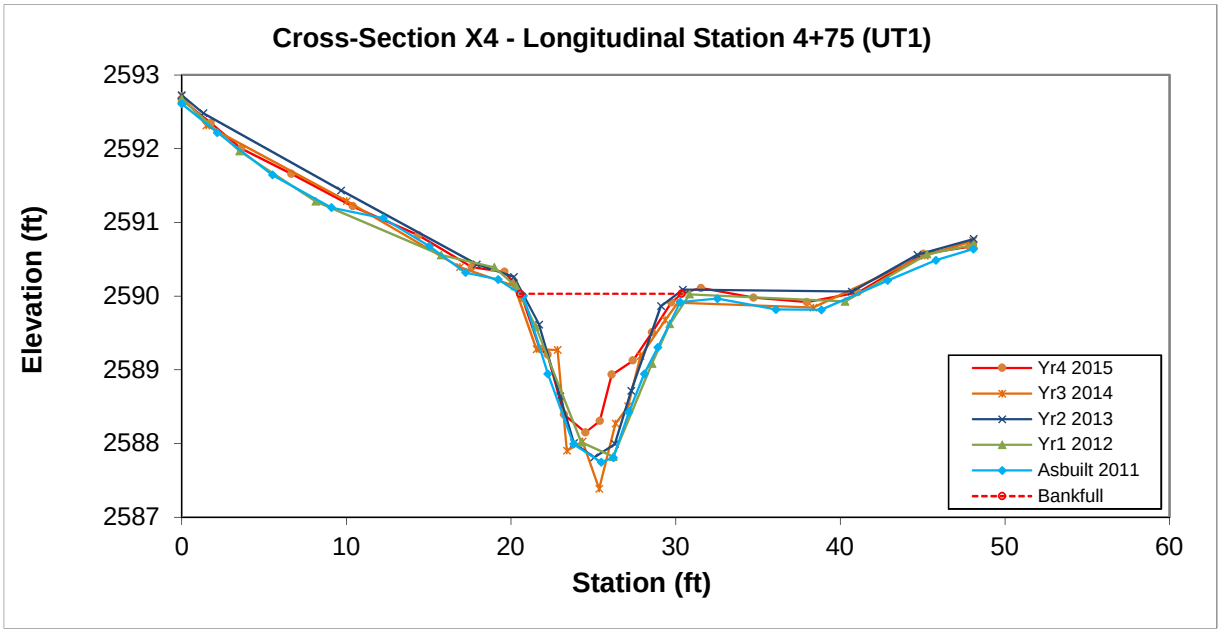


Photo 7: XS-4 facing right bank

Photo 8: XS-4 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	2.5	4.96	0.5	0.74	9.95	1	7.2	2639.2	2639.21

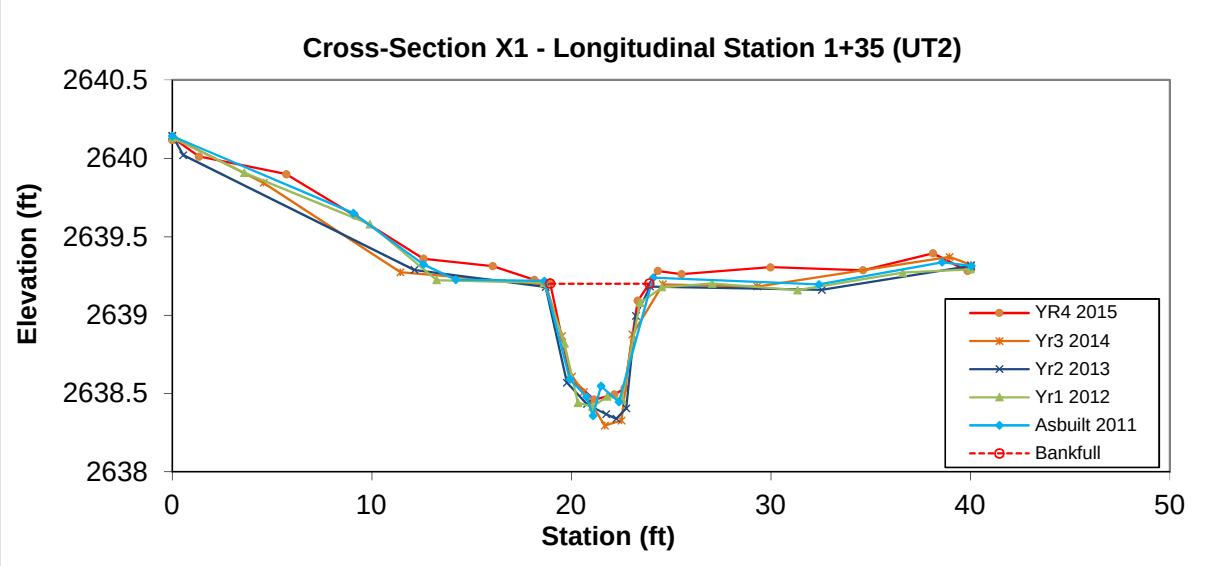


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		4	6.52	0.62	1.07	10.53	1	5.2	2634.05	2634.06

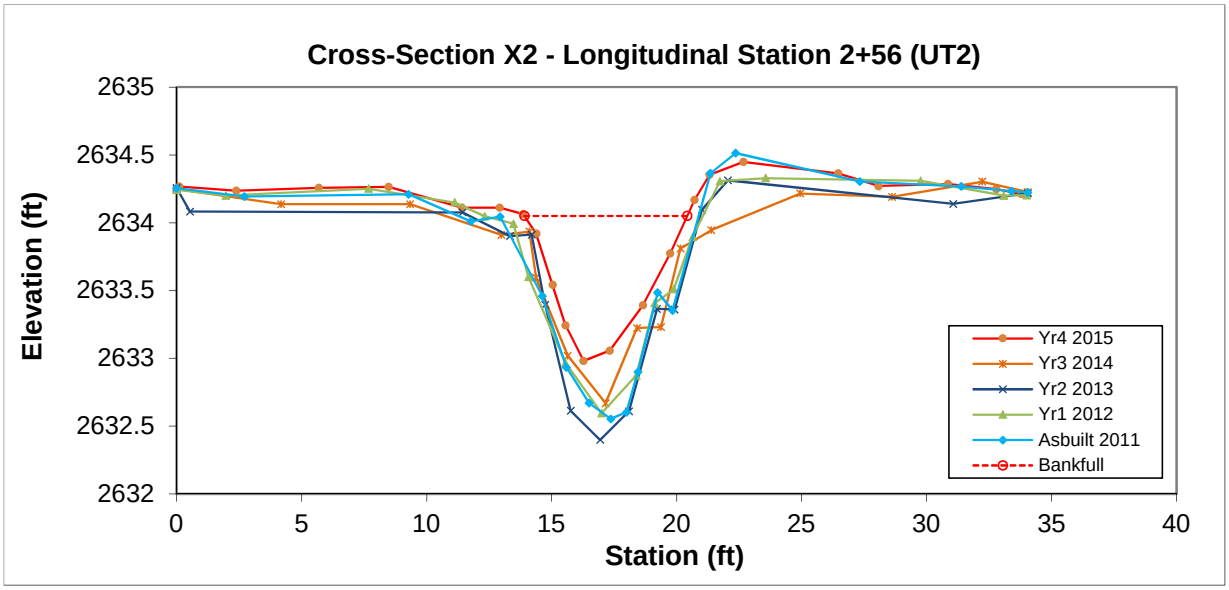
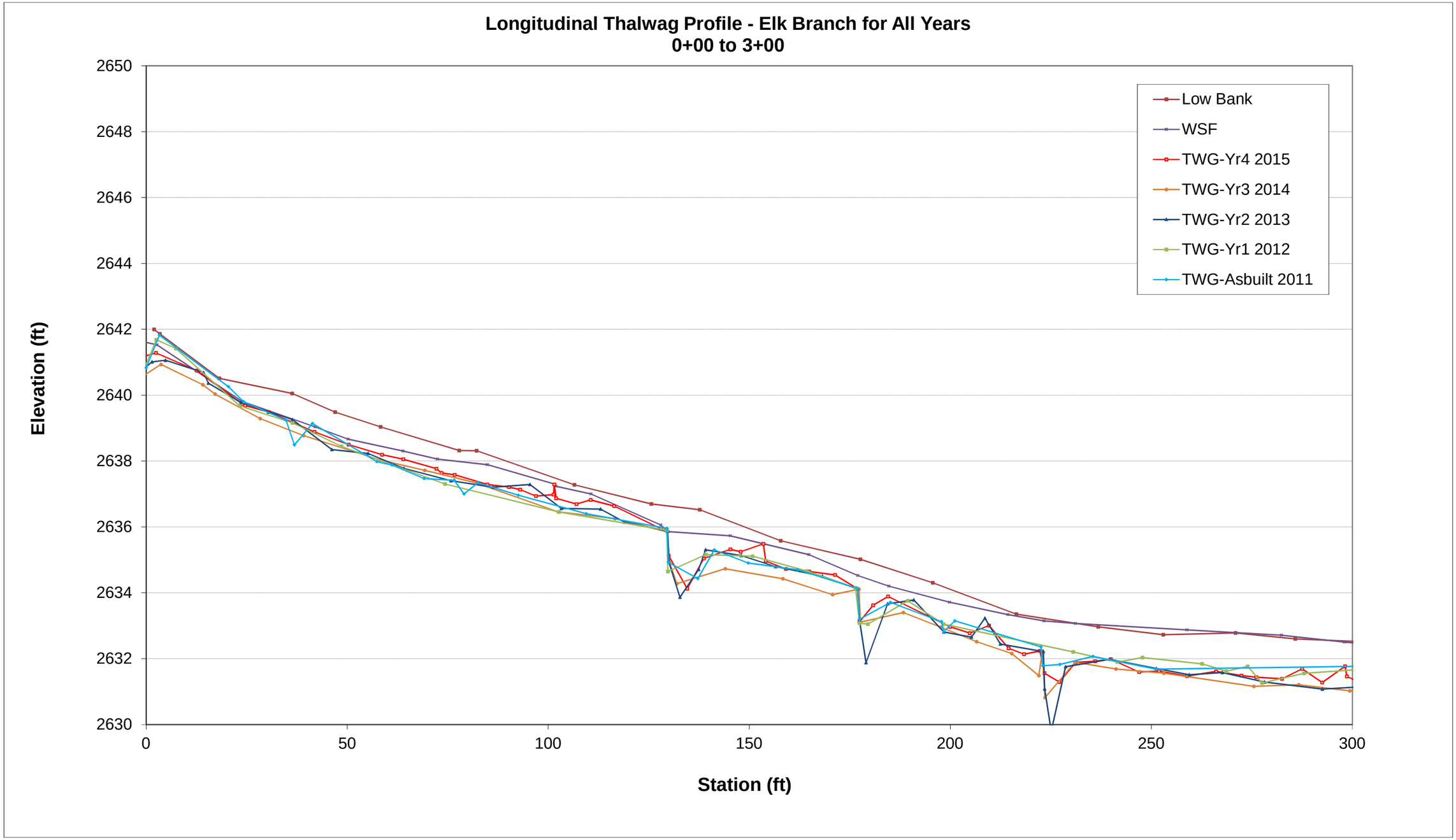
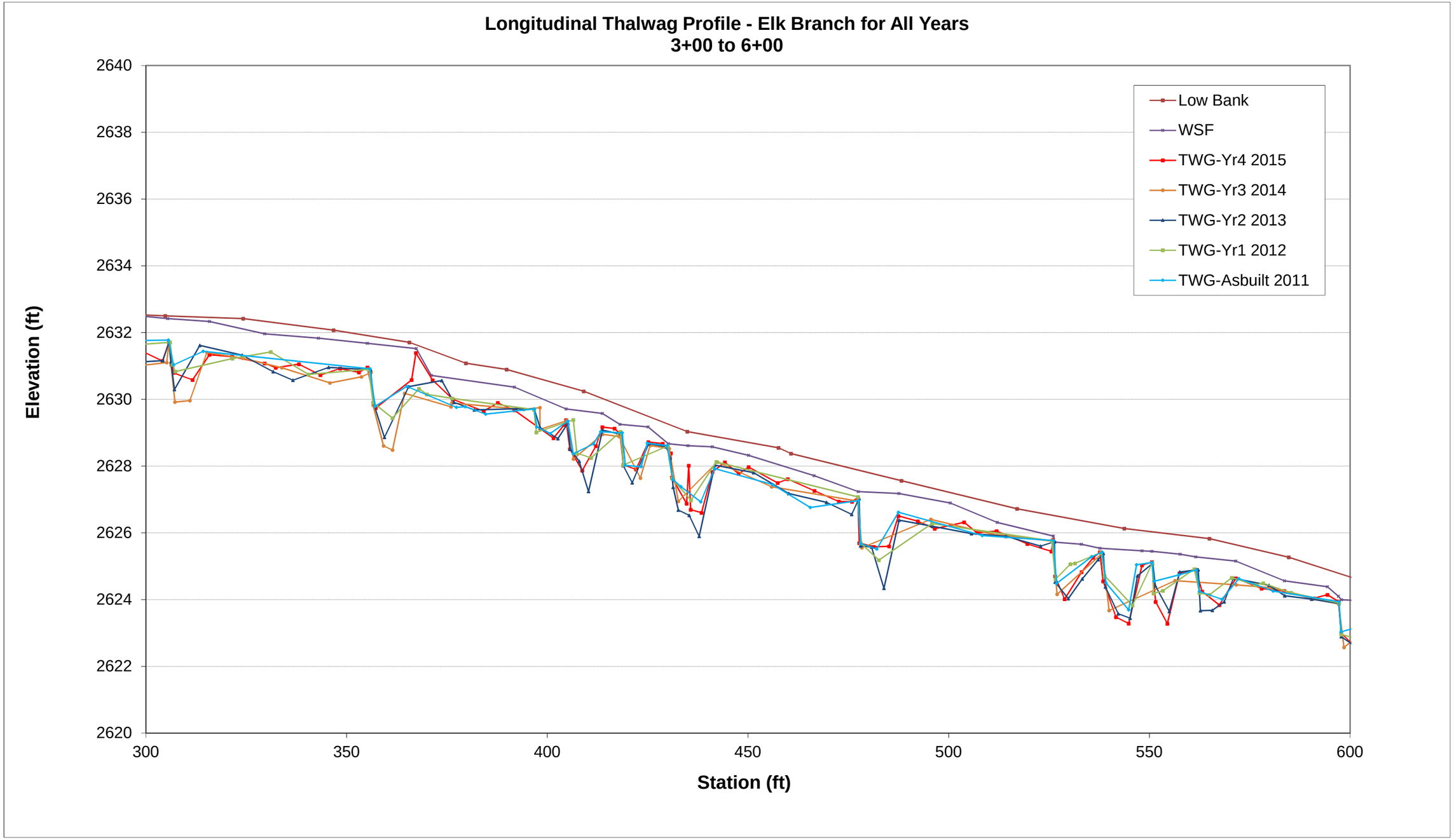


Photo 3: XS-2 facing right bank

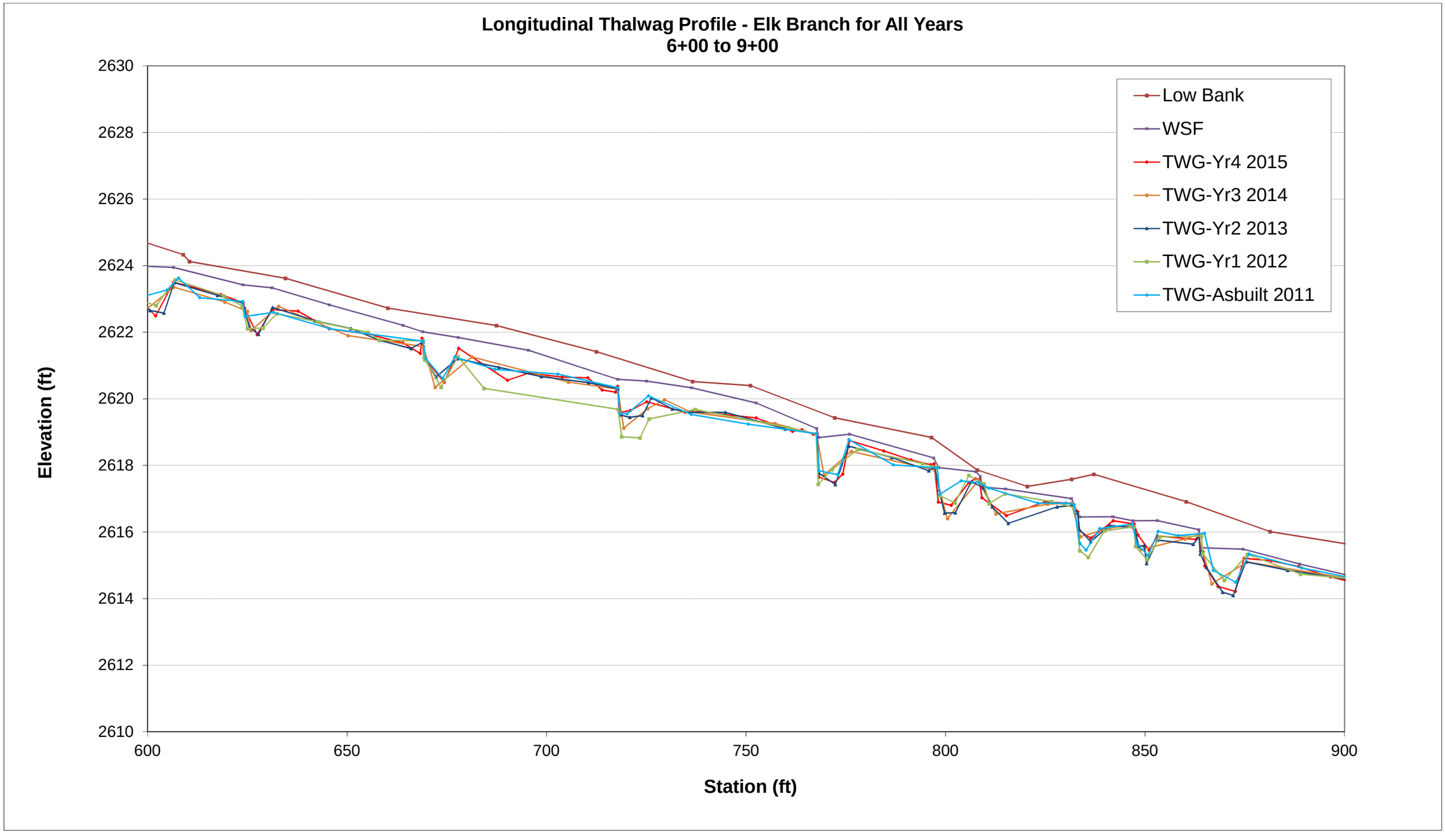
Photo 4: XS-2 facing left bank at channel



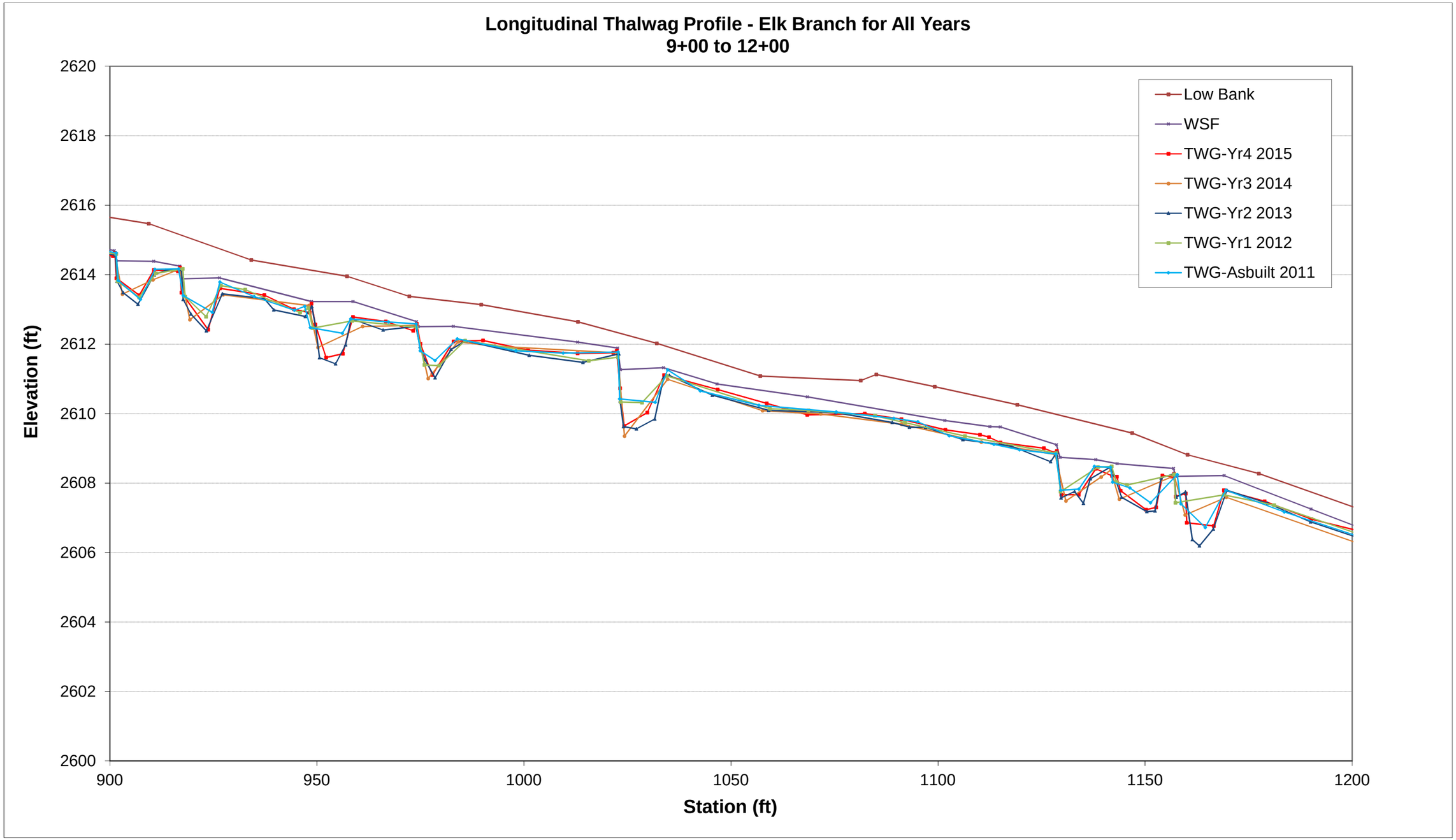
Elk Branch Profile 0+00 to 3+00
Year to Year comparison.



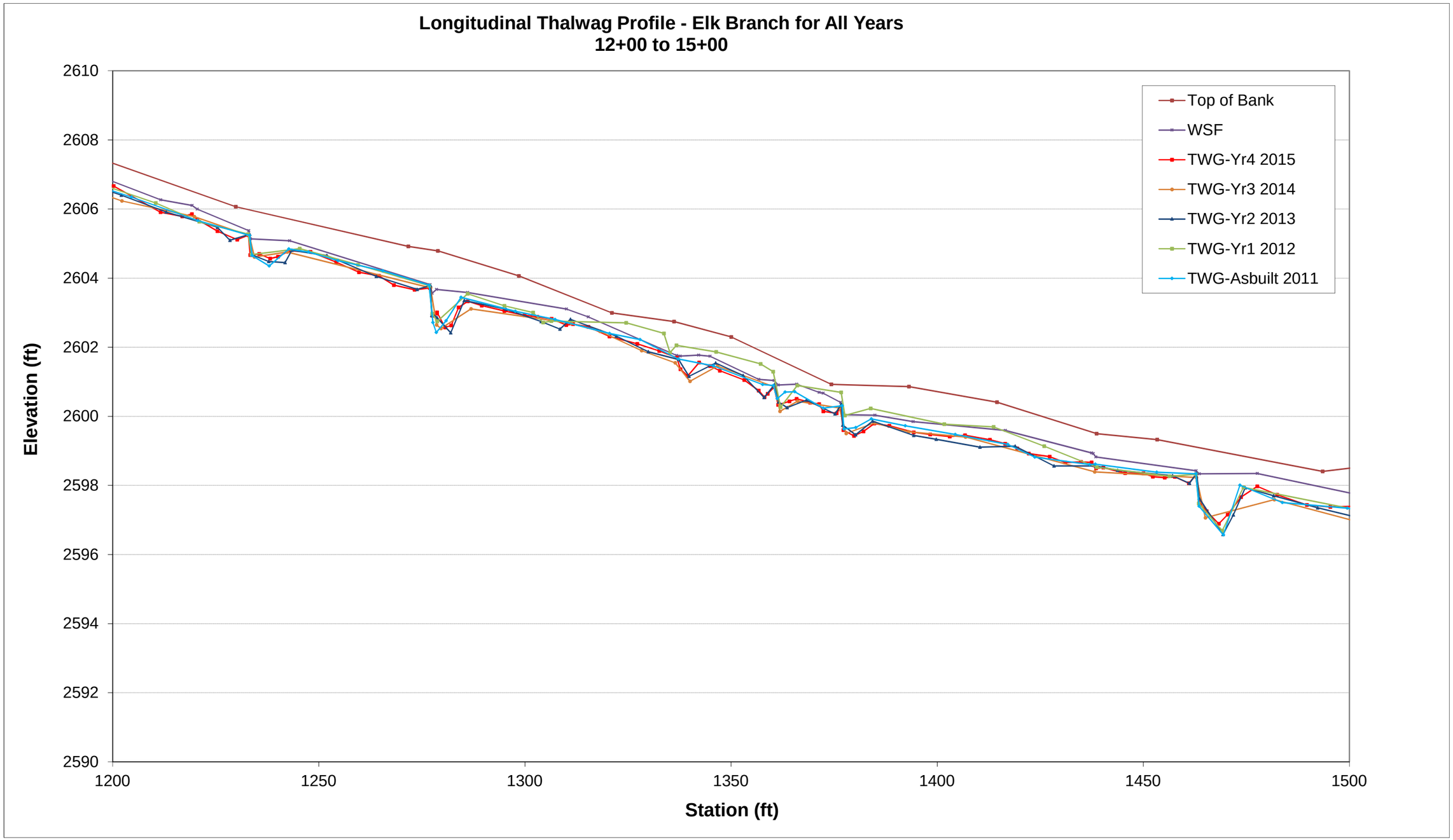
Elk Branch Profile 3+00 to 6+00
Year to Year comparison.



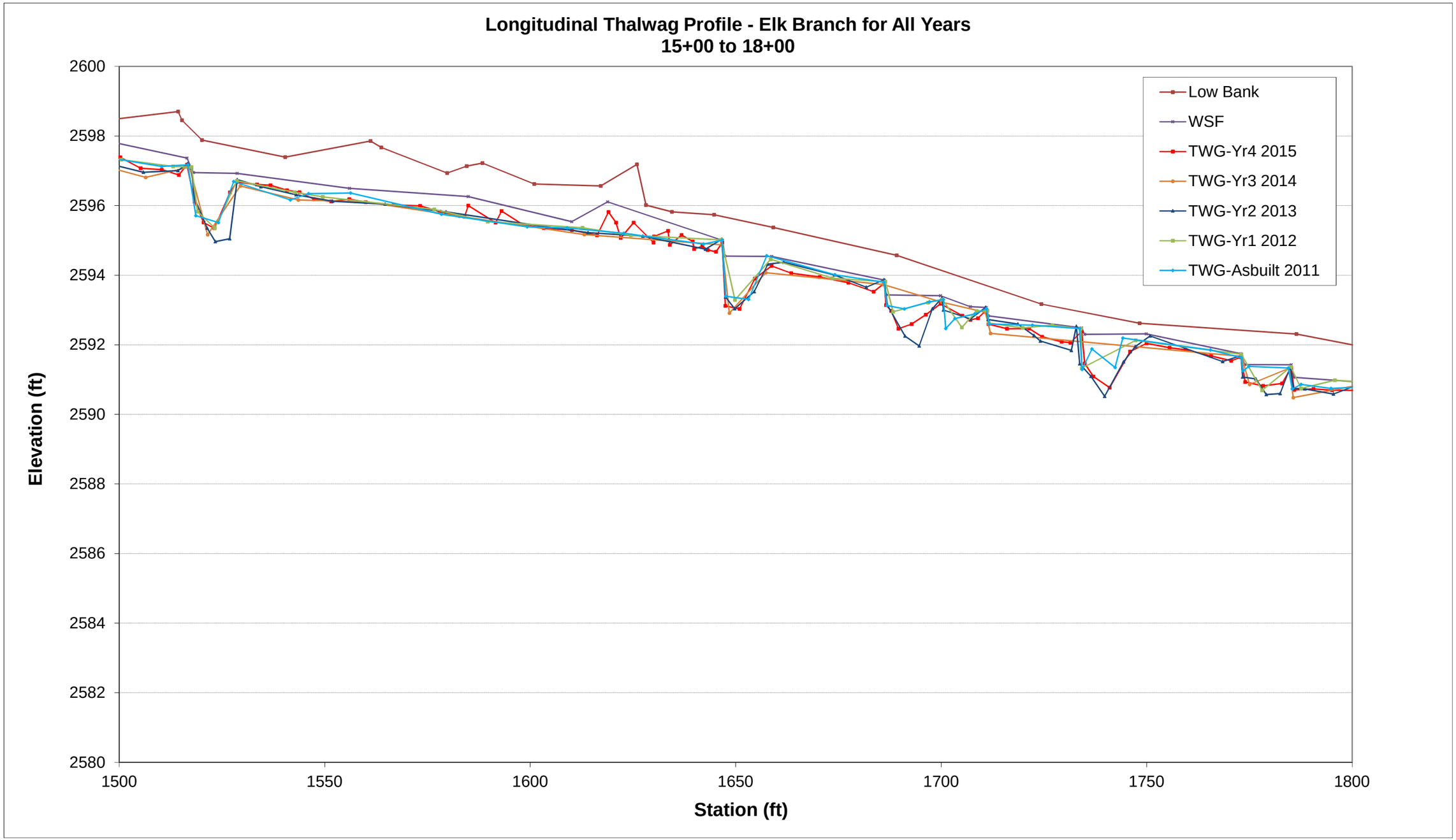
Elk Branch Profile 6+00 to 9+00
Year to Year comparison.



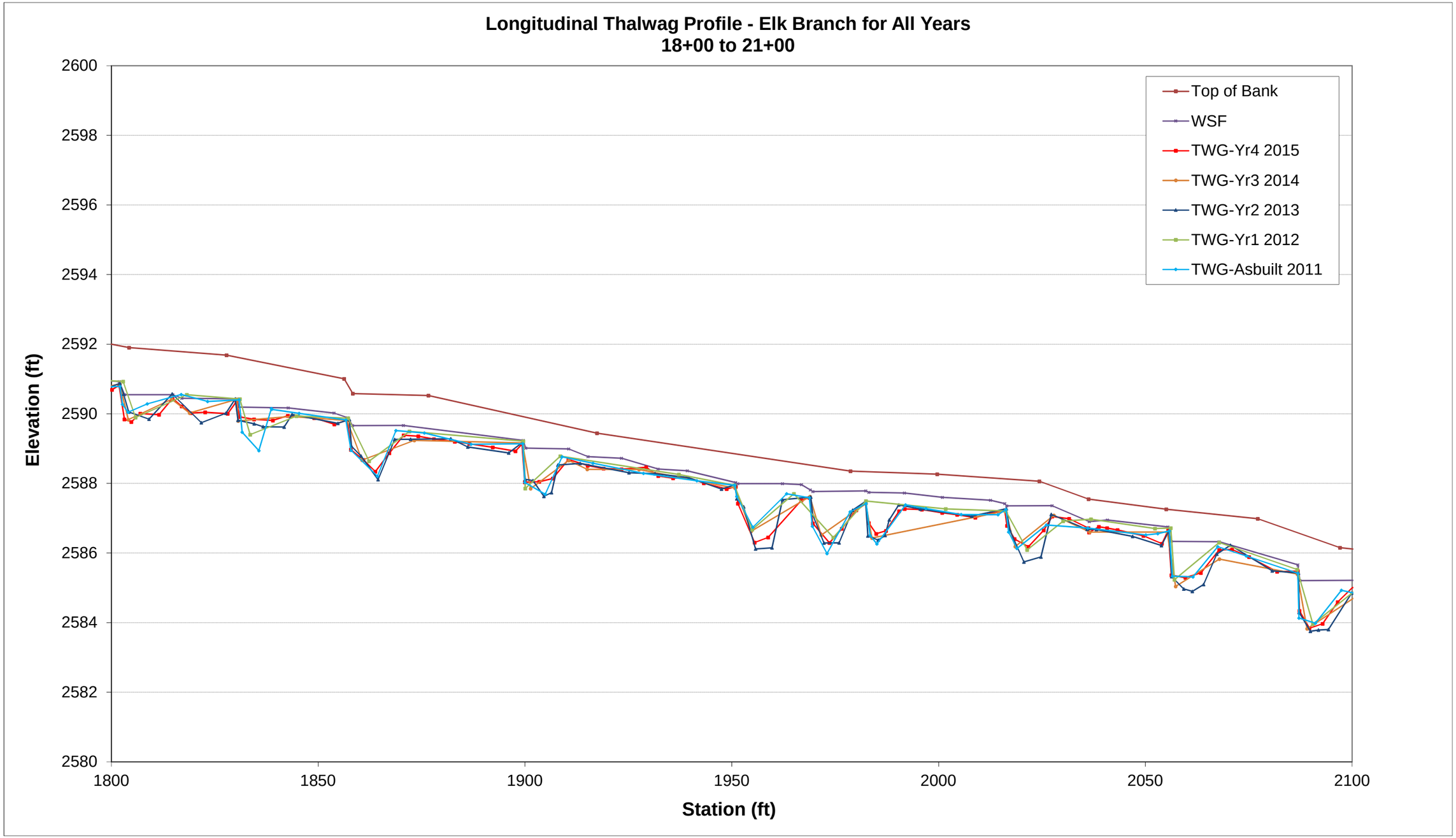
Elk Branch Profile 9+00 to 12+00
Year to Year comparison.



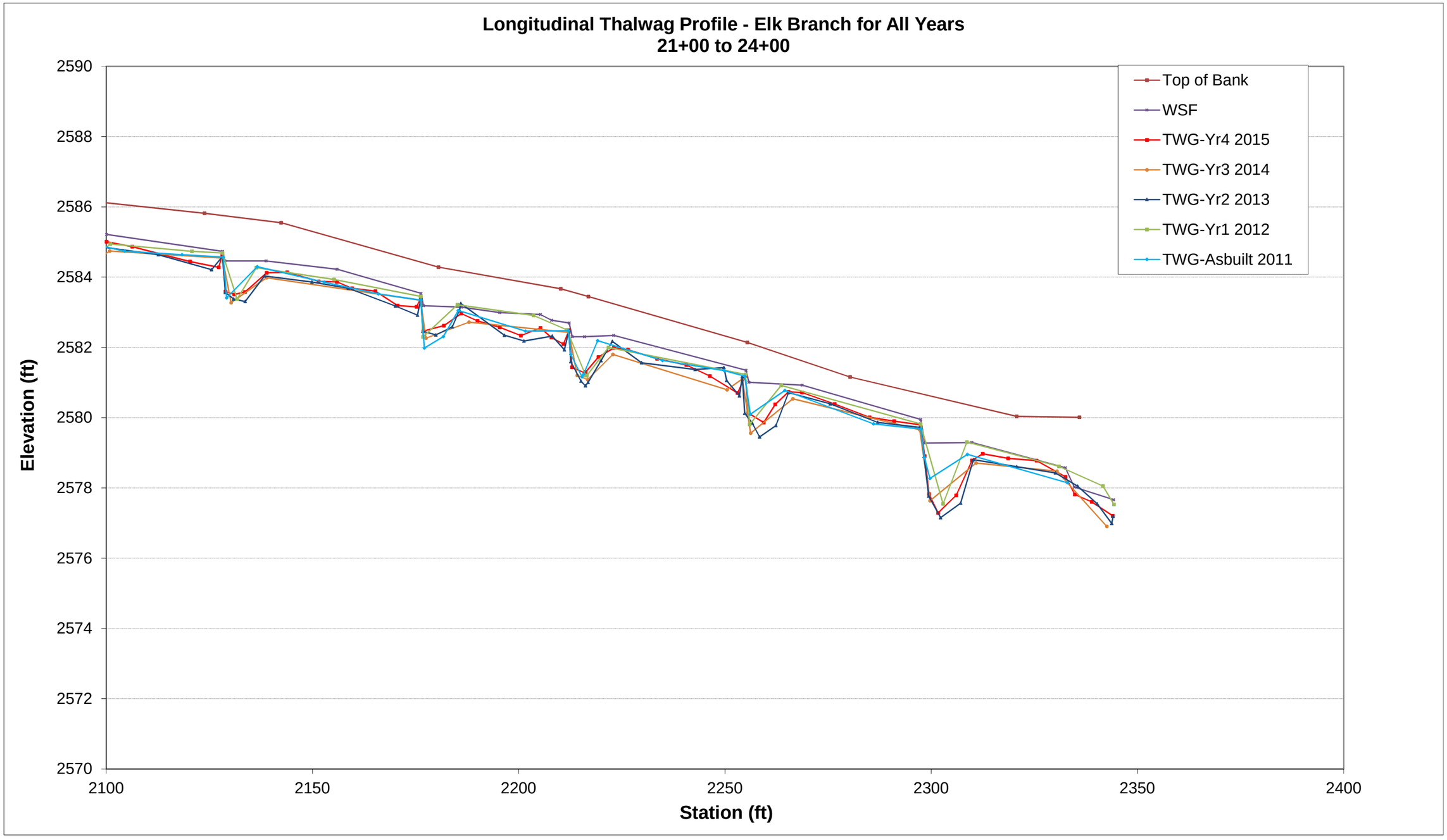
Elk Branch Profile 12+00 to 15+00
Year to Year comparison.



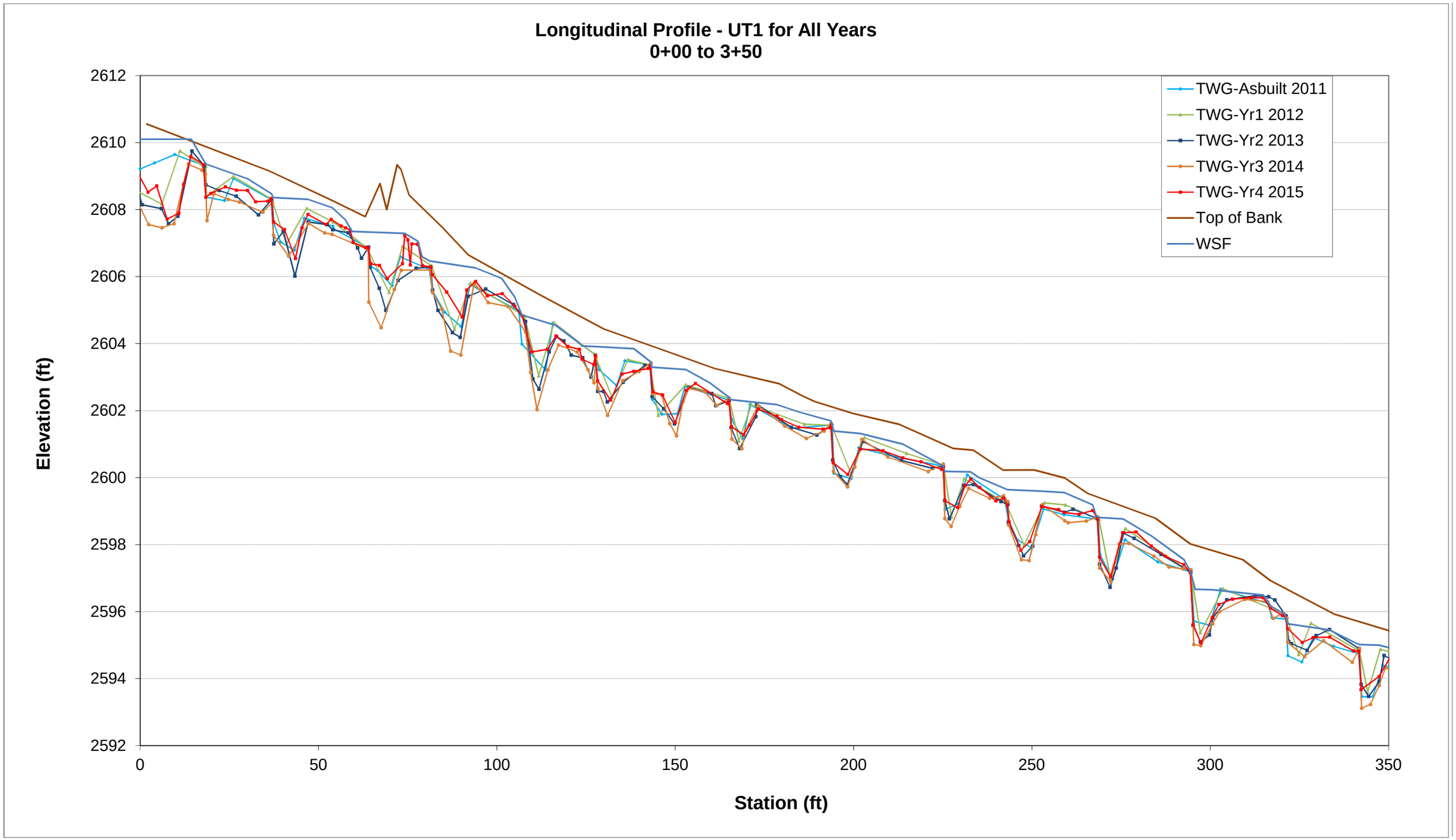
Elk Branch Profile 15+00 to 18+00
Year to Year comparison.



Elk Branch Profile 18+00 to 21+00
Year to Year comparison.

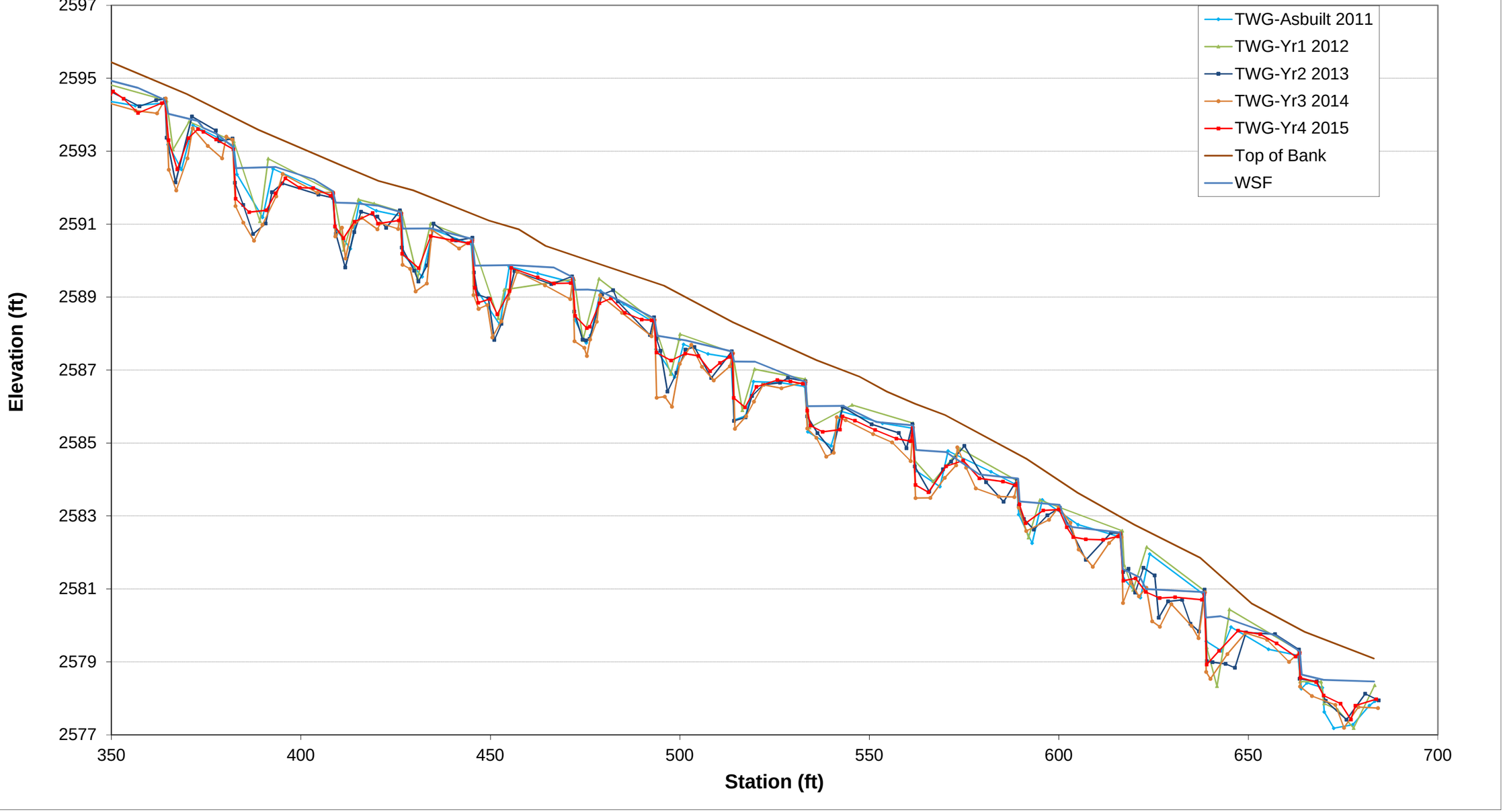


Elk Branch Profile 21+00 to 24+00
Year to Year comparison.

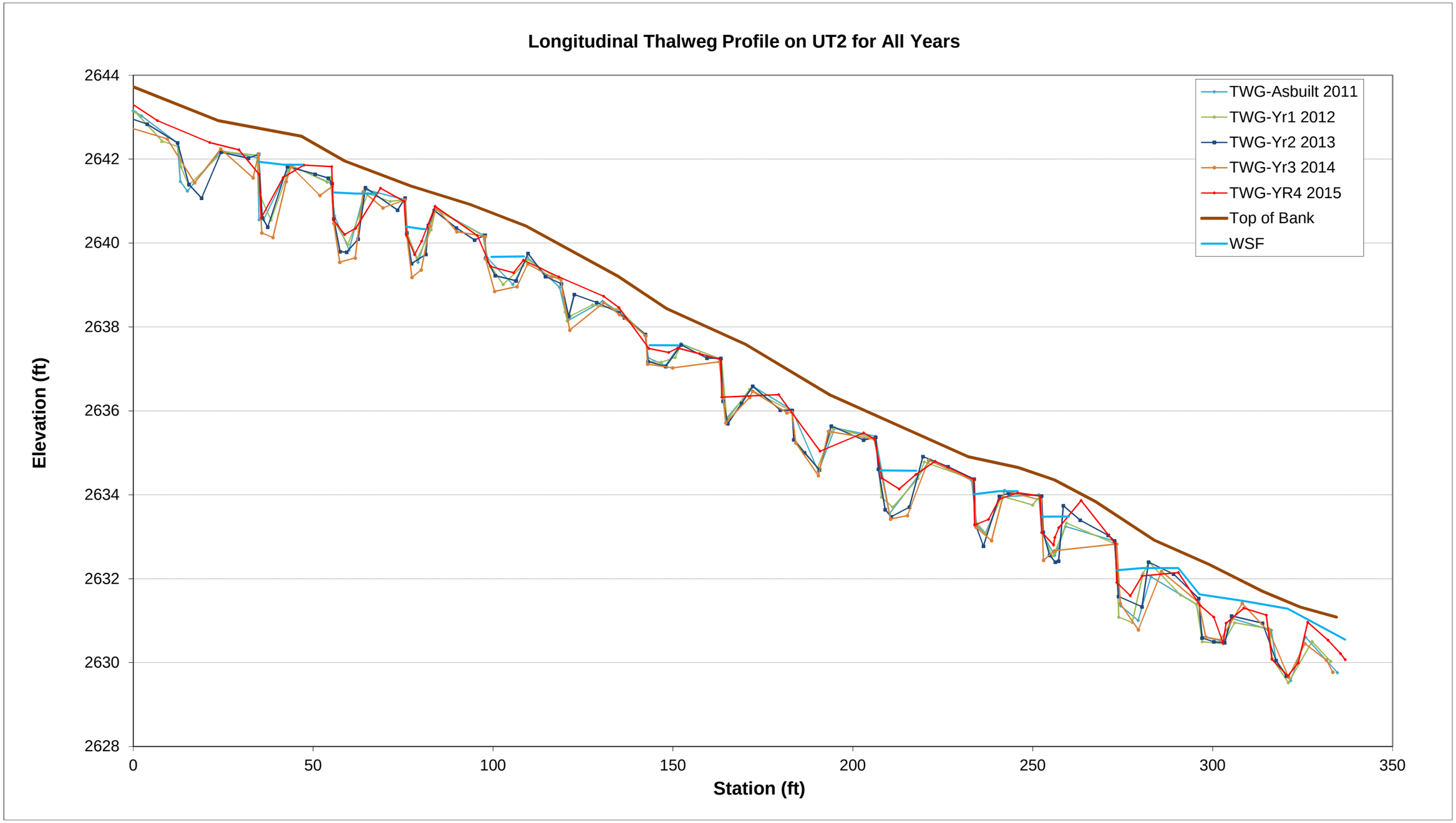


UT1 Profile 0+00 to 3+50
Year to Year comparison.

Longitudinal Profile - UT1 for All Years
3+50 to 7+00



UT1 Profile 3+50 to 7+00



UT2 Profile 0+00 to 3+50
Year to Year comparison.

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%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	-----	-----	-----	-----	-----	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	100%	100%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	
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%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	-----	-----	-----	-----	-----	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	100%	100%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	
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%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	-----	-----	-----	-----	-----	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	100%	100%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	100%	100%	100%	100%	-----	
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%	100%	100%	
Pools	100%	100%	100%	100%	100%	
Thalweg	100%	100%	100%	100%	100%	
Meanders	-----	-----	-----	-----	-----	
Bed General	100%	100%	100%	100%	100%	
Bank Condition	100%	100%	100%	100%	100%	
Rock/Log Drops	100%	100%	100%	100%	100%	
Vanes / J Hooks etc.	-----	-----	-----	-----	-----	
Wads and Boulders	-----	-----	-----	-----	-----	

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

Table 12. Visual Morphological Stability Assessment

Elk Branch Mitigation Project -Project No. 92665

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
Elk Branch Reach 1 (951 LF)						
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)						
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)						
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 (279 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)	279	279	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	279	279	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?	242	242	0	100	**100%**
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?	11	11	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**

UT3 (36 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?	3	3	0/0	100	
	2. Armor stable (e.g. no displacement)?	3	3	0/0	100	
	3. Facet grades appears stable?	3	3	0/0	100	
	4. Minimal evidence of embedding/fining?	3	3	0/0	100	
	5. Length appropriate?	3	3	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	2	2	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	2	2	0/0	100	
	3. Length appropriate?	2	2	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)	36	36	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	36	36	0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	2	2	0/0	100	
	2. Height appropriate?	2	2	0/0	100	
	3. Angle and geometry appear appropriate?	2	2	0/0	100	
	4. Free of piping or other structural failures?	2	2	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**

[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. It should be noted that this was difficult to access as thick stands of herbaceous vegetation was covering the channel and even the drop structures were located by feeling along the bottom.

[2] 100%f the structures and riffles had a centered thalweg.

[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.

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			Monitoring Year 4		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	----	----	6.4	----	----	5.0	----
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	----	----	30.5	----	----	28.3	----
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	----	----	0.5	----	----	0.5	----
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	----	----	0.9	----	----	0.9	----
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	----	----	3.1	----	----	2.5	----
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	----	----	13.0	----	----	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	----	----	4.8	----	----	5.7	----
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	----	----	1.3	----	----	1.0	----
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.6	----	----	4.1	----	----	3.9	----	----	3.4	----	----	4.2	----
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)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	18.0	33.6	50.7	21.1	29.2	37.2	20.4	30.8	38.0	12.8	38.3	93.6	22.9	31.6	38.5
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	0.011	0.024	0.039	0.008	0.034	0.074
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	2.5	6.4	9.5	2.3	7.5	13.2	8.6	10.2	13.4	7.5	11.7	18.2	9.7	12.5	17.4
Pool Spacing (ft)	-----	42	-----	157	42.0	136.5	231.0	9.0	29.5	50.0	17.1	39.6	54.6	14.7	39.2	54.1	17.2	39.9	52.7	26.5	49.9	106.6	32.1	56.0	100.8
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	-----	-----	0.7	-----	-----	0.7	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.6	-----	-----	2.8	-----	-----	2.6	-----	-----	2.3	-----	-----	3.1	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	901	-----	-----	901	-----	-----	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	0.05	0.10	0.14			
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	7-13	-----	-----	-----	-----	-----	-----	7	11	14	7	11	14	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	-----	-----	1.09	-----	-----	1.09	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.033	-----	-----	0.032	-----	-----	0.029	-----	-----	0.027	-----	-----	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			Monitoring Year 4		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	----	----	7.9	----	----	8.5	----
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	----	----	32.7	----	----	32.4	----
Bankfull Mean Depth (ft)	.44-.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.51	----	----	0.40	----	----	0.42	----	----	0.3	----	----	0.4	----
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	----	----	0.8	----	----	0.6	----
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	----	----	2.7	----	----	2.9	----
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	----	----	22.8	----	----	22.4	----
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	----	----	3.9	----	----	4.0	----
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	----	----	1.0	----	----	1.0	----
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.5	----	----	3.6	----	----	3.1	----	----	3.9	----	----	3.6	----
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)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	34.0	45.0	63.7	31.4	43.9	63.8	35.0	44.0	64.0	20.5	52.2	107.2	25.3	62.6	97.9
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	0.010	0.022	0.038	0.013	0.031	0.044
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	4.0	4.9	6.0	5.1	9.0	11.7	9.0	12.0	14.0	8.5	11.7	18.9	8.6	12.0	13.8
Pool Spacing (ft)	-----	42	-----	157	42	137	231	9.0	29.5	50.0	21.7	43.4	56.7	27.8	44.0	54.1	21.0	41.0	55.0	16.0	61.1	127.0	28.8	40.8	52.9
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			18/28/37/82/123			8.1/23/39/76/110		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.7	-----	-----	0.7	-----	-----	0.7	-----	-----	0.7	-----	-----	0.6	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.7	-----	-----	2.5	-----	-----	2.1	-----	-----	2.6	-----	-----	2.1	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	642	-----	-----	642	-----	-----	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	0.05	0.10	0.14	0.05	0.10	0.14
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	7-13	-----	-----	-----	-----	-----	-----	7	11	14	7	11	14	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	-----	-----	1.09	-----	-----	1.09	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.027	-----	-----	0.028	-----	-----	0.028	-----	-----	0.027	-----	-----	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			Monitoring Year 4		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	----	----	12.6	----	----	9.6	----
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	----	----	44.4	----	----	42.6	----
Bankfull Mean Depth (ft)	.44-.61	0.48	0.80	1.12	0.60	0.85	1.10	0.40	0.58	0.75	----	0.65	----	----	0.53	----	----	0.52	----	----	0.4	----	----	0.4	----
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	----	----	0.9	----	----	0.6	----
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	----	----	5.1	----	----	3.8	----
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	----	----	31.3	----	----	24.3	----
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	----	----	3.5	----	----	4.5	----
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	----	----	1.0	----	----	1.0	----
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	-----	1.8	-----	-----	2.4	-----	-----	2.1	-----	-----	2.1	-----	-----	2.8	-----
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)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	5.5	22.6	41.7	12.5	25.4	42.1	11.0	24.0	40.0	13.7	32.2	53.4	19.5	26.0	32.1
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	0.003	0.014	0.022	0.017	0.029	0.035
Pool Length (ft)	-----	-----	-----	-----	13.0	14.5	16.0	-----	-----	-----	4.1	7.6	13.6	7.9	9.3	11.2	8.1	11.2	13.0	10.6	16.4	33.8	11.3	13.7	16.1
Pool Spacing (ft)	-----	42.0	-----	156.5	42.0	136.5	231.0	9.0	29.5	50.0	10.4	29.0	50.2	16.7	31.1	54.9	17.0	33.0	56.0	29.2	44.1	63.5	17.9	32.6	40.9
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	1.2/6.6/13/65/130			-6/14/31-39/51-88/110-21			.6-1.5/2-7/6.2-19/19-65/26-130			---			---			---			---			---		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	-----	-----	0.9	-----	-----	0.9	-----	-----	0.9	-----	-----	0.5	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.9	-----	-----	2.0	-----	-----	1.8	-----	-----	1.8	-----	-----	1.3	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	403	-----	-----	403	-----	-----	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	0.05	0.10	0.14	0.05	0.10	0.14
Rosgen Classification	-----	-----	Cb/B/G/Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	7-13	-----	-----	-----	----	----	----	7	11	14	7	11	14	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	-----	-----	1.09	-----	-----	1.09	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.021	-----	-----	0.023	-----	-----	0.021	-----	-----	0.020	-----	-----	0.020	-----

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			Monitoring Year 4		
Dimension - Riffle*	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	----	----	12.9	----	----	11.4	----
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	----	----	>44.0	----	----	43.9	----
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	----	----	0.7	----	----	0.6	----
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	----	----	2.2	----	----	1.1	----
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	----	----	9.4	----	----	6.8	----
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	----	----	17.7	----	----	19.2	----
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	----	----	3.4	----	----	3.8	----
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	----	----	1.0	----	----	1.0	----
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	-----	1.2	-----	-----	1.2	-----	-----	1.0	-----	-----	1.1	-----	-----	1.5	-----
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)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	19.4	30.4	39.6	19	30	40	17	27	38	18.8	26.5	38.2	19.2	27.3	31.6
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	0.007	0.016	0.026	0.027	0.033	0.043
Pool Length (ft)	-----	-----	-----	-----	13.0	14.5	16.0	-----	-----	-----	7.4	9.2	11.0	4.6	9.4	14.0	9.0	10.0	12.0	10.7	12.8	15.9	10.7	12.0	13.3
Pool Spacing (ft)	-----	42.0	-----	156.5	42.0	136.5	231.0	9.0	29.5	50.0	30.6	39.4	47.9	33.5	39.4	45.0	39.0	43.0	48.0	31.8	40.7	47.2	35.2	39.5	42.8
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	-----	-----	1.40	-----	-----	1.40	-----	-----	1.4	-----	-----	0.6	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.6	-----	-----	1.69	-----	-----	1.41	-----	-----	1.6	-----	-----	0.9	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	279	-----	-----	279	-----	-----	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	0.05	0.10	0.14	0.05	0.10	0.14
Rosgen Classification	-----	-----	Cb/B/G /Eb4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	13-23	-----	-----	-----	----	----	----	7	11	14	7	11	14	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	-----	-----	1.09	-----	-----	1.09	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.024	-----	-----	0.02	-----	-----	0.02	-----	-----	0.026	-----	-----	0.025	-----

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			Monitoring Year 4		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	6.4	9.0	12.6	7.1	7.6	7.9
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	30.5	35.9	44.4	33.5	37.5	40.1
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	0.3	0.4	0.5	0.3	0.4	0.5
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	0.8	0.9	0.9	0.5	0.8	1.1
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	2.4*	2.6*	2.9	2.7	3.3*	3.7	2.7	3.6	5.1	2.5	3.3	3.9
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	13.0	22.4	31.3	14.1	18.2	25.3
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	3.5	4.1	4.8	4.3	5.0	5.7
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	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	4.2*	3.7	2.8*	2.7	2.0	3.0	3.7	2.6	3.3	4.1
Pattern																									
Channel Beltwidth (ft)	-----	-----	-----	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	1.10	2.60	4.10	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	11	17	24	11	15	22	11	15	19	10	15	23	10	16	23
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	0.015	0.038	0.126	0.024	0.043	0.062
Pool Length (ft)	-----	-----	-----	-----	13	15	16	-----	-----	-----	2	4	6	2	5	8	7	9	11	6	10	15	7	12	21
Pool Spacing (ft)	-----	-----	-----	-----	42	137	231	9	13	17	20	23	26	18	21	24	19	23	24	8	22	31	16	23	27
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	-----	-----	0.53	-----	-----	1.26	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.54	-----	-----	2.00	-----	-----	1.48	-----	-----	1.58	-----	-----	4.17	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	685	-----	-----	-----	-----	-----	654	-----	-----	656	-----	-----	656	-----	-----	656	-----	-----	656	-----	-----	691	-----
Drainage Area (SM)	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----	-----	0.06	-----
Rosgen Classification	-----	-----	B4/G	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	10-12	-----	-----	-----	----	----	----	3	7	10	-----	10	-----	-----	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	-----	-----	1.04	-----	-----	1.05	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.046	-----	-----	0.046	-----	-----	0.048	-----	-----	0.046	-----	-----	0.046	-----

*These datum have been corrected and should be used rather than data shown in previous monitoring reports.

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			Monitoring Year 4		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	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	----	----	5.8	----	----	5.7	----
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	----	----	38.9	----	----	35.0	----
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	----	----	0.49	----	----	0.56	----
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	----	----	0.88	----	----	0.91	----
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	----	----	2.8	----	----	3.3	----
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	----	----	11.9	----	----	10.2	----
Entrenchment Ratio	-----	1.9	4.8	7.7	1.3	2.3	3.2	-----	3.0	-----	----	7.2	----	----	6.3	----	----	7.6	----	----	6.7	----	----	6.2	----
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	----
Bankfull Velocity (fps)	-----	-----	-----	-----	-----	-----	-----	2.0	4.0	6.0	----	2.1	----	----	2.3	----	----	2.1	----	----	2.1	----	----	1.8	----
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)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	9.0	12.0	13.8	9.0	13.1	14.9	10.0	13.0	15.0	5.9	10.5	13.6	9.2	13.3	26.0
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	0.016	0.048	0.091	0.043	0.074	0.113
Pool Length (ft)	-----	-----	-----	-----	13.0	14.5	16.0	-----	-----	-----	3.0	6.6	11.4	4.1	6.8	9.4	8.0	10.0	12.0	8.6	11.1	15.1	12.9	15.4	17.8
Pool Spacing (ft)	----	-----	-----	-----	42.0	136.5	231.0	9.0	25.5	42.0	15.2	22.2	27.3	17.8	21.0	23.5	19.0	21.0	23.0	14.5	21.3	28.0	16.1	24.7	38.9
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	-----	-----	0.9	-----	-----	1.0	-----
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.3	-----	-----	2.1	-----	-----	1.9	-----	-----	2.0	-----	-----	1.9	-----
Additional Reach Parameters																									
Channel length (ft)	-----	-----	185	-----	-----	-----	-----	-----	244	-----	-----	241	-----	-----	241	-----	-----	241	-----	-----	241	-----	-----	241	-----
Drainage Area (SM)	-----	-----	0.01	-----	0.45	1.025	1.60	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----	-----	0.01	-----
Rosgen Classification	-----	-----	B4/G	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----	-----	B4	-----
Bankfull Discharge (cfs)	2-3	-----	-----	-----	----	-----	----	-----	6	-----	-----	6	-----	-----	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	-----	-----	1.04	-----	-----	1.04	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	0.039	-----	-----	0.039	-----	-----	0.040	-----	-----	0.041	-----	-----	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	6.4	5.0		6.0	5.7	5.1	6.7	8.5		8.1	7.3	8.2	7.9	8.1	
Floodprone Width (ft)	30.9	24.3	26.4	30.5	28.3		32.5	32.5	32.5	32.5	32.5		34.6	32.5	35.6	32.7	32.4	
BF Cross Sectional Area (ft^2)	4.1	2.6	2.7	3.1	2.5		7.3	6.3	4.8	6.4	7.5		4.2	2.9	3.4	2.7	2.9	
BF Mean Depth (ft)	0.7	0.5	0.5	0.5	0.5		1.2	1.1	0.9	1.0	0.9		0.5	0.4	0.4	0.3	0.4	
BF Max Depth (ft)	1.0	0.7	0.9	0.9	0.9		2.2	1.8	1.5	1.9	2.1		0.8	0.8	1.0	0.8	0.8	
Width/Depth Ratio	9.0	12.0	10.1	13.0	10.1		4.9	5.1	5.5	6.9	9.7		15.8	18.4	19.6	22.8	22.4	
Entrenchment Ratio	5.1	4.4	5.1	4.8	5.7		5.4	5.7	6.4	4.9	3.8		4.3	4.4	4.3	3.9	4.0	
Wetted Perimeter (ft)	7.4	6.5	6.2	7.4	6.0		8.5	7.9	7.0	8.6	10.3		9.1	8.1	9.1	8.6	8.8	
Hydraulic Radius (ft)	0.6	0.4	0.4	0.4	0.4		0.9	0.8	0.7	0.7	0.7		0.5	0.4	0.4	0.3	0.3	
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	9.4	12.6	9.6	
Floodprone Width (ft)	45.0	46.5	45.2	44.4	42.6	
BF Cross Sectional Area (ft2)	5.7	4.4	4.9	5.1	3.8	
BF Mean Depth (ft)	0.7	0.5	0.5	0.4	0.4	
BF Max Depth (ft)	1.0	0.8	1.0	0.9	0.6	
Width/Depth Ratio	13.3	15.6	18.0	31.3	24.3	
Entrenchment Ratio	5.2	5.6	4.8	3.5	4.5	
Wetted Perimeter (ft)	10.0	9.3	10.5	13.4	10.4	
Hydraulic Radius (ft)	0.6	0.5	0.5	0.4	0.4	

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)	5.5	63.7	35.7	12.5	63.8	28.6	11.0	63.6	33.8	12.8	107.2	32.9	19.5	97.9	32.1			
Riffle Slope (ft/ft)	0.010	0.045	0.025	0.005	0.041	0.027	0.008	0.039	0.021	0.011	0.039	0.023	0.008	0.074	0.030			
Pool Length (ft)	2.5	13.6	7.1	2.3	13.2	8.7	8.1	13.8	11.8	7.5	33.8	12.1	8.6	17.4	13.3			
Pool Spacing (ft)	10.4	56.7	44.4	14.7	54.9	44.7	16.6	56.2	43.9	26.5	127.0	47.3	17.9	100.8	40.9			
Substrate																		
d50 (mm)	17			27			30			37			39					
d84 (mm)	38			69			72			82			76					
Additional Reach Parameters																		
Valley Length (ft)	2121			2121			2121			2121			2121					
Channel Length (ft)	1946			1946			1946			1946			1946					
Sinuosity	1.09			1.09			1.09			1.09			1.09					
Water Surface Slope (ft/ft)	0.027			0.027			0.029			0.029			0.027					
BF Slope (ft/ft)	0.021	0.033	0.027	0.023	0.032	0.028	0.021	0.029	0.025	0.020	0.027	0.027	0.020	0.029	0.026			
Rosgen Classification	B4			B4			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	10.3	12.9	11.4	
Floodprone Width (ft)	43.8	44.2	44.1	>44.0	>43.9	
BF Cross Sectional Area (ft2)	9.0	8.7	10.4	9.4	6.8	
BF Mean Depth (ft)	1.0	1.0	1.0	0.7	0.6	
BF Max Depth (ft)	2.0	2.1	2.5	2.2	1.1	
Width/Depth Ratio	9.3	9.4	10.2	17.7	19.2	
Entrenchment Ratio	4.8	4.9	4.3	3.4	3.8	
Wetted Perimeter (ft)	11.1	11.0	12.3	14.4	12.6	
Hydraulic Radius (ft)	0.8	0.8	0.8	0.7	0.5	
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)	19.4	39.6	31.2	18.9	39.9	29.9	16.5	38.0	27.0	18.8	38.2	25.8	19.2	31.6	27.3			
Riffle Slope (ft/ft)	0.021	0.039	0.026	0.021	0.041	0.025	0.018	0.049	0.024	0.007	0.026	0.015	0.027	0.043	0.033			
Pool Length (ft)	7	11	9	5	14	10	9	12	11	11	16	13	11	13	12			
Pool Spacing (ft)	31	48	40	33	45	40	39	48	42	32	47	42	35	43	40			
Substrate																		
d50 (mm)	---			---			---			---			---					
d84 (mm)	---			---			---			---			---					
Additional Reach Parameters																		
Valley Length (ft)	304			304			304			304			304					
Channel Length (ft)	279			279			279			279			279					
Sinuosity	1.09			1.09			1.09			1.09			1.09					
Water Surface Slope (ft/ft)	0.027			0.027			0.028			0.029			0.038					
BF Slope (ft/ft)	0.017	0.024	0.021	0.023			0.023			0.027			0.025					
Rosgen Classification	B4/Eb4			B4/Eb4			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	6.7	7.9		6.5	6.96	7.0	8.0	7.1		7.3	7.79	8.3	9.8	7.7		9.4	10.3	9.9	9.5	9.8	
Floodprone Width (ft)	35.7	36.89	36.9	34.1	33.5		37.6	34.75	40.9	45.0	40.1		34.8	33.03	37.8	39.6	38.8		45.2	45.88	45.9	46.9	43.7	
BF Cross Sectional Area (ft2)	3.1	2.45	2.7	2.1	2.5		3.8	2.91	3.6	4.7	3.5		3.6	2.61	3.7	5.0	3.9		11.9	12.36	11.7	10.7	9.4	
BF Mean Depth (ft)	0.46	0.38	0.37	0.32	0.31		0.59	0.42	0.52	0.59	0.50		0.5	0.34	0.45	0.50	0.51		1.3	1.2	1.2	1.12	0.96	
BF Max Depth (ft)	0.68	0.58	0.79	0.67	0.53		0.8	0.59	0.93	1.18	0.90		0.71	0.91	1.04	1.33	1.09		2.2	2.2	2.3	2.51	1.88	
Width/Depth Ratio	14.7	17.3	19.7	21.1	25.3		11.0	16.67	13.6	13.4	14.1		14.5	23.2	18.3	19.5	15.3		7.5	8.58	8.3	8.5	10.2	
Entrenchment Ratio	5.3	5.7	5.1	5.1	4.3		5.8	5.0	5.8	5.6	5.7		4.8	4.2	4.6	4.0	5.0		4.8	4.45	4.7	4.9	4.5	
Wetted Perimeter (ft)	7.7	7.3	8.0	7.3	8.5		7.7	7.8	8.1	9.1	8.1		8.3	8.5	9.2	10.8	8.8		11.9	12.7	12.2	11.8	11.7	
Hydraulic Radius (ft)	0.41	0.34	0.34	0.29	0.29		0.50	0.37	0.45	0.51	0.44		0.44	0.31	0.40	0.46	0.45		1.00	0.97	0.96	0.91	0.80	
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	9.7	22.8	14.3	9.9	22.8	16.2			
Riffle Slope (ft/ft)	0.018	0.104	0.080	0.037	0.080	0.063	0.022	0.064	0.044	0.015	0.126	0.031	0.024	0.062	0.043			
Pool Length (ft)	2.4	6.4	3.8	2.2	7.7	4.6	6.7	10.9	9.6	6.0	15.40	9.50	7.18	22.84	16.20			
Pool Spacing (ft)	30.6	25.6	23.2	17.7	23.6	22.1	19.1	24.3	23.3	8.0	31.0	22.4	15.6	26.8	22.8			
Substrate																		
d50 (mm)	----			----			----			----			----					
d84 (mm)	----			----			----			----			----					
Additional Reach Parameters																		
Valley Length (ft)	662			662			662			662			662					
Channel Length (ft)	683			683			683			683			691					
Sinuosity	1.04			1.04			1.04			1.04			1.04					
Water Surface Slope (ft/ft)	0.049			0.046			0.046			0.047			0.046					
BF Slope (ft/ft)	0.046			0.046			0.048			0.046			0.046					
Rosgen Classification	B			B			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	5.8	5.0		7.9	7.4	6.5	6.8	6.5	
Floodprone Width (ft)	38.9	36.9	39.5	38.9	35.9		34.0	34.0	34.1	34.0	34.0	
BF Cross Sectional Area (ft2)	2.8	2.6	2.9	2.8	2.5		6.6	5.9	5.9	4.6	4.0	
BF Mean Depth (ft)	0.52	0.44	0.55	0.49	0.50		0.83	0.80	0.91	0.67	0.62	
BF Max Depth (ft)	0.86	0.76	0.84	0.88	0.74		1.49	1.40	1.50	1.23	1.07	
Width/Depth Ratio	10.3	13.3	9.5	11.9	10.0		9.5	9.3	7.2	10.2	10.5	
Entrenchment Ratio	7.2	6.3	7.6	6.7	7.2		4.3	4.6	5.2	5.0	5.2	
Wetted Perimeter (ft)	6.4	6.7	6.3	6.8	6.0		9.6	9.0	8.3	8.2	7.8	
Hydraulic Radius (ft)	0.4	0.4	0.5	0.4	0.4		0.7	0.7	0.7	0.6	0.5	
Substrate												
d50 (mm)												
d84 (mm)												

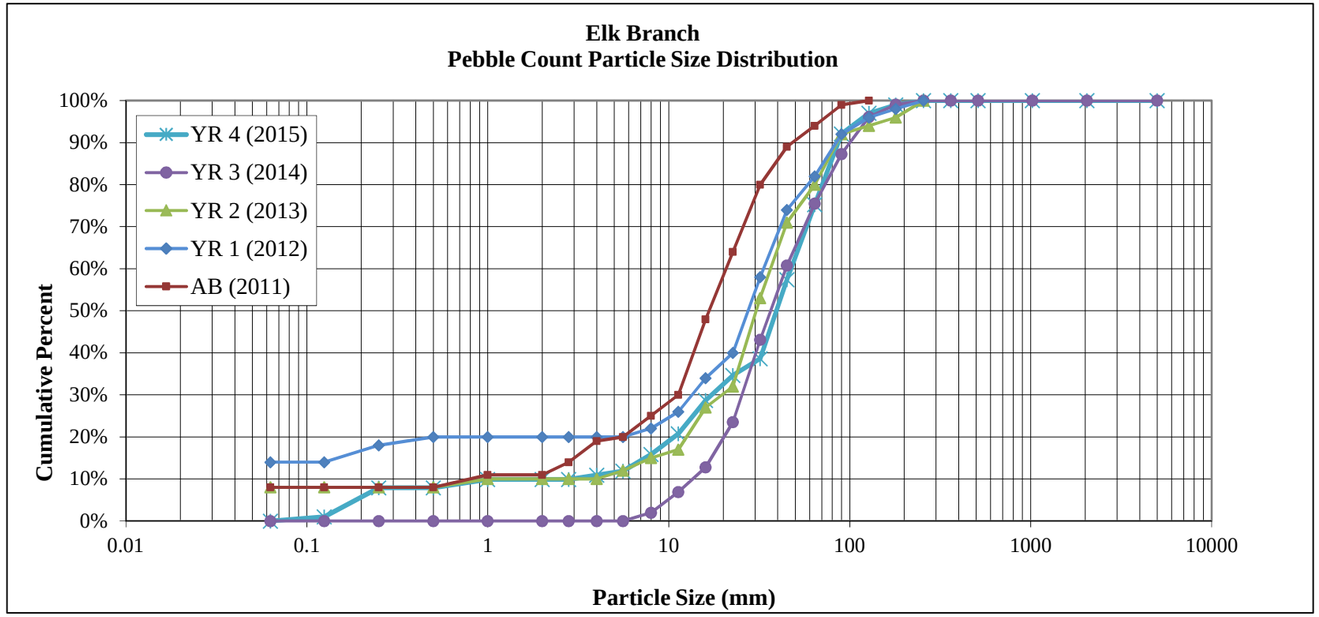
Parameter	AB (2011)			MY-1 (2012)			MY-2 (2013)			MY-3 (2014)			MY-4 (2015)			MY-5 (2016)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	9.0	13.8	12.6	9.0	14.9	13.4	10.0	14.9	14.2	5.9	13.6	10.9	9.2	26.0	13.3			
Riffle Slope (ft/ft)	0.026	0.080	0.047	0.038	0.056	0.050	0.042	0.065	0.054	0.016	0.091	0.044	0.043	0.113	0.074			
Pool Length (ft)	3	11	5	4	9	7	8	12	9	8.6	15.1	11.6	12.9	17.8	15.4			
Pool Spacing (ft)	15	27	23	18	24	22	19	23	20	14.5	28.0	21.3	16.1	38.9	24.7			
Substrate																		
d50 (mm)	----			----			----			----			----			----		
d84 (mm)	----			----			----			----			----			----		
Additional Reach Parameters																		
Valley Length (ft)	320			320			320			320			320					
Channel Length (ft)	241			241			241			241			241					
Sinuosity	----	1.04	----	----	1.04	----	----	1.04	----	----	1.04	----	----	1.04	----			
Water Surface Slope (ft/ft)	----	0.038	----	----	0.038	----	----	0.039	----	0.040			0.039					
BF Slope (ft/ft)	0.039	0.049	0.044		0.039			0.040		0.041			0.040					
Rosgen Classification	B4			B4			B4			B4			B4					

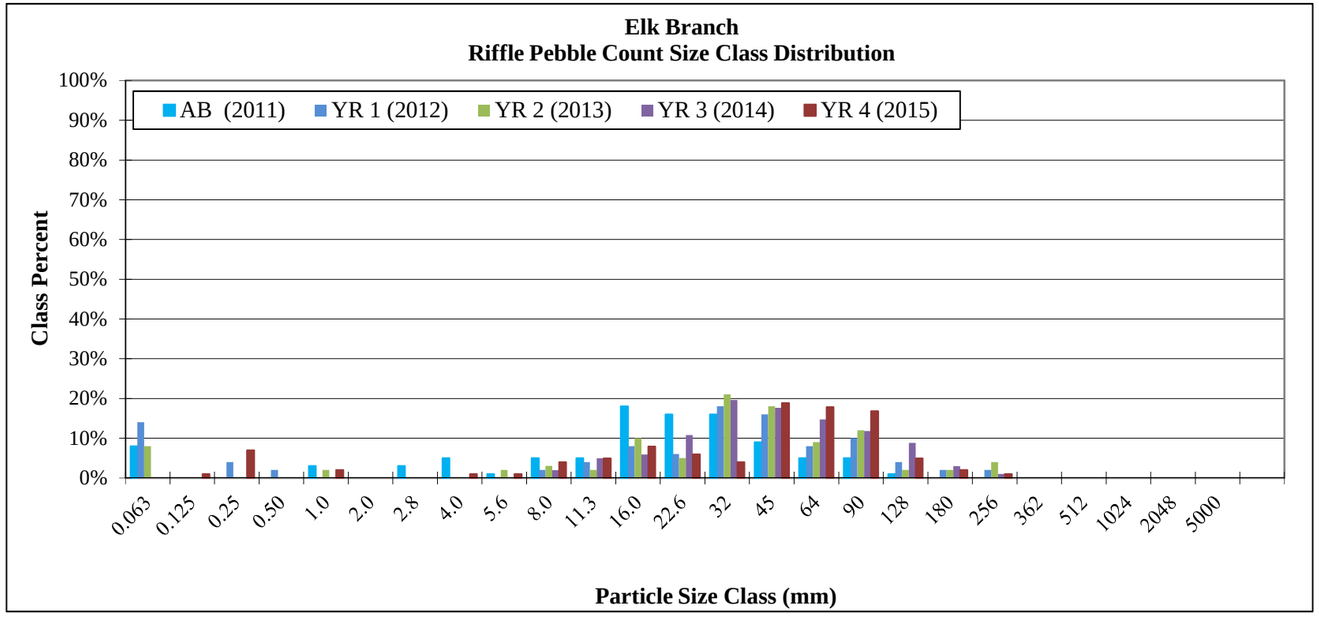
Figure B1. Elk Branch Pebble Count
Elk Branch Mitigation Project, EEP# 92665

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

			2015		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt / Clay	Silt / Clay	< .063			0%
Sand	Very Fine	.063 - .125	1		0%
	Fine	.125 - .25	7		0%
	Medium	.25 - .50			0%
	Coarse	.50 - 1.0	2		0%
	Very Coarse	1.0 - 2.0			0%
Gravel	Very Fine	2.0 - 2.8			0%
	Very Fine	2.8 - 4.0	1		0%
	Fine	4.0 - 5.6	1		0%
	Fine	5.6 - 8.0	4	2%	2%
	Medium	8.0 - 11.0	5	5%	7%
	Medium	11.0 - 16.0	8	6%	13%
	Coarse	16 - 22.6	6	11%	24%
	Coarse	22.6 - 32	4	20%	43%
	Very Coarse	32 - 45	19	18%	61%
	Very Coarse	45 - 64	18	15%	75%
Cobble	Small	64 - 90	17	12%	87%
	Small	90 - 128	5	9%	96%
	Large	128 - 180	2	3%	99%
	Large	180 - 256	1	1%	100%
Boulder	Small	256 - 362			100%
	Small	362 - 512			100%
	Medium	512 - 1024			100%
	Large-Very Large	1024 - 2048			100%
Bedrock	Bedrock	> 2048			100%
Total% of Whole Count			101	100%	

Summary Data	
Channel Materials	
D_{16} =	8.10
D_{35} =	23.00
D_{50} =	39.00
D_{84} =	76.00
D_{95} =	110.00
D_{100} =	200.00





Elk Branch
Photo Log - Reference Photo Points

Notes: Photos for Elk Branch were taken October 20, 2015.

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

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 9: looking downstream

Photo Point 10: looking upstream

Photo Point 10: looking downstream

Photo Point 11: looking upstream

Photo Point 11: looking downstream

Photo Point 12: looking upstream

Photo Point 12: looking downstream

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 October 20, 2015

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

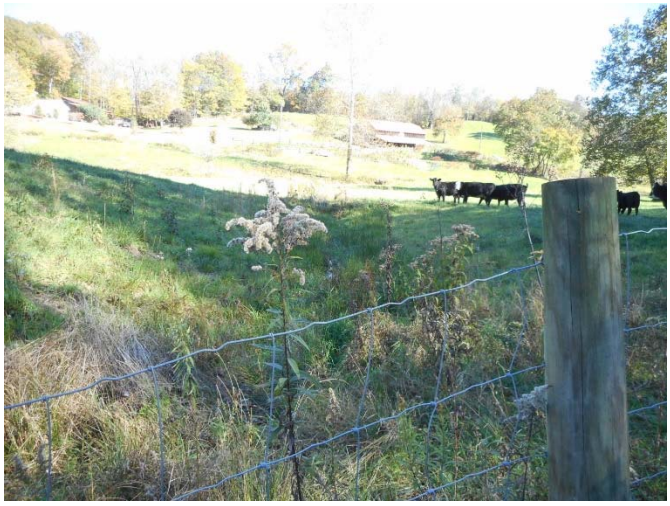


Photo Point 5: looking downstream

UT2 to Elk Branch
Photo Log - Reference Photo Points

Notes: Photos for UT2 to Elk Branch were taken October 20, 2015.

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