Sink Hole Creek Mitigation Project

Year 3 Monitoring Report

Mitchell County, North Carolina

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Prepared for: North Carolina Ecosystem Enhancement Program (NCEEP)

NCEEP Project Manager: Harry Tsomides

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Contract Number: D06125-C, EEP Project Number: 92663

Project Construction: 2010

Data Collection Period: 2013-2014

Date Submitted: 2014

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EXECUTIVE SUMMARY

The Sink Hole Creek site was restored through a full delivery contract with the North Carolina Ecosystem Enhancement Program (NCEEP). This report documents the completion of the project and presents Year 3 monitoring data for the five-year monitoring period. The goals for the restoration project were as follows:

- To create geomorphically stable conditions on the Sink Hole Creek project site;
- The reduction of sediment and nutrient loading through restoration of riparian areas and stream banks and the exclusion of livestock from the streams corridors;
- To improve and restore hydrologic connections between the creek and floodplain;
- The restoration and preservation of headwater tributaries to the North Toe River, French Broad River Basin; and
- To improve aquatic and terrestrial habitat along the project corridor.

To accomplish these goals, the following objectives were implemented:

- Restoration of incised, eroding, and channelized streams by creating stable channels that have access to its floodplain;
- Improvement of water quality by establishing buffers for nutrient removal from runoff and by stabilizing streambanks to reduce bank erosion;
- Improvement of in-stream habitat by providing a more diverse bedform with riffles and pools, creating deeper pools, developing areas that increase oxygenation, providing woody debris for habitat, and reducing bank erosion;
- Improvement of terrestrial habitat by planting riparian areas with native vegetation and protection of 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 eight vegetation monitoring plots 100 square meters (m^2) (10m x 10m) in size were surveyed to predict survival of the woody vegetation planted on-site. Year 3 of vegetation monitoring indicates a range of 283 to 688 stems per acre, with an average survival rate of 521 stems per acre. The data shows that the Site has met the interim stem survival criteria for Year 3 (320 stems per acre) and is on track to meet the final success criteria of 260 trees per acre by the end of Year 5.

The design implemented at the Sink Hole Creek mitigation project site involved both Priority Level I and II approaches. The resulting design should ultimately yield primarily a B-type channel for Sink Hole Creek and Reach 2 of UT1. Unnamed tributaries 2 and 3 should become stable A and B-type channels. Restoration work was completed in accordance with the approved design approach provided in the mitigation plan for Sink Hole Creek. Longitudinal profile and cross-section data indicate that the project streams have remained stable since baseline monitoring data were collected in the fall of 2010. Although stable, there are sections of UT2-Reach 2 and UT3 where the stream goes subsurface. Stream flow was found to go subsurface for 349 linear feet (LF), with UT2 Reach 2 experiencing 55 LF of subsurface flow and UT3 experiencing 294 LF of subsurface flow. However, as A-type streams, this is not an unusual circumstance. 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 geomorphic data presented in Appendix B, this site is currently on track to meet the success criteria specified in the Sink Hole Creek Mitigation Plan.

Summary information and data related to the occurrence of items such as beaver impacts or encroachment, and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report appendices. Besides subsurface flow in isolated segments on UT2 and UT3, the only other notable project concern observed during Year 3 monitoring was the temporary encroachment of cattle at the lower end of UT2, two areas of invasive species encroachment,

and the two boulder steps on Sink Hole Creek Reach 2 that had the wing boulders fall into the pool due to high flows. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report (formerly Mitigation Plan) and in the Mitigation Plan (formerly Restoration Plan) documents available on EEP's website. All raw data supporting the tables and figures in the appendices is available from EEP upon request.

1.0 PROJECT BACKGROUND

The Sink Hole Creek mitigation site is located approximately four miles southwest of Bakersville, in Mitchell County, North Carolina (Figure 1 in Appendix A). The project site is situated in the French Broad River Basin, within North Carolina Division of Water Quality (NCDWQ) sub-basin 04-03-06 and United States Geologic Survey (USGS) hydrologic unit 06010108040010. The Sink Hole Creek mitigation project is located in a watershed that is predominantly forested, but also contains a small number of residences near Sink Hole Creek and its tributaries. A quarter of the drainage is in some form of pasture land or hay production. Sink Hole Creek and its tributaries have been impaired by historical and recent land management practices that include timber harvesting, pasture conversion, channelization, and livestock grazing. In addition, a historic mica mine is located 1,000 feet north of the intersection of NC Highway 80 and Water Street (SR 1182). Prior to restoration, stream channelization and channel dredging were evident through much of the project site. Over time, these practices have contributed excessive sediment and nutrient loading to Sink Hole Creek and ultimately to the North Toe River which is home to the endangered Appalachian elktoe mussel (*Alamidonta raveneliana*). A significant loss of woody streambank vegetation occurred during the development of the land for agricultural use. Livestock had open access to portions of Sink Hole Creek, the section of UT1below NC Hwy. 80, UT2, and UT3. Past dredging activities had cut Sink Hole Creek off from its floodplain resulting in an incised channel; while in other sections, stream banks were trampled down, creating over widened channel conditions that contributed to additional sediment and nutrient loading. Land immediately surrounding the preservation reach of UT1 above Hwy. 80 is in forested cover.

The project involved restoration or enhancement of 4,703 LF along four (4) on-site streams: Sink Hole Creek and three (3) smaller unnamed tributaries (UT1, UT2 and UT3). In addition, 1,076 LF of the headwaters of UT 1 were preserved. Sink Hole Creek and UT1 are shown on the USGS topographic quadrangle for the site as being perennial and intermittent streams, respectively. Based on a field evaluation, Sink Hole Creek and the restoration reach of UT1, UT2 and UT3, all were determined to be perennial features using the NCDWQ stream assessment protocol.

1.1 Location and Setting

To reach the project site, follow US Highway 19/23 north from Asheville for approximately 20 miles and take US Highway 19N (Exit 9) towards Burnsville and Spruce Pine. Continue along US Highway 19 (which becomes US-19E), for 25 miles. At Spruce Pine, turn left onto NC Highway 226 and continue for approximately 6.5 miles to State Road 1191. Turn left onto 1191, continue for approximately 1.7 miles, turn left onto NC Highway 80 and travel another 6.5 miles to Water Street (State Road 1182). Part of the project area is adjacent to the intersection of Water Street and NC Highway 80; UT 2 and UT3 are located in a pasture approximately .6 miles east on Water Street, on the left side of the road (Figure 1).

The Sink Hole Creek project site is located approximately four miles southwest of Bakersville in the small community of Bandana, Mitchell County, North Carolina. To reach the project site, follow US Highway 19/23 north from Asheville for approximately 20 miles and take the US Highway 19N exit, Exit 9, towards Burnsville and Spruce Pine. Continue along US Highway 19 (which becomes US-19E), for 25 miles, at Spruce Pine turn left onto NC Highway 226 and continue for approximately 6.5 miles to State Road 1191. After turning left onto NC Highway 1191, continue for approximately 1.7 miles. Turn left onto NC Highway 80 and travel another 6.5 miles to Water Street (State Road 1182). Part of the project area is adjacent to the intersection of Water Street and NC Highway 80; UT 2 and UT3 are located in a pasture approximately .6 miles east on Water Street, on the left side of the road.

"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 -

YANCEY

MITCHELL

AVERY

MADISON

BURKE

MCDOWELL

Elk Park

Newland

Bakersville

Crossnore

Burnsville

Spruce Pine

Marion

Text

04-02-01

HU 06010108040010

Sink Hole Creek Project Site

FRENCH BROAD
04-03-06

FRENCH BROAD
04-03-07

CATAWBA
03-08-31

CATAWBA
03-08-30

NC226

NC261

NC197

NC80

NC194

NC181

NC126

US19 W

US19 E

US221

US70

US-19 W

19W

19E

19

221

70

40

I40

Location Inset

Project
Watershed/Reaches

Roses Branch Rd

Gragg Branch Rd

Fred Sparks Rd

White Oak Rd

Mine Creek Rd

Water St

Abernathy Rd

Slagle Rd

Conley Ridge Rd

Wing Rd

Lunday Rd

SR#1314

SR#1237

SR#1483

SR#1179

SR#1181

SR#1253

SR#1250

Map Inset

Mitchell County, NC

LEGEND:

- NCDWQ Sub-basin
- Counties
- USGS Hydrologic Unit
- Project Hydrologic Unit
- Mitchell County

0 1 2 4 Miles

Ecosystem Enhancement PROGRAM

Baker

Figure 1. Project Vicinity Map

**Sink Hole Creek
Restoration Project
Mitchell County, NC**

1.2 Mitigation Structure and Objectives

Table 1 summarizes project data for each reach and restoration approach used. The design implemented at the Sink Hole Creek mitigation project site involved both Priority Level 1 and 2 approaches. The resulting design should ultimately yield primarily a B-type channel for Sink Hole Creek and Reach 2 of UT1. Unnamed tributaries 2 and 3 should become stable A and B-type channels. Restoration and enhancement work were completed in accordance with the approved design approach provided in the mitigation plan for Sink Hole Creek.

Table 1. Project Mitigation Structure and Objectives Table
Sink Hole Creek Mitigation Project-NCEEP Project #92663

Project Segment or Reach ID	Existing Feet/ Acres	Mitigation Type	Approach	Target Stream Type	Footage or Acreage	Mitigation Ratio	Mitigation Units	Stationing	Comment
Sink Hole Creek									
Reach 1	1,036 LF	R	PII	Cb/ Eb	1,019LF	1.0:1	1,019	0+13 to 11+23	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
Reach 2	1,062 LF	R	PII		1,073LF	1.0:1	1,073	11+23 to 22+08	Pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT1									
Reach 1	1,076 LF	P			1,076 LF	5.0:1	215	-	Preservation reach-no adjustments made.
Reach 2	489 LF	R	PII	B	489 LF	1.0:1	489	0+13 to 5+14	Slight pattern adjustment, removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT 2									
Reach 1	579 LF	R	PI	Aa^+/ B	596 LF	1.0:1	596	0+22 to 6+30	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.
Reach 2	879 LF	R	PI	B/A	882 LF	1.0:1	885	6+30 to 15+12	Adjust pattern, improve dimension by removal of vertical banks and increased floodplain connectivity, and restore profile via grade control and constructed riffles.
UT 3									
Reach 1	586 LF	R	PI	Aa^+/ B	641 LF	1.0:1	641	0+00 to 6+41	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 (LF)	Riparian Wetland (Ac)	Nonriparian Wetland (Ac)	Total Wetland (Ac)	Buffer (Ac)	Comment
4,918	NA	NA	NA		

Notes:

Anthropogenic land use alteration, such as channelization of streams for agricultural purposes, in the Sink Hole Creek watershed, has resulted in various stream corridor impairments. Incision, bank destabilization, erosion, and other ongoing stream processes typical of streams adjusting to modification, were found along various reaches of Sink Hole Creek and the unnamed tributaries within the project area.

In accordance with the approved mitigation plan for the site, construction activities began in May 2010. Project activity on Sink Hole Creek and UT1-Reach 2, consisted of making adjustments to channel dimension, pattern, and profile. A Priority II Restoration approach was used on these stream reaches to restore floodplain connectivity. In addition, some sinuosity was incorporated based on the valley shape and the channel profile was stabilized by creating a step-pool morphology using grade control structures, including constructed riffles. The dimension was improved by eliminating the presence of vertical banks, improving floodplain connectivity by the removal of manmade levies, and correcting prior channelization by making slight adjustments to channel pattern where feasible.

A Priority I Restoration approach was implemented on UT2 and UT3 to raise the channel bed elevation, create a more stable profile, adjust channel alignment and to re-establish a riparian buffer to stabilize the streambanks. Both channels required extensive work as both had been essentially reduced to functioning as severely incised ditches with vertical, eroding banks and an unstable profile that had been cut off from the surrounding floodplain and had multiple headcuts.

Throughout the project, providing vertical stability was the most important project objective to achieve channel stability, water quality, and habitat goals. In-stream structures (constructed riffles, boulder steps, log vanes, and log rollers) were used to control streambed grade, reduce stresses on streambanks, and promote diversity of bedform and habitat. Reach-wide grade control was provided by the aforementioned in-stream structures and by bedrock where present. Structures were spaced at a distance that resulted in the downstream header protecting the upstream footer to create a redundancy that will ensure long term vertical stability.

Stream dimensions were adjusted to eliminate vertical banks and erosion resulting from excessive shear stress and a 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. Native vegetation was planted across the site, and the entire mitigation site is protected through a permanent conservation easement.

1.3 Project History and Background

The chronology of the Sink Hole Creek mitigation project is presented in Table 2 while the contact information for designers, contractors and plant material suppliers is presented in Table 3. Relevant project background information is presented in Table 4. Total stream length across the project increased from approximately 5,707 LF to 5,779 LF (excluding easement breaks).

Table 2. Project Activity and Reporting History
Sink Hole Creek Mitigation Project-NCEEP Project #92663

Activity or Report	Data Collection Complete	Completion or Delivery
Restoration Plan		May 2009
Final Design-90%		June 2009
Construction		August 2010
Temporary S&E mix applied to entire project area		May-July 2010
Permanent seed mix applied to project site		August 2010
Containerized and B&B plantings set out		April 2011
Flood Event		July 2010
Installation of crest gauges		January 2011
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	April 2011 (Vegetation Monitoring)	May 2011 (last of plantings completed in April)

Table 2. Project Activity and Reporting History Sink Hole Creek Mitigation Project-NCEEP Project #92663		
	November-December 2010 (Geomorphic Monitoring)	
Year 1 Monitoring	November 2011	April 2012
Year 2 Monitoring	January 2013	March 2013
Year 3 Monitoring	November 2013	February 2014
Year 4 Monitoring		
Year 5 Monitoring		

Table 3. Project Contacts Table Sink Hole Creek Mitigation Project-NCEEP Project #92663	
Designer	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Micky Clemmons, Tel. 828.350.1408 x2002
Construction Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: Bill Wright, Tel. 919.818.6686
Planting & Seeding Contractor	
River Works, Inc.	8000 Regency Parkway, Suite 200, Cary, NC 27511 Contact: George Morris, Tel. 919.818.6686
Seed Mix Sources	Green Resources
Nursery Stock Suppliers	Arborgen and Hillis Nursery
Monitoring	
Michael Baker Engineering, Inc.	797 Haywood Rd Suite 201, Asheville, NC 28806 Contact: Matthew Reid, Tel. 828.350.1408 x2006

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCEEP Project #92663	
Project County	Mitchell County, NC
Physiograhic Region	Blue Ridge
Ecoregion	Blue Ridge Mountains-Southern Crystalline Ridges and Mountains
Project River Basin	French Broad
USGS HUC for Project	6010108040010
NCDWQ Sub-basin for Project	04-03-06
Within extent of EEP Watershed Plan?	In a TLW (French Broad River Basin Priorities Report-2009)
WRC Class	Cold Water
NCDWQ classification	Sink Hole-C; Tr , UT1-n/a UT2-n/a, UT3-n/a
% of Project Easement Fenced or Demarcated	100% (post-construction)
Beaver Activity Observed During Design Phase?	No
Drainage Area (Square Miles)	

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCEEP Project #92663	
Sink Hole Creek Reach 1	.72 mi^2
Sink Hole Creek Reach 2	.84 mi^2
UT1Reach 1	.07 mi^2
UT1 Reach2	.09 mi^2
UT2 Reach 1	.02 mi^2
UT2 Reach 2	.08 mi^2
UT3	.02 mi^2
Stream Order	Sink Hole-2nd , UT1-1st, UT2-zero order, UT3-zero order
Restored Length	
Sink Hole Creek Reach 1	1,019 LF
Sink Hole Creek Reach 2	1,073 LF
UT1Reach 1	1,076 LF
UT1Reach 2	489 LF
UT2 Reach 1	596 LF
UT2 Reach 2	885 LF
UT3	641 LF
Perennial or Intermittent	Perennial except Reach 1 of UT1 (intermittent)
Watershed Type	Rural (Predominantly Forested)
Watershed LULC Distribution (Percent area)	
Forest	66%
Shrub	0.4%
Pasture/Crops	28%
Developed Open Space	6%
Drainage Impervious Cover Estimate (%)	<10%
NCDWQ AU/Index #	7-2-56
303d Listed / Upstream of 303d Listed Segment	No/ No
Reasons for 303d Listing or Stressor	-
Total Acreage of Easement	9.46
Total Vegetated Acreage w/in Easement	n/a (Easement vegetated with exception of stream channel)
Total Planted Acreage within the Easement	~9.46 Acres
Rosgen Classification (Pre-existing)	
Sink Hole Creek Reach 1	Eb/Cb
Sink Hole Creek Reach 2	G/Eb
UT1 Reach2	Cb/B
UT2 Reach 1	Aa^+
UT2 Reach 2	A
UT3	A
Rosgen Classification of As-built	
Sink Hole Creek Reach 1	Cb,Eb
Sink Hole Creek Reach 2	Cb,Eb

Table 4. Project Background Table Sink Hole Creek Mitigation Project-NCEEP Project #92663	
UT1 Reach2	B
UT2 Reach 1	Aa+,B
UT2 Reach 2	A,B
UT3	Aa+,B
Valley Type	II
Valley Slope	.028-.03 (Sink Hole), .028 (UT1), .1-.055 (UT2), .1 (UT3)
Trout Waters Designation	Yes (Supporting Waters, Trib. to designated TW)
Species of Concern	No

1.4 Monitoring Plan View

The current conditions plan view (CCPV) depicts the monitoring features for the Sink Hole Creek Mitigation Project. The plan set also provides call outs at locations where stream and vegetation problem areas are present. Figure 2 illustrates the project as it is delineated by reach.

LEGEND

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

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET
- STREAM PROBLEM AREAS
- VEGETATION PROBLEM AREAS

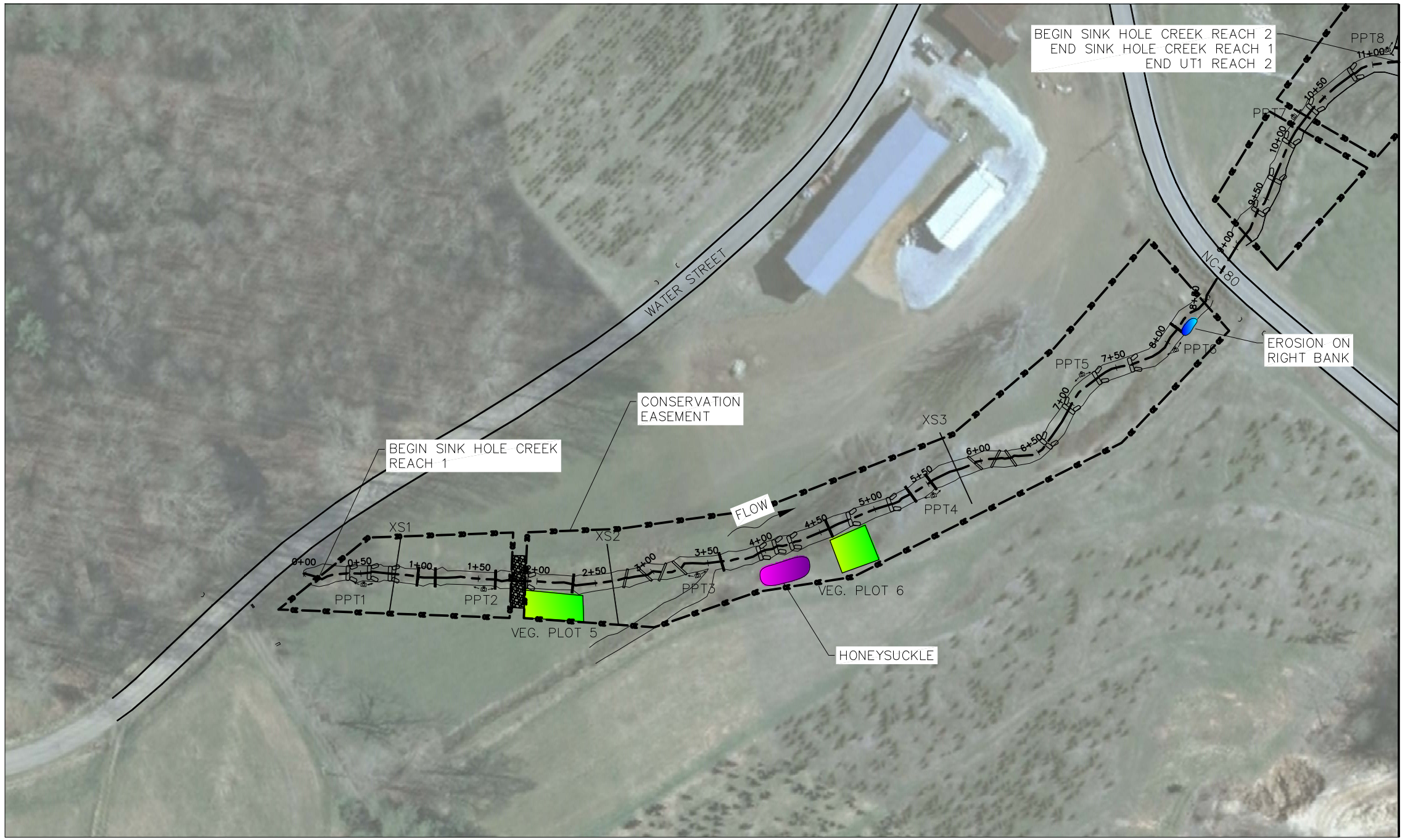
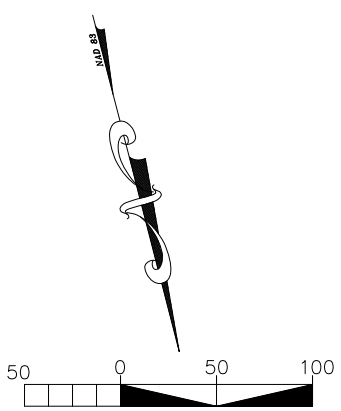


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

MATCHLINE SHEET 2

SINK HOLE CREEK
CURRENT CONDITION
PLAN VIEW
YEAR 3 MONITORING



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SINK HOLE CREEK RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION
PLAN VIEW

Ecosystem Enhancement Program

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

EEP Project No.	92663
Baker Project No.	111084
Date:	1/8/2014
DESIGNED:	MDR
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	3 of 5
Sheet:	1 of 4

LEGEND

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

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET
- STREAM PROBLEM AREAS
- VEGETATION PROBLEM AREAS

MATCHLINE SHEET 1

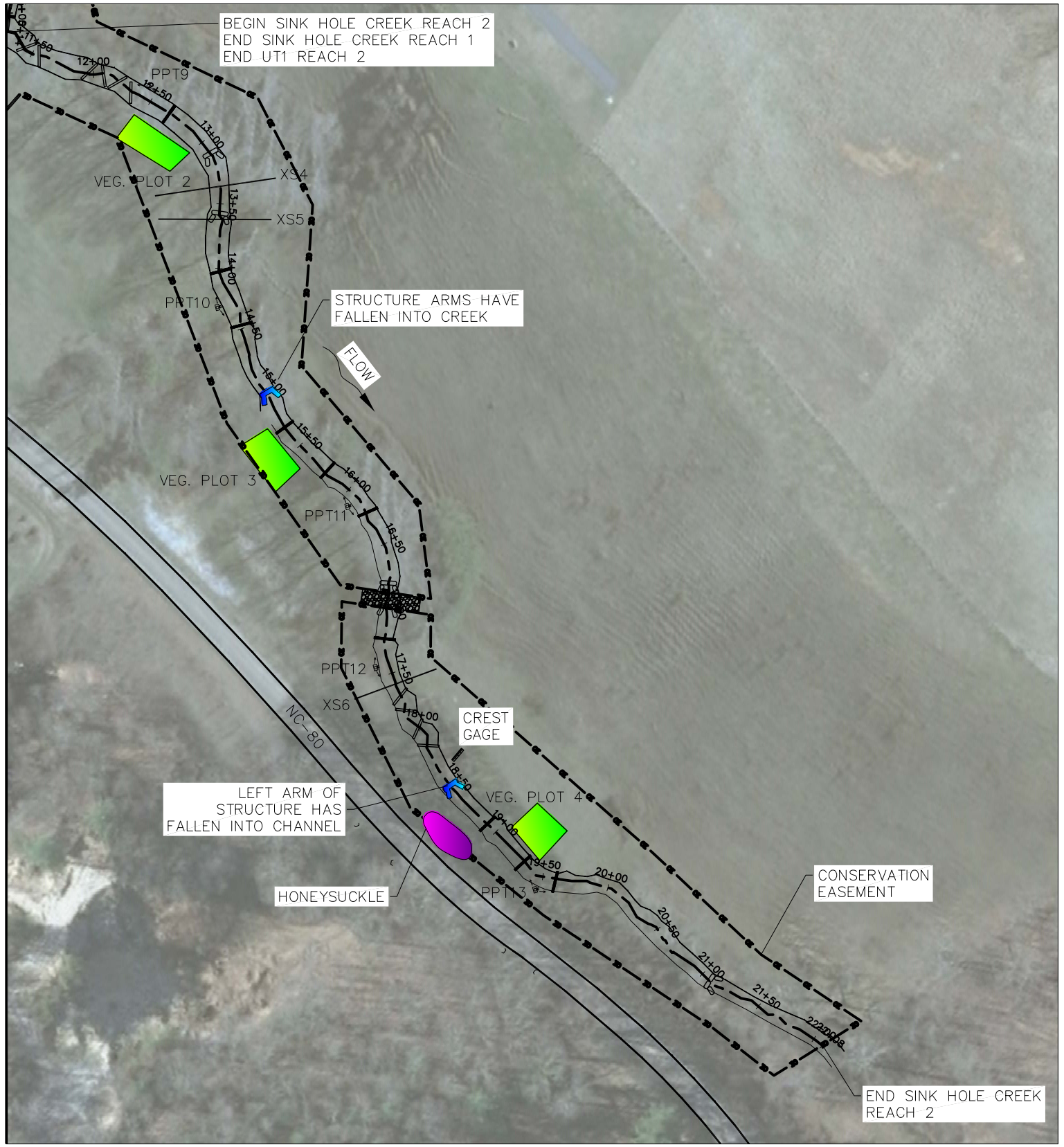
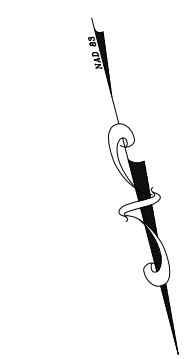


IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

SINK HOLE CREEK
CURRENT CONDITION
PLAN VIEW
YEAR 3 MONITORING



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SINK HOLE CREEK RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION PLAN VIEW

Ecosystem Enhancement Program

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LEGEND

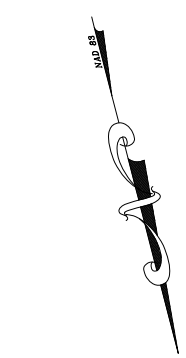
- CE — CE — CONSERVATION EASEMENT
- DESIGNED CENTERLINE
- DESIGNED STREAM BANK
- FENCE
- CROSS SECTION
- PHOTO POINT

PROJECT CONDITION

- VEG PLOT CRITERIA MET
- VEG PLOT CRITERIA UNMET
- STREAM PROBLEM AREAS
- VEGETATION PROBLEM AREAS

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

UT1
CURRENT CONDTION
PLAN VIEW
YEAR 3 MONITORING



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SINK HOLE CREEK RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA

CURRENT CONDITION
PLAN VIEW

Ecosystem Enhancement Program

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Date:	1/8/2014
DESIGNED:	MDR
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	3 of 5
Sheet:	3 of 4

UT2 and UT3
CURRENT CONDITION
PLAN VIEW
YEAR 3 MONITORING

IMAGE SOURCE: NC STATEWIDE ORTHOIMAGERY, 2010

50 0 50 100

NAD 83

BEGIN UT2 REACH 1
END UT2 REACH 2
BEGIN UT2 REACH 2
END UT3
BEGIN UT3
END UT2 REACH 1
CREST GAGE
FENCE
CONSERVATION EASEMENT
BARE FLOOD PLAIN
BUFFER ENCROACHMENT FENCE DOWN
VEG. PLOT 7
VEG. PLOT 8
FLOW
STA: 0+47–1+07
STA: 1+36–1+53
STA: 1+57–3+47
STA: 4+91–5+18
STA: 7+95–8+21
STA: 8+25–8+54

PROJECT CONDITION
- VEGETATION PROBLEM AREAS
- STREAM PROBLEM AREAS
- VEG PLOT CRITERIA UNMET
- VEG PLOT CRITERIA MET

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

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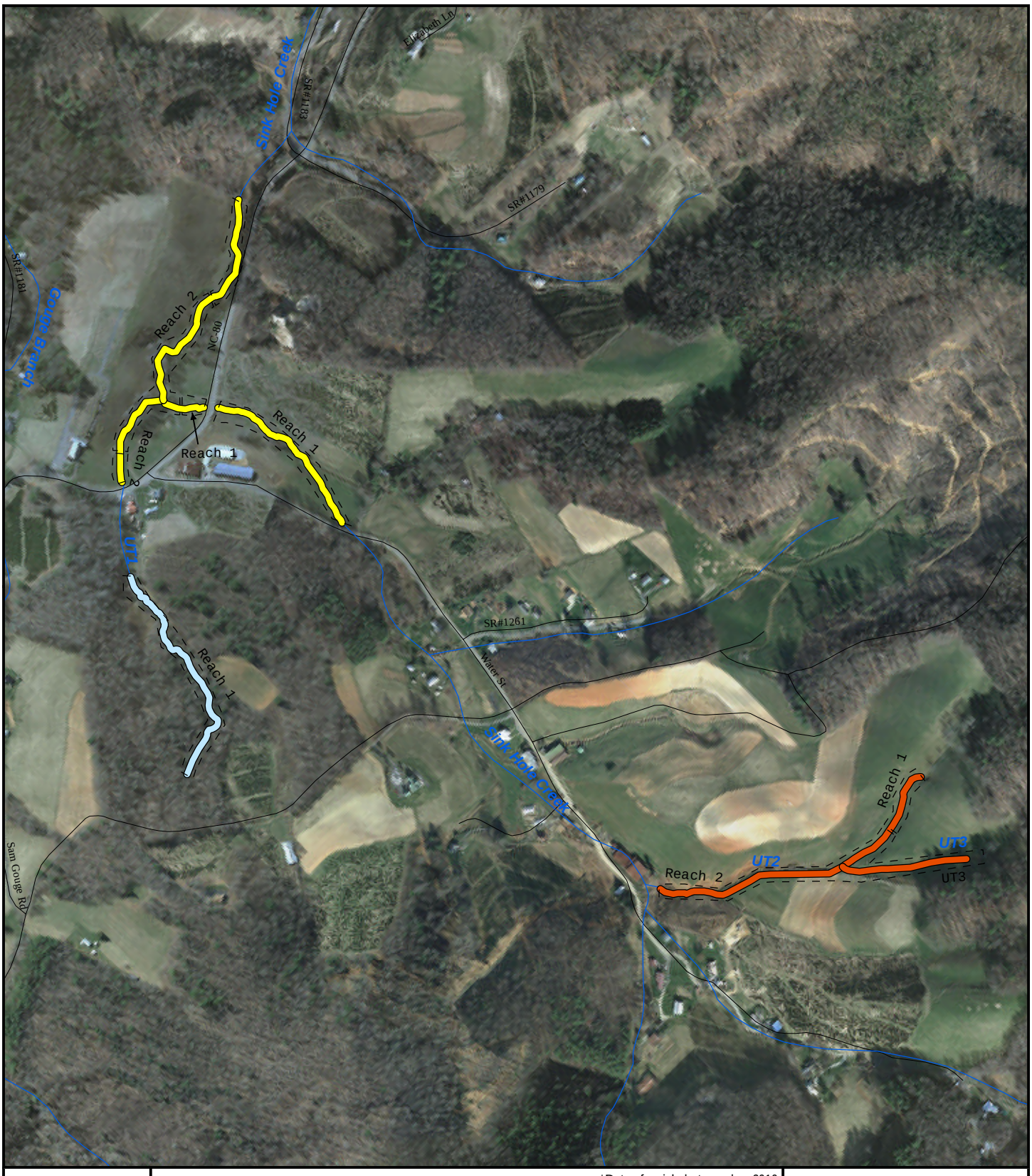
SINK HOLE CREEK RESTORATION PROJECT
MITCHELL COUNTY, NORTH CAROLINA
CURRENT CONDITION
PLAN VIEW

EEP Project No.	92663
Baker Project No.	111084
Date:	1/8/2014
DESIGNED:	MDR
DRAWN:	MDR
APPROVED:	MMC
Monitoring Year:	3 of 5
Sheet:	4 of 4



LEGEND:

*Date of aerial photography: 2010

Proposed Project Component
- Preservation
- Priority I Restoration
- Priority II Restoration

Proposed Easement

Streams

0 200 400 800 Feet

Ecosystem Enhancement Program

Figure 2. Restoration Summary Map

Sink Hole Creek Restoration Project Mitchell County, NC

Baker

2.0 PROJECT CONDITION AND MONITORING RESULTS

The five-year monitoring plan for the Sink Hole Creek mitigation project includes criteria to evaluate the success of the vegetation and stream components of the project. The specific locations of vegetation plots, permanent cross-sections, reference photo stations and crest gauges are shown on the Year 3 CCPV submitted with this report.

2.1 Vegetation Assessment

2.1.1 Vegetation

Successful restoration of the vegetation on a site is dependent upon hydrologic restoration, active planting of preferred canopy species, and volunteer regeneration of the native plant community. In order to determine if the criteria are achieved, eight (8) 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. Level 1 CVS vegetation monitoring will occur in spring, after leaf-out has occurred, or in the fall prior to leaf fall. At the end of the first growing season, during baseline surveys, species composition, density, and survival were evaluated. Individual quadrant data provided during subsequent monitoring events will include diameter, height, density, and coverage quantities. Relative values will be calculated, and importance values will be determined. Individual seedlings will be marked to ensure that they can be found in succeeding monitoring years. Mortality will be determined from the difference between the previous year's living, planted seedlings and the current year's living, planted seedlings.

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

The interim measure of vegetative success for the site is the survival of at least 320, 3-year old, planted trees per acre at the end of the Year 3 monitoring period. The final vegetative success criteria is the survival of 260, 5-year old, planted trees per acre at the end of the Year 5 monitoring period. If the measurement of vegetative density proves to be inadequate for assessing plant community health, additional plant community health indices may be considered.

Temporary seeding applied to streambanks beneath the erosion matting sprouted within two weeks of application and has provided excellent ground coverage. Live stakes and bare root trees planted are also flourishing and will increasingly contribute to streambank stability and shading of the stream. Bare-root trees were planted throughout the conservation easement with the exception of the preservation reach. A minimum 30-foot buffer was established along all restored stream reaches. In general, bare-root vegetation was planted at a target density of 680 stems per acre, in an 8-foot by 8-foot grid pattern. Planting of bare-root trees was completed in the winter of 2010-2011. Species planted are listed below.

Table 5. Riparian Buffer Plantings per Acre
Sink Hole Creek Mitigation Project-NCEEP Project #92663

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Riparian Buffer Plantings				
Trees Overstory				
Sycamore	*Platanus occidentalis*	8	54	FACW-
River Birch	*Betula nigra*	5	34	FACW
White Oak	*Quercus alba*	5	34	FACU
Red Maple	*Acer rubrum*	8	54	FAC
Tulip Poplar	*Liriodendron tulipifera*	5	34	FAC
Yellow Birch	*Betula alleghaniensis (lutea)*	5	34	FACU+
Black (Sweet) Birch	*Betula lenta*	5	34	FACU
Northern Red Oak	*Quercus rubra*	5	34	FACU
Sugar Maple	*Acer saccharum*	5	34	FACU-
Mockernut Hickory	*Carya alba (tomentosa)*	3	20	N/A
Scarlet Oak	*Quercus coccinea*	2	14	N/A
Trees Understory				
Black Willow	*Salix nigra*	4	27	OBL
Ironwood	*Carpinus caroliniana*	5	34	FAC
Witch Hazel	*Hamamelis virginiana*	4	27	FACU
Sourwood	*Oxydendrum arboreum*	5	34	FACU
Flowering Dogwood	*Cornus florida*	6	41	FACU
Rhododendron	*Rhododendron maximum*	7	48	FAC-
Tag Alder	*Alnus serrulata*	7	48	
Redbud	*Cercis canadensis*	6	41	FACU
Shrubs				
Rivercane (giant cane)	*Arundinaria gigantea*	15	102	FACW
Spicebush	*Lindera benzoin*	15	102	FACW
Deerberry	*Vaccinium stamineum*	10	68	FACU
Eastern Sweetshrub, Sweetshrub	*Calycanthus floridus, Calycanthus spp.*	15	102	FACU
Sweetpepperbush	*Clethra spp.*	15	102	N/A
Winterberry	*Ilex verticillata*	10	68	FACW
Virginia Sweetspire	*Itea virginica*	15	102	FACW+
Chokeberry	*Photinia*	5	34	N/A
Riparian Livestake Plantings				
Ninebark	*Physocarpus opulifolius*	10	68	FAC-
Elderberry	*Sambucus canadensis*	20	136	FACW-

Table 5. Riparian Buffer Plantings per Acre
Sink Hole Creek Mitigation Project-NCEEP Project #92663

Common Name	Scientific Name	% Planted by Species	Planting Totals	Wetness Tolerance
Buttonbush	*Cephalanthus occidentalis*	10	68	OBL
Silky Willow	*Salix sericea*	35	238	OBL
Silky Dogwood	*Cornus amomum*	25	170	FACW+

Note: Species selection may change due to refinement or availability at the time of planting. Planting density based on planting schedule of 680 stems per acre as described in the mitigation plan.

2.1.2 Soil Data

Table 6. Preliminary Soil Data
Sink Hole Creek Mitigation Project-NCEEP Project #92663

Dominant Soil Series and Characteristics	Bandana/ Dillsboro/Saunook-Thunder/Dellwood-Reddies				
	Depth (in.)	% Clay	K Factor	T Factor	% OM
Sink Hole Creek Reach 1	>80”	10-20	.15	4	4-10%
Sink Hole Creek Reach 2	>80”	10-20	.15	4	4-10%
UT1Reach 1	~87”	27-35	.1	5	4-10%
UT1 Reach2	>80”	10-20	.15	4	4-8%
UT2 Reach 1	>80”	7-20/ 15-28	.05/.02	5	4-10%/ 6-14%
UT2 Reach 2	>80”	5-15/ 5-18	.05	3	4-8%
UT3	>80”	7-20/ 15-28	.05/.02	5	4-10%/ 6-14%

2.1.3 Vegetative Problem Areas

There are two areas within the conservation easement where invasive species have encroached. One area on Sink Hole Creek Reach 1 near vegetation plot 6 and another area on Sink Hole Creek Reach 2 near vegetation plot 4. Honeysuckle has been identified and will be treated in spring 2014. There is also a small area that is essentially bare on the left flood plain near the confluence of UT2 and UT3. This area will be reseeded prior to the 2014 growing season. Invasive species encroachment areas and the bare flood plain area are identified on the Year 3 CCPV.

2.1.4 Stem Counts

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

2.1.4.1.1 Results

Table 7 in Appendix A presents information on the stem counts for each of the vegetation monitoring plots. Data from the Year 3 monitoring event showed a range of 283-688 planted stems per acre, with approximately 88% of the stems showing no signs of damage. The average density of planted bare root stems, based on data collected from the eight monitoring plots during Year 3 monitoring, is 521 stems per acre which indicates that the Site is meeting

the minimum success interim criteria of 320 trees per acre by the end of Year 3 and the final success criteria of 260 trees per acre by the end of Year 5. The locations of the vegetation plots are shown on the CCPV.

As shown in Table 8 (Appendix A), there are two small areas where invasive species have been identified, one small area of bare flood plain, and an area of bank erosion caused by high flows due to record precipitation in 2013. Although the density of herbaceous cover varies across the site, conditions observed on-site during the Year 3 monitoring survey found ground cover in the easement area to be sufficient for aiding in site stabilization and in some location was very thick. Declines in various tree and shrub species that were observed in Year 3 monitoring were likely due to natural causes including being outcompeted by dense herbaceous cover or the herbaceous vegetation provides cover for rodents that would chew and girdle trees. Survival rates of planted woody stems in the vegetation plots indicate that plantings across the easement area are of sufficient density to meet regulatory requirements, as well as the site stabilization and habitat enhancement goals originally set forth in the mitigation plan. Multiple small stems were observed in the project area. As these stems continue to grow and planted vegetation continues to flourish, the site should have no difficulty in meeting the final success criteria. 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 (to a lesser degree for reasons noted below), bed composition, bank stability, bankfull flows, and stability of reference sites documented by photographs. Crest gauges, as well as high flow marks (wrack lines, laid over vegetation, etc.) 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, fifteen permanent cross-sections, four longitudinal profile sections and two crest gauges were installed. Detailed channel morphology was surveyed with a total station and survey data is georeferenced.

2.2.1.1 Dimension

Fifteen permanent cross-sections were installed to help evaluate the success of the mitigation project. Permanent cross-sections were established throughout the project site as follows: six cross-sections were located on Sink Hole Creek, two cross-sections were located on both UT1 and UT3 and five 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 used. A common benchmark is used for cross-sections and consistently referenced to facilitate comparison of year-to-year data. The cross-sectional surveys include points measured at breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg, if these features are present. Riffle cross-sections are classified using the Rosgen Stream Classification System.

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

2.2.1.1.1 Results

As-built cross-section monitoring data for stream stability was collected in November and December, 2010. The fifteen permanent cross-sections along the restored channels were re-surveyed in November 2013 to document stream dimension for Monitoring Year 3. Cross-sectional data is presented in Appendix B and the location of cross-sections is shown on the CCPV submitted with this report.

The cross-sections show that there has been little to no adjustment in stream dimension across the project reaches since construction. What adjustment has occurred has primarily been observed in riffle cross-sections that are exhibiting signs of narrowing. Based on field observation, this narrowing can be attributed to herbaceous vegetation that has become 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 3 were surveyed during November 2013; profiles of the various project reaches are provided in Appendix B. A longitudinal profile was conducted for the entire project length on Sink Hole Creek, UT2, UT3 and Reach 2 of UT1. Longitudinal profiles are replicated annually during the five year monitoring period.

Measurements taken along longitudinal profiles include thalweg, water surface, and the 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, glide) and the maximum pool depth. Elevations of grade control structures were also included in the longitudinal profiles surveyed. Surveys were tied to a permanent benchmark. Although pattern adjustments were made in each reach for channel alignment considerations such as following the low point of the valley, pattern adjustments were not made with the intent to increase sinuosity. Sink Hole Creek and its tributaries are A and B-type streams primarily characterized by step-pool sequences. Consequently, pattern information is not provided in Appendix B as these parameters are generally associated with meandering, riffle-pool type channels. However, as the site is monitored, reaches will be evaluated for significant changes in pattern. Any changes that occur which warrants repair will be discussed in future monitoring reports.

2.2.1.2.1 Results

The longitudinal profiles show that the bed features are also stable across the project site. As noted in the Stream Reach Morphology Data Tables in Appendix B (Tables 13 and 14), riffle and pool characteristics do not appear to have changed much and are acceptable when compared to reference reach and design data provided for each of the project reaches. Given the location of these project reaches in the valley and the spacing of structures in these streams, it is expected that the profiles will display little change over the course of the monitoring period.

The Year 3 longitudinal profiles for UT2 and UT3 also do not appear to have changed much since the previous monitoring year. Adjustments that have occurred have been minor in nature, and have not resulted in a loss of structures. Both herbaceous and woody vegetation have come in well on these tributaries, including the steeper reaches of UT2 Reach 1 and UT3. Closely spaced grade control structures have also helped maintain the overall profile desired. No notable channel profile adjustments or bank erosion were observed.

Although no areas of instability were noted in the project area during Year 3 monitoring, there are intermittent spaces on UT2 and UT3 where flow was subsurface. This is not completely unexpected given that stable Aa+ to B-type streams are prone to have short sections where flow periodically goes subsurface. Unnamed tributary 2 and UT3 are both Aa+ to B-type channels as they drain toward Sink Hole Creek. The stationing at which the stream goes subsurface is provided in Table 10 in Appendix B. While we believe this to be a short-term, episodic type occurrence we will monitor these sections with subsurface flow to determine if corrective action is necessary.

2.2.1.3 Substrate and Sediment Transport

Bed material analysis consisted of pebble counts being taken in the same constructed riffle each year during annual geomorphic surveys of the project site. These samples, combined with evidence provided by changes in cross-sectional and profile data will reveal changes in sediment gradation that occur over time as the stream adjusts to upstream sediment loads. Significant changes in sediment gradation will be evaluated with respect to stream stability and watershed changes.

2.2.1.3.1 Results

For this project, a pebble count was collected on Reaches 1 and 2 of Sink Hole Creek. As noted in pebble count exhibits in Appendix B, the pebble count for Reach 1 of Sink Hole indicates some coarsening in the bedload for the d50 - d95 substrate component. The pebble count taken in Reach 2 shows a similar trend. Visual observations of Sink Hole Creek 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 3 monitoring survey. In fact, the pebble count data shows that there is a coarsening of the stream bed which is an indication that the stream is moving fines through the system and larger pebbles are making up a greater percentage of the bed material.

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 to measure flows at or above the bankfull elevation. One crest gauge was placed near the confluence of UT2 and UT3, while another gauge was set up near the end of the project area on Reach 2 of Sink Hole Creek. 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

During the Year 3 monitoring period, the site was found to have had at least two bankfull events based on crest gauge readings obtained on UT2 and Reach 2 of Sink Hole Creek. Information on these events is provided in Table 9 of Appendix B.

2.2.3 Photographic Documentation of Site

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

2.2.3.1 Lateral Reference Photos

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

2.2.3.2 Structure Photos

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

Lateral and structure photographs are used to evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, structure function and stability, and a subjective judgment of the effectiveness of erosion control measure. 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.

Photographs of the restoration project were taken in November 2013. The photographs illustrate stable conditions across the project site. Vegetative growth along the streambanks and riparian buffers has become dense and improved since construction was completed in 2010. Structures are functioning as designed.

2.2.4 Stream Stability Assessment

In-stream structures installed within the restored streams included constructed riffles, log drops, log sequences, and boulder steps. The Year 3 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. The structures that are not functioning properly are those associated with the subsurface sections on UT2 and UT3. UT2 and UT3 are headwater tributaries that receive minimal flow relative to channel size from two springs at the upstream limit of the project reaches. Structures that appeared to be piping at the time of our survey should correct naturally over time as substrate moves through the channel and are not a concern at this time. There were also two boulder steps on Sink Hole Creek Reach 2 that had the side boulder wings fall into the pool as a result of the high flows due to record amount of precipitation in 2013. These structures are functioning correctly and will be monitored to determine if corrective action should be taken.

Frequent spacing of log drops, log sequences and boulder drops have greatly enhanced bedform diversity as well as promoting more stable A 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 3 monitoring data are summarized in Tables 13 and 14 of Appendix B.

2.3 Areas of Concern

At this time, no areas of concern were noted in the project reaches. The linear feet of subsurface flow observed in Monitoring Year 3 (349 LF) has decreased in comparison to Monitoring Year 1 (375 LF); at this time, no actions are proposed. The steeper tributaries where flow tends to be intermittent in certain segments will continue to be monitored.

As noted in the Executive Summary, cattle recently broke through a section of fencing and entered the easement area. The area of disturbance is roughly concentrated around the last 150 to 200 feet of UT2 before it exits the project area. Baker brought this to the attention of the landowner; he indicated that he will repair the broken fence section.

3.0 REFERENCES

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

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

APPENDIX A

VEGETATION RAW DATA

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

Table 7. Stem Count Arranged by Plot
Sink Hole Creek Mitigation Project-#92663

Tree Species	Plots								As-built Totals	MY 1 Totals	MY 2 Totals	MY 3 Totals	MY 4 Totals	MY 5 Totals	Survival %	Probable Cause
	1	2	3	4	5	6	7	8								
Acer rubrum		1	2			1	1		4	7	5	5			100%	
Acer saccahrum		1							1	1	1	1			100%	
Asimina triloba								5	0	5	5	5			100%	
Betula alleghaniensis	4								6	6	6	4			67%	Dense herbaceous cover
Betula lenta		2	1	1					8	5	5	4			50%	Natural causes (animal)
Betula nigra	1	2	4	4	2		2	1	32	19	19	16			50%	Natural causes (animal)
Carya alba		1	1	1	1	1			12	5	7	5			33%	Re-identification
Liriodendron tulipfera			1	3			1		10	8	7	5			50%	Natural causes
Physocarpus opulifolius									1	1	1	0			0%	
Platanus occidentalis		1			2	2		2	8	7	7	7			88%	
Quercus alba									1	1	1	0			0%	
Quercus muehlenbergii		1							0	1	1	1			100%	
Quercus rubra	1		4	2	2	4	3	1	13	20	20	17			100%	
Shrub Species																
Alnus serrulata	1	4		3		1			6	10	11	9			100%	
Calycanthus									2	0	0	0			0%	Dense herbaceous cover
Cercis canadensis			2		3	2	5		33	19	15	12			36%	Herbaceous cover; isolated ponding in pockets
Cornus florida		1	1						1	3	3	2			100%	
Hamamelis virginiana									1	0	0	0			0%	Re-identification
Lindera benzoin			1		1			2	0	5	5	4			100%	
Salix nigra						1			0	1	1	1			100%	
Vaccinium stamineum					2				3	3	3	2			67%	
Viburnum prunifolium					2	1			7	5	5	3			43%	Natural causes (animal)
Stems/plot	7	14	17	14	15	13	12	11							13	
Stems/acre Year 3	283	567	688	567	607	526	486	445							521	

Table 7b. Stem Count Arranged by Plot
Sink Hole Creek Mitigation Project-#92663

			Current Plot Data (MY3 2012)																							Annual Means								
			E92663-01-0001			E92663-01-0002			E92663-01-0003			E92663-01-0004			E92663-01-0005			E92663-01-0006			E92663-01-0007			E92663-01-0008			MY3 (2013)			MY2 (2012)			MY0 (2011)		
Scientific Name	Common Name	Species Type	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer rubrum	red maple	Tree				1	1	1	2	2	2							1	1	1	1	1	1				5	5	5	5	5	5	7	7	7
Acer saccharum	sugar maple	Tree				1	1	1																			1	1	1	1	1	1	1	1	1
Alnus serrulata	hazel alder	Tree	1	1	1	4	4	4				3	3	3				1	1	1							9	9	9	11	11	11	10	10	10
Asimina triloba	pawpaw	Tree																						5	5	5	5	5	5	5	5	5	5	5	5
Betula alleghaniensis	yellow birch	Tree	4	4	4																						4	4	4	6	6	6	6	6	6
Betula lenta	sweet birch	Tree				2	2	2	1	1	1	1	1	1													4	4	4	5	5	5	5	5	5
Betula nigra	river birch	Tree	1	1	1	2	2	2	4	4	4	4	4	4	2	2	2				2	2	2	1	1	1	16	16	16	19	19	19	19	19	19
Carya alba	mockernut hickory	Tree				1	1	1	1	1	1	1	1	1	1	1	1	1	1	1							5	5	5	7	7	7	5	5	5
Cercis canadensis	eastern redbud	Tree							2	2	2				3	3	3	2	2	2	5	5	5				12	12	12	15	15	15	19	19	19
Cornus florida	flowering dogwood	Tree				1	1	1	1	1	1																2	2	2	3	3	3	3	3	3
Itea virginica	Virginia sweetspire	Shrub																															1	1	1
Lindera benzoin	northern spicebush	Shrub							1	1	1				1	1	1							2	2	2	4	4	4	5	5	5	4	4	4
Lindera benzoin var. benzoin	northern spicebush	Shrub																															1	1	1
Liriodendron tulipifera	tuliptree	Tree							1	1	1	3	3	3							1	1	1				5	5	5	7	7	7	8	8	8
Physocarpus opulifolius	common ninebark	Shrub																												1	1	1	1	1	1
Platanus occidentalis	American sycamore	Tree				1	1	1							2	2	2	2	2	2				2	2	2	7	7	7	7	7	7	7	7	7
Quercus alba	white oak	Tree																												1	1	1	1	1	1
Quercus muehlenbergii	chinkapin oak	Tree				1	1	1																			1	1	1	1	1	1	1	1	1
Quercus rubra	northern red oak	Tree	1	1	1				4	4	4	2	2	2	2	2	2	4	4	4	3	3	3	1	1	1	17	17	17	20	20	20	20	20	20
Salix nigra	black willow	Tree																1	1	1							1	1	1	1	1	1	1	1	1
Vaccinium stamineum	deerberry	Shrub													2	2	2										2	2	2	3	3	3	3	3	3
Viburnum prunifolium	blackhaw	shrub													2	2	2	1	1	1							3	3	3	5	5	5	5	5	5
Stem count			7	7	7	14	14	14	17	17	17	14	14	14	15	15	15	13	13	13	12	12	12	11	11	11	103	103	103	128	128	128	133	133	133
size (ares)			1			1			1			1			1			1			1			1			8			8			8		
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.20			0.20			0.20		
Species count			4	4	4	9	9	9	9	9	9	6	6	6	8	8	8	8	8	8	5	5	5	5	5	5	18	18	18	20	20	20	22	22	22
Stems per ACRE			283	283	283	567	567	567	688	688	688	567	567	567	607	607	607	526	526	526	486	486	486	445	445	445	521	521	521	647	647	647	673	673	673

Table 8. Vegetation Problem Areas
Sink Hole Creek Mitigation Project: Project No. 92663

Sink Hole Reach 1 (1,019 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	8+25 to 8+35	Right bank bare from erosion caused by high flows due to record precipitation in 2013.	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	4+00 to 4+25	Honeysuckle on right flood plain.	N/A
Sink Hole Reach 2 (1,073 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	18+50 to 19+00	Honeysuckle on right flood plain.	N/A
UT1 Reach 2 (489 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A
UT2 Reach 1 (596 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	6+75 to 6+90	Small area of bare flood plain likely caused by compacted soil.	N/A
Invasive/Exotic Populations	N/A	N/A	N/A
UT2 Reach 2 (885 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A
UT3 (641 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Other	N/A	N/A	N/A
Bare Bank	N/A	N/A	N/A
Bare Bench	N/A	N/A	N/A
Bare Flood Plain	N/A	N/A	N/A
Invasive/Exotic Populations	N/A	N/A	N/A

Sink Hole Creek Mitigation Project
Photo Log - Vegetation Plot Photo Points (Year 3)

Notes:

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

10/17/2013

Photo 1: Veg Plot 1

10/17/2013

Photo 2: Veg Plot 1: Herbaceous Plot

10/17/2013

Photo 3: Veg Plot 2

10/17/2013

Photo 4: Veg Plot 2: Herbaceous Plot

10/17/2013

Photo 5: Veg Plot 3

10/17/2013

Photo 6: Veg Plot 3: Herbaceous Plot

Photo Log - Vegetation Plot Photo Points (Year 3)

10/17/2013

Photo 7: Veg Plot 4

10/13/2013

Photo 8: Veg Plot 4: Herbaceous Plot

10/17/2013

Photo 9: Veg Plot 5

10/17/2013

Photo 10: Veg Plot 5: Herbaceous Plot

10/17/2013

Photo 11: Veg Plot 6

10/17/2013

Photo 12: Veg Plot 6: Herbaceous Plot

Photo Log - Vegetation Plot Photo Points (Year 3)

10/17/2013

Photo 13: Veg Plot 7

10/17/2013

Photo 14: Veg Plot 7: Herbaceous Plot

10/17/2013

Photo 15: Veg Plot 8

10/17/2013

Photo 16: Veg Plot 8: Herbaceous Plot

APPENDIX B

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

Table 9. Verification of Bankfull or Greater than Bankfull Events
Sink Hole Creek Restoration Project-#92663

Date of Data Collection	Date of Event	Method of Data Collection	Gauge Watermark Height (inches)		
			Sink Hole Cr. Reach 1	Sink Hole Cr. Reach 2	UT2 Reach 1
11/4/2011	Between 6/29/11 and 11/04/11	Gauge measurement.	-	1.97	-
11/4/2011	Between 6/29/11 and 11/04/11	Gauge measurement.	-	7.48	1.8
11/6/2012	Between 11/04/11 and 11/6/12	Gauge measurement	-	2.70, 8.25	-
12/19/2012	Between 11/04/11 and 12/19/12	Gauge measurement	-	-	1.44
11/15/2013	Between 11/16/12 and 11/15/13	Gauge measurement	-	1.5	.8, 1.9

Table 10. Stream Problem Areas
Sink Hole Creek Mitigation Project: Project No. 92663

Sink Hole Creek Reach 1 (1,019 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Bank Erosion	8+15 to 8+25	Bank Erosion on right bank. High flows from record precipitation in 2013 likely cause.	N/A
Sink Hole Creek Reach 2 (1,073 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Structure Arm Failure	15+05 and 18+55	Structure arms on two boulder steps have fallen into channel. High flows from record precipitation in 2013 likely cause. Structures are functioning.	N/A
UT2 Reach 2(885 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Subsurface flow	7+95 to 8+21, 8+25 to 8+54	Channel is dry from flow going subsurface. Steepness of channel (Aa+ stream type in sections) is a likely factor as well.	N/A
Temporary cattle disturbance to easement	10+50 to 11+50	Cattle recently broke section of fencing and entered easement on left floodplain. Landowner repairing fence. Disturbance not severe enough to warrant assembly of equipment on-site or re-planting of area.	N/A
UT3 (641 LF)			
Feature Issue	**Station No.**	**Suspected Cause**	**Photo Number**
Subsurface flow	0+47 to 1+07, 1+36 to 1+53, 1+57 to 3+47, 4+91 to 5+18	Channel is dry from flow going subsurface in three areas. Steepness of channel (Aa+ stream type) likely a factor as well.	N/A

Notes:

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Eb	19	13.72	1.38	2.55	7.52	1	4.9	2594.95	2594.95

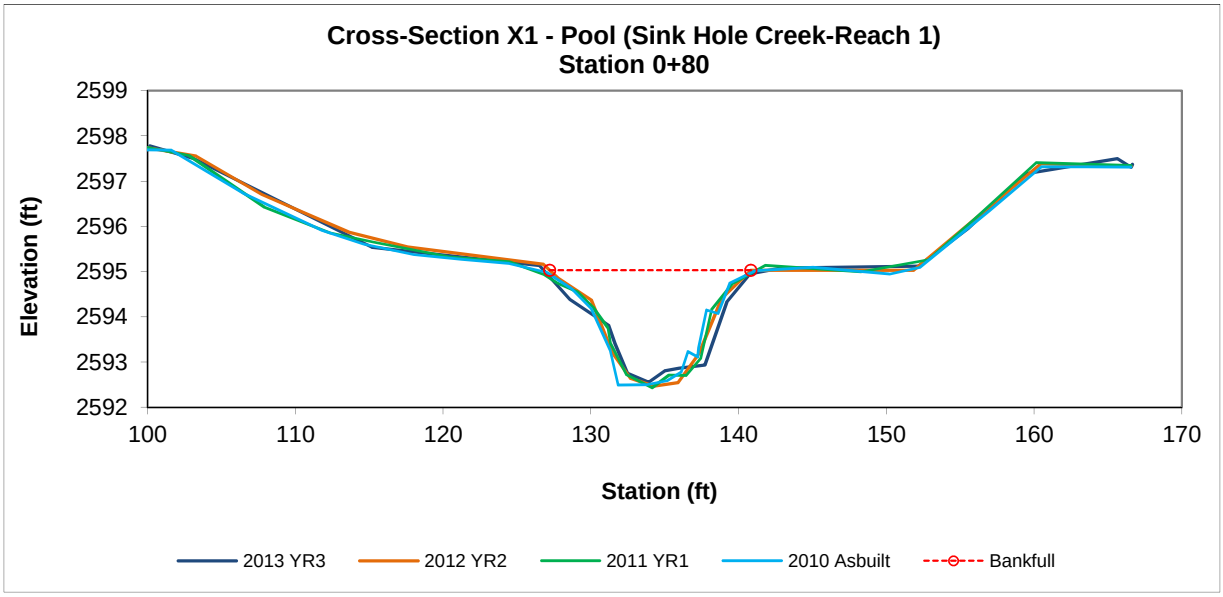


Photo 1: XS-1 facing right bank

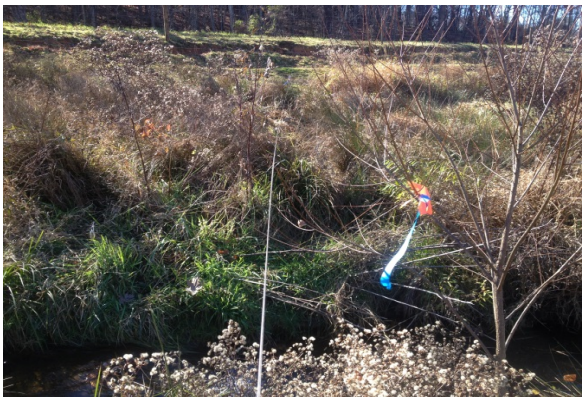


Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Cb	5.3	8.14	0.65	1.42	12.58	1	8.5	2589.99	2589.99

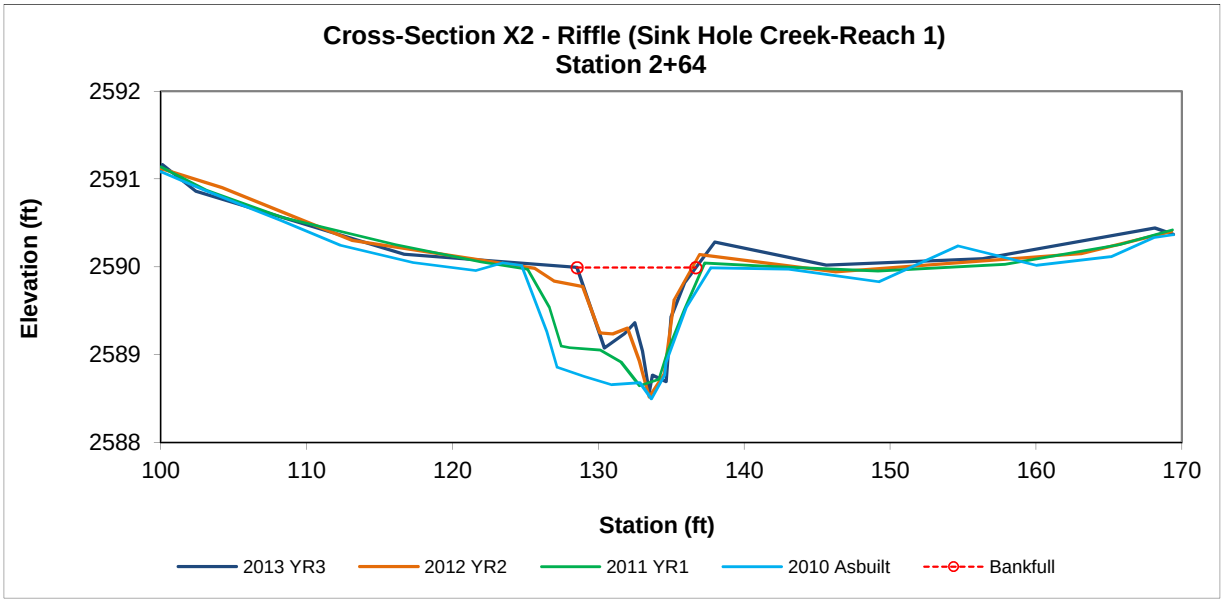


Photo 5: XS-2 facing right bank

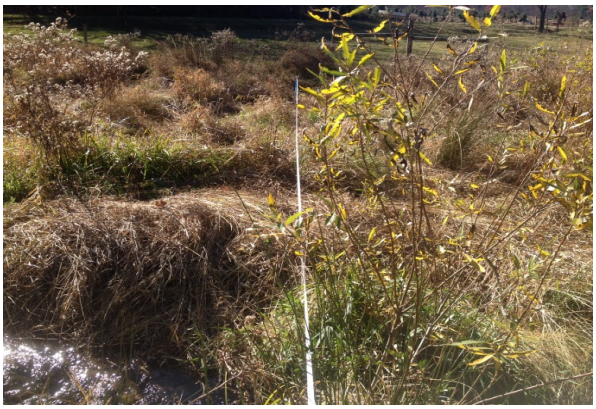


Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	14.5	13.49	1.07	2.05	12.59	1	4.3	2580.66	2580.66

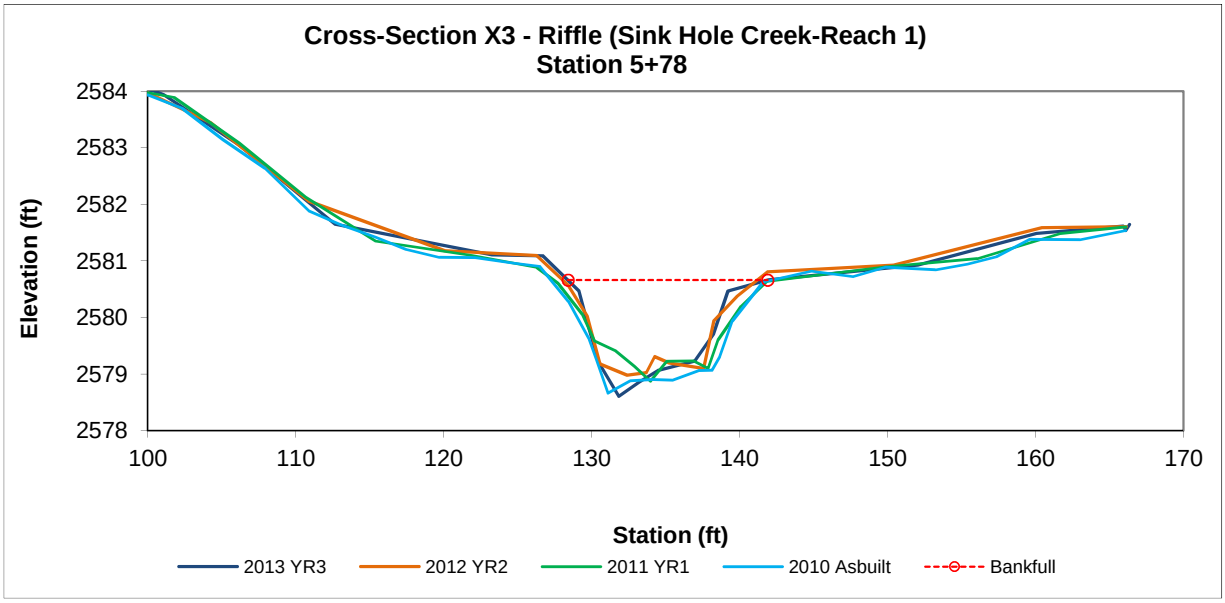


Photo 8: XS-3 facing right bank

Photo 9: XS-3 facing left bank

Photo 10: XS-3 facing upstream

Photo 11: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	Cb	11.7	10.56	0.51	2.21	20.7	1	8	2562.3	2562.3

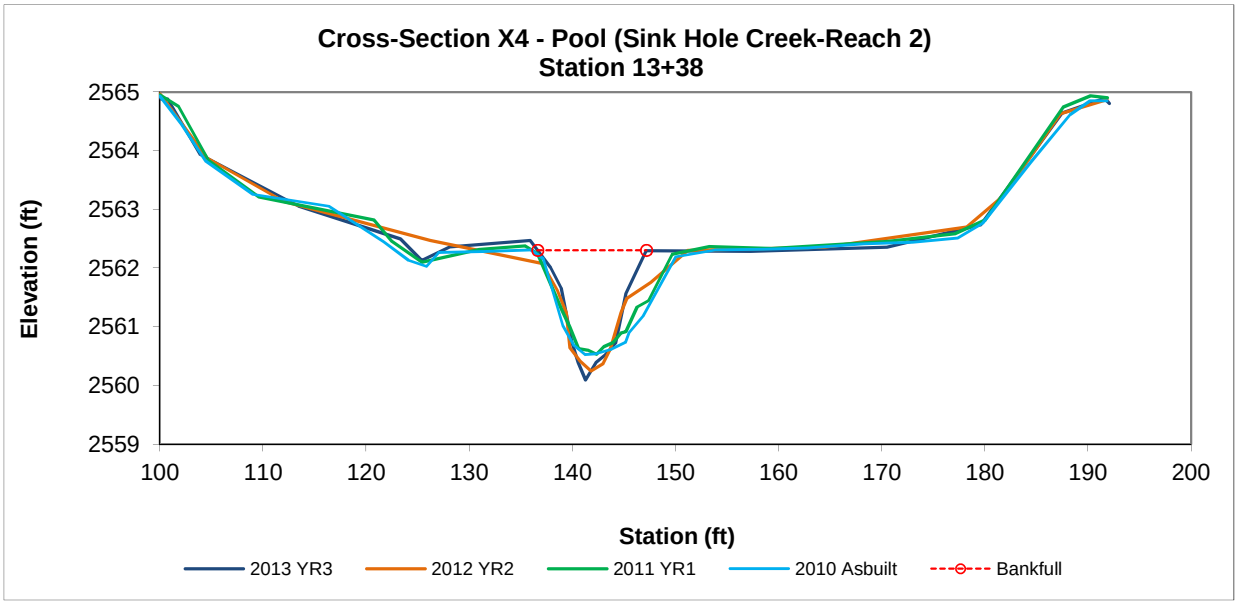


Photo 12: XS-4 facing right bank

Photo 13: XS-4 facing left bank

Photo 14: XS-4 facing upstream

Photo 15: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	24.3	17.35	1.4	2.55	12.39	1	4.3	2561.67	2561.67

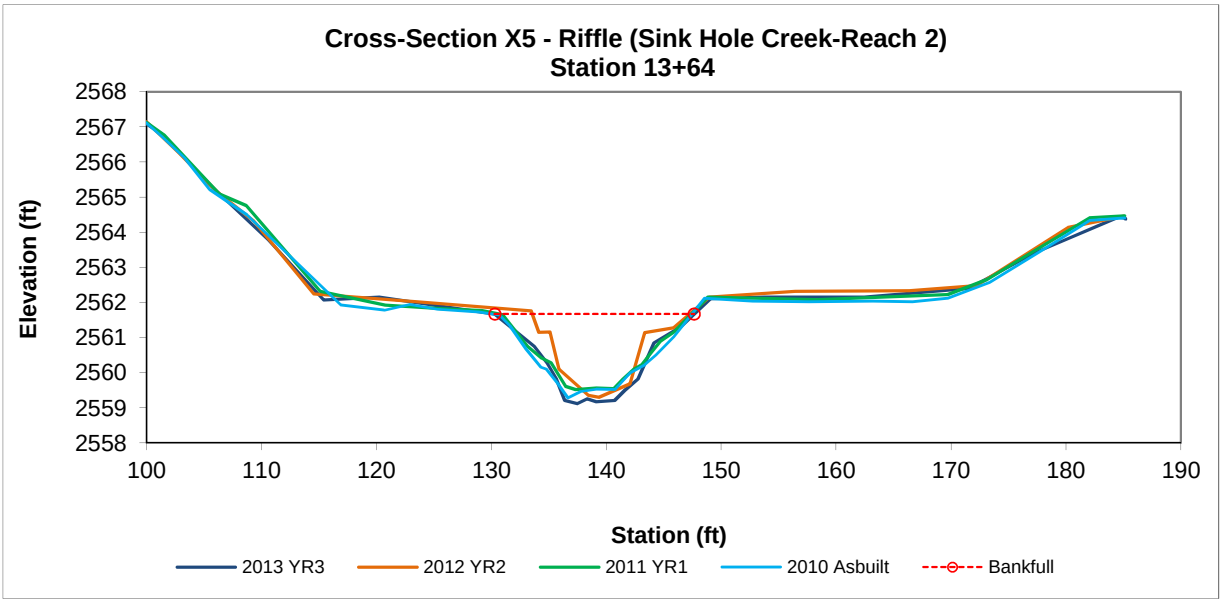


Photo 16: XS-5 facing right bank

Photo 17: XS-5 facing left bank

Photo 18: XS-5 facing upstream

Photo 19: XS-5 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	Eb	13.8	14.2	0.97	1.95	14.63	1	3.8	2553.42	2553.42

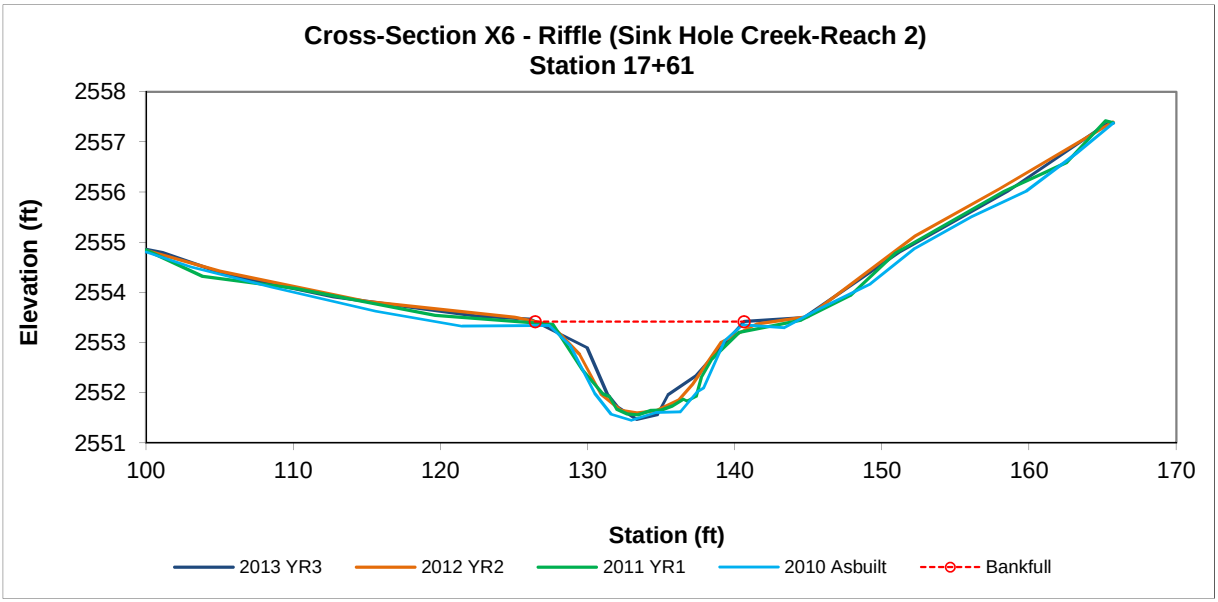


Photo 20: XS-6 facing right bank

Photo 21: XS-6 facing left bank

Photo 22: XS-6 facing upstream

Photo 23: XS-6 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	9.4	9.1	1.03	1.47	8.84	1.1	4.7	2582.69	2582.89

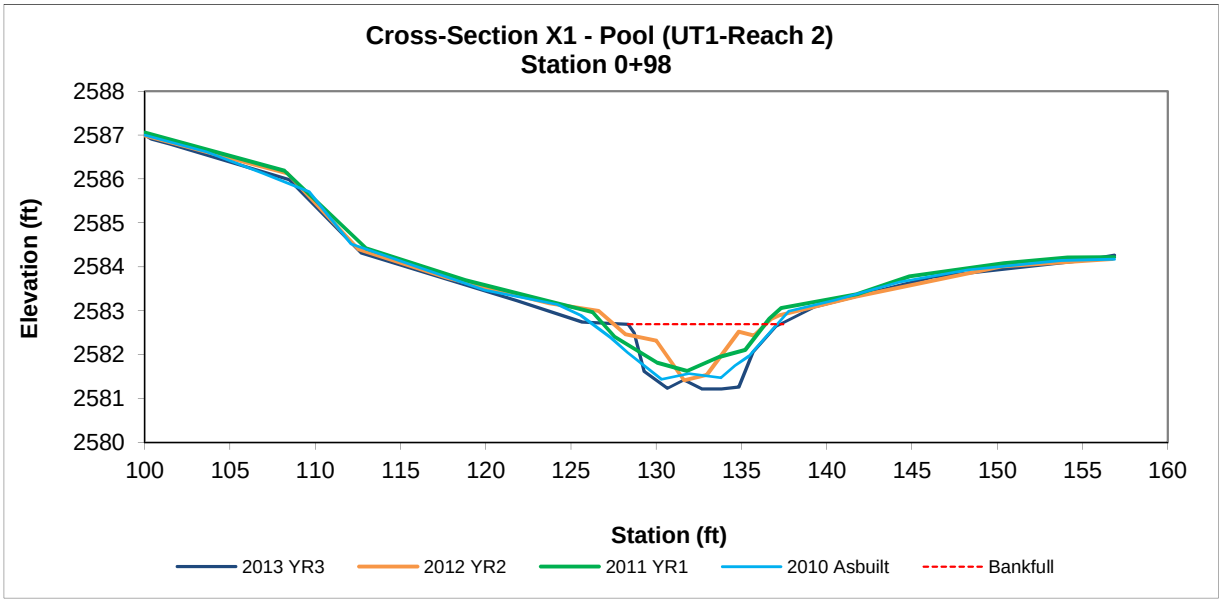


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	4	10.45	0.38	1.1	27.41	1.1	3.7	2579.02	2579.09

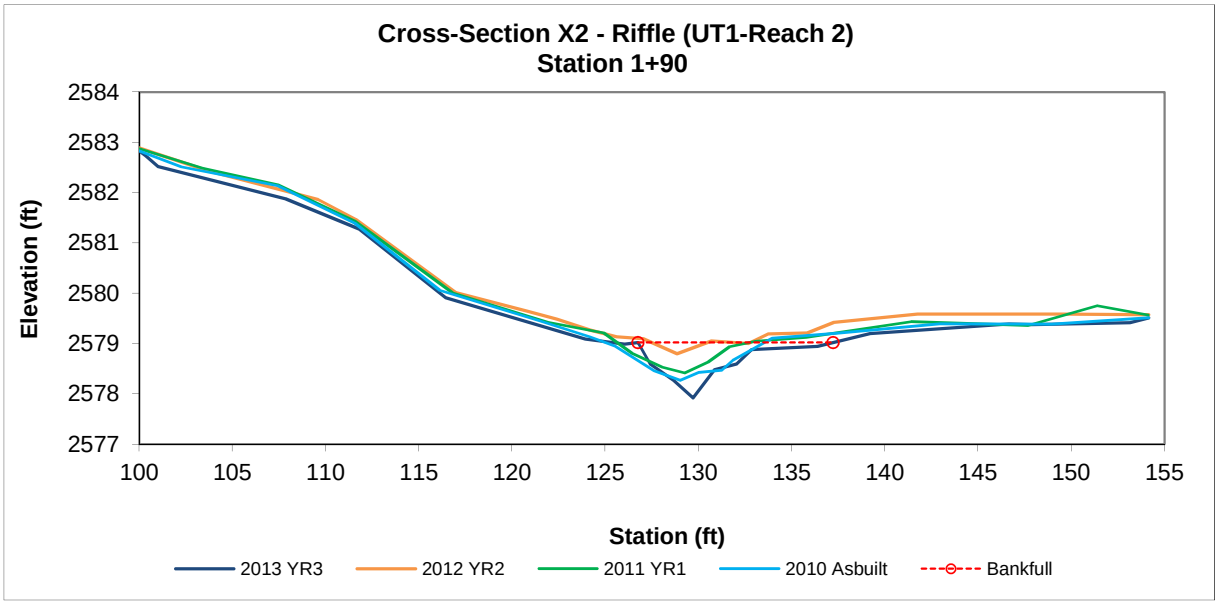


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	0.7	3.76	0.18	0.64	20.45	0.8	9.7	2768.88	2768.75

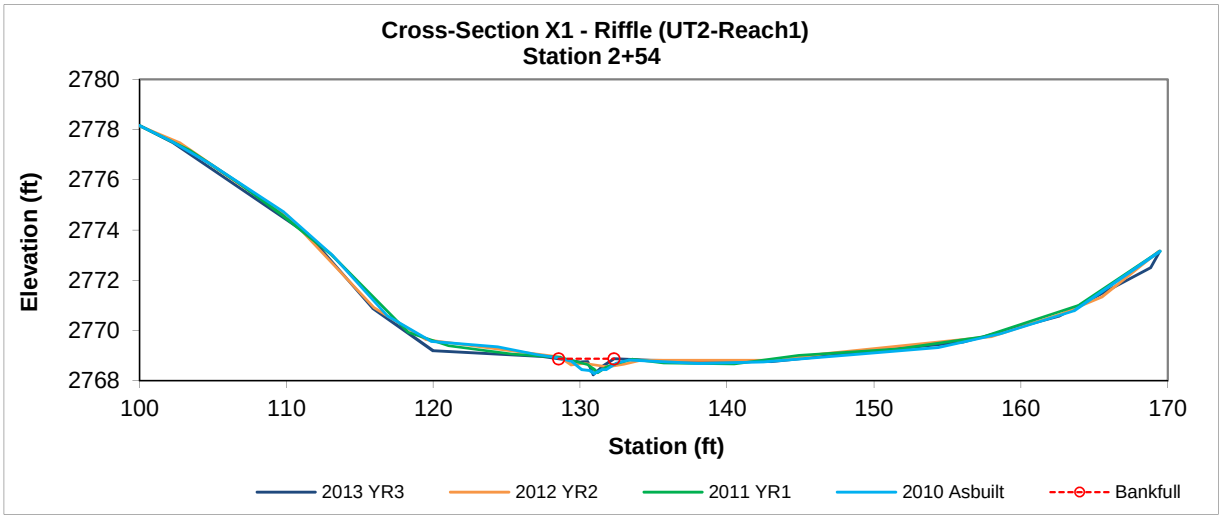


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	2.1	4.63	0.45	0.93	10.37	1.1	4.9	2752.78	2752.9

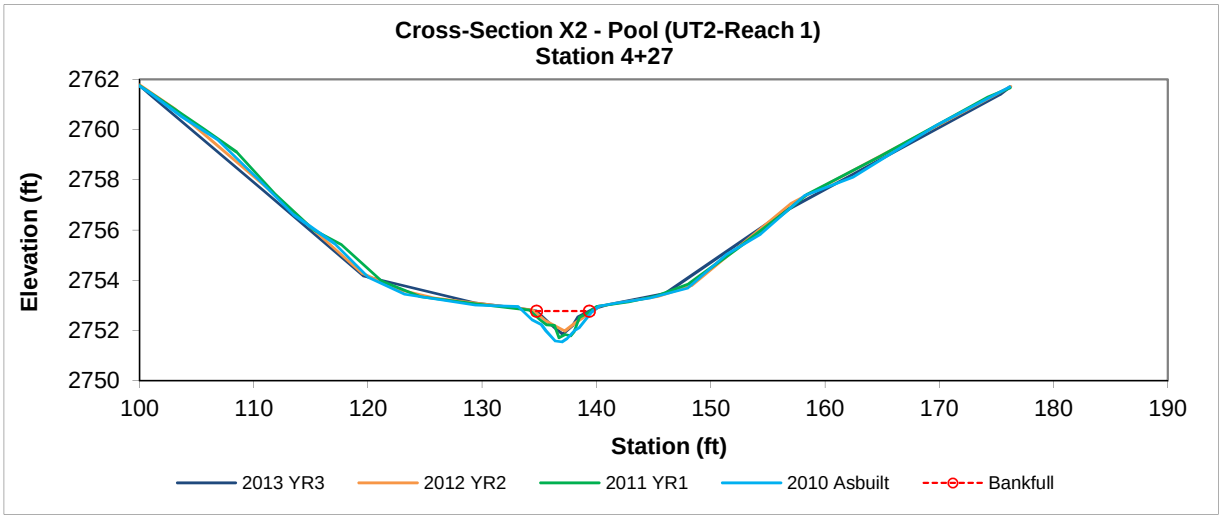


Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	A	2.5	5.28	0.47	1.1	11.29	1	7.8	2737.05	2737.05

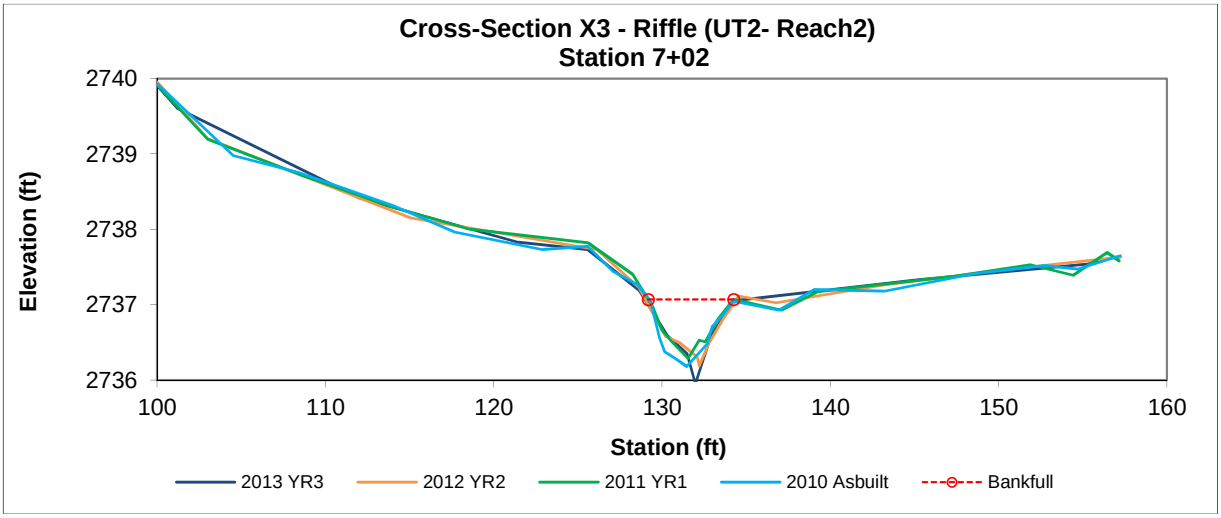


Photo 9: XS-3 facing right bank

Photo 10: XS-3 facing left bank

Photo 11: XS-3 facing upstream

Photo 12: XS-3 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	A	4.8	6.9	0.7	1.55	9.86	1	6.9	2723.85	2723.85

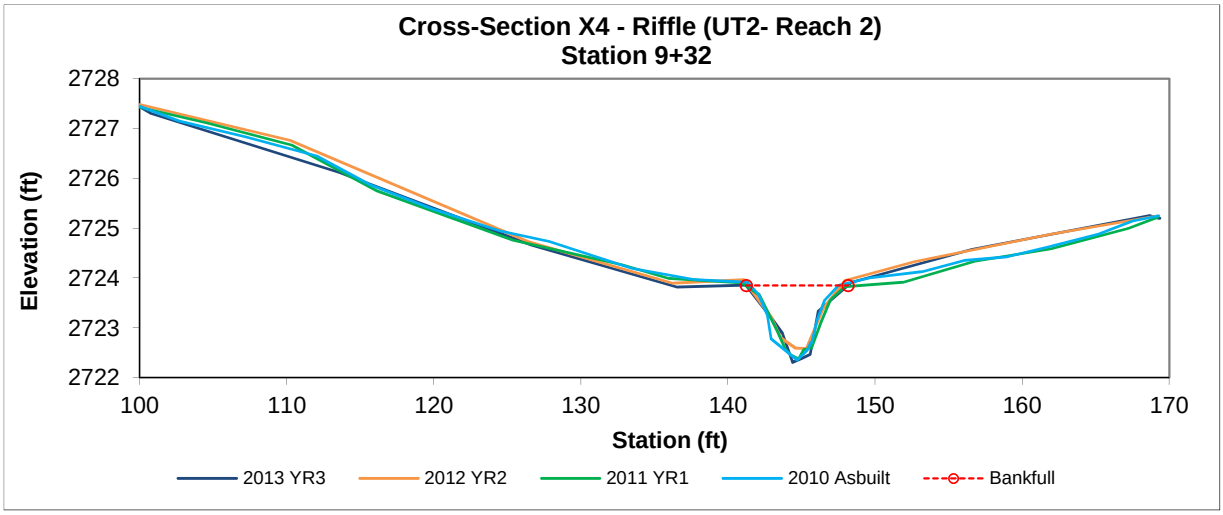


Photo 13: XS-4 facing right bank

Photo 14: XS-4 facing left bank

Photo 15: XS-4 facing upstream

Photo 16: XS-4 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	A	6.8	8.98	0.76	1.7	11.84	1	7.5	2716.22	2716.22

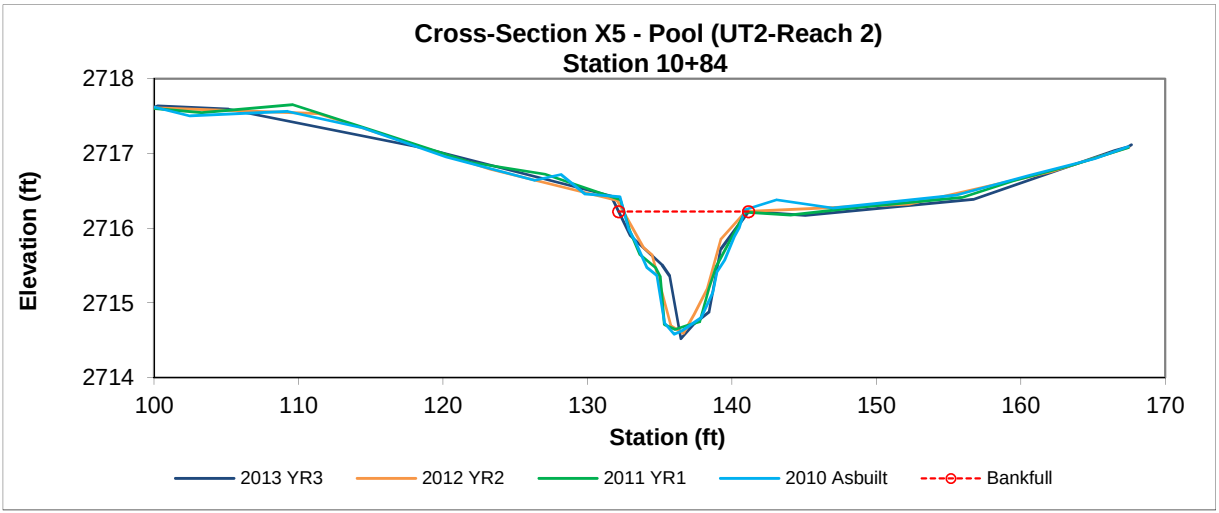


Photo 17: XS-5 facing right bank

Photo 18: XS-5 facing left bank

Photo 19: XS-5 facing upstream

Photo 20: XS-5 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	B	3.6	6.87	0.53	1.01	13.08	1	5.5	2762.64	2762.64

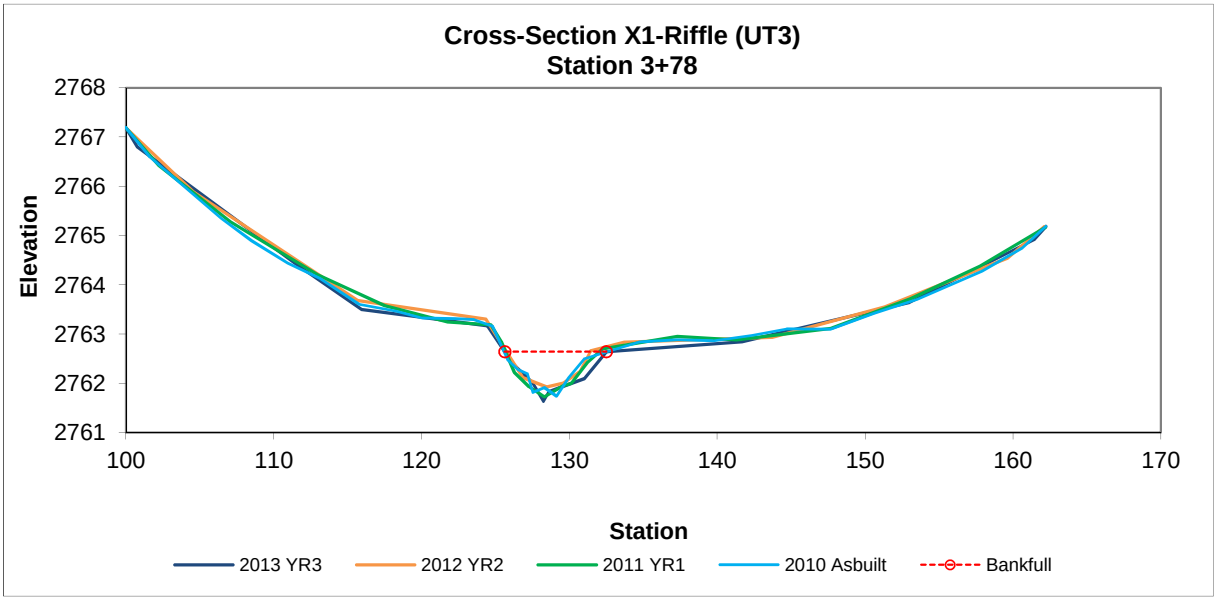


Photo 1: XS-1 facing right bank

Photo 2: XS-1 facing left bank

Photo 3: XS-1 facing upstream

Photo 4: XS-1 facing downstream

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool	B	6	7.48	0.8	1.6	9.33	1	6.4	2757.44	2757.44

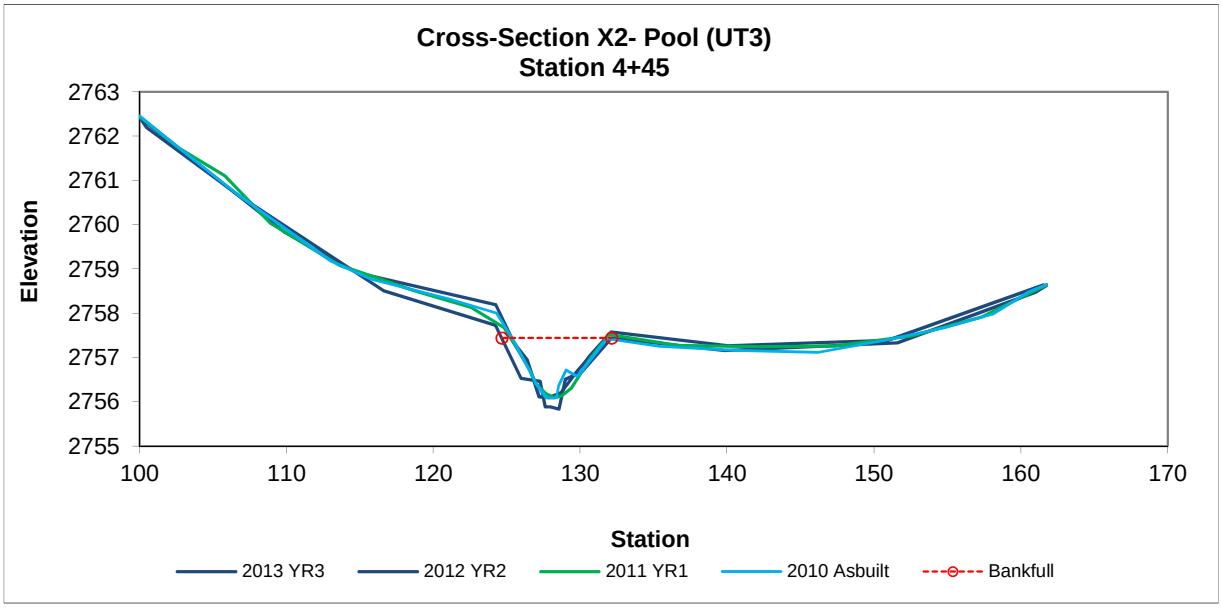


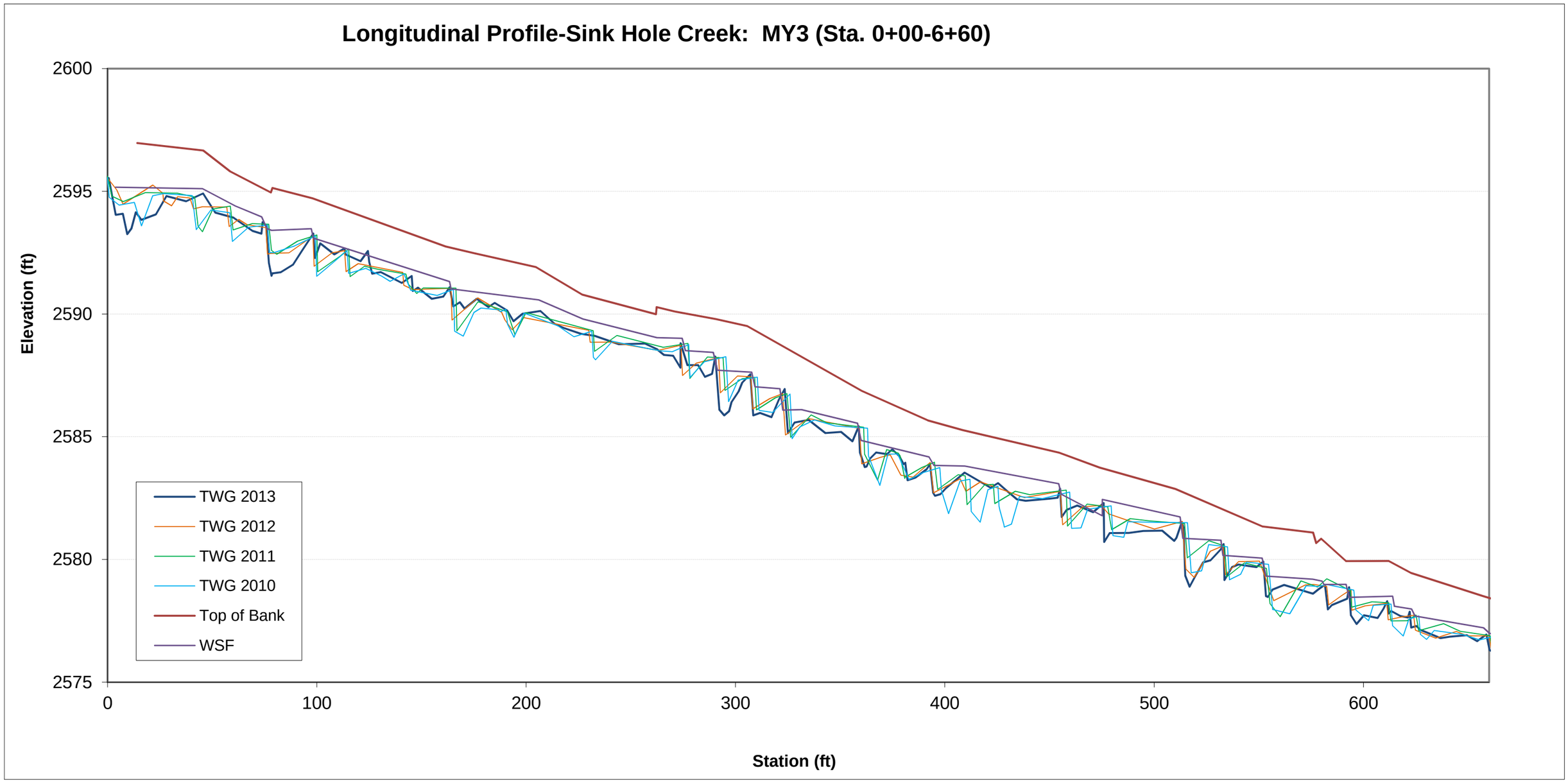
Photo 5: XS-2 facing right bank

Photo 6: XS-2 facing left bank

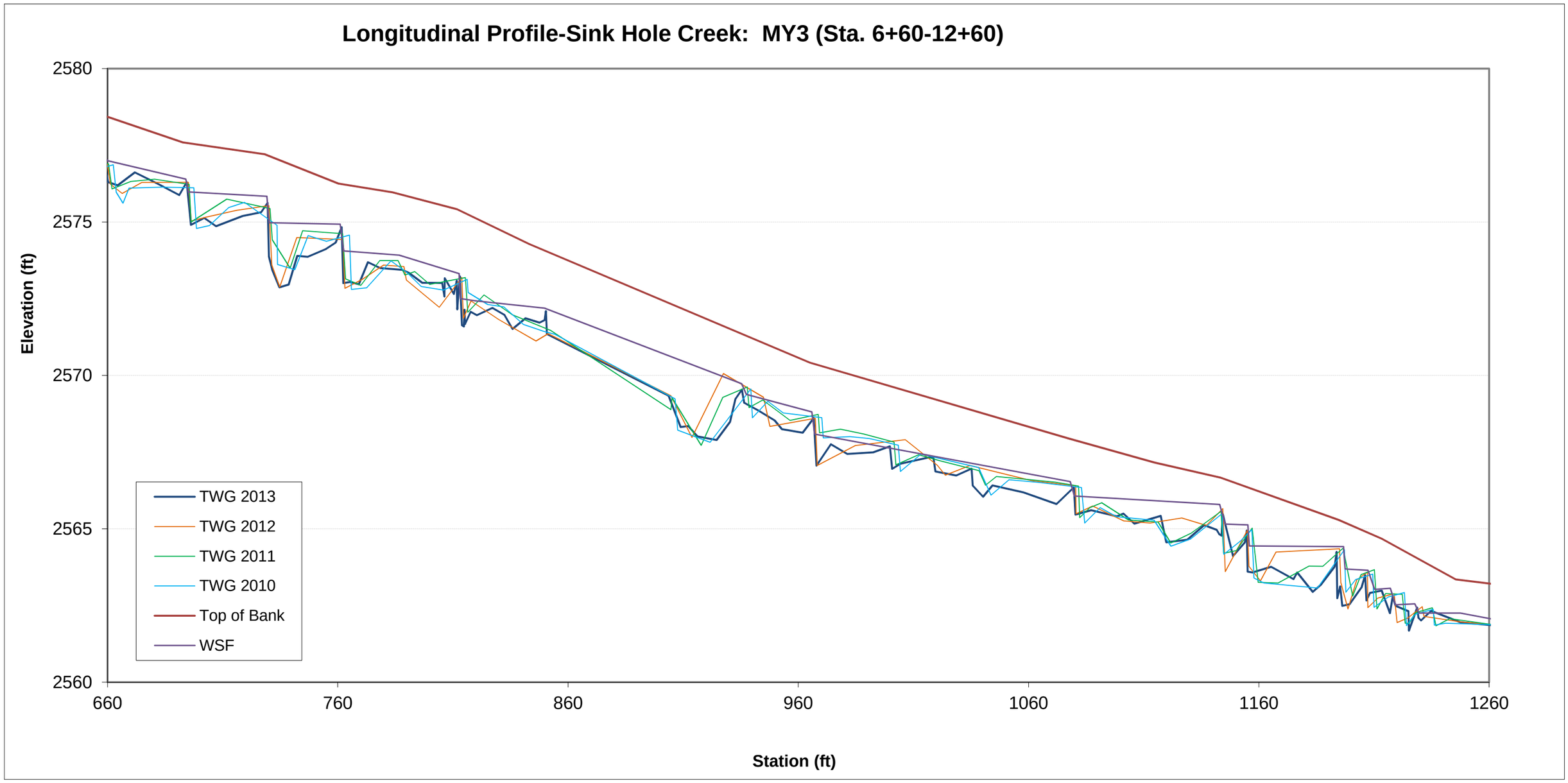
Photo 7: XS-2 facing upstream

Photo 8: XS-2 facing downstream

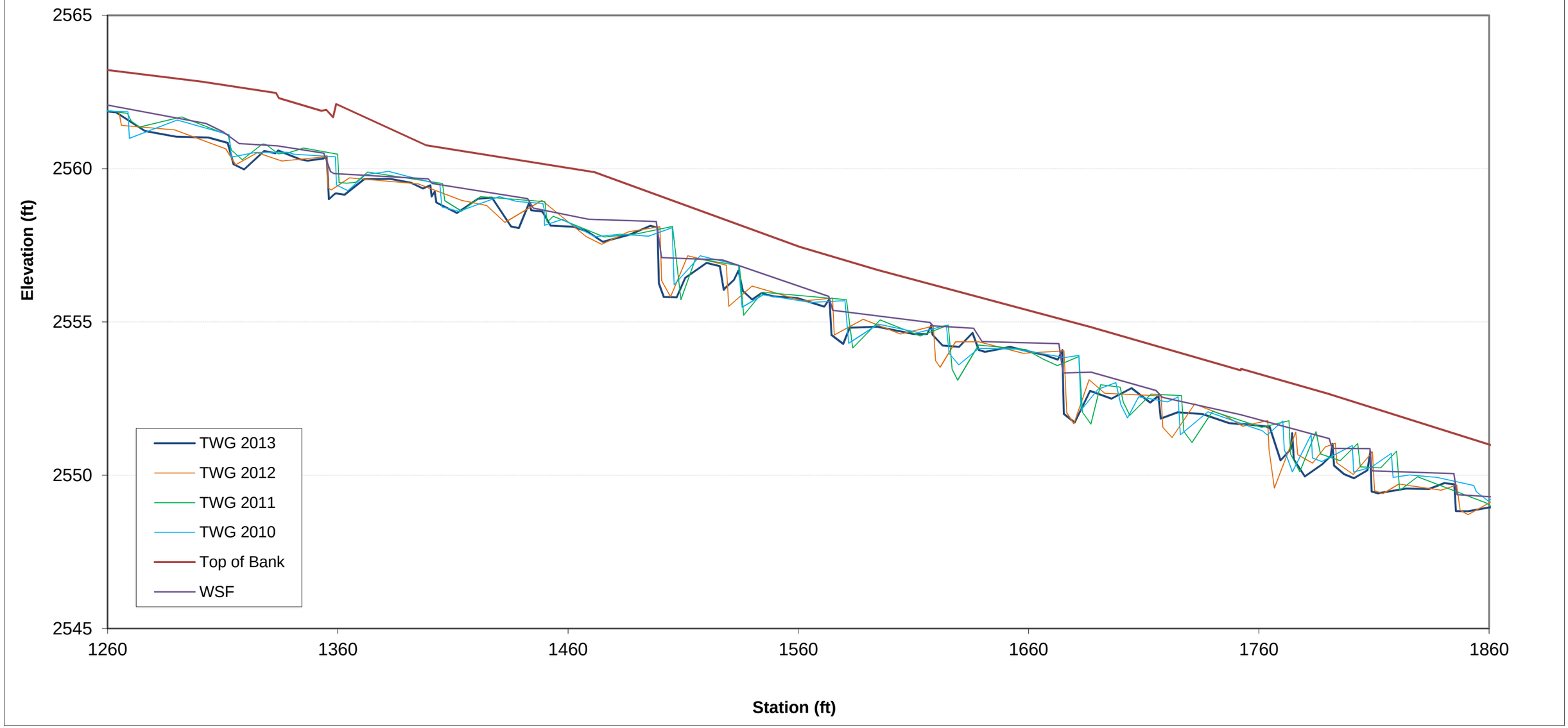
Longitudinal Profile-Sink Hole Creek: MY3 (Sta. 0+00-6+60)



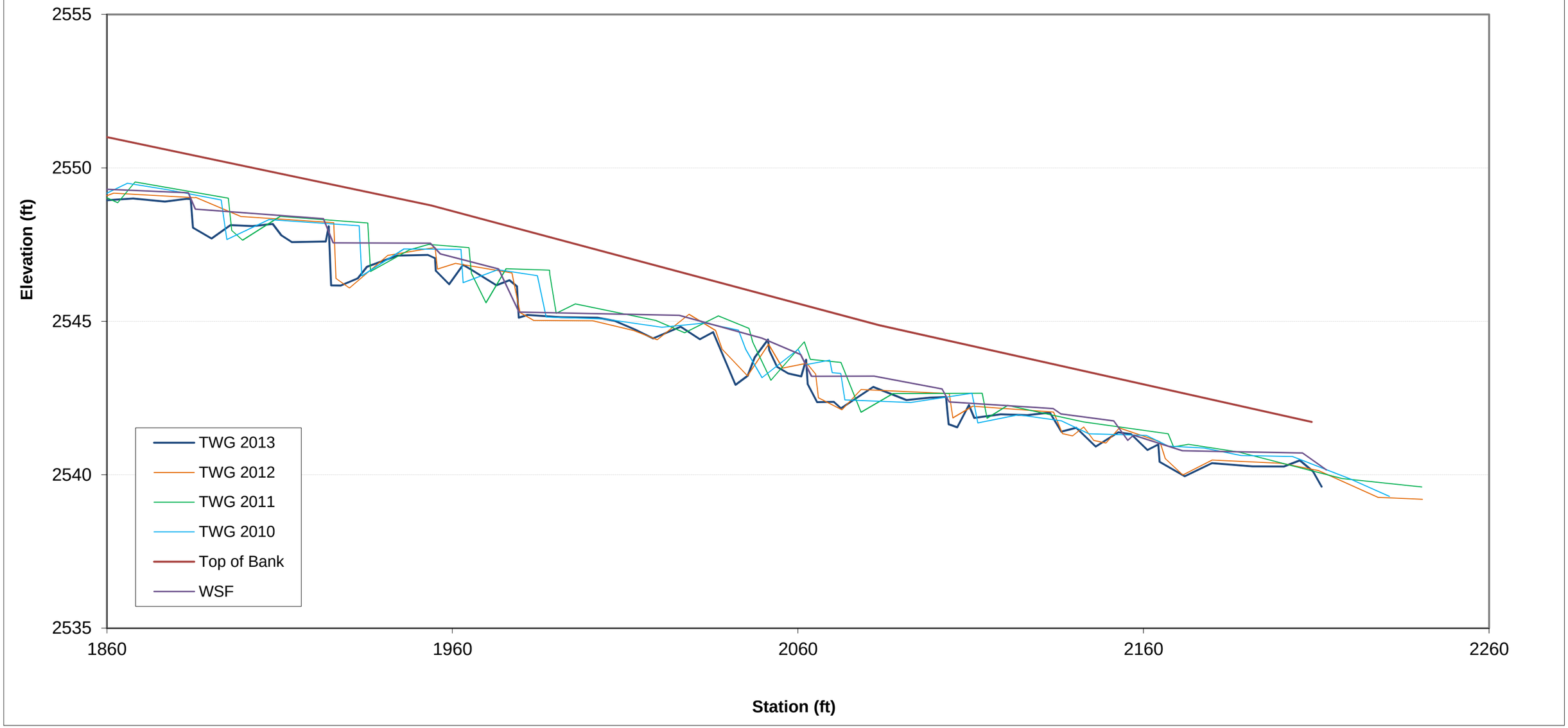
Longitudinal Profile-Sink Hole Creek: MY3 (Sta. 6+60-12+60)



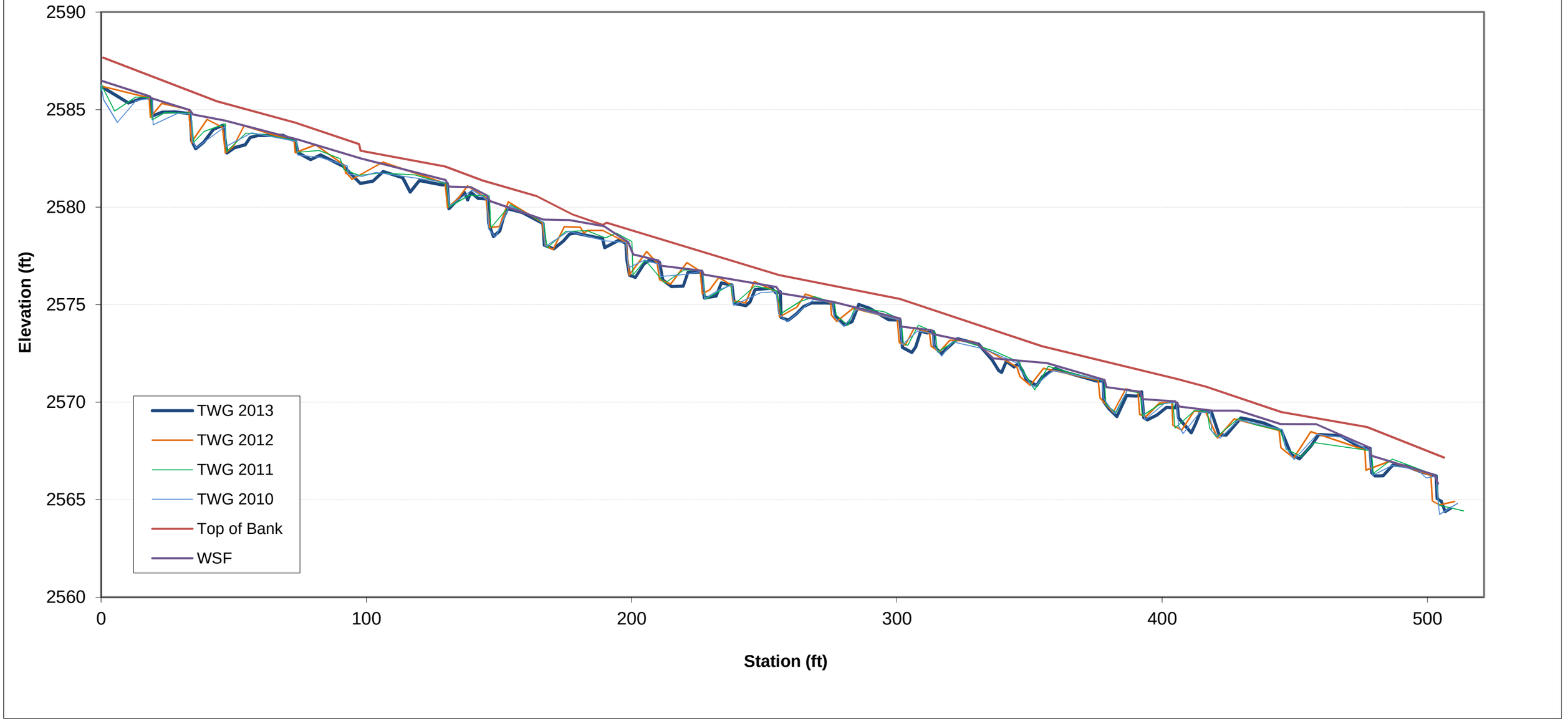
Longitudinal Profile-Sink Hole Creek: MY3 (Sta. 12+60-18+60)



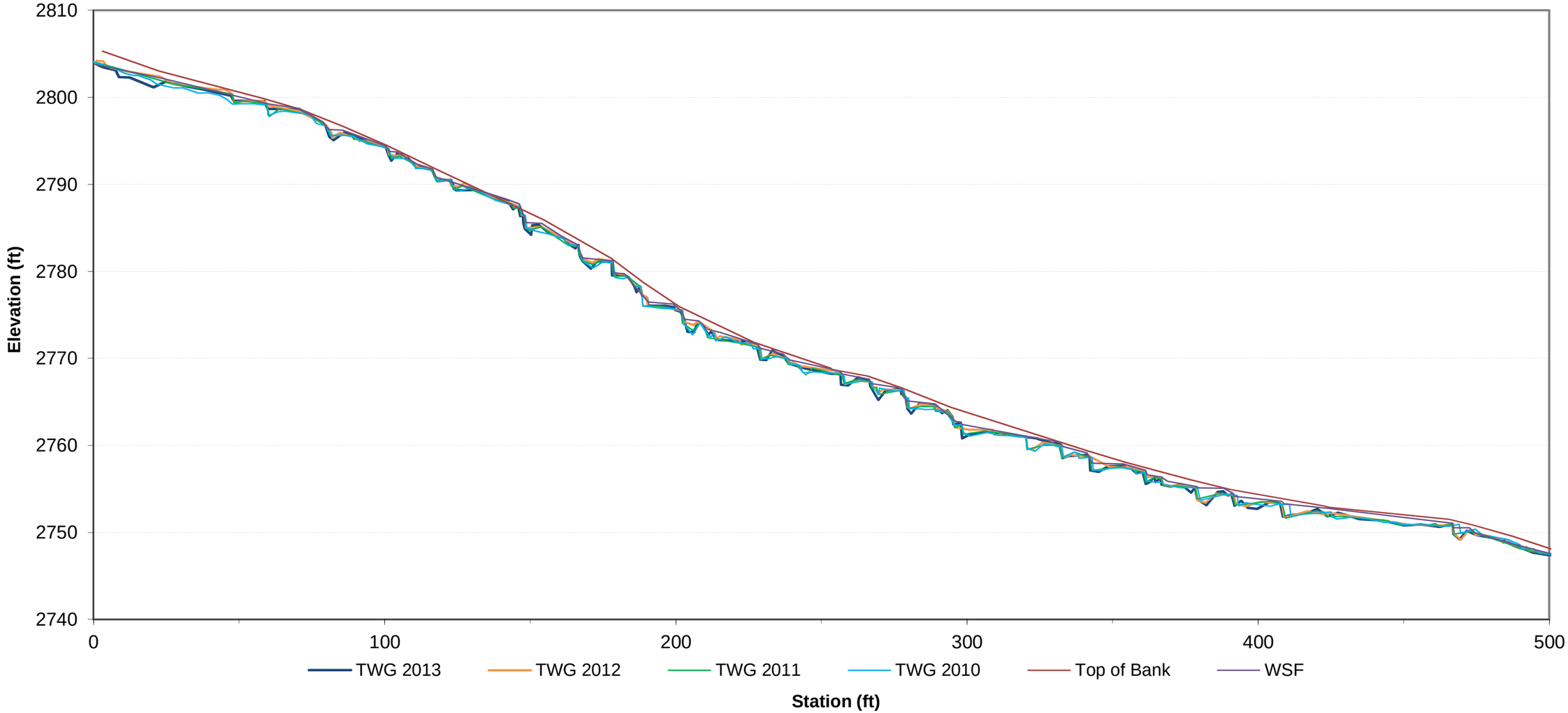
Longitudinal Profile-Sink Hole Creek: MY3 (Sta. 18+60-22+60)



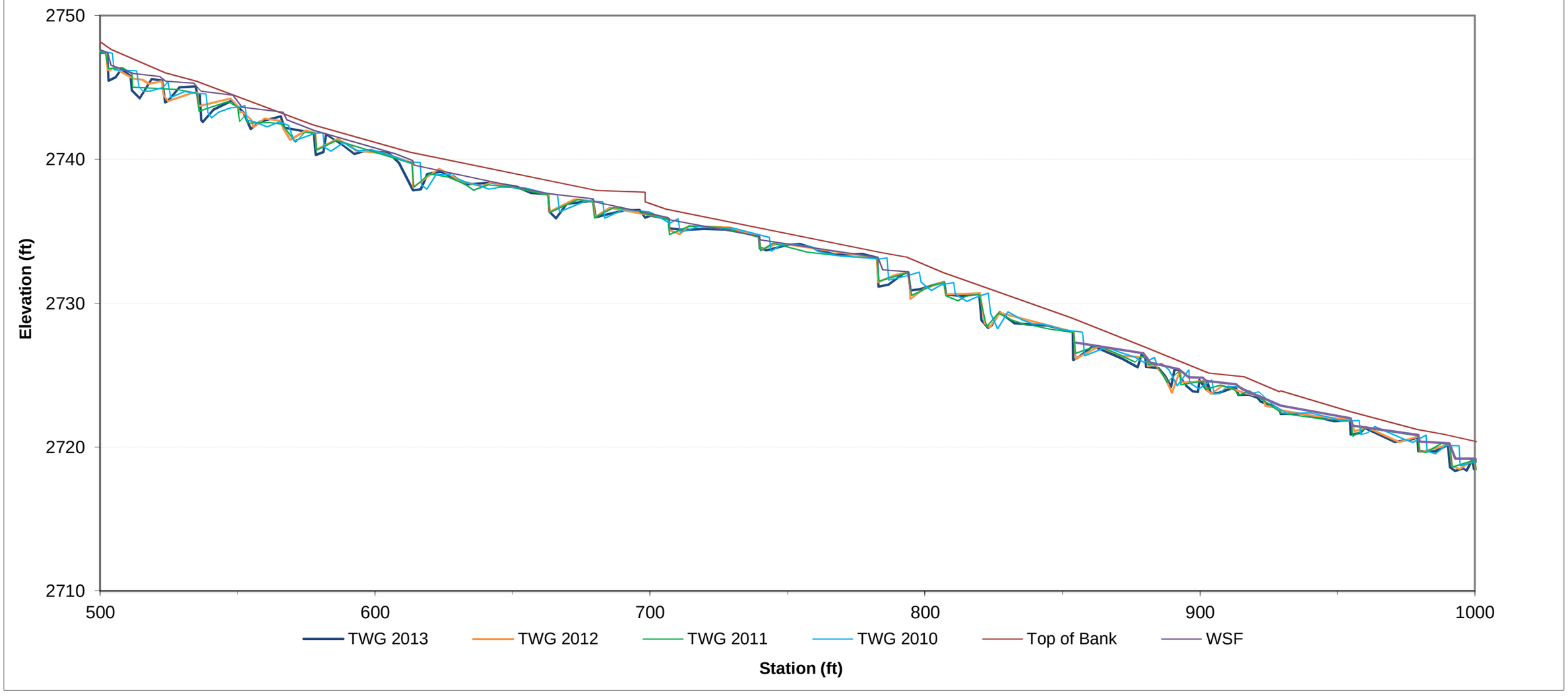
Longitudinal Profile-UT1 (Reach 2): MY 3



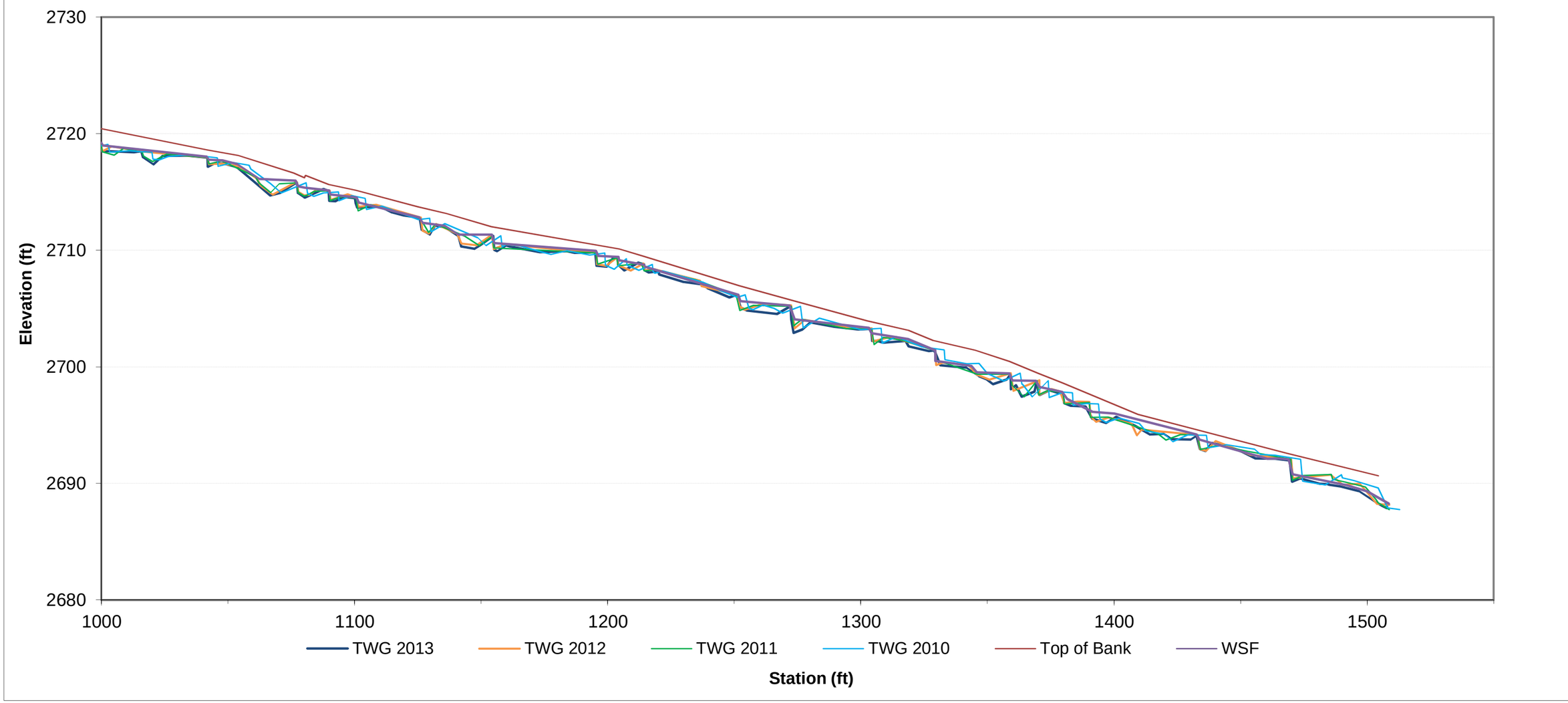
Longitudinal Profile- UT2: MY3 (Sta. 0+00-5+00)



Longitudinal Profile- UT2: MY3 (Sta. 5+00-10+00)



Longitudinal Profile- UT2: MY3 (Sta. 10+00-15+50)




Longitudinal Profile-UT3: MY3 (Sta. 0+00-3+60)
Elevation (ft)
2820
2810
2800
2790
2780
2770
2760
0
100
200
300
Station
2013 TWG
2012 TWG
2011 TWG
2010 TWG
Top of Bank
WSF

Longitudinal Profile-UT3: MY3 (Sta. 0+00-3+60)

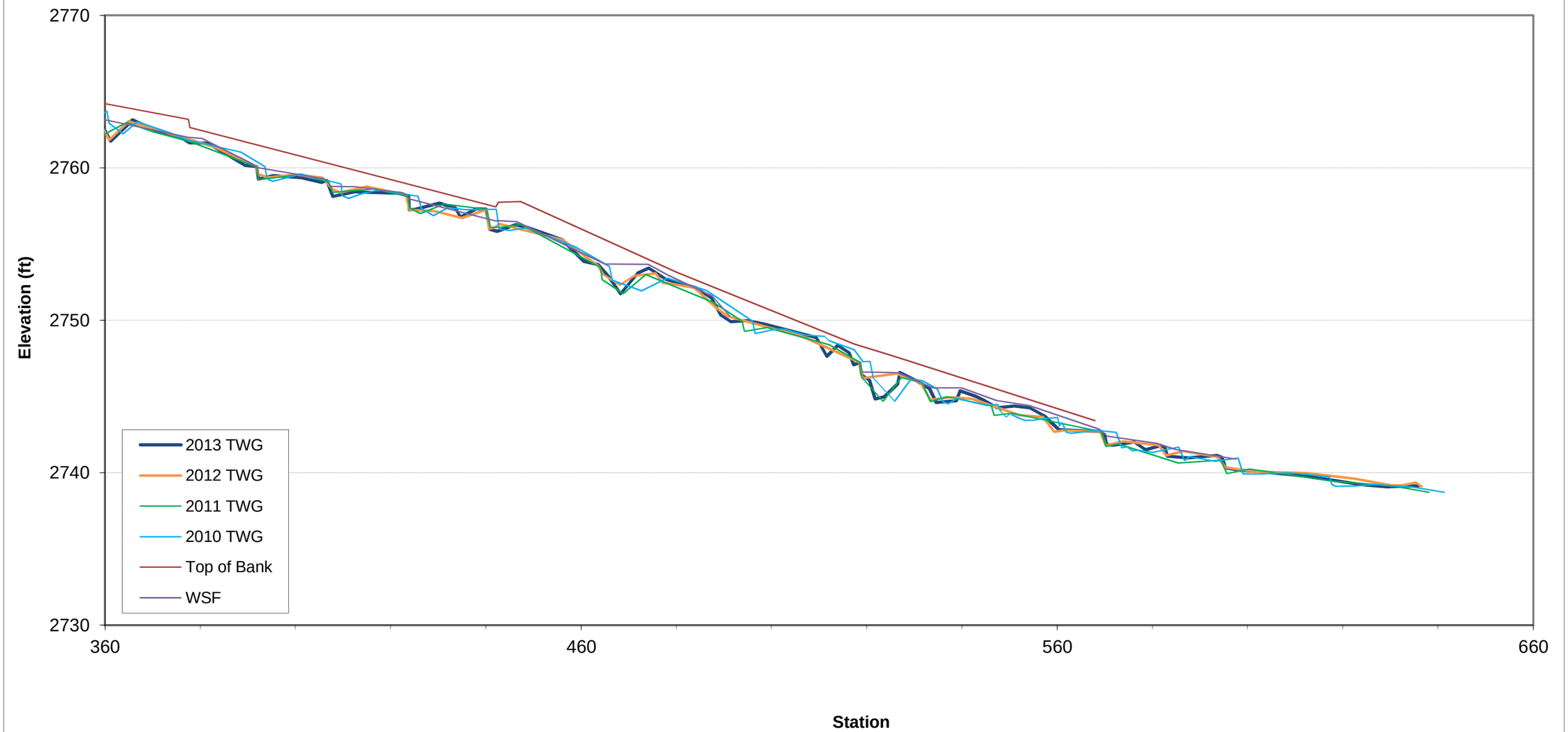


Table 11. Categorical Visual Morphological Stability Assessment						
Sink Hole Creek Mitigation Project: Project No. 92663						
Sink Hole Creek Reach 1 (1,019 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	100%	100%	100%		
Bank Condition	100%	100%	100%	98%		
Rock/Log Drops	100%	100%	100%	100%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		
Sink Hole Creek Reach 2 (1,073 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	100%	100%	100%		
Bank Condition	100%	100%	100%	100%		
Rock/Log Drops	100%	100%	100%	98%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		
UT1 Reach 2 (489 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	100%	100%	100%		
Bank Condition	100%	100%	100%	100%		
Rock/Log Drops	100%	100%	100%	100%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		

UT2 Reach 1 (596 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	100%	98%	100%		
Bank Condition	100%	100%	100%	100%		
Rock/Log Drops	100%	100%	97%	100%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		
UT2 Reach 2 (885LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	94%	96%	96%		
Bank Condition	100%	100%	100%	100%		
Rock/Log Drops	100%	99%	97%	98%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		
UT3 (641 LF)						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
Riffles	100%	100%	100%	100%		
Pools	100%	100%	100%	100%		
Thalweg	100%	100%	100%	100%		
Meanders	100%	100%	100%	100%		
Bed General	100%	79%	94%	77%		
Bank Condition	100%	100%	100%	100%		
Rock/Log Drops	100%	99%	93%	88%		
Vanes / J Hooks etc.	-----	-----	-----	-----		
Wads and Boulders	-----	-----	-----	-----		

Table 12. Visual Morphological Stability Assessment

Sink Hole Creek Mitigation Project: Project No. 92663

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
Sink Hole Reach 1 (1,019 LF)						
A. Riffles	1. Present?	25	25	0/0	100	
	2. Armor stable (e.g. no displacement)?	25	25	0/0	100	
	3. Facet grades appears stable?	25	25	0/0	100	
	4. Minimal evidence of embedding/fining?	25	25	0/0	100	
	5. Length appropriate?	25	25	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	34	34	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	34	34	0/0	100	
	3. Length appropriate?	34	34	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?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%** [3]
E. Bed General	1. General channel bed aggradation areas (bar formation)	1,019	1,019	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	1,019	1,019	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	34	34	0/0	100	
	2. Height appropriate?	34	34	0/0	100	
	3. Angle and geometry appear appropriate?	34	34	0/0	100	
	4. Free of piping or other structural failures?	34	34	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**
Sink Hole Reach 2 (1,073 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?	19	19	0/0	100	
	2. Armor stable (e.g. no displacement)?	19	19	0/0	100	
	3. Facet grades appears stable?	19	19	0/0	100	
	4. Minimal evidence of embedding/fining?	19	19	0/0	100	
	5. Length appropriate?	19	19	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	27	27	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	27	27	0/0	100	
	3. Length appropriate?	27	27	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?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	1,073	1,073	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	1,073	1,073	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	22	24	0/0	92	
	2. Height appropriate?	24	24	0/0	100	
	3. Angle and geometry appear appropriate?	24	24	0/0	100	
	4. Free of piping or other structural failures?	24	24	0/0	100	**98%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT1 Reach 2 (489 LF)						
Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
A. Riffles	1. Present?	15	15	0/0	100	
	2. Armor stable (e.g. no displacement)?	15	15	0/0	100	
	3. Facet grades appears stable?	15	15	0/0	100	
	4. Minimal evidence of embedding/fining?	15	15	0/0	100	
	5. Length appropriate?	15	15	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	24	24	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	24	24	0/0	100	
	3. Length appropriate?	24	24	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?	2	2	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	2	2	0/0	100	
	3. Apparent Rc within spec?	2	2	0/0	100	
	4. Sufficient floodplain access and relief?	2	2	0/0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	489	489	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	489	489	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	24	24	0/0	100	
	2. Height appropriate?	24	24	0/0	100	
	3. Angle and geometry appear appropriate?	24	24	0/0	100	
	4. Free of piping or other structural failures?	24	24	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 Reach 1 (596 LF)						
Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
A. Riffles	1. Present?	23	23	0/0	100	
	2. Armor stable (e.g. no displacement)?	23	23	0/0	100	
	3. Facet grades appears stable?	23	23	0/0	100	
	4. Minimal evidence of embedding/fining?	23	23	0/0	100	
	5. Length appropriate?	23	23	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	27	27	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	27	27	0/0	100	
	3. Length appropriate?	27	27	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?	2	2	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	2	2	0/0	100	
	3. Apparent Rc within spec?	2	2	0/0	100	
	4. Sufficient floodplain access and relief?	2	2	0/0	100	**100%**
E. Bed General[4]	1. General channel bed aggradation areas (bar formation)	596	596	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	596	596	0/0	100	**100%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	28	28	0/0	100	
	2. Height appropriate?	28	28	0/0	100	
	3. Angle and geometry appear appropriate?	28	28	0/0	100	
	4. Free of piping or other structural failures?	28	28	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 Reach 2 (885 LF)						
Feature Category	Metric (per As-Built and reference baselines)	(# Stable) Number Performing as Intended	Total number per As-Built	Total Number / feet in unstable state	% Performing in Stable Condition	Feature Perfomance Mean or Total
A. Riffles	1. Present?	23	23	0/0	100	
	2. Armor stable (e.g. no displacement)?	23	23	0/0	100	
	3. Facet grades appears stable?	23	23	0/0	100	
	4. Minimal evidence of embedding/fining?	23	23	0/0	100	
	5. Length appropriate?	23	23	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	37	37	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	37	37	0/0	100	
	3. Length appropriate?	37	37	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?	3	3	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	3	3	0/0	100	
	3. Apparent Rc within spec?	3	3	0/0	100	
	4. Sufficient floodplain access and relief?	3	3	0/0	100	**100%**
E. Bed General[4]	1. General channel bed aggradation areas (bar formation)	885	885	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	856	885	29	97	**98%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	37	37	0/0	100	
	2. Height appropriate?	37	37	0/0	100	
	3. Angle and geometry appear appropriate?	37	37	0/0	100	
	4. Free of piping or other structural failures?	34	37	0/0	92	**98%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

UT3 (641 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?	25	25	0/0	100	
	2. Armor stable (e.g. no displacement)?	25	25	0/0	100	
	3. Facet grades appears stable?	25	25	0/0	100	
	4. Minimal evidence of embedding/fining?	25	25	0/0	100	
	5. Length appropriate?	25	25	0/0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggradation or migration?)	34	34	0/0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	34	34	0/0	100	
	3. Length appropriate?	34	34	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?	1	1	0/0	100	
	2. Of those eroding, # w/concomitant point bar formation?	1	1	0/0	100	
	3. Apparent Rc within spec?	1	1	0/0	100	
	4. Sufficient floodplain access and relief?	1	1	0/0	100	**100%**
E. Bed General[4]	1. General channel bed aggradation areas (bar formation)	641	641	0/0	100	
	2. Channel bed degradation - areas of increasing down-cutting or head cutting?	341	641	300	53	**77%**
F. Vanes, Rock/Log Drop Structures	1. Free of back or arm scour?	34	34	0/0	100	
	2. Height appropriate?	34	34	0/0	100	
	3. Angle and geometry appear appropriate?	34	34	0/0	100	
	4. Free of piping or other structural failures?	18	34	9	53	**88%**
G. Wads/ Boulders	1. Free of scour?	N/A	N/A	N/A	N/A	
	2. Footing stable?	N/A	N/A	N/A	N/A	**N/A**

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

[2] Of the structures and riffles that contained flow, 100% had a centered thalweg. Centering of the thalweg for all remaining structures and riffles lacking baseflow that are located within the 'dry' portion of the reach will be re-assessed in the Year 4 monitoring report.

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

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

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary
Sink Hole Creek: Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	16.9	11.7	19.7	27.6	12.3	12.7	13.0	12.9	13.5	14.2	12.6	13.5	14.3	10.8	12.6	14.4	8.1	10.8	13.5						
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	58.0	63.7	69.4	56.7	63.0	69.4	58.0	63.6	69.3	58.6	64.0	69.4						
Bankfull Mean Depth (ft)	1.00	0.60	0.85	1.10	1.00	1.05	1.10	0.95	1.09	1.23	0.78	0.90	1.01	0.56	0.84	1.11	0.65	0.86	1.07						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.48	1.72	1.96	1.34	1.55	1.76	1.46	1.65	1.83	1.42	1.74	2.05						
Bankfull Cross Sectional Area (ft2)	17.7	18.3	19.4	20.4	12.6	13.3	14.0	12.2	14.8	17.4	9.8	12.2	14.5	6.0	11.0	16.0	5.3	9.9	14.5						
Width/Depth Ratio	-----	8.6	12.0	15.4	11.8	11.9	12.0	11.6	12.6	13.6	14.1	15.2	16.2	13.0	16.1	19.2	12.6	12.6	12.6						
Entrenchment Ratio	-----	1.6	2.0	2.4	5.4	6.8	8.1	4.1	4.8	5.4	4.0	4.7	5.5	4.0	5.2	6.4	4.3	6.4	8.5						
Bank Height Ratio	-----	1.0	1.4	1.8	-----	1.0	-----	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0						
Bankfull Velocity (fps)	-----	-----	8.3	-----	-----	6.3	-----	----	5.7	----	----	6.9	----	----	7.6	----	----	8.5	----						
Pattern																									
Channel Beltwidth (ft)*	-----	16	36	55	45	60	74	30	47	70	30	47	70	30	47	70	30	47	70						
Radius of Curvature (ft)*	-----	28	38	47	31	38	45	32	39	47	32	39	47	32	39	47	32	39	47						
Meander Wavelength (ft)*	-----	70	165	260	138	142	145	135	140	146	135	140	146	135	140	146	135	140	146						
Meander Width Ratio*	-----	1.1	2.6	4.1	3.7	4.7	5.7	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9	2.4	3.5	4.9						
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	9	21	32	7	21	32	10	23	46	19	30	46						
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.010	0.023	0.053	0.016	0.027	0.062	0.003	0.022	0.052	0.015	0.027	0.041						
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	7	15	21	8	14	22	11	15	17	13	19	23						
Pool Spacing (ft)	-----	42	137	231	18	40	62	17	35	66	15	33	46	15	33	57	21	38	61						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.1/6.6/14/71/110			.3/8/10/50/95			8/20/31/93/152			.6/16/34/110/172			6/25/42/119/185			9/25/41/113/165			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.9	-----	-----	1.5	-----	-----	1.4	-----	-----	1.4	-----	-----	1.6	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	12.0	-----	-----	8.7	-----	-----	9.7	-----	-----	10.7	-----	-----	13.3	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1036	-----	-----	1122	-----	-----	1122	-----	-----	1122	-----	-----	1122	-----						
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----	-----	0.72	-----						
Rosgen Classification	-----	-----	B4c	-----	-----	B4c/C4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----						
Bankfull Discharge (cfs)	78	-----	161	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----	-----	84	-----						
Sinuosity	-----	1.08	1.09	1.09	1.10	1.15	1.20	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----						
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.026	-----	-----	0.029	-----	-----	0.029	-----	-----	0.029	-----						

Notes: Pattern data generated from subreach of Reach 1, directly upstream of the NC Hwy. 80 culvert, where channel slope decreases.

Table 13. Stream Reach Morphology Data Table
Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary
Sink Hole Creek: Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			(As-Built)			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	17.7	11.7	19.7	27.6	12.3	12.7	13.0	13.1	14.9	16.7	12.3	14.4	16.4	13.9	14.0	14.1	14.2	15.8	17.4						
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	54.3	62.2	70.1	51.3	59.5	67.7	52.2	62.0	71.8	54.6	64.2	73.8						
Bankfull Mean Depth (ft)	1.04	0.60	0.85	1.10	1.00	1.05	1.10	1.18	1.29	1.40	1.04	1.18	1.31	1.00	1.17	1.33	0.97	1.19	1.40						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	1.40	-----	1.88	2.12	2.36	1.65	1.90	2.14	1.75	2.11	2.46	1.95	2.25	2.55						
Bankfull Cross Sectional Area (ft2)	19.2	18.3	19.4	20.4	12.6	13.3	14.0	15.5	19.4	23.3	12.8	17.1	21.4	13.8	16.3	18.8	13.8	19.1	24.3						
Width/Depth Ratio	-----	8.6	12.0	15.4	11.8	11.9	12.0	11.0	11.5	11.9	11.8	12.2	12.5	10.6	12.2	13.9	12.4	13.5	14.6						
Entrenchment Ratio	-----	1.6	2.0	2.4	5.4	6.8	8.1	4.2	4.2	4.2	4.1	4.2	4.2	3.8	4.4	5.1	3.8	4.1	4.3						
Bank Height Ratio	-----	1.0	1.4	1.8	-----	1.0	-----	1.0	1.0	1.0	1.0	1.0	1.0	0.8	0.9	1.0	1.0	1.0	1.0						
Bankfull Velocity (fps)	-----	-----	7.2	-----	-----	6.4	-----	----	4.4	----	----	5.0	----	----	5.2	----	----	4.5	----						
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)	-----	-----	-----	-----	-----	-----	-----	10	24	56	9	27	46	9	25	40	20	27	40						
Riffle Slope (ft/ft)	-----	0.036	0.045	0.055	0.038	0.044	0.050	0.017	0.023	0.046	0.007	0.021	0.046	0.008	0.022	0.046	0.016	0.020	0.025						
Pool Length (ft)	-----	13	15	16	-----	-----	-----	9	13	18	4	10	17	7	11	25	10	18	32						
Pool Spacing (ft)	-----	42	137	231	18	42	65	12	42	62	11	42	62	9	39	77	9	32	67						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	0.1/6.6/14/71/110			.3/8/10/50/95			8/18/26/79/135			11/20/34/134/212			19/41/58/143/245			17/35/52/128/245			-----			-----		
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.5	-----	-----	1.6	-----	-----	1.6	-----	-----	1.4	-----	-----	1.6	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	9.6	-----	-----	7.1	-----	-----	8.1	-----	-----	7.4	-----	-----	7.0	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	1062	-----	-----	1073	-----	-----	1073	-----	-----	1073	-----	-----	1073	-----						
Drainage Area (SM)	-----	0.72	0.78	0.84	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----	-----	0.84	-----						
Rosgen Classification	-----	-----	B4c	-----	-----	B4c	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----	-----	Cb4/Eb4	-----						
Bankfull Discharge (cfs)	88	-----	139	-----	----	85	----	----	85	----	----	85	----	----	85	----	----	85	----						
Sinuosity	-----	-----	1.16	-----	1.10	1.15	1.20	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----	-----	1.10	-----						
BF slope (ft/ft)	-----	0.024	0.026	0.028	0.025	0.025	0.026	-----	0.023	-----	-----	0.025	-----	-----	0.023	-----	-----	0.023	-----						

Table 13. Stream Reach Morphology Data Table

Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary: UT1 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.8	11.7	19.7	27.6	6.0	6.7	7.4	-----	9.5	-----	-----	12.5	-----	-----	11.0	-----	-----	10.5	-----						
Floodprone Width (ft)	-----	20.0	30.5	41.0	20.0	30.5	41.0	-----	36.9	-----	-----	37.3	-----	-----	33.1	-----	-----	38.7	-----						
Bankfull Mean Depth (ft)	0.53	0.60	0.85	1.10	0.50	0.55	0.60	-----	0.45	-----	-----	0.33	-----	-----	0.15	-----	-----	0.38	-----						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	-----	0.83	-----	-----	0.79	-----	-----	0.41	-----	-----	1.10	-----						
Bankfull Cross Sectional Area (ft2)	5.1	10.2	21.6	33.0	3.2	3.9	4.6	-----	4.3	-----	-----	4.1	-----	-----	1.7	-----	-----	4.0	-----						
Width/Depth Ratio	-----	10.7	18.9	27.0	11.4	11.7	12.0	-----	21.1	-----	-----	37.7	-----	-----	72.4	-----	-----	27.4	-----						
Entrenchment Ratio	-----	1.3	16.7	32.0	9.5	13.1	16.7	-----	3.9	-----	-----	3.0	-----	-----	3.0	-----	-----	3.7	-----						
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	0.7	-----	-----	1.0	-----	-----	1.1	-----						
Bankfull Velocity (fps)	-----	-----	1.0	-----	-----	5.1	-----	-----	4.7	-----	-----	4.9	-----	-----	11.8	-----	-----	5.0	-----						
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	5	13	20	5	14	21	5	14	21	13	16	18						
Riffle Slope (ft/ft)	-----	0.040	0.043	0.046	0.038	0.068	0.098	0.025	0.043	0.062	0.021	0.037	0.073	0.029	0.049	0.083	0.030	0.043	0.053						
Pool Length (ft)	-----	13	15	16	9	23	37	5	8	11	4	8	13	5	7	10	8	11	14						
Pool Spacing (ft)	-----	42	137	231	9	23	37	11	19	34	10	19	37	10	20	34	12	19	32						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/12/32/81/155			.2/12/32/81/155			-----			-----			-----			-----								
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	1.5	-----	-----	1.0	-----	-----	0.8	-----	-----	0.4	-----	-----	0.9	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	7.7	-----	-----	4.8	-----	-----	3.8	-----	-----	4.3	-----	-----	4.5	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	489	-----	-----	489	-----	-----	489	-----	-----	489	-----	-----	489	-----						
Drainage Area (SM)	-----	-----	0.09	-----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----	-----	0.09	----						
Rosgen Classification	-----	-----	A6a+/B4c	-----	-----	B4/C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----	-----	C4	-----						
Bankfull Discharge (cfs)	16	-----	22	-----	----	20	----	----	20	----	----	20	----	----	20	----	----	20	----						
Sinuosity	-----	-----	1.16	----	1.10	1.15	1.20	-----	1.16	-----	-----	1.16	-----	-----	1.16	-----	-----	1.16	-----						
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.042	-----	-----	0.04	-----	-----	0.041	-----	-----	0.041	-----						

Note:

Table 13. Stream Reach Morphology Data Table

Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary: UT2 Reach 1

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.5	11.7	19.7	27.6	-----	4.0	-----	-----	4.2	-----	-----	4.4	-----	-----	5.1	-----	-----	3.8	-----						
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	-----	30.6	-----	-----	31.9	-----	-----	19.2	-----	-----	36.5	-----						
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.26	-----	-----	0.20	-----	-----	0.15	-----	-----	0.18	-----						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.53	-----	-----	0.53	-----	-----	0.25	-----	-----	0.65	-----						
Bankfull Cross Sectional Area (ft2)	2.1	10.2	21.6	33.0	----	1.5	----	-----	1.1	-----	-----	0.9	-----	-----	0.7	-----	-----	0.7	-----						
Width/Depth Ratio	-----	10.7	18.9	27.0	----	10.8	----	-----	16.3	-----	-----	21.5	-----	-----	34.0	-----	-----	20.5	-----						
Entrenchment Ratio	-----	1.3	16.7	32.0	17.4	21.1	24.8	-----	7.2	-----	-----	7.3	-----	-----	34.8	-----	-----	9.7	-----						
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	0.8	-----						
Bankfull Velocity (fps)	-----	-----	1.1	-----	-----	3.3	-----	-----	4.6	-----	-----	5.6	-----	-----	6.8	-----	-----	7.1	-----						
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	4	12	18	7	12	18	4	12	19	12	16	22						
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.136	0.152	0.167	0.046	0.107	0.149	0.045	0.112	0.176	0.047	0.121	0.185	0.112	0.136	0.170						
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3	6	10	3	8	11	7	11	14	8	11	13						
Pool Spacing (ft)	-----	-----	-----	-----	6	14	21	10	14	22	7	14	22	9	15	34	11	16	34						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----			-----			-----			-----							
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	579	-----	-----	596	-----	-----	596	-----	-----	596	-----	-----	596	-----						
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----						
Rosgen Classification	-----	-----	Aa^{+}	-----	-----	$Aa^{+}4$	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----						
Bankfull Discharge (cfs)	5	-----	24	-----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----						
Sinuosity	-----	-----	1.07	----	1.10	1.15	1.20	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----						
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.107	-----	-----	0.107	-----	-----	0.109	-----	-----	0.109	-----						

Note: No sediment data was collected for UT2 and UT3 during the design phase due to the extremely poor substrate present. For UT1, UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile.

Table 13. Stream Reach Morphology Data Table

Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary: UT2 Reach 2

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	7.5	11.7	19.7	27.6	6.0	6.7	7.4	4.9	5.5	6.0	5.1	5.8	6.5	5.7	6.3	6.9	5.3	6.1	6.9						
Floodprone Width (ft)	-----	20.0	30.5	41.0	70.0	85.0	100.0	38.3	43.7	49.1	33.2	40.9	48.6	39.1	43.3	47.5	40.9	44.2	47.5						
Bankfull Mean Depth (ft)	0.51	0.60	0.85	1.10	0.50	0.55	0.60	0.52	0.67	0.81	0.43	0.58	0.72	0.47	0.61	0.74	0.47	0.59	0.70						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	0.70	0.75	0.80	0.86	1.18	1.50	0.79	1.12	1.45	0.92	1.15	1.37	1.10	1.33	1.55						
Bankfull Cross Sectional Area (ft2)	4.7	10.2	21.6	33.0	3.2	3.9	4.6	2.5	3.7	4.9	2.2	3.5	4.7	2.7	3.9	5.1	2.5	3.7	4.8						
Width/Depth Ratio	-----	10.7	18.9	27.0	11.4	11.7	12.0	7.4	8.5	9.5	9.0	10.5	11.9	9.3	10.7	12.1	9.9	10.6	11.3						
Entrenchment Ratio	-----	1.3	16.7	32.0	9.5	13.1	16.7	7.8	8.0	8.2	6.5	7.0	7.5	6.9	6.9	6.9	6.9	7.4	7.8						
Bank Height Ratio	-----	-----	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)	-----	-----	0.6	-----	-----	4.9	-----	-----	5.1	-----	-----	5.5	-----	-----	4.9	-----	-----	5.2	-----						
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	13	18	27	11	19	27	8	16	27	12	18	27						
Riffle Slope (ft/ft)	-----	0.040	0.043	0.046	0.081	0.089	0.098	0.052	0.072	0.091	0.025	0.060	0.092	0.034	0.062	0.097	0.041	0.057	0.084						
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	5	8	11	3	7	11	3	8	11	7	10	13						
Pool Spacing (ft)	-----	-----	21	-----	9	23	37	9	25	43	12	26	43	11	27	43	12	27	43						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----	.2/12/32/81/155			.2/12/32/81/155			-----			-----			-----			-----								
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	879	-----	-----	882	-----	-----	882	-----	-----	882	-----	-----	882	-----						
Drainage Area (SM)	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----	-----	0.08	-----						
Rosgen Classification	-----	-----	Aa+	-----	-----	A4	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----	-----	A/B	-----						
Bankfull Discharge (cfs)	15	-----	14	-----	----	19	----	----	19	----	----	19	----	----	19	----	----	19	----						
Sinuosity	-----	-----	1.04	----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----	-----	1.13	-----						
BF slope (ft/ft)	-----	0.038	0.047	0.057	0.038	0.046	0.055	-----	0.055	-----	-----	0.056	-----	-----	0.055	-----	-----	0.055	-----						

Note: No sediment data was collected for UT2 and UT3 during the design phase due to the extremely poor substrate present. For UT1, UT2 and UT3, no sediment capacity check was performed as these steep headwater tributaries are degradational systems by nature and they are being built primarily out of colluvial material that is designed to be immobile.

Table 13. Stream Reach Morphology Data Table

Sink Hole Creek Mitigation Project #92663

Stream Reach Data Summary: UT3

Parameter	Regional Curve Equation	Reference Reach(es) Data			Design			As-Built			Yr 1			Yr 2			Yr 3			Yr 4			Yr 5		
Dimension - Riffle	Eq.	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max	Min	Mean	Max
Bankfull Width (ft)	4.5	11.7	19.7	27.6	-----	4.0	-----	-----	5.2	-----	-----	6.6	-----	-----	6.2	-----	-----	6.9	-----						
Floodprone Width (ft)	-----	20.0	30.5	41.0	69.6	84.4	99.2	-----	25.2	-----	-----	35.9	-----	-----	29.2	-----	-----	37.8	-----						
Bankfull Mean Depth (ft)	0.33	0.60	0.85	1.10	----	0.40	----	-----	0.41	-----	-----	0.58	-----	-----	0.50	-----	-----	0.53	-----						
Bankfull Max Depth (ft)	-----	0.90	1.70	2.50	-----	0.50	-----	-----	0.76	-----	-----	0.98	-----	-----	0.76	-----	-----	1.01	-----						
Bankfull Cross Sectional Area (ft2)	2.1	10.2	21.6	33.0	----	1.5	----	-----	2.1	-----	-----	3.9	-----	-----	3.1	-----	-----	3.6	-----						
Width/Depth Ratio	-----	10.7	18.9	27.0	----	10.8	----	-----	12.7	-----	-----	11.5	-----	-----	12.5	-----	-----	13.1	-----						
Entrenchment Ratio	-----	1.3	16.7	32.0	17.4	21.1	24.8	-----	4.8	-----	-----	5.4	-----	-----	4.7	-----	-----	5.5	-----						
Bank Height Ratio	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----	-----	1.0	-----						
Bankfull Velocity (fps)	-----	-----	0.5	-----	-----	3.3	-----	-----	2.3	-----	-----	1.3	-----	-----	1.6	-----	-----	1.4	-----						
Pattern																									
Channel Beltwidth (ft)	-----	16	36	55	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Radius of Curvature (ft)	-----	28	38	47	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Wavelength (ft)	-----	70	165	260	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Meander Width Ratio	-----	3.5	5.8	8.0	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Profile																									
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	10	17	27	11	17	21	5	17	28	10	19	31						
Riffle Slope (ft/ft)	-----	-----	-----	-----	0.136	0.152	0.167	0.060	0.113	0.168	0.064	0.125	0.169	0.091	0.116	0.158	0.093	0.124	0.168						
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	3	5	6	4	5	9	2	4	7	4	6	7						
Pool Spacing (ft)	-----	-----	-----	-----	6	13	20	10	15	21	8	15	23	9	15	24	10	15	22						
Substrate and Transport Parameters																									
d16 / d35 / d50 / d84 / d95	-----		-----			-----			-----			-----			-----			-----						
Reach Shear Stress (competency) lb/f2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Stream Power (transport capacity) W/m2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----						
Additional Reach Parameters																									
Channel length (ft)	-----	-----	-----	-----	-----	586	-----	-----	641	-----	-----	641	-----	-----	641	-----	-----	641	-----						
Drainage Area (SM)	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----	-----	0.02	-----						
Rosgen Classification	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----	-----	Aa+/B	-----						
Bankfull Discharge (cfs)	5	-----	11	-----	----	5	----	----	5	----	----	5	----	----	5	----	----	5	----						
Sinuosity	-----	-----	1.02	----	1.10	1.15	1.20	-----	1.03	-----	-----	1.02	-----	-----	1.02	-----	-----	1.02	-----						
BF slope (ft/ft)	-----	0.105	0.106	0.108	0.105	0.106	0.108	-----	0.111	-----	-----	0.111	-----	-----	0.114	-----	-----	0.114	-----						

Note:

Table 14. Cross-Section Morphology Data Table

Sink Hole Creek Mitigation Project #92663

	Sink Hole Creek Reach 1																	
Parameter	Cross Section 1 Pool						Cross Section 2 Riffle						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)	14.1	16.6	13.6	13.7			12.9	12.6	10.8	8.1			14.2	14.3	14.4	13.5		
Floodprone Width (ft)	64.0	66.6	64.0	66.7			69.4	69.4	69.3	69.4			58.0	56.7	58.0	58.6		
BF Cross Sectional Area (ft2)	18.6	20.3	19.0	19.0			12.2	9.8	6.0	5.3			17.4	14.5	16.0	14.5		
BF Mean Depth (ft)	1.31	1.23	1.39	1.38			0.95	0.78	0.56	0.65			1.23	1.01	1.11	1.07		
BF Max Depth (ft)	2.51	2.69	2.56	2.55			1.48	1.34	1.46	1.42			1.96	1.76	1.83	2.05		
Width/Depth Ratio	10.8	13.5	9.8	7.5			13.6	16.2	19.2	12.6			11.6	14.1	13.0	12.6		
Entrenchment Ratio	>4.5	4.0	4.7	4.9			>5.4	5.5	6.4	8.5			>4.1	4.0	4.0	4.3		
Wetted Perimeter (ft)	16.8	19.0	16.4	16.5			14.8	14.2	11.9	9.4			16.7	16.3	16.7	15.6		
Hydraulic Radius (ft)	1.1	1.1	1.2	1.2			0.8	0.7	0.5	0.6			1.0	0.9	1.0	0.9		
Substrate																		
d50 (mm)																		
d84 (mm)																		

	Sink Hole Creek Reach 2																	
Parameter	Cross Section 4 Pool						Cross Section 5 Riffle						Cross Section 6 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	13.1	13.0	12.6	10.6			16.7	16.4	14.1	17.4			13.1	12.3	13.9	14.2		
Floodprone Width (ft)	80.4	80.1	80.0	85.0			70.1	67.7	71.8	73.8			54.3	51.3	52.2	54.6		
BF Cross Sectional Area (ft2)	14.2	13.4	10.8	11.7			23.3	21.4	18.8	24.3			15.5	12.9	13.8	13.8		
BF Mean Depth (ft)	1.08	1.02	0.86	0.51			1.40	1.31	1.33	1.40			1.18	1.04	1.00	0.97		
BF Max Depth (ft)	1.67	1.71	1.83	2.21			2.36	2.14	2.46	2.55			1.88	1.65	1.75	1.95		
Width/Depth Ratio	12.1	12.7	14.7	20.7			11.9	12.5	10.6	12.4			11.0	11.8	13.9	14.6		
Entrenchment Ratio	6.1	6.1	6.3	8.0			4.2	4.1	5.1	4.3			>4.2	4.2	3.8	3.8		
Wetted Perimeter (ft)	15.3	15.1	14.4	11.6			19.5	19.0	16.8	20.2			15.4	14.4	15.9	16.1		
Hydraulic Radius (ft)	0.9	0.9	0.8	1.0			1.2	1.1	1.1	1.2			1.0	0.9	0.9	0.9		

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)	0	0	0	30	70	51	30	70	51	30	70	51						
Radius of Curvature (ft)	0	0	0	32	51	39	32	51	39	32	51	39						
Meander Wavelength (ft)	0	0	0	135	331	227	135	331	227	135	331	227						
Meander Width Ratio	0.0	0.0	0.0	1.8	5.5	3.8	1.8	5.5	3.8	1.8	5.5	3.8						
Profile																		
Riffle length (ft)	9	56	22	9	46	27	9	46	23	10	42	22						
Riffle Slope (ft/ft)	0.010	0.050	0.020	0.007	0.046	0.020	0.003	0.052	0.017	0.014	0.041	0.024						
Pool Length (ft)	7	21	14	4	17	11	7	25	13	10	27	17						
Pool Spacing (ft)	12	66	39	11	62	46	9	77	36	9	64	33						
Substrate																		
d50 (mm)	31(R1) / 26(R2)			34(R1) /110(R2)			42(R1) /58(R2)			41(R1) /52(R2)								
d84 (mm)	93(R1) / 79(R2)			110(R1) /134(R2)			119(R1) /143(R2)			113(R1) /128(R2)								
Additional Reach Parameters																		
Valley Length (ft)	2006			2006			2006			2006								
Channel Length (ft)	2207			2207			2207			2207								
Sinuosity	1.10			1.10			1.10			1.10								
Water Surface Slope (ft/ft)	0.025			0.025			0.025			0.025								
BF Slope (ft/ft)	0.025			0.026			0.026			0.026								
Rosgen Classification	B/Cb4			Cb4/Eb4			Cb4/Eb4			Cb4/Eb4								

Table 14. Cross-Section Morphology Data Table

Sink Hole Creek Mitigation Project #92663

UT1 Reach 2

Parameter	Cross Section 1 Pool						Cross Section 2 Riffle					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	12.7	11.9	10.4	9.1			9.5	12.5	11.0	10.5		
Floodprone Width (ft)	44.8	44.0	44.1	42.9			36.9	37.3	33.1	38.7		
BF Cross Sectional Area (ft2)	12.3	10.0	7.2	9.4			4.3	4.1	1.7	4.0		
BF Mean Depth (ft)	0.97	0.84	0.69	1.03			0.45	0.33	0.15	0.38		
BF Max Depth (ft)	1.55	1.42	1.49	1.47			0.83	0.79	0.41	1.10		
Width/Depth Ratio	13.1	14.1	15.2	8.8			21.1	37.7	72.4	27.4		
Entrenchment Ratio	3.5	3.7	4.2	4.7			3.9	3.0	3.0	3.7		
Wetted Perimeter (ft)	14.6	13.6	11.8	11.2			10.4	13.1	11.3	11.2		
Hydraulic Radius (ft)	0.8	0.7	0.6	0.8			0.4	0.3	0.1	0.4		
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	5	20	13	5	22	14	5	21	15	13	18	15						
Riffle Slope (ft/ft)	0.025	0.062	0.043	0.021	0.073	0.037	0.029	0.083	0.041	0.030	0.063	0.043						
Pool Length (ft)	5	11	8	4	13	6	5	10	7	7	13	12						
Pool Spacing (ft)	11	34	15	10	37	17	10	34	19	11	32	19						
Substrate																		
d50 (mm)		-			-			-			-							
d84 (mm)		-			-			-			-							
Additional Reach Parameters																		
Valley Length (ft)		422			422			422			422							
Channel Length (ft)		489			489			489			489							
Sinuosity		1.16			1.16			1.16			1.16							
Water Surface Slope (ft/ft)		0.040			0.040			0.040			0.040							
BF Slope (ft/ft)		0.042			0.040			0.041			0.041							
Rosgen Classification		C4			C4			C4			C4							

Table 14. Cross-Section Morphology Data Table

Sink Hole Creek Mitigation Project #92663

UT2 Reach 1

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)	4.2	4.4	5.1	3.8			7.0	5.4	5.4	4.6		
Floodprone Width (ft)	30.6	31.9	19.2	36.5			30.2	26.6	24.9	22.9		
BF Cross Sectional Area (ft2)	1.1	0.9	0.7	0.7			5.3	2.9	2.4	2.1		
BF Mean Depth (ft)	0.26	0.20	0.15	0.18			0.75	0.54	0.44	0.45		
BF Max Depth (ft)	0.53	0.53	0.25	0.64			1.40	1.09	0.84	0.93		
Width/Depth Ratio	16.3	21.5	34.8	20.5			9.4	10.1	12.2	10.4		
Entrenchment Ratio	7.2	7.3	3.8	9.7			4.3	4.9	4.6	4.9		
Wetted Perimeter (ft)	4.7	4.8	5.4	4.1			8.5	6.5	6.3	5.5		
Hydraulic Radius (ft)	0.2	0.2	0.1	0.2			0.6	0.4	0.4	0.4		
Substrate												
d50 (mm)												
d84 (mm)												

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	4	18	11	4	18	12	4	19	13	5	22	14						
Riffle Slope (ft/ft)	0.046	0.149	0.123	0.045	0.176	0.121	0.047	0.185	0.118	0.057	0.170	0.123						
Pool Length (ft)	3	10	7	3	11	8	7	14	11	8	13	11						
Pool Spacing (ft)	10	22	13	7	22	13	9	34	13	11	34	13						
Substrate																		
d50 (mm)		-			-			-			-							
d84 (mm)		-			-			-			-							
Additional Reach Parameters																		
Valley Length (ft)		527			527			527			527							
Channel Length (ft)		596			596			596			596							
Sinuosity		1.13			1.12			1.12			1.12							
Water Surface Slope (ft/ft)		0.107			0.105			0.106			0.106							
BF Slope (ft/ft)		0.107			0.107			0.109			0.109							
Rosgen Classification		A/B			A/B			A/B			A/B							

Table 14. Cross-Section Morphology Data Table

Sink Hole Creek Mitigation Project #92663

UT2 Reach 2

Parameter	Cross Section 3						Cross Section 4						Cross Section 5					
	Riffle						Riffle						Pool					
	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5	AB	MY1	MY2	MY3	MY4	MY5
Dimension																		
BF Width (ft)	4.9	5.1	5.7	5.3			6.0	6.5	6.9	6.9			8.4	8.4	8.4	9.0		
Floodprone Width (ft)	38.3	33.2	39.1	40.9			49.1	48.6	47.5	47.5			67.4	67.4	67.5	67.7		
BF Cross Sectional Area (ft2)	2.5	2.2	2.7	2.5			4.9	4.7	5.1	4.8			8.1	7.3	6.6	6.8		
BF Mean Depth (ft)	0.52	0.43	0.47	0.47			0.81	0.72	0.74	0.70			0.96	0.88	0.78	0.76		
BF Max Depth (ft)	0.86	0.79	0.92	1.10			1.50	1.45	1.37	1.55			1.67	1.57	1.63	1.70		
Width/Depth Ratio	9.5	11.9	12.1	11.3			7.4	9.0	9.3	9.9			8.8	9.6	10.9	11.8		
Entrenchment Ratio	7.8	6.5	6.9	7.8			8.2	7.5	6.9	6.9			8.0	8.1	8.0	7.5		
Wetted Perimeter (ft)	5.9	5.9	6.6	6.2			7.6	8.0	8.4	8.3			10.3	10.1	10.0	10.5		
Hydraulic Radius (ft)	0.4	0.4	0.4	0.4			0.6	0.6	0.6	0.6			0.8	0.7	0.7	0.6		
Substrate																		
d50 (mm)																		
d84 (mm)																		

Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	13	27	18	11	27	20	8	27	18	12	27	16						
Riffle Slope (ft/ft)	0.052	0.091	0.077	0.025	0.092	0.060	0.034	0.097	0.062	0.041	0.084	0.054						
Pool Length (ft)	5	11	8	3	11	7	3	11	9	6	13	10						
Pool Spacing (ft)	9	43	26	12	43	32	11	43	31	12	43	31						
Substrate																		
d50 (mm)		-			-			-			-							
d84 (mm)		-			-			-			-							
Additional Reach Parameters																		
Valley Length (ft)		781			781			781			781							
Channel Length (ft)		882			882			882			882							
Sinuosity		1.13			1.13			1.13			1.13							
Water Surface Slope (ft/ft)		0.058			0.058			0.058			0.058							
BF Slope (ft/ft)		0.055			0.056			0.055			0.055							
Rosgen Classification		A/B			A/B			A/B			A/B							

Table 14. Cross-Section Morphology Data Table

Sink Hole Creek Mitigation Project #92663

UT3

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)	5.2	6.6	6.2	6.9			6.2	6.9	6.9	7.48		
Floodprone Width (ft)	25.2	35.9	29.2	37.8			44.5	46.8	47.4	47.54		
BF Cross Sectional Area (ft2)	2.1	3.9	3.1	3.6			4.2	5.6	5.7	6.00		
BF Mean Depth (ft)	0.41	0.58	0.50	0.53			0.69	0.82	0.81	0.80		
BF Max Depth (ft)	0.76	0.98	0.76	1.01			1.28	1.42	1.48	1.60		
Width/Depth Ratio	12.7	11.5	12.5	13.1			9.0	8.4	8.5	9.33		
Entrenchment Ratio	4.8	5.4	4.7	5.5			7.2	6.8	6.8	6.40		
Wetted Perimeter (ft)	6.0	7.8	7.2	7.9			7.6	8.5	8.6	9.1		
Hydraulic Radius (ft)	0.4	0.5	0.4	0.5			0.6	0.7	0.7	0.7		
Substrate												
d50 (mm)												
d84 (mm)												

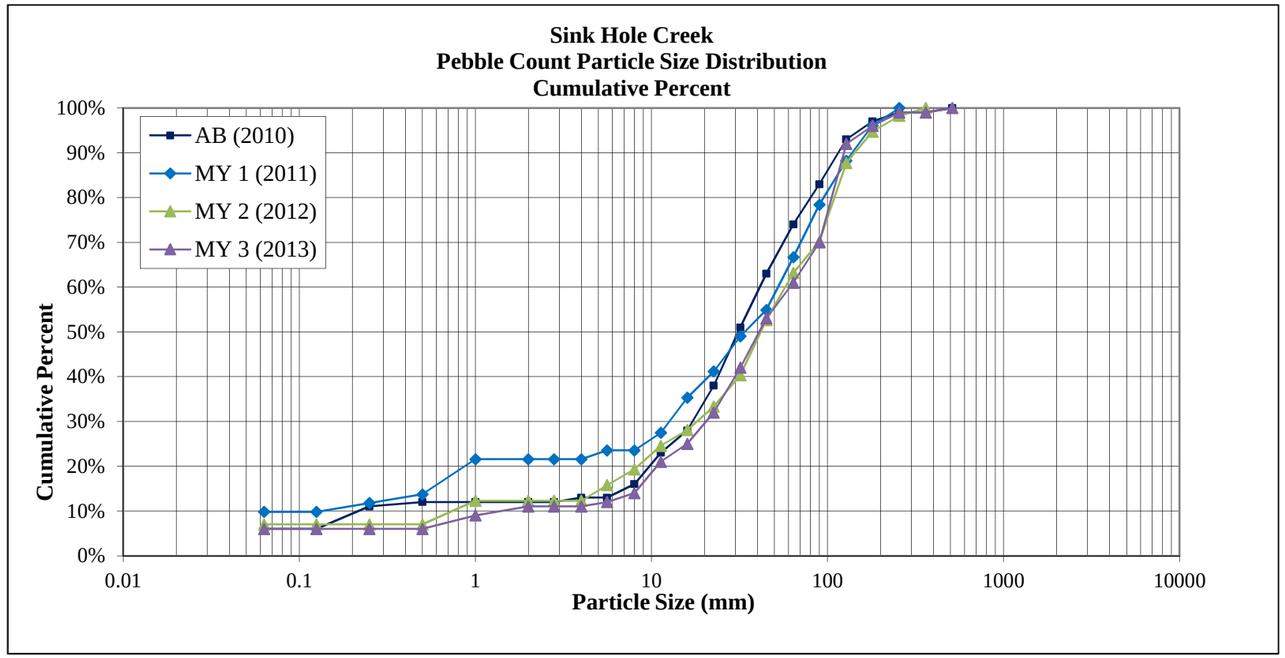
Parameter	AB (2010)			MY-1 (2011)			MY-2 (2012)			MY-3 (2013)			MY-4 (2014)			MY-5 (2015)		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Pattern																		
Channel Beltwidth (ft)																		
Radius of Curvature (ft)																		
Meander Wavelength (ft)																		
Meander Width Ratio																		
Profile																		
Riffle length (ft)	10	27	14	11	21	19	5	28	17	10	31	17						
Riffle Slope (ft/ft)	0.060	0.168	0.113	0.064	0.169	0.123	0.091	0.158	0.108	0.093	0.168	0.113						
Pool Length (ft)	3	6	5	4	9	5	2	7	4	4	7	6						
Pool Spacing (ft)	10	21	17	8	23	17	9	24	14	10	22	15						
Substrate																		
d50 (mm)	-			-			-			-								
d84 (mm)	-			-			-			-								
Additional Reach Parameters																		
Valley Length (ft)	622			622			622			622								
Channel Length (ft)	641			641			641			641								
Sinuosity	1.03			1.02			1.02			1.02								
Water Surface Slope (ft/ft)	0.105			0.106			0.106			0.106								
BF Slope (ft/ft)	0.111			0.111			0.114			0.114								
Rosgen Classification	A/B			A/B			A/B			A/B								

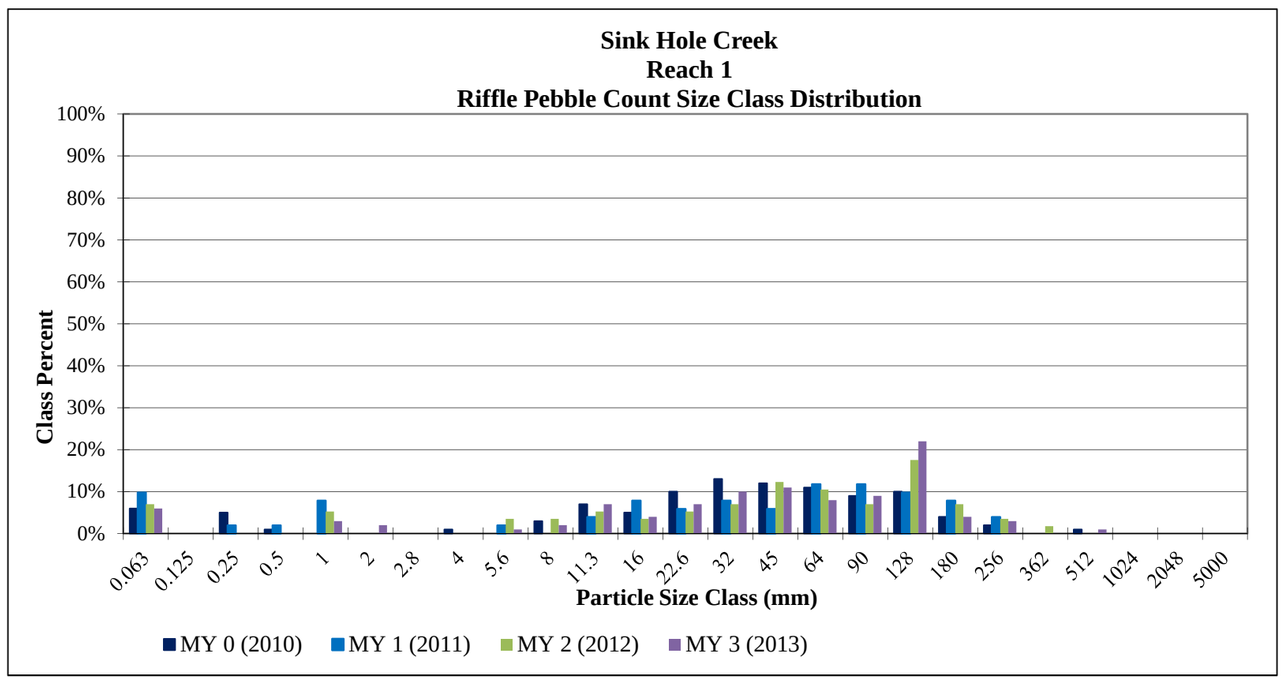
Cross-Section Pebble Count (Sink Hole Creek-Reach 1)
Sink Hole Creek Mitigation Project, EEP# 92663

SITE OR PROJECT:	Sink Hole Creek
REACH/LOCATION:	Reach 1, 1st riffle downstream of VP6
FEATURE:	Riffle

			2013		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt/Clay	Silt / Clay	< .063	6	6%	6%
Sand	Very Fine	.063 - .125		0%	6%
	Fine	.125 - .25		0%	6%
	Medium	.25 - .50		0%	6%
	Coarse	.50 - 1.0	3	3%	9%
	Very Coarse	1.0 - 2.0	2	2%	11%
Gravel	Very Fine	2.0 - 2.8		0%	11%
	Very Fine	2.8 - 4.0		0%	11%
	Fine	4.0 - 5.6	1	1%	12%
	Fine	5.6 - 8.0	2	2%	14%
	Medium	8.0 - 11.0	7	7%	21%
	Medium	11.0 - 16.0	4	4%	25%
	Coarse	16 - 22.6	7	7%	32%
	Coarse	22.6 - 32	10	10%	42%
	Very Coarse	32 - 45	11	11%	53%
	Very Coarse	45 - 64	8	8%	61%
Cobble	Small	64 - 90	9	9%	70%
	Small	90 - 128	22	22%	92%
	Large	128 - 180	4	4%	96%
	Large	180 - 256	3	3%	99%
Boulder	Small	256 - 362		0%	99%
	Small	362 - 512	1	1%	100%
	Medium	512 - 1024		0%	100%
	Large-Very Large	1024 - 2048		0%	100%
Bedrock	Bedrock	> 2048		0%	100%
Total % of whole count			100	100%	100%

Summary Data	
Channel materials	
D_{50} =	41.00
D_{84} =	112.61
D_{95} =	165.29



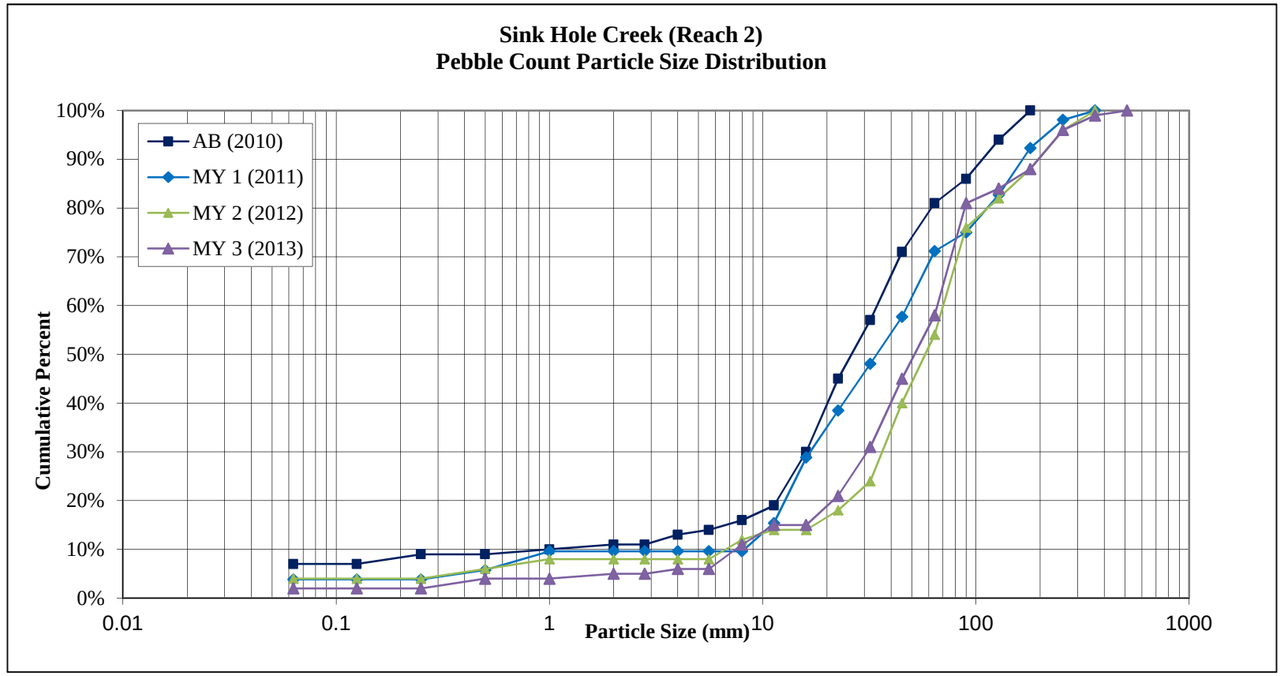


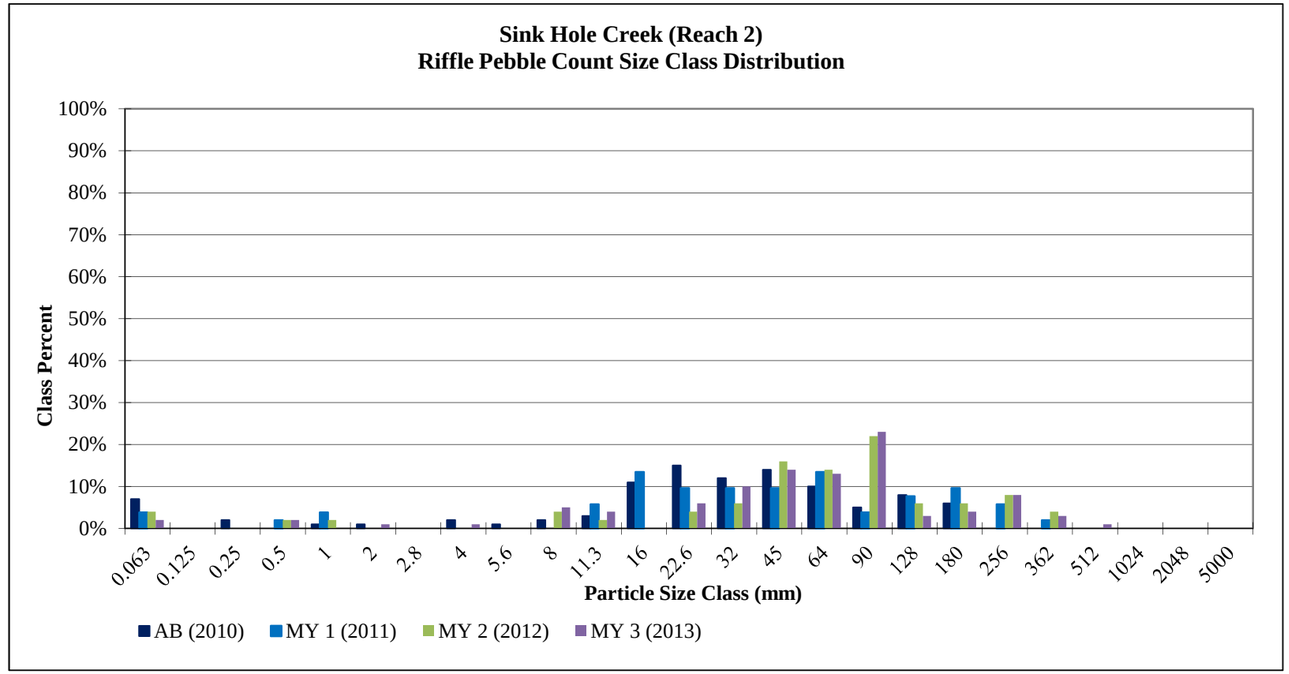
Cross-Section Pebble Count (Sink Hole Creek-Reach 2)
Sink Hole Creek Mitigation Project, EEP# 92663

SITE OR PROJECT:	Sink Hole Creek
REACH/LOCATION:	Reach 2, 1st riff upstream of VP4
FEATURE:	Riffle

			2013		
MATERIAL	**PARTICLE**	**SIZE (mm)**	**Total**	**Class %**	**% Cum**
Silt/Clay	Silt / Clay	< .063	2	2%	2%
Sand	Very Fine	.063 - .125		0%	2%
	Fine	.125 - .25		0%	2%
	Medium	.25 - .50	2	2%	4%
	Coarse	.50 - 1.0		0%	4%
	Very Coarse	1.0 - 2.0	1	1%	5%
Gravel	Very Fine	2.0 - 2.8		0%	5%
	Very Fine	2.8 - 4.0	1	1%	6%
	Fine	4.0 - 5.6		0%	6%
	Fine	5.6 - 8.0	5	5%	11%
	Medium	8.0 - 11.0	4	4%	15%
	Medium	11.0 - 16.0		0%	15%
	Coarse	16 - 22.6	6	6%	21%
	Coarse	22.6 - 32	10	10%	31%
	Very Coarse	32 - 45	14	14%	45%
	Very Coarse	45 - 64	13	13%	588%
Cobble	Small	64 - 90	23	23%	81%
	Small	90 - 128	3	3%	84%
	Large	128 - 180	4	4%	88%
	Large	180 - 256	8	8%	96%
Boulder	Small	256 - 362	3	3%	99%
	Small	362 - 512	1	1%	100%
	Medium	512 - 1024		0%	100%
	Large-Very Large	1024 - 2048		0%	100%
Bedrock	Bedrock	> 2048		0%	100%
Total % of whole count			100	100%	100%

Summary Data	
Channel materials	
D_{50} =	51.53
D_{84} =	128.00
D_{95} =	244.97





Sink Hole Creek
Photo Log - Reference Photo Points

Notes: Photos for Sink Hole Creek were taken November 2013.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking upstream

Photo Point 1: looking downstream

Photo Point 2: looking upstream

Photo Point 2: looking downstream

Photo Point 3: looking upstream

Photo Point 3: looking downstream

Photo Point 4: looking upstream

Photo Point 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 12: looking upstream

Photo Point 12: looking downstream

Photo Point 13: looking upstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Sink Hole Creek – UT1 Reach 1 Preservation Reach
Photo Log - Reference Photo Points

Notes: Photos for UT1 Reach 1 Preservation Reach were taken November 2013.

1. 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 downstream

Photo Point 1: looking upstream

Photo Point 2: looking upstream

Photo Point 3: looking upstream

Photo Point 4: looking upstream

Photo Point 5: looking upstream

Photo Point 6: looking upstream

Photo Point 7: looking upstream

Photo Point 8: looking downstream

Photo Point 8: looking upstream

UT 1 to Sink Hole Creek-Reach 2
Photo Log - Reference Photo Points

Notes: Photos for UT1-Reach 2 were taken in November 2013.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

UT1 Photo Point 1: looking upstream

UT1 Photo Point 1: looking downstream

UT1 Photo Point 2: looking upstream

UT1 Photo Point 2: looking downstream

UT1 Photo Point 3: looking upstream

UT1 Photo Point 3: looking downstream

UT1 Photo Point 4: looking upstream

Sink Hole Creek – UT2
Photo Log - Reference Photo Points

Notes: Photos for UT2 were taken November 2013.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking 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 7: looking upstream

Photo Point 7: view of confluence with UT3

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 downstream

Photo Point 13: looking upstream

Photo Point 13: looking downstream

Photo Point 14: looking upstream

Photo Point 14: looking downstream

Sink Hole Creek – UT3
Photo Log - Reference Photo Points

Notes: Photos for UT3 were taken November 2013.

1. Photo point locations are shown on the plan views in the actual location the picture was taken.
2. All points are marked with a wooden stake and flagging tape. For channel points, the stake is set up on an adjacent bank.

Photo Point 1: looking 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