EMH&T
Engineers, Surveyors, Planners, Scientists

January 6, 2014

Mr. Guy Pearce
Full Delivery Supervisor
Ecosystem Enhancement Program
217 West Jones Street, Suite 3000A
Raleigh, North Carolina 27603

Subject: Year 5 Monitoring Report for Stream Mitigation of Beaverdam Creek; Union County, NC; SCO# D06054-C

Dear Guy,

On behalf of Wetlands Resource Center, EMH&T Inc. is pleased to submit the Year 5 Monitoring Report for Beaverdam Creek (SCO# D06054-C). This report contains data from the stream (geomorphic) and vegetation monitoring conducted in May and September 2013, respectively. Three hard copies and one electronic copy of the document are being provided in accordance with established submission guidelines.

We understand a final close-out meeting for this project will be conducted in Spring 2014. If there are any specific issues you wish for us to discuss prior to that meeting, please do not hesitate to contact either Cal Miller of Wetlands Resource Center at (614) 864-7511 or me at (614) 775-4205.

Sincerely,

EVANS, MECHWART, HAMBLETON & TILTON, INC.

Miles F. Hebert, PE, CFM
Director, Water Resources Engineering

Enclosure

Copies: Cal Miller, WRC

Year 5 Monitoring Report for Stream Restoration of Beaverdam Creek and Unnamed Tributaries

Union County, NC
SCO # D06054-C

Prepared for:
NCDENR – EEP
2728 Capital Blvd, Suite 1H 103
Raleigh NC 27604

Submitted: January 6, 2014

Prepared by:

Wetlands Resource Center
3970 Bowen Road
Canal Winchester, Ohio 43110
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And

EMH&T
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I. EXECUTIVE SUMMARY

The Beaverdam Creek stream restoration project is located near the town of Wingate, Union County, North Carolina. Prior to restoration, active use of the land for cattle grazing resulted in impaired, channelized, eroding, incised and entrenched stream channels. The project reaches include the restoration of 460 linear feet of the Beaverdam Creek main stem, 2,300 linear feet of an unnamed tributary (UT1) and 284 linear feet of a second unnamed tributary (UT2). Restoration of the project streams, completed in March 2009, provided the desired habitat and stability features required to improve and enhance the ecologic health of the streams for the long-term. The following report documents the Year 5 annual monitoring for this project.

Vegetative monitoring was completed in September 2013 following the Carolina Vegetation Survey methodology. Stem counts completed at eight vegetation plots show an average density of 471 stems/ acre for the site; far surpassing the 260 stems/acre goal for the site in Year 5. This number is down slightly from the Year 4 average of 501 stems/acre, the Year 3 average of 552 stems/acre, the Year 2 average of 542 stems/acre, and the Year 1 average of 587 stems/acre. However, this minor amount of woody stem mortality is to be expected. In Year 5, all but one plot had stem densities meeting the minimum requirement. Additionally, a large number of recruit stems were found in each plot. All of the plots had stem densities meeting the minimum requirement with recruits in Year 5. A few vegetative problem areas of low concern were noted in the project area, included scattered populations of problematic species (*Microstegium vimineum; Ligustrum; Rosa multiflora; Lonicera japonica*). Although not impacting the survival of the woody vegetation, the problematic species has been proactively managed by herbicide treatment and have begun to die back.

Monitoring of the streams has previously identified some problem areas along UT1 and UT2. The banks of a few of the outside meander bends are steep and vegetation had not fully established to stabilize the slopes. Vegetation density has increased in density in these areas and is forming a root mass to help stabilize the channel banks. These areas are no longer considered of any concern at this time. Areas of channel instability were not observed along the Beaverdam Creek main stem.

The visual stream stability assessment revealed that the majority of stream features are functioning as designed and constructed on the Beaverdam Creek main stem and unnamed tributaries. Dimensional measurements of the monumented cross-sections remain stable when compared to as-built conditions. Comparisons between the Year 1-5 long-term stream monitoring profiles and the as-built data demonstrate generalized channel stability with minimal change from as-built conditions. The substrate of the constructed riffles on all project reaches has settled into particle distributions more suitable to that of the designed channel, with median particle sizes in the coarse gravel category for the main stem and UT1 and the cobble category for UT2. Based on the crest gage network installed on the project reaches, three bankfull events have been recorded since construction was completed, as detailed in Table IX. No bankfull event was recorded in Year 4 for the project reaches.

The following tables summarize the geomorphological changes along the restoration reaches for each stream.

Beaverdam Creek Main Stem

Parameter	Pre-Restoration	As-built	Year 1	Year 2	Year 3	Year 4	Year 5
Length (ft.)	**416**	**460**	**460**	**460**	**460**	**460**	**460**
Bankfull Width (ft.)	**11.2**	**18.5**	**17.9**	**17.5**	**16.4**	**18.9**	**18.2**
Bankfull Max Depth (ft.)	**1.1**	**2.3**	**2.1**	**2.0**	**1.9**	**2.1**	**2.1**
Width/Depth Ratio	**9.2**	**18.4**	**17.6**	**16.4**	**15.2**	**18.2**	**18.8**
Entrenchment Ratio	**3.7**	**7.4**	**7.5**	**7.6**	**8.0**	**6.8**	**7.4**
Bank Height Ratio	**1.6**	**1**	**1**	**1**	**1**	**1**	**1**
Sinuosity	**1.07**	**1.48**	**1.48**	**1.48**	**1.48**	**1.48**	**1.48**

Unnamed Tributary 1 (UT1)

Parameter	Pre-Restoration	As-built	Year 1	Year 2	Year 3	Year 4	Year 5
Length (ft.)	**1,867**	**2,300**	**2,300**	**2,300**	**2,300**	**2,300**	**2,300**
Bankfull Width (ft.)	**11.2**	**11.5**	**10.8**	**10.3**	**11.5**	**12.1**	**10.7**
Bankfull Max Depth (ft.)	**1.2**	**1.8**	**1.6**	**1.8**	**1.8**	**1.8**	**1.6**
Width/Depth Ratio	**15**	**15**	**13.5**	**15.5**	**15.2**	**18.1**	**15.6**
Entrenchment Ratio	**2.7**	**8.7**	**8.9**	**9.2**	**8.4**	**7.9**	**8.9**
Bank Height Ratio	**1.8**	**1**	**1**	**1**	**1**	**1**	**1**
Sinuosity	**1.14**	**1.45**	**1.45**	**1.45**	**1.45**	**1.45**	**1.45**

Unnamed Tributary 2 (UT2)

Parameter	Pre-Restoration	As-built	Year 1	Year 2	Year 3	Year 4	Year 5
Length (ft.)	**203**	**284**	**284**	**284**	**284**	**284**	**284**
Bankfull Width (ft.)	**4.9**	**6.7**	**6.4**	**6.9**	**7.0**	**6.4**	**7.0**
Bankfull Max Depth (ft.)	**1.0**	**1.1**	**1.0**	**1.0**	**0.9**	**1.0**	**1.0**
Width/Depth Ratio	**8.3**	**11.3**	**11.7**	**15.4**	**14.3**	**14.9**	**14.6**
Entrenchment Ratio	**4.3**	**13.6**	**6.8**	**11.9**	**5.1**	**5.9**	**5.1**
Bank Height Ratio	**2.1**	**1**	**1**	**1**	**1**	**1**	**1**
Sinuosity	**1.02**	**1.49**	**1.49**	**1.49**	**1.49**	**1.49**	**1.49**

II. PROJECT BACKGROUND

A. Location and Setting

The project is located northwest of the intersection of White Store Road (SR 1003) and Snyder Store Road (SR 1945), 3.8 miles south of the town of Wingate, Union County, North Carolina, as shown on **Figure 1**. The project includes restoration activities along Beaverdam Creek main stem and two unnamed tributaries, designated UT1 and UT2.

The directions to the project site are as follows:

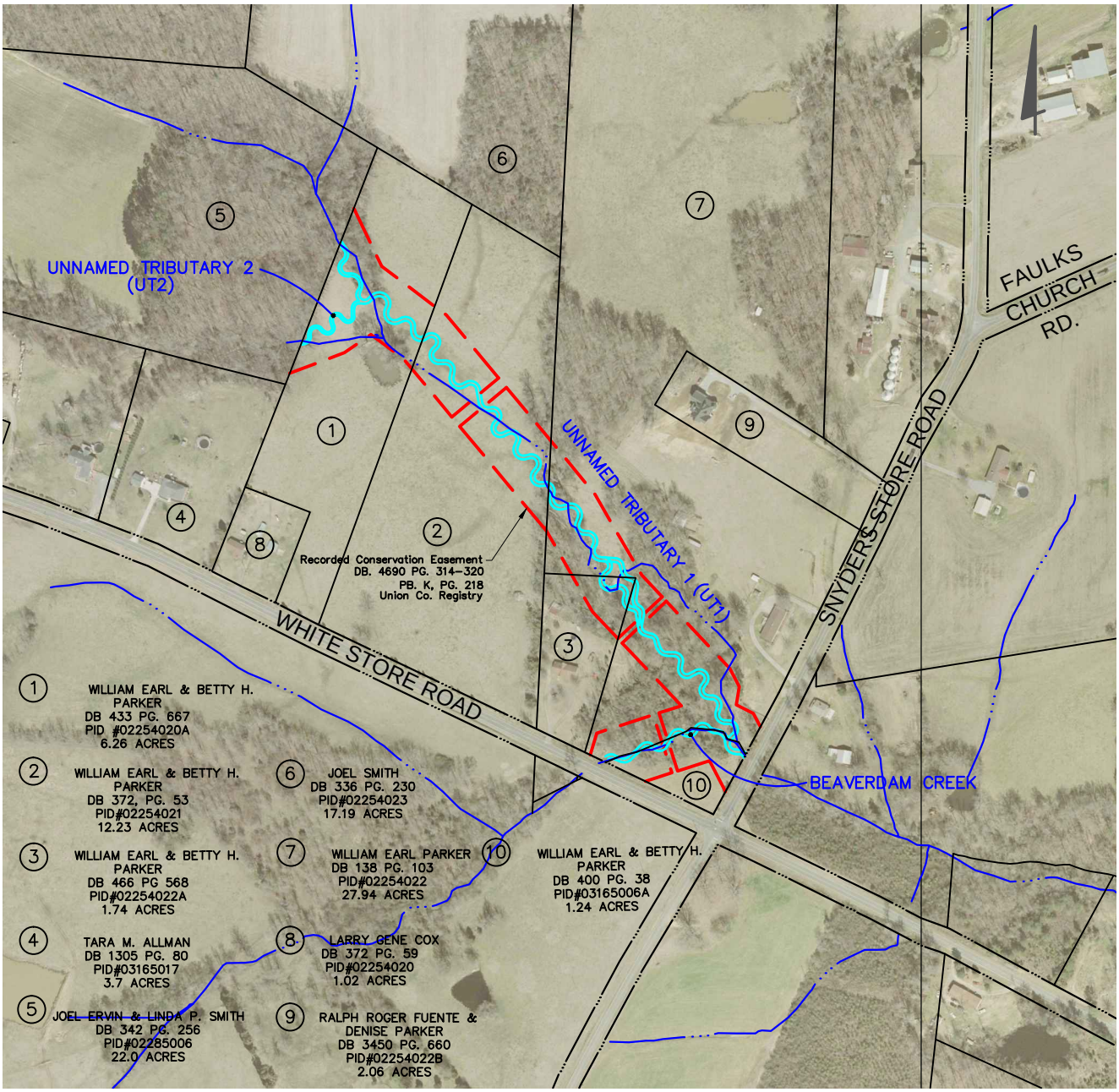
> From Monroe, North Carolina, drive east on US-74. Approximately 3.5 miles east of Monroe, make a slight right turn onto US-601 and travel for 4.1 miles. Turn left at Hinson Street/McRorie Road (NC-1952) and travel 0.6 mile then turn right at Old Pageland Monroe Road (NC-1941) and go 0.3 mile. Turn left at Bivens Street/Nash Road (NC-1954) and travel 1.3 miles. Turn right at White Store Road (NC-1003) and go approximately 0.6 mile. Turn left onto Snyder Store Road (NC-1945) and arrive at the site. The project is located on properties owned by Mrs. Betty H. Parker. The Betty Parker residence is located at 1822 Snyder Store Road, Wingate, NC 28174. As a courtesy to the property owners, please inform Mrs. Parker when you are conducting at field visit along the restored project stream reaches.

B. Project Structure, Mitigation Type, Approach and Objectives

Pre-restoration land use surrounding the project streams was active cattle pasture land. Historic stream relocation, channelization and cattle intrusion were the primary causes leading to instability along each of the project reaches. Cattle had unrestricted access to the project stream reaches for watering and, in areas where established riparian canopy corridors exists, cattle accessed the project reaches for shade. The unstable stream banks contributed significant quantities of sediment and nutrient laden runoff from the project stream reaches into the larger Beaverdam Creek and Lanes Creek watersheds due to head cutting and bank destabilization attributed to hoof-shear.

The upper two-thirds of the UT1 reach and the entire UT2 reach within the project boundaries had sparse riparian vegetation along their stream corridors. Vegetation along the existing stream corridors was dysfunctional with respect to bank stabilization, nutrient uptake and sediment removal from overland runoff. The downstream one-third of the UT1 and Beaverdam Creek main stem reaches have relatively narrow, pre-existing established hardwood forested riparian corridors. However, these corridors exhibited denuding of the understory, shrub and herbaceous ground cover vegetation due to cattle grazing and browsing. Typical species observed within the corridor included *Ulmus alata* (winged elm), *Quercus phellos* (willow oak), *Quercus velutina* (black oak), *Acer negundo* (boxelder), *Asimina triloba* (pawpaw), *Lonicera* species (honeysuckle), and *Carex* species (sedge).

Prior to restoration, a number of anthropogenic factors impacted the stream channel and riparian corridor along the impaired main stem reach, resulting in its unstable deeply incised condition. In its impaired state, Beaverdam Creek maintained E channel dimensions, albeit under incised conditions. The deeply incised nature of the channel was attributed to uncontrolled cattle intrusion (herbaceous groundcover grazing, shrub vegetation browsing and hoof shear) resulting in a denuded riparian



Evans, Mechwart, Hambleton & Tilton, Inc.
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UNION COUNTY, NORTH CAROLINA

BEAVERDAM CREEK RESTORATION

FIGURE 1: SITE VICINITY MAP

N.C. ECOSYSTEM ENHANCEMENT PROGRAM

Date: December, 2013

Not To Scale

Ecosystem Enhancement PROGRAM

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corridor and destabilized, eroding stream banks. In addition to cattle intrusion, channelization increased erosive forces acting on the streambed and channel banks during seasonal precipitation events, and bankfull and greater flows. The stream's high degree of channel incision, (BHR range 1.56 - 1.60), low sinuosity (K = 1.08), denuded and destabilized stream banks composed of stratified silty soils, and relatively steep profile slope (0.0169 ft/ft, or 89.2 ft/mi) had resulted in a deeply incised, unstable channel with a high erosion potential. It was estimated 21 cubic yards per year (or 28 tons per year) of sediment was being eroded from the unstable, vertical to undercut stream banks along the main stem impaired reach into the larger Beaverdam Creek watershed. This estimate represents a bank erosion rate of 0.5 ft/yr.

A number of anthropogenic factors impacted the stream channel and riparian corridor along the UT1 reach, resulting in its unstable deeply incised condition. In its impaired state along the lower forested reach, UT1 had C4 channel morphology, albeit under incised conditions. The deeply incised nature of the channel was attributed to uncontrolled cattle intrusion (herbaceous groundcover grazing, shrub vegetation browsing and stream bank hoof shear) resulting in a denuded riparian corridor and destabilized, eroding stream banks. The stream's high degree of channel incision (BHR range 1.41 - 1.76), low sinuosity (K = 1.16), denuded and destabilized stream banks, and profile slope (0.0058 ft/ft, or 30.6 ft/mi) had resulted in a deeply incised, unstable channel with high stream bank and streambed erosion potential. It was estimated 67 cubic yards per year (or 87 tons per year) of sediment was being eroded from the unstable stream banks along the forested segment of UT1 impaired reach. This estimate represents a bank erosion rate of 0.5 ft/yr.

Upstream of the forested corridor on UT1, pre-existing bank erosion hazard indices were not calculated. This segment of the impaired reach was significantly different from the forested reach. Aggradation was the dominant depositional process as the land use was open pasture land with non-uniform channel geometry, modified by hoof shear together with low profile gradient. In its impaired state, the upper UT1 stream segment lacked suitable features for aquatic habitat.

The reach along UT2 was also impacted by a number of anthropogenic factors, resulting in an unstable deeply incised condition. In its impaired state, UT2 exhibited E4 channel morphology, under incised conditions. The deeply incised nature of the channel was attributed to uncontrolled cattle intrusion, herbaceous groundcover grazing, shrub vegetation browsing and stream bank hoof shear, resulting in a denuded riparian corridor and destabilized, eroding stream banks. In addition to cattle intrusion, channelization increased erosive forces acting on the streambed and channel banks during seasonal precipitation events, bankfull and greater flows. The stream's high degree of channel incision (BHR range 1.80 – 2.12), low sinuosity (K = 1.01), denuded and destabilized stream banks, and relatively steep profile slope (0.0192 ft/ft, or 101.4 ft/mi) had resulted in a deeply incised, unstable stream channel with a high sediment supply. It was estimated 4 cubic yards per year (or 5 tons per year) of sediment was being eroded from the unstable stream banks along the UT2 impaired reach, representing a bank erosion rate of 0.25 ft/yr.

The mitigation goals and objectives for the project streams are related to restoring stable physical and biological function of the project streams beyond pre-restoration (impaired reach) conditions. Pre-restoration conditions consisted of impaired, channelized, eroding, incised and entrenched stream channels. Nutrient and sediment loading, vegetative denuding and destabilized stream banks associated with hoof shear from uncontrolled cattle access was evident.

The specific mitigation goals and objectives proposed and achieved for the project are listed below.

- Stable stream channels with features inherent of ecologically diverse environments, with appropriate streambed features including appropriately spaced pool and riffle sequences, and riparian corridors planted with diversified, indigenous vegetation.
- Superimposed reference reach boundary conditions on the impaired project reaches in the restoration design and construction of improvements.
- Constructed stream channels with the appropriate geometry and gradient to convey bankfull flows while entraining bedload and suspended sediment (wash load) readily available to the streams.
- Created an improved connection between the bankfull channels and their flood prone areas, with stable channel geometries, protective vegetation and jute coir fabric to prevent erosion.
- Minimized future land use impacts to project stream reaches by conveying a perpetual, restrictive conservation easement to the State of North Carolina, including stream corridor protection via livestock exclusion fencing at the surveyed and recorded conservation easement boundaries, with gates at the edge of the riparian corridor on river right and left at reserved conservation easement crossings adjacent to active pasture land.

The restoration of Beaverdam Creek main stem, UT1 and UT2 met the project goals and objectives set forth in the restoration plan, by providing desired habitat and stability features required to enhance and provide long-term ecologic health for the project reaches. More specifically, the completed restoration project has accomplished the enhancements listed below.

Beaverdam Creek Main Stem:

- Reversed the effects of channelization using a Priority Level I restoration approach; restoration increased the width/depth ratio from 9.19 to 18.8 after five years of monitoring.
- Restored natural pattern to the channel alignment, increasing the sinuosity from 1.07 to 1.48, while maintaining a stable relationship between the valley slope and bankfull slope (the bankfull slope was steeper than the valley slope prior to restoration and is now less than the valley slope with the completed restoration). Stable pattern, profile and dimension were restored based on extrapolation from reference reach boundary conditions.
- Stabilized eroding stream banks by providing an appropriately sized channel with stable channel bank slopes built with a combination of embedded stone, topsoil, natural fabrics and hearty vegetative protective cover. The average Bank Height Ratio was decreased from 1.60 to 1.00 (extremely incised to stable).
- Created re-connection between the restored stream channel and the adjacent flood prone area by raising the bankfull channel to the elevation of the adjacent floodplain. The completed restoration increased the average entrenchment ratio from 3.68 to 7.4 after five years of monitoring.
- Created in-stream aquatic habitat features, including appropriately spaced pool and riffle sequences, and a stable transition of the main stem reach thalweg to the invert of the downstream culvert carrying Beaverdam Creek under Snyders Store Road.
- Re-vegetated the riparian corridor with indigenous canopy, mid-story, shrub and herbaceous ground cover, preserving existing forested riparian corridors where present.

Unnamed Tributary 1 (UT1):

- Reversed the effects of channelization through a combination of Priority Level I and Priority Level II restoration techniques. The average width/depth ratio of the restored UT1 project reach is 15.6 in Year 5. Stable pattern, profile and dimension were restored based on extrapolation from reference reach boundary conditions.
- Restored natural pattern to the channel alignment, increasing stream channel sinuosity from 1.14 to 1.45.
- Stabilized eroding stream banks by providing appropriately sized channels with stable stream bank slopes. The average Bank Height Ratio has been reduced from 1.76 to 1.00 (extremely incised to stable).
- Created re-connection between the restored stream channel and the adjacent flood prone area by a combination of raising the stream bed and/or lowering the adjacent floodplain. The completed restoration increased the average entrenchment ratio from 2.74 to 8.90 in Year 5. Created in-stream aquatic habitat features including appropriately spaced pool and riffle sequences with a stable transition of the UT1 reach thalweg at its confluence with Beaverdam Creek.
- Re-vegetated the riparian corridor with indigenous canopy, mid-story, shrub and herbaceous ground cover, preserving existing forested riparian corridors where present.

Unnamed Tributary 2 (UT2):

- Reversed the effects of channelization through a combination of Priority Level I and Priority Level II restoration techniques. The width/depth ratio of the restored UT2 project reach was increased from 8.32 to 14.6 after five years of monitoring. Stable pattern, profile and dimension were restored based on extrapolation from reference reach boundary conditions.
- Restored natural pattern to the channel alignment, increasing stream channel sinuosity from 1.02 to 1.49.
- Stabilized eroding stream banks by providing an appropriately sized channel with stable stream bank slopes. The average Bank Height Ratio has been reduced from 2.12 to 1.00 (extremely incised to stable).
- Created re-connection between the restored stream channel and the adjacent flood prone area by a combination of raising the stream bed and/or lowering the adjacent floodplain. The completed restoration increased the average entrenchment ratio from 4.33 to 5.1.
- Created in-stream aquatic habitat features including appropriately spaced pool and riffle sequences, with a stable transition of the UT2 reach thalweg at its confluence with UT1.
- Re-vegetated the riparian corridor with indigenous canopy, mid-story, shrub and herbaceous ground cover.

Information on the project structure and objectives is included in Tables I and II.

Table I. Project Structure Table
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C

Project Segment/Reach ID	Linear Footage or Acreage
Beaverdam Creek Main stem	460 ft
UT1	2,300 ft
UT2	284 ft
TOTAL	**3,044 ft**

Table II. Project Mitigation Objectives Table Beaverdam Creek Stream Restoration / EEP Project No. D06054-C					
Project Segment/ Reach ID	**Mitigation Type**	**Linear Footage or Acreage**	**Mitigation Ratio**	**Mitigation Units**	**Comment**
Beaverdam Creek Main stem	Priority Level I Restoration	460 ft	1	460 SMU's	Restore dimension, pattern, and profile
UT1	Priority Level I/II Restoration	2,300 ft	1	2,300 SMU's	Restore dimension, pattern, and profile
UT2	Priority Level I/II Restoration	284 ft	1	284 SMU's	Restore dimension, pattern, and profile
TOTAL		**3,044 ft**		**3,044 SMU's**	

C. Project History and Background

Project activity and reporting history are provided in Table III. The project contact information is provided in Table IV. The project background history is provided in Table V.

Table III. Project Activity and Reporting History Beaverdam Creek Stream Restoration / EEP Project No. D06054-C			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration plan	Apr 2007	Jul 2007	Jan 2008
Final Design - 90%[1]	--	--	--
Construction	Dec 2008	N/A	Nov 2008
Temporary S&E applied to entire project area[2]	Dec 2008	N/A	Nov 2008
Permanent plantings	Mar 2009	N/A	Apr 2009
Mitigation plan/As-built	Jul 2009	April 2009 (vegetation) December 2008 (geomorphology)	Apr 2009
Year 1 monitoring	2009	Sep 2009 (vegetation) Jul 2009 (geomorphology)	Nov 2009
Year 2 monitoring	2010	Sep 2010 (vegetation) May 2010 (geomorphology)	Dec 2010
Year 3 monitoring	2011	Sep 2011 (vegetation) May 2011 (geomorphology)	Dec 2011
Year 4 monitoring	2012	Sep 2012 (vegetation) May 2012 (geomorphology)	Dec 2012
Year 5 monitoring	2013	Sep 2013 (vegetation) May 2013 (geomorphology)	Dec 2013

[1]Full-delivery project; 90% submittal not provided.
[2]Erosion and sediment control applied incrementally throughout the course of the project.

N/A: Data collection is not an applicable task for these project activities.

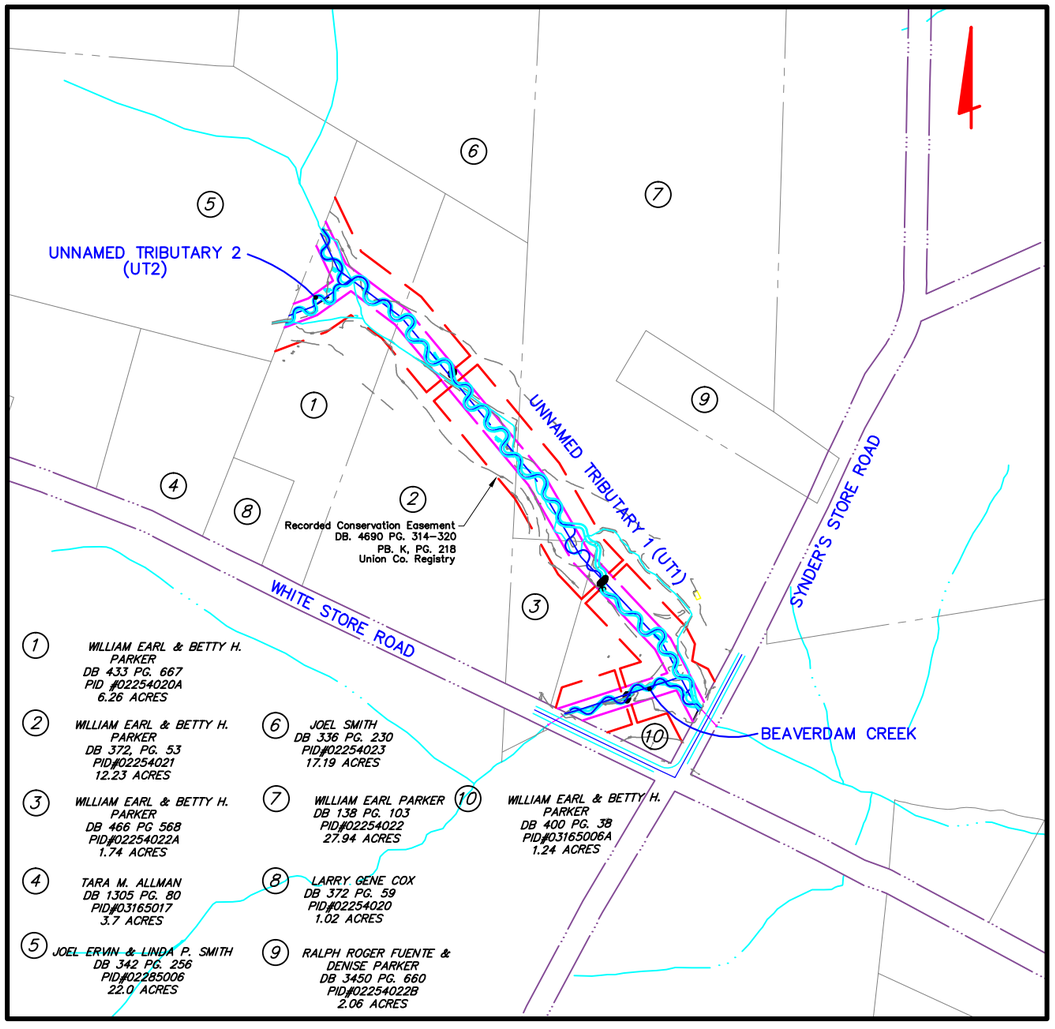
Table IV. Project Contact Table Beaverdam Creek Stream Restoration / EEP Project No. D06054-C	
Designer	Evans, Mechwart, Hambleton & Tilton, Inc. 5500 New Albany Road, Columbus, OH 43054
Construction Contractor	South Mountain Forestry 6624 Roper Hollow, Morganton, NC 28655
Monitoring Performers	Evans, Mechwart, Hambleton & Tilton, Inc. 5500 New Albany Road, Columbus, OH 43054
Stream Monitoring POC	Jud M. Hines, EMH&T
Vegetation Monitoring POC	Melissa Queen-Darby, EMH&T

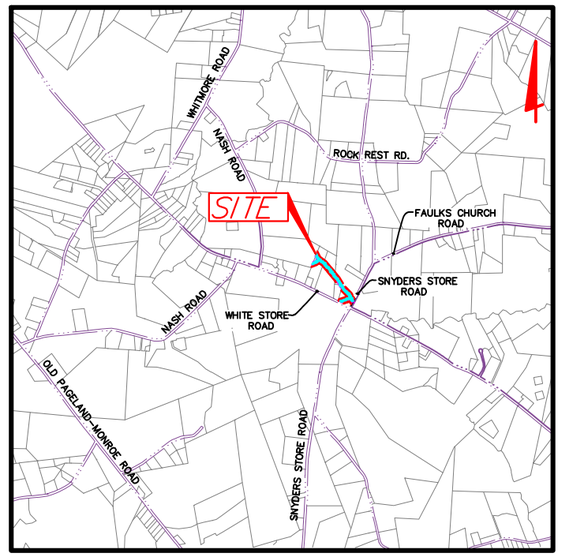
Table V. Project Background Table Beaverdam Creek Stream Restoration / EEP Project No. D06054-C	
Project County	Union
Drainage Area	Main stem-0.491 sq mi UT1-0.2375 sq mi UT2-0.0765 sq mi
Drainage Impervious Cover Estimate	0.48%
Stream Order	Main stem, UT1-2nd UT2-1st
Physiographic Region	Piedmont
Ecoregion	Carolina Slate Belt
Rosgen Classification of As-built	C4
Dominant Soil Types	Chewacla silt loam, Cid channery silt loam
Reference Site ID	Davis Branch
USGS HUC for Project and Reference	03040105
NCDWQ Sub-basin for Project and Reference	03040105081030
NCDWQ Classification for Project and Reference	Project-WS-V Reference-C
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	Yes
Reason for 303d listing or stressor	Sediment, agriculture
% of project easement fenced	95%

D. Monitoring Plan View

The monitoring plan view is included as Figure 2.

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
NC EEP PROJECT NO. D06054-C
2013





VICINITY MAP
Not To Scale

Job No.	2009-0327	Sheet	1/5
Date	December, 2013	Scale	As Noted

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK
AND UNNAMED TRIBUTARIES
NC EEP PROJECT NO. D06054-C
PLAN

Ecosystem Enhancement Program

EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers, Planners & Surveyors
5020 New Abbott Road, Columbia, OH 43201
Phone (614)775-4500 Fax (614)775-4800

REVISIONS

MARK	DATE	DESCRIPTION

Recorded Conservation Easement
DB. 4690 PG. 314-320
PB. K, PG. 218
Union Co. Registry

As Built Gate

As Built Fence

Ex. Stream
(To Be Filled after Construction)

WILLIAM EARL PARKER
DB. 138 PG. 103
PID#02254022
27.94 ACRES

WILLIAM EARL PARKER
DB. 138 PG. 103
PID#02254022
27.94 ACRES

Ex. 60" Stm.
(Do Not Disturb)

BEGIN PROJECT
RESTORATION REACH
STA. 0+00.00
BEAVERDAM CREEK

Ex. Fence
(Do Not Disturb)

VP-1

Bankfull Width

Limits of Beltwidth

Low Water Crossing

WHITE STORE ROAD

X-Sec 7

X-Sec 8

Ex. R/W

WILLIAM EARL & BETTY M PARKER
DB 400 PG. 38
PID#03165008A
1.24 ACRES

Ex. 72" Stm.
(Do Not Disturb)

Ex. Fence
(Do Not Disturb)

SNYDERS STORE ROAD

For Unnamed Tributary 1 (See Sheet 3)

END PROJECT
RESTORATION REACH
STA. 4+75.49
BEAVERDAM CREEK

40 0 40 Feet
20
Scale: 1" = 40'

LEGEND

- Vegetation Plot (VP)
- Crest Gauge Location
- Cross Section Monument
- Ex. Property Line
- Recorded Conservation Easement
- As-Built Thalweg and Stationing
- As-Built Riffle
- As-Built Cross Vane
- Fixed Photo Locations

Job No. 2009-0327
Sheet 2/5
Date December, 2013
Scale Hor. 1" = 40'
Ver. 1" = 5'

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
NC EEP PROJECT NO. D06054-C
PLAN

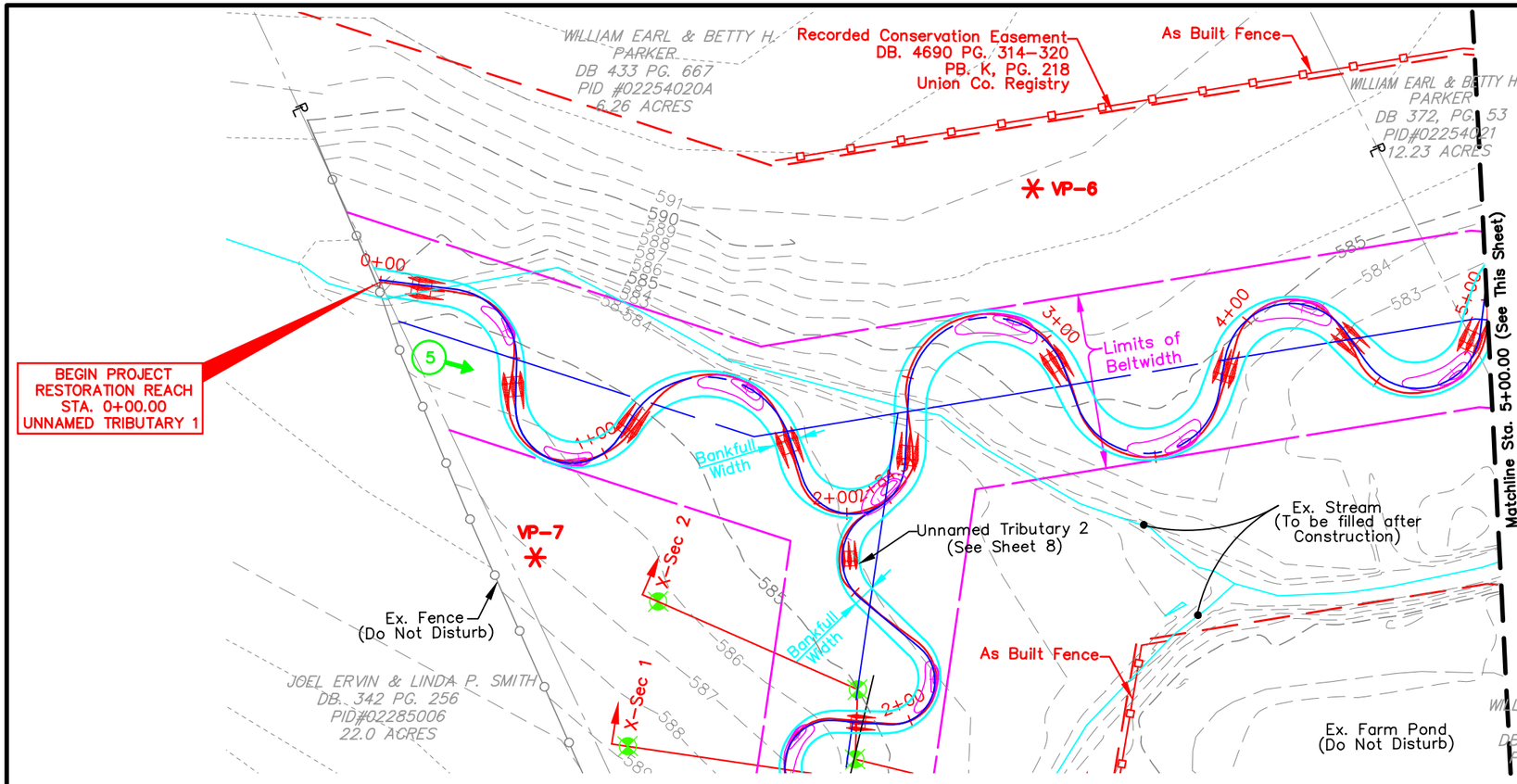
Ecosystem Enhancement Program

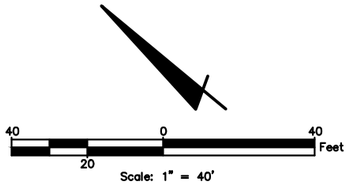
EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers, Surveyors, Planners & Landscape Architects
5500 New Albany Road, Columbus, OH 43054
Phone (614) 775-4500 Fax (614) 775-4800

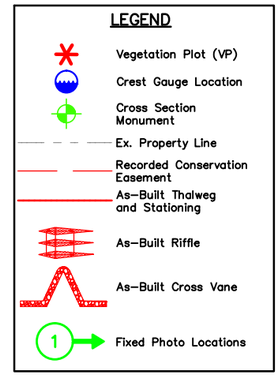
REVISIONS

MARK	DATE	DESCRIPTION

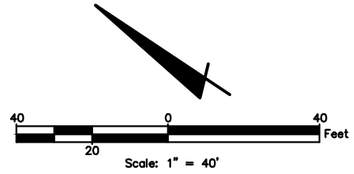
J:\20090327\20090327env\Dwg\Exhibits\Year 5-Figure 2 - Monitoring Plan View.dwg Last Saved By: jcramer, 1/3/2014 2:17 PM Last Printed By: Cramer, James, 1/3/2014 2:19 PM (No Xrefs)







Note:
Gates were not required at the crossing at Approx. Sta. 8+00 because the current land use is row crops.



Job No. 2009-0327
Sheet 3/5
Date December, 2013
Scale Hor: 1" = 40'
Ver: 1" = 5'

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
NC EEP PROJECT NO. D06054-C
PLAN

Ecosystem Enhancement Program

EMHT
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers, Surveyors, Planners & Scientists
5500 New Albany Road, Columbus, OH 43054
Phone (614) 775-4500
Fax (614) 775-4800

REVISIONS
MARK | DATE | DESCRIPTION

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Recorded Conservation Easement
DB. 4690 PG. 314–320
PB. K, PG. 218
Union Co. Registry

As Built Fence

Ex. Fence
(To be removed within Conservation Easement)

WILLIAM EARL PARKER
DB 138 PG. 103
PID#02254022
27.94 ACRES

VP-2

Ex. Stream
(To be filled after construction)

Matchline Sta. 12+00.00 (See Sheet 3)

Limits of Beltwidth

14+00
15+00
16+00
17+00
18+00

Ex. Fence
(To be removed within Conservation Easement)

Abandoned Farm Pond
(Do Not Disturb)

Ex. Fence
(To be removed within Conservation Easement)

As Built Gate

Matchline Sta. 18+50.00 (See This Sheet)

As Built Fence

WILLIAM EARL & BETTY H. PARKER
DB 372, PG. 53
PID#02254021
12.23 ACRES

Ex. Fence
(Do Not Disturb)

Ex. Stream
(To be filled after construction)

X-Sec 5
X-Sec 6

Ex. R/W

SNYDERS STORE ROAD

Matchline Sta. 18+50.00 (See This Sheet)

Bankfull Width

19+00
20+00
21+00
22+00
23+00
4+00

23+45.11
4+75.49

Ex. 72" Stm.

END PROJECT
RESTORATION REACH
STA. 23+45.11
UNNAMED TRIBUTARY 1

Recorded Conservation Easement
DB. 4690 PG. 314–320
Union Co. Registry

WILLIAM EARL PARKER
DB 138 PG. 103
PID#02254022
27.94 ACRES

Limits of Beltwidth

40 0 40 Feet
20
Scale: 1" = 40'

LEGEND

- Vegetation Plot (VP)
- Crest Gauge Location
- Cross Section Monument
- Ex. Property Line
- Recorded Conservation Easement
- As-Built Thalweg and Stationing
- As-Built Riffle
- As-Built Cross Vane
- Fixed Photo Locations

NOTES:
The channel location was adjusted between station 15+50 and station 18+00 in order to preserve the abandoned farm pond.

40 0 40 Feet
20
Scale: 1" = 40'

Job No. 2009-0327
Sheet 4/5
Date December, 2013
Scale Hor. 1" = 40'
Ver. 1" = 5'

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK
AND UNNAMED TRIBUTARIES
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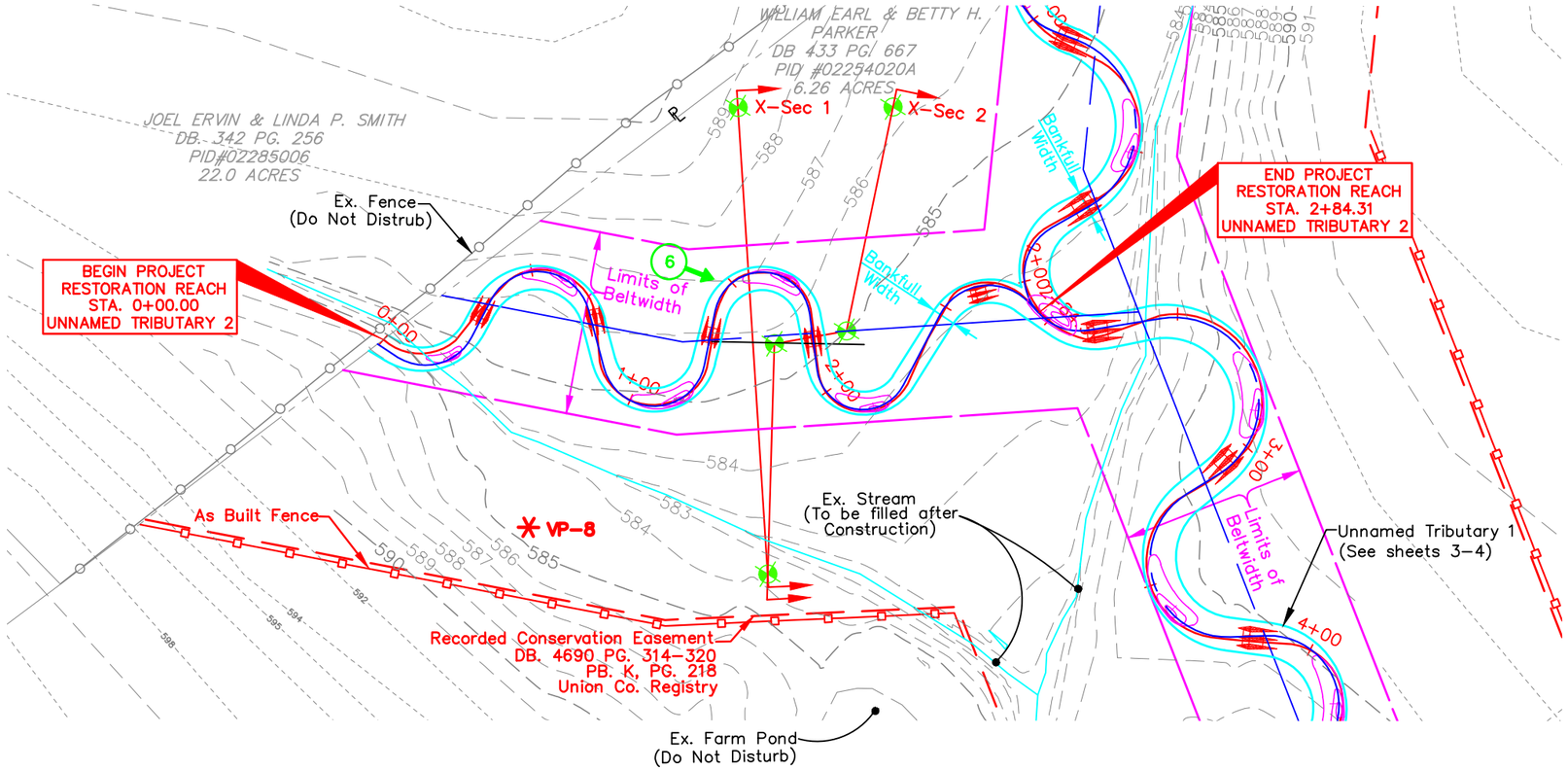

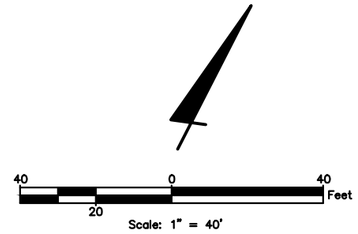

LEGEND

- Vegetation Plot (VP)
- Crest Gauge Location
- Cross Section Monument
- Ex. Property Line
- Recorded Conservation Easement
- As-Built Thalweg and Stationing
- As-Built Riffle
- As-Built Cross Vane
- Fixed Photo Locations

NOTES:
The channel location was adjusted between station 15+50 and station 18+00 in order to preserve the abandoned farm pond.

UNION COUNTY, NORTH CAROLINA
FIGURE 2 - MONITORING PLAN VIEW
FOR
BEAVERDAM CREEK AND UNNAMED TRIBUTARIES
NC EEP PROJECT NO. D06054-C
PLAN

Job No. 2009-0327
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Scale Hor. 1" = 40' Ver. 1" = 5'

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III. PROJECT CONDITION AND MONITORING RESULTS

A. Vegetation Assessment

1. Soil Data

Soil information was obtained from the NRCS Soil Survey of Union County, North Carolina (USDA NRCS, January, 1996). The soils along the main stem of Beaverdam Creek and along the lower 300-feet reach of UT1 within the project area include the Chewacla silt loam, 0 to 2 percent slopes, frequently flooded. This map unit consists mainly of very deep, nearly level, somewhat poorly drained soils developed on floodplains. It is mostly present on broad flats along major streams and rivers and on narrow flats along minor creeks and drainageways. Typically the surface layer is brown silt loam approximately seven inches thick. The subsoil is 45 inches thick. On site, the Chewacla unit is mapped adjacent to the Goldston soils. Where the Chewacla unit occurs adjacent to areas of Goldston soils, small areas of soils encounter bedrock at a depth of less than 60 inches below ground surface. Contrasting inclusions make up about 15 percent of this mapped unit.

The upper reach of UT1 and the entire length of UT2 is mapped Cid channery silt loam, 1 to 5 percent slopes. This map unit consists mainly of moderately deep, moderately well drained and somewhat poorly drained, nearly level and gently sloping Cid and similar soils on flats, on ridges in the uplands, in depressions and in headwater drainageways. Typically, the surface layer is light brownish gray channery silt loam four inches thick. The subsurface layer is a pale yellow channery silt loam 5 inches thick. The subsoil is 18 inches thick. Weathered, fractured bedrock is encountered at a depth of about 27 inches. Hard, fractured bedrock is encountered at a depth ranging from 20 to 40 inches.

Data on the soils series found within and near the project site is summarized in Table VI.

Table VI. Preliminary Soil Data
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C

Series	Max. Depth (in.)	% Clay on Surface	K[1]	T[2]	% Organic Matter
Chewacla silt loam, 0 to 2 percent slopes (ChA)	72	12-27	0.28	5	1-4
Cid channery silt loam, 1 to 5 percent slopes (CmB)	32	12-27	0.32	2	0.5-2
Goldston-Badin complex, 2 to 8 percent slopes (GsB)	27	5-15	0.05	1	0.5-2

[1]Erosion Factor K indicates the susceptibility of a soil to sheet and rill erosion, ranging from 0.05 to 0.69.
[2]Erosion Factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity, measured in tons per acre per year.

2. Vegetative Problem Areas

Vegetative Problem Areas are defined as areas either lacking vegetation or containing populations of exotic vegetation. Each problem area identified during monitoring year 5 is summarized in Table VII.

Photographs of the vegetative problem areas are provided in Appendix A. There were a few locations where vegetation problem areas were noted but no photograph is available for this report.

Table VII. Vegetative Problem Areas
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C

Feature/Issue	Station # / Range	Probable Cause	Photo #
Invasive Population	12+50-15+00 UT1	Microstegium: encroachment from outside source	VPA 1
	00+75-2+500 main stem; 5+10-7+00, 1+00-2+00 UT1; 00+75-2+75 UT2	Ligustrum (Privet)	N/A
	5+10-7+00, 1+00-2+00 UT1; 00+75-2+75 UT2	Rosa multiflora	N/A

N/A – photos of these vegetation problem areas were not available for this report

In Years 2 and 3, a few areas along the tributaries of Beaverdam Creek were noted to have low overall herbaceous cover in the riparian corridor, leading to noticeable bare banks. These areas were small patches near the stream channel and are most likely caused by poor, rocky soil. The areas mentioned above have become vegetated and are no longer concern in Year 5.

A few areas with a population of Japanese stiltgrass (*Microstegium vimineum)* were noted during 2010 (Year 2) monitoring. *Microstegium vimineum* continues to be present along UT1 in Year 5. The population has slightly decreased and shifted its location along UT1. In Year 4, it covered the channel and/or areas of the riparian corridor between stations 14+00 and 17+50, as well as between stations 19+50 and 20+00. It is now between stations 12+50 and 15+00, as well as between stations 22+50 and 23+00 in Year 5. This species is common alongside streams and ditches and at the edges of forests and damp fields and, as such, was likely present before the onset of restoration activities. As further evidence of a pre-existing population, the locations where this species is present are those areas that were minimally or not impacted during restoration of the stream channels.

In the Year 2 report it was hypothesized that the vegetation from the permanent seeding would spread to fill in sparsely covered areas. At the time of 2010 vegetation monitoring the stiltgrass did not appear to be impacting the survival of woody stems and was therefore considered a problem area of low concern. This observation remains the same in Years 3, 4 and 5. Proactive management in the form of herbicide treatments were conducted in the fall of 2009 and the spring of 2010. Two treatments were applied in Years 3 & 4; one application in the spring and the other in the fall for each year. Because it appeared that stiltgrass was not responding to herbicide treatment, a more intensive herbicidal spraying effort was conducted in the spring and fall of 2013.

During Year 5, a few additional vegetation problem areas were observed. These included small patches of Privet (*Ligustrum*), Multiflora rose (*Rosa multiflora*), and Japanese honeysuckle (*Lonicera japonica*). None of these species appear to be impacting the survival of woody stems and are therefore considered problem areas of low concern. Herbicide treatment has been applied to these areas in the fall of 2013 to prevent the further spread of these species. These areas will be observed again in the early spring of 2014 for a possible second herbicide application.

3. Vegetation Problem Area Plan View

The location of each vegetation problem area is shown on the vegetative problem area plan view included in Appendix A. Each problem area is color coded with yellow for areas of low concern (areas to be watched) or red for high concern (areas where maintenance is warranted).

4. Stem Counts

A summary of the stem count data for each species arranged by plot is shown in Table VIII. Table VIIIa provides the survival information for planted species, while Table VIIIb provides the total stem count for the plots, including all planted and recruit stems. This data was compiled from the information collected on each plot using the *CVS-EEP Protocol for Recording Vegetation, Version 4.0*. Additional data tables generated using the CVS-EEP format are included in Appendix A. All vegetation plots are labeled as VP on Figure 2.

Table VIIIa. Stem counts for each species arranged by plot - planted stems.
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C

	Plots								Year 0	Year 1	Year 2	Year 3	Year 4	Year 5	Survival
Species	1	2	3	4	5	6	7	8	Totals	Totals	Totals	Totals	Totals	Totals	%
Shrubs															
Alnus serrulata			4	1	2	2	1	1	13	11	12	12	10	11	110
Aronia arbutifolia									7	7	6	5	1	0	0
Cephalanthus occidentalis		3	4	6	5				32	30	30	20	19	18	95
Cornus amomum		1		4					6	6	6	7	6	5	83
Trees															
Diospyros virginiana							7		2	2	2	11	8	7	88
Fraxinus pennsylvanica									3	0	1	1	1	0	0
Liriodendron tulipifera	2	2	1						7	5	5	5	4	5	125
Nyssa sylvatica			1		3				0	0	0	0	3	4	133
Platanus occidentalis	4	7	2	10		1	1	9	40	32	34	35	35	34	97
Quercus bicolor						1		2	2	2	1	2	1	3	300
Quercus coccinea									0	0	0	1	1	0	0
Quercus palustris							1	1	4	4	3	3	3	2	67
Sambucus canadensis			1						0	0	0	0	1	1	100
Taxodium distichum	1					2			6	3	6	6	6	3	50
Year 5 Totals	7	13	13	21	10	6	10	13	122	104	107	109	99	93	94
Live Stem Density	284	527	527	851	405	243	405	527							
Average Live Stem Density	**471**														

Table VIIIb. Stem counts for each species arranged by plot - all stems. Beaverdam Creek Stream Restoration / EEP Project No. D06054-C													
	Plots								Year 1	Year 2	Year 3	Year 4	Year 5
Species	1	2	3	4	5	6	7	8	Totals	Totals	Totals	Totals	Totals
Shrubs													
Alnus serrulata			4	1	2	2	1	1	12	12	11	11	11
Aronia arbutifolia									7	6	5	2	0
Cephalanthus occidentalis		3	4	6	5				30	31	21	19	18
Cornus amomum		1		4					6	6	7	7	5
Ilex verticillata							1		0	0	0	0	1
DON'T KNOW									0	0	4	4	0
Sambucus canadensis			6						4	4	5	1	6
Trees													
Diospyros virginiana							8		2	2	11	9	8
Fraxinus pennsylvanica	14	14	19						9	44	89	1	47
Liquidambar styraciflua	50	16	18	13	13	7	35	20	142	267	184	184	172
Liriodendron tulipifera	2	2	1						7	6	17	5	5
Nyssa sylvatica			1		3				0	0	0	3	4
Platanus occidentalis	4	10	2	10		1	1	20	37	36	76	35	48
Quercus alba									0	1	2	2	0
Quercus bicolor						1		4	2	1	1	1	5
Quercus coccinea									0	0	13	13	0
Quercus palustris							1	1	4	4	13	3	2
Taxodium distichum	1					2			6	6	6	6	3
Ulmus americana	10		1				10		0	0	0	0	21
Ulmus rubra									2	2	2	2	0
Year 5 Totals	81	46	56	34	23	13	57	46	268	426	467	308	356
Live Stem Density	3281	1863	2268	1377	932	527	2309	1863					
Average Live Stem Density	**1802**												

The average stem density of planted species for the site far exceeds the minimum criteria of 260 stems per acre after five years. For the third consecutive year, every plot has a stem density above the minimum. A large number of recruit stems (356 total) were found in all plots in Year 5. The recruit stems more than double the total stem density across the site, raising the total by 283%.

5. Vegetation Plot Photos

Vegetation plot photos are provided in Appendix A.

B. Stream Assessment

1. Hydrologic Criteria

Two crest-stage stream gages were installed along the project, on near station 5+50 along UT1 and the other near station 3+80 on Beaverdam Creek main stem (which also corresponds to station 22+75 along UT1). The locations of the crest-stage stream gages are shown on the monitoring plan view (Figure 2). These crest gages are set at or above the bankfull elevation of each stream channel. Bankfull events were recorded during Years 1, 2, and 3 for both crest gages as well as Year 5 along UT1, as documented in Table IX. This brings the total number of bankfull events to four along the UT1 and three along the main stem. Photographs of the crest gages and observed bankfull events are provided in Appendix B.

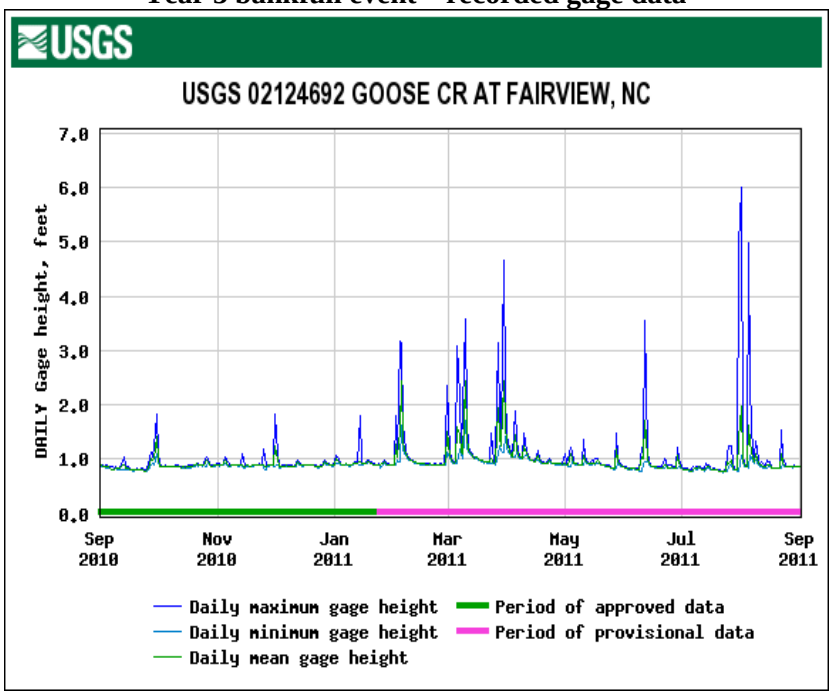
Table IX. Verification of Bankfull Events

Date of Data Collection	Monitoring Year	Date of Occurrence	Method	Photo #
4/8/2009	1	2/28/09-3/1/09*	Crest gage at 5+50 on UT1	BF 1
4/8/2009	1	2/28/09-3/1/09*	Crest gage at 3+80 on main stem	BF 5
9/19/2010	2	1/25/2010, 02/5/2010 or 07/12/2010*	Crest gage at 5+50 on UT1	BF 2
9/19/2010	2	1/25/2010, 02/5/2010 or 07/12/2010*	Crest gage at 3+80 on main stem	BF 6
5/16/2011	3	3/10/2011 or 3/30/2011	Crest gage at 5+50 on UT1	BF 3
5/16/2011	3	3/10/2011 or 3/30/2011	Crest gage at 3+80 on main stem	BF7
5/14/2013	5	4/29/13 or 5/6/13*	Crest gage at 5+50 on UT1	BF 4

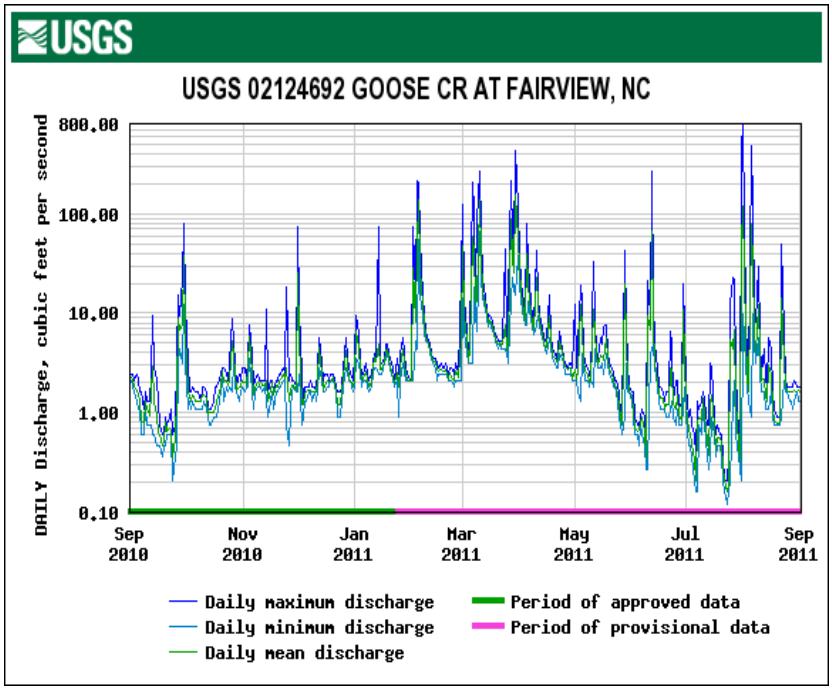
*Date is approximate; based on a review of recorded gage data

A discussion of the Year 1 and 2 bankfull events is provided in the respective monitoring reports. For Year 3, the most likely dates for the bankfull event(s) are estimated to be after the rain events that led to the elevated gage heights and higher peak flood discharge events recorded at USGS Gage 02124692 on March 10 and 30, 2011. This gage is located along Goose Creek at Fairview, NC, which lies approximately 10 miles north of Monroe and 16 miles northwest of Wingate, NC. As these are the largest precipitation events since the completion of Year 2 monitoring, it is likely that at least one of these lead to the bankfull event recorded by both crest gages during Year 3. On March 10, 2011, the recorded mean gage height at the Goose Creek station was 2.44 feet and maximum gage height was 3.58 feet. On that day, mean daily discharge was 140 ft^3/s and maximum daily discharge was 266 ft^3/s. On March 30, 2011, the recorded mean gage height measured 2.45 feet and maximum gage height measured 4.66 feet. On that day, mean daily discharge was 154 ft^3/s and maximum daily discharge was 424 ft^3/s. The discharge and gage height recorded at the Fairview gage station are shown on the graphs below.

Year 3 bankfull event – recorded gage data



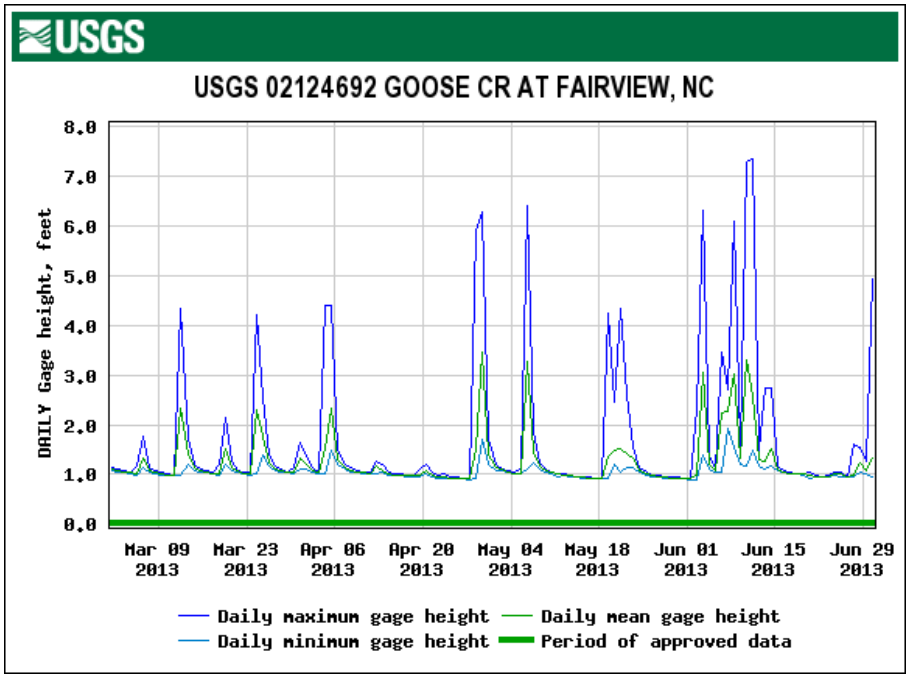
USGS Surface-Water Daily Data for North Carolina
http://waterdata.usgs.gov/nc/nwis/dv?



USGS Surface-Water Daily Data for North Carolina
http://waterdata.usgs.gov/nc/nwis/dv?

When the crest gages were read in May 2013 for Year 5, the crest gage furthest upstream on UT1 registered a bankfull event at a height of 10-1/2 inches above the bottom of the crest gage. The crest gage along the main stem of Beaverdam Creek near the confluence with UT1 did not document a bankfull event for Year 5, although it is likely to have occurred. Year 3 (May 2011) was the last recorded bankfull event along the main stem, at a height of 1-inch above the bottom of the crest gage. The Year 5 observed bankfull event is likely associated with the rainfall event that led to the elevated gage heights and higher peak flood discharge events recorded at USGS Gage 02124692 on April 29 or May 6, 2013. On April 29, 2013, the recorded maximum gage height at the Goose Creek station was 6.29 feet and the maximum recorded discharge was 856 ft^3/s. On May 6, 2013, the recorded maximum gage height was 6.39 feet and the maximum recorded discharge was 892 ft^3/s.

Year 5 bankfull event – recorded gage data



USGS Surface-Water Daily Data for North Carolina
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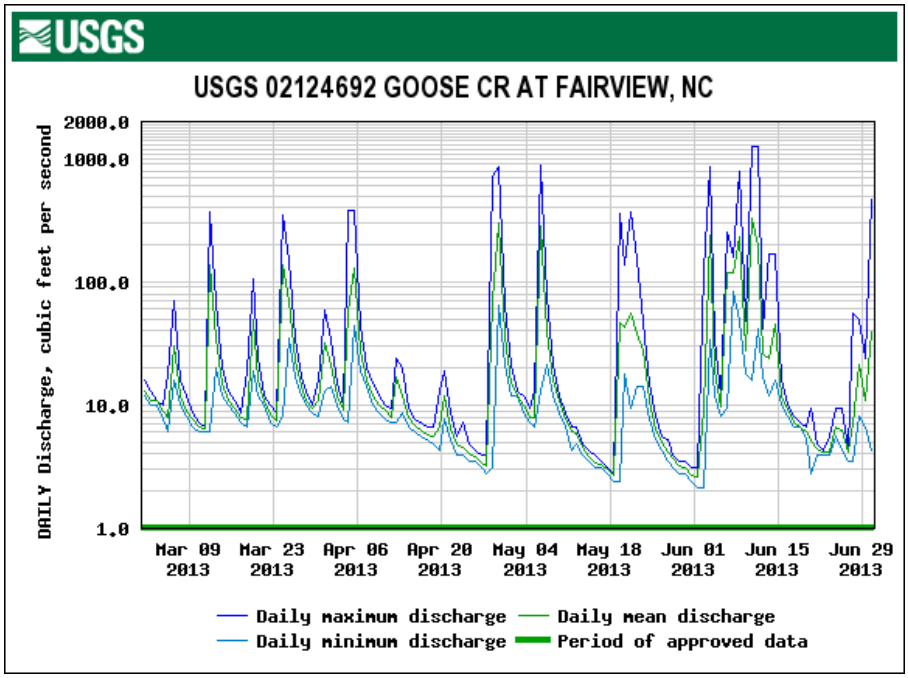


USGS Surface-Water Daily Data for North Carolina
http://waterdata.usgs.gov/nc/nwis/dv?

2. Stream Problem Areas

A summary of the areas of concern identified during the visual assessment of the stream for Year 5 is included in Table X. Since no stream problem areas of concern were noted in 2013, stream problem area photos have not been included in Appendix B.

Table X. Stream Problem Areas
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C

Feature Issue	Station Numbers	Suspected Cause	Photo Number
NA	NA	NA	NA

As in past monitoring years, areas of stream channel instability were not observed along the Beaverdam Creek main stem in 2013. During Year 4, the only type of stream problem areas noted along UT1 and UT2 were isolated to a few outside meander bends. The channel banks of these outside bends did not have enough established vegetation to stabilize the slopes and it appeared that minor erosion was taking place. These areas were considered low concern during Year 4 because they were not actively eroding beyond the minor sloughing of loose soil. Stream side vegetation has continued to increase in density providing bank stabilization along UT1 and UT2 over the past year, allowing these stream problem areas to be de-listed from Table X and taken off the Stream Problem Area Map in Year 5.

No recommendations regarding bank stabilization remediation were warranted during Year 4 and no remedial maintenance took place. These areas were noted in order that they be watched to catch any erosion problems that may occur before vegetation becomes fully established along these slopes.

Year 5 monitoring showed that these areas did not have developing problems and again no management was needed.

3. Stream Problem Areas Plan View

Since no stream problem areas of concern were noted during the Year 5 stream assessment, the stream problem area plan view map is not included in Appendix B.

4. Stream Problem Areas Photos

Since no stream problem areas of concern were noted during the Year 5 stream assessment, stream problem area photos are not included in Appendix B.

5. Fixed Station Photos

Photographs were taken at each established photograph station on September 5, 2013. These photographs are provided in Appendix B.

6. Stability Assessment

The visual stream assessment was performed to determine the percentage of stream features that remain in a state of stability after the first year of monitoring. The visual assessment for each reach is summarized in Tables XIa through Table XIc. This summary was compiled from the more comprehensive Table B1, included in Appendix B. Only those structures included in the as-built survey were assessed during monitoring and reported in the tables.

Table XIa. Categorical Stream Feature Visual Stability Assessment
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C
Segment/Reach: Main Stem

Feature	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles[1]	100%	100%	100%	98%	98%	100%
B. Pools[2]	100%	100%	100%	100%	100%	100%
C. Thalweg	100%	100%	100%	100%	100%	100%
D. Meanders	100%	100%	100%	100%	100%	100%
E. Bed General	100%	100%	100%	100%	100%	100%
F. Vanes / J Hooks etc. [3]	N/A	N/A	N/A	N/A	N/A	N/A
G. Wads and Boulders[3]	N/A	N/A	N/A	N/A	N/A	N/A

Table XIb. Categorical Stream Feature Visual Stability Assessment Beaverdam Creek Stream Restoration / EEP Project No. D06054-C Segment/Reach: UT1						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles[1]	100%	99%	99%	100%	100%	100%
B. Pools[2]	100%	95%	94%	94%	95%	95%
C. Thalweg	100%	100%	100%	100%	100%	100%
D. Meanders	100%	94%	93%	93%	93%	93%
E. Bed General	100%	100%	100%	100%	100%	100%
F. Vanes / J Hooks etc. [3]	N/A	N/A	N/A	N/A	N/A	N/A
G. Wads and Boulders[3]	N/A	N/A	N/A	N/A	N/A	N/A

Table XIc. Categorical Stream Feature Visual Stability Assessment Beaverdam Creek Stream Restoration / EEP Project No. D06054-C Segment/Reach: UT2						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles[1]	100%	100%	100%	92%	92%	96%
B. Pools[2]	100%	100%	100%	93%	93%	93%
C. Thalweg	100%	100%	100%	100%	100%	100%
D. Meanders	100%	88%	92%	92%	92%	96%
E. Bed General	100%	100%	100%	100%	100%	100%
F. Vanes / J Hooks etc. [3]	N/A	N/A	N/A	N/A	N/A	N/A
G. Wads and Boulders[3]	N/A	N/A	N/A	N/A	N/A	N/A

[1]Riffles are assessed using the longitudinal profile. A riffle is determined to be stable based on a comparison of location and elevation with respect to the as-built profile.

[2]Pools are assessed using the longitudinal profile. A pool is determined to be stable based on a comparison of location and elevation with respect to the as-built profile and a consideration of appropriate depth.

[3]Those features not included in the stream restoration were labeled N/A. This includes structures such as rootwads and boulders.

The Year 5 visual stream stability assessment revealed that the majority of stream features are functioning as designed and constructed on the Beaverdam Creek main stem and the two unnamed tributaries. There was only one area of notable instability along the main stem in Years 3 and 4. This area corresponded to a riffle that has experienced moderate erosion. The longitudinal profile overlay located in Appendix B reveals that the riffle has degraded during monitoring years 3 and 4. For Year 5, the riffle crests seem reasonable consistent with the previous year's data and there appears to be stability in these features along the entire main stem project reach.

In previous monitoring years, there were a few meanders along UT1 experiencing minor erosion along the outer bends. In Year 4 (2012), there was evidence of this issue improving due to increased channel bank vegetation cover. There were also six pools along UT1 not matching the as-built condition, attributed to sedimentation occurring in the center of these pools, although all remain

present and retain their essential function. Previous monitoring years revealed a trend of aggradation in the pools along the project reach of UT2. All four pools along the reach have aggraded between .25 foot and .5 foot since the As-Built survey was completed; however, all of these pools remain functional. Both UT1 and UT2 are prone to brief periods of flash flooding followed by longer periods with a much smaller quantity and rate of flow. The flash flood events suspend silt and sand particles and move gravel and cobble. Because these flooding events are short-lived, the sediment does not have a chance to wash out of the system and the more consistent lower flows settle the sediment into the pools.

7. Quantitative Measures

Graphic interpretations of cross-sections, profiles and substrate particle distributions are presented in Appendix B. A summary of the baseline morphology for the site is included in Table XII and XIII and is based on the more detailed monitoring data shown in the appendix. Table XIII contains a summary of the geomorphic analysis of all monitoring cross sections, including pools and riffles. Table XII only includes a summary of riffle cross sections, plus a summary of the geomorphic analysis of the stream profile, stream pattern, and various reach parameters and provides the determined Rosgen stream classification. These tables offer a year to year comparison of the observed and calculated geomorphic data to assess the stability of the restored stream channel. We have considered the data compiled into these tables to offer the summary conclusions presented below.

The stream pattern data provided for Years 1 thru 5 is the same as the data provided from the As-Built survey. Bed form features continue to evolve along the restored reaches as shown on the long-term longitudinal profiles; however, there is notable stability in the various channel reaches. Dimensional measurements of the monumented cross-sections remain stable when compared to as-built conditions. Riffle lengths and slopes are stable. Pool to pool spacing is representative of As-Built conditions. The comparison of the As-Built and Year 1 thru 5 long-term stream monitoring profile data shows generalized stability. As mentioned in the Stability Assessment section above, on the main stem one riffle was observed to have experienced moderate degradation in 2011 and 2012; however, the Year 5 monitoring results suggest stability at the riffles structures. On UT2, areas of instability centered around the aggradation of pool features. Areas of instability for UT1 were similar to the issues on UT2.

Although there were have previously been some very minor areas of channel bank erosion along the various project reaches, the natural progression of vegetative cover has eliminated the need for any other remedial maintenance work. Overall, the substrate is stable, as are the stream channel dimensions and profiles.

In Year 5, the substrate of the constructed riffles on the main stem, UT1 and UT2 have continued to settle into the median particle distribution that would be expected after five years of bankfull flow events. Riffles on the UT1 and UT2 average a D_{50} in the coarse gravel and cobble range, respectively. Riffles on the main stem average a D_{50} in the very course gravel range. The composite particle distributions (defined as the average of D_{50} particle values for all cross sections within each reach) fall within the gravel range for Beaverdam Creek main stem and UT1. Because of this, these reaches remain classified as C4/1 reaches. The D_{50} of the composite particle distribution for UT2 falls within the cobble range in Year 5 and, therefore, this channel can be classified as a C3/1 reach.

IV. METHODOLOGY

Year 5 vegetation monitoring was conducted in September 2013 using the *CVS-EEP Protocol for Recording Vegetation, Version 4.0* (Lee, M.T., Peet, RK., Roberts, S.R., Wentworth, T.R. 2006). Year 5 stream monitoring was conducted in May 2013 so as to provide close to a full year between the Year 4 and Year 5 geomorphic surveys.

Table XII: Baseline Geomorphologic and Hydraulic Summary
Beaverdam Creek and Tributaries Restoration / EEP Project No. D06054-C
Station/Reach: Beaverdam Creek Main Stem Station 0+00 to 4+76

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design			As-Built (Riffle XS-8)			Year 1 (Riffle XS-8)			Year 2 (Riffle XS-8)			Year 3 (Riffle XS-8)			Year 4 (Riffle XS-8)			Year 5 (Riffle XS-8)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median
Dimension																														
Drainage Area (mi²)			0.5712			0.5712			0.4910			0.4910			0.4910			0.4910			0.4910			0.4910			0.4910			0.4910
BF Width (ft)			11.24			12.91			7.44			11.20			18.48			17.73			17.50			16.38			18.91			18.23
Floodprone Width (ft)						50.00			27.40			50.00			135.63			133.69			132.80			131.26			128.17			133.93
BF Cross Sectional Area (ft²)			15.03			15.65			6.05			13.68			18.48			17.91			18.76			17.71			19.63			17.72
BF Mean Depth (ft)			1.33			1.21			0.81			1.22			1.00			1.01			1.07			1.08			1.04			0.97
BF Max Depth (ft)						1.61			1.14			1.80			2.30			2.06			2.00			1.93			2.07			2.09
Width/Depth Ratio			8.45			10.67			9.19			9.18			18.43			17.55			16.36			15.17			18.18			18.79
Entrenchment Ratio						3.87			3.68			4.46			7.36			7.54			7.59			8.01			6.78			7.35
Bank Height Ratio						1.00			1.60			1.00			1.00			1.00			1.00			1.00			1.00			1.00
Wetted Perimeter (ft)			13.90			13.72			8.05			12.05			19.09			18.34			18.14			17.02			19.50			19.19
Hydraulic Radius (ft)			1.08			1.14			0.75			1.14			0.97			0.98			1.03			1.04			1.01			0.92
Pattern																														
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00			50.00			50.00			50.00			50.00			50.00			50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	28.00	17.00	17.00	28.00	17.00	17.00	28.00	17.00	17.00	28.00	17.00	17.00	28.00	17.00	17.00	28.00	17.00	17.00	28.00	17.00
*Meander Wavelength (ft)				80.10	116.50	99.20				59.01	93.85	72.68	59.01	93.85	72.68	59.01	93.85	72.68	59.01	93.85	72.68	59.01	93.85	72.68	59.01	93.85	72.68	59.01	93.85	72.68
*Meander Width Ratio				2.15	4.11	2.94						4.46			2.71			2.82			2.86			3.05			2.64			2.74
Profile																														
Riffle Length (ft)				12.0	18.5	15.0	41.0	62.0	51.3	11.7	38.7	24.0	14.7	22.9	17.6	15.1	23.2	17.9	15.4	24.1	23.1	6.5	21.2	14.8	9.5	23.0	14.9	9.5	23.0	14.9
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0194	0.0328	0.0246	0.0285	0.0939	0.0458	0.0319	0.0720	0.0458	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	0.0256	0.0484	0.0351	No Flow	No Flow	No Flow
Pool Length (ft)				12.04	29.09	21.20	17.2	21.9	19.5	16.29	32.40	18.28	16.87	39.62	28.68	13.67	36.46	28.91	22.65	57.80	43.40	20.8	45.2	38.1	19.9	47.4	34.4	19.9	47.4	34.4
Pool Spacing (ft)				33.42	43.70	38.56	67.7	104.9	86.3	28.88	71.06	42.65	29.82	58.36	47.57	31.55	54.33	46.74	23.32	59.28	42.27	33.7	65.5	49.2	33.4	61.8	49.8	33.4	61.8	49.8
Substrate																														
D50 (mm)						69.2			9.5			9.5			40.5			31.0			75.1			28.4			46.9			56.9
D84 (mm)						140.1			17.2			17.2			162.8			60.2			147.1			58.9			146.6			141.5
Additional Reach Parameters																														
Valley Length (ft)						974			387			387			320			320			320			320			320			320
Channel Length (ft)						1129			416			463			475			475			475			475			475			475
Sinuosity						1.2			1.07			1.20			1.48			1.48			1.48			1.48			1.48			1.48
Water Surface Slope (ft/ft)						0.0311			0.0300			0.0158			0.0101			0.0102			0.0101			0.0100			0.0106			0.0101
BF Slope (ft/ft)						0.0326			0.0300			0.0169			0.0106			0.0102			0.0114			0.0114			0.0098			0.0106
Rosgen Classification						E3/1b**			E4/1			E4/1			C4/1			C4/1			C4/1			C4/1			C4/1			C4/1
Bankfull Discharge (cfs)			73.1			77.6			66.7			66.7			66.7			66.7			66.7			66.7			66.7			66.7
Bankfull Velocity (ft/sec)			4.9			5.0			11.0			4.9			3.6			3.7			3.6			3.8			3.4			3.8

Notes: Blank fields = Historic project documentation necessary to provide these data were collected/compiled.
Where no min/max values is provided, and only one value was measured or computed, that value is presented as the mean or median value.
* Inclusion will be project specific and determined primarily by As-built monitoring plan/success criteria
E3/1b ("E3/1"** E stream type channel morphology, large cobble substrate with bedrock control; E3/1**"b"** bankfull slope greater than 0.02 ft/ft.)
The water surface slope in years 1, 2, 3 and 5 represents the "channel slope" since the channel was dry.

Table XII: Baseline Geomorphologic and Hydraulic Summary
Beaverdam Creek and Tributaries Restoration / EEP Project No. D06054-C
Station/Reach: UT1 Sta. 0+00 to 23+45

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design			As-Built (Riffle XS-3 & XS-6)			Year 1 (Riffle XS-3 & XS-6)			Year 2 (Riffle XS-3 & XS-6)			Year 3 (Riffle XS-3 & XS-6)			Year 4 (Riffle XS-3 & XS-6)			Year 5 (Riffle XS-3 & XS-6)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median
Dimension																														
Drainage Area (mi^2)			0.5712			0.5712			0.2371			0.2371			0.2371			0.2371			0.2371			0.2371			0.2371			0.2371
BF Width (ft)			11.24			12.91			11.22			9.00	9.22	13.80	11.51	9.66	11.84	10.75	9.12	10.00	9.56	10.41	12.50	11.46	11.32	12.82	12.07	9.21	12.22	10.72
Floodprone Width (ft)						50.00			30.70			50.00	86.55	110.03	98.29	83.50	107.54	95.52	81.42	109.58	95.50	87.23	105.88	96.56	84.64	106.64	95.64	82.84	100.60	91.72
BF Cross Sectional Area (ft^2)			15.03			15.65			8.42			9.00	7.49	10.19	8.84	7.71	9.35	8.53	6.66	7.50	7.08	8.07	9.64	8.86	7.51	8.80	8.16	5.95	8.79	7.37
BF Mean Depth (ft)			1.33			1.21			0.75			1.00	0.74	0.81	0.78	0.79	0.80	0.80	0.58	0.82	0.70	0.65	0.93	0.79	0.59	0.78	0.69	0.65	0.72	0.69
BF Max Depth (ft)						1.61			1.17			1.50	1.64	1.95	1.80	1.57	1.58	1.58	1.61	1.88	1.75	1.70	1.95	1.83	1.59	1.98	1.79	1.42	1.69	1.56
Width/Depth Ratio			8.45			10.67			14.96			9.00	11.38	18.65	15.02	12.08	14.99	13.54	11.12	19.86	15.49	11.19	19.23	15.21	14.51	21.73	18.12	14.17	16.97	15.57
Entrenchment Ratio						3.87			2.74			5.56	7.97	9.39	8.68	8.64	9.08	8.86	8.93	9.51	9.22	8.38	8.47	8.43	7.48	8.32	7.90	6.78	10.92	8.85
Bank Height Ratio						1.00			1.76			1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Wetted Perimeter (ft)			13.90			13.72			14.52			11.00	9.82	14.22	12.02	10.16	12.25	11.21	9.79	12.11	10.95	11.16	13.34	12.25	11.74	13.68	12.71	9.81	14.14	11.98
Hydraulic Radius (ft)			1.08			1.14			1.00			0.82	0.72	0.76	0.74	0.76	0.76	0.76	0.55	0.77	0.66	0.60	0.86	0.73	0.55	0.75	0.65	0.61	0.62	0.62
Pattern																														
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00			50.00			50.00			50.00			50.00			50.00			50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				17.00	25.00	20.00	13.00	25.00	18.00	13.00	25.00	18.00	13.00	25.00	18.00	13.00	25.00	18.00	13.00	25.00	18.00	13.00	25.00	18.00
*Meander Wavelength (ft)				80.10	116.50	99.20				63.29	93.84	75.00	63.29	93.84	75.00	63.29	93.84	75.00	63.29	93.84	75.00	63.29	93.84	75.00	63.29	93.84	75.00	63.29	93.84	75.00
*Meander Width Ratio				2.15	4.11	2.94						5.56			4.34			4.65			5.23			4.36			4.14			4.67
Profile																														
Riffle Length (ft)				12.0	18.5	15.0	47.0	60.0	53.5	10.5	46.1	28.6	7.6	30.2	15.5	8.7	31.3	16.9	8.7	39.2	16.4	7.1	34.7	16.5	6.0	37.3	15.0	6.0	37.3	15.0
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0117	0.0185	0.0151	0.0228	0.0957	0.0381	0.0088	0.0702	0.0247	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow
Pool Length (ft)				12.04	29.09	21.20	24.60	39.40	31.20	18.69	40.99	27.93	22.96	57.82	36.89	19.50	56.80	35.50	34.82	74.00	50.77	23.02	69.86	44.57	17.51	71.13	40.55	17.51	71.13	40.55
Pool Spacing (ft)				33.42	43.70	38.56	35.40	76.60	54.70	32.70	85.05	54.28	18.07	79.78	50.30	13.40	76.80	49.80	19.59	91.41	49.26	24.11	79.79	51.51	19.82	76.43	46.41	19.82	76.43	46.41
Substrate																														
D50 (mm)						69.2			5.5			5.5	61.4	76.1	68.7	28.5	32.9	30.7	49.4	75.4	62.4	46.1	47.4	46.7	32.0	40.1	36.1	40.7	56.4	48.5
D84 (mm)						140.1			16.1			16.1	143.6	175.5	159.5	84.4	97.1	90.8	100.1	143.0	121.6	74.4	84.8	79.6	85.8	87.6	86.7	93.8	148.8	121.3
Additional Reach Parameters																														
Valley Length (ft)						974			1637			1594			1622			1622			1622			1622			1622			1622
Channel Length (ft)						1129			1867			2328			2345			2345			2345			2345			2345			2345
Sinuosity						1.2			1.14			1.46			1.45			1.45			1.45			1.45			1.45			1.45
Water Surface Slope (ft/ft)						0.0311			0.0051			0.0047			0.0047			0.0044			0.0044			0.0044			0.0045			0.0046
BF Slope (ft/ft)						0.0326			0.0058			0.0047			0.0042			0.0044			0.0038			0.0040			0.0047			0.0041
Rosgen Classification						E3/1b**			C4/1			E4/1			C3/1			C4/1			C4/1			C4/1			C4/1			C4/1
Bankfull Discharge (cfs)			73.1			77.6			32.2			32.2			32.2			32.2			32.2			32.2			32.2			32.2
Bankfull Velocity (ft/sec)			4.9			5.0			3.8			3.6			3.6			3.8			4.5			3.6			3.9			4.4

Notes: Blank fields = Historic project documentation necessary to provide these data were collected/compiled.
Where no min/max values is provided, and only one value was measured or computed, that value is presented as the mean or median value.
* Inclusion will be project specific and determined primarily by As-built monitoring plan/success criteria
E3/1b ("E3/1"** E stream type channel morphology, large cobble substrate with bedrock control; E3/1**"b"** bankfull slope greater than 0.02 ft/ft.)
The water surface slope in years 1, 2, 3 and 5 represents the "channel slope" since the channel was dry.

Table XII: Baseline Geomorphologic and Hydraulic Summary
Beaverdam Creek and Tributaries Restoration / EEP Project No. D06054-C
Station/Reach: UT2 Sta. 0+00 to 2+84

Parameter	Regional Curve Data			Davis Branch Reference Reach			Pre-Existing Condition			Design			As-Built (Riffle XS-2)			Year 1 (Riffle XS-2)			Year 2 (Riffle XS-2)			Year 3 (Riffle XS-2)			Year 4 (Riffle XS-2)			Year 5 (Riffle XS-2)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median	Min	Max	Median
Dimension																														
Drainage Area (mi²)			0.5712			0.5712			0.0765			0.0765			0.0765			0.0765			0.0765			0.0765			0.0765			0.0765
BF Width (ft)			11.24			12.91			4.91			6.30			6.77			6.43			6.91			6.99			6.42			7.02
Floodprone Width (ft)						50.00			21.24			50.00			92.21			43.89			82.57			35.55			37.92			35.93
BF Cross Sectional Area (ft²)			15.03			15.65			2.88			4.30			4.10			3.51			3.13			3.46			2.79			3.35
BF Mean Depth (ft)			1.33			1.21			0.59			0.68			0.60			0.55			0.45			0.49			0.43			0.48
BF Max Depth (ft)						1.61			0.99			1.00			1.06			0.96			1.02			0.91			0.95			1.00
Width/Depth Ratio			8.45			10.67			8.32			9.26			11.28			11.69			15.36			14.27			14.93			14.63
Entrenchment Ratio						3.87			4.33			7.94			13.61			6.82			11.95			5.08			5.90			5.12
Bank Height Ratio						1.00			2.12			1.00			1.00			1.00			1.00			1.00			1.00			1.00
Wetted Perimeter (ft)			13.90			13.72			5.70			6.77			7.13			6.75			7.42			8.42			7.07			8.18
Hydraulic Radius (ft)			1.08			1.14			0.51			0.63			0.57			0.52			0.42			0.41			0.39			0.41
Pattern																														
*Channel Beltwidth (ft)				27.80	53.00	38.00						50.00			50.00			50.00			50.00			50.00			50.00			50.00
*Radius of Curvature (ft)				16.40	45.30	29.40				12.50	16.00	14.50	12.50	16.00	14.50	12.50	16.00	14.50	12.50	16.00	14.50	12.50	16.00	14.50	12.50	16.00	14.50	12.50	16.00	14.50
*Meander Wavelength (ft)				80.10	116.50	99.20				58.08	59.76	58.92	58.08	59.76	58.92	58.08	59.76	58.92	58.08	59.76	58.92	58.08	59.76	58.92	58.08	59.76	58.92	58.08	59.76	58.92
*Meander Width Ratio				2.15	4.11	2.94						7.94			7.39			7.78			7.24			7.15			7.79			7.12
Profile																														
Riffle Length (ft)				12.0	18.5	15.0	33.0	72.4		13.2	27.1	22.7	12.4	23.9	15.7	11.8	19.6	16.5	6.8	28.4	16.3	8.0	25.1	15.1	6.5	28.4	13.7	6.5	28.4	13.7
Riffle Slope (ft/ft)				0.0283	0.0799	0.0520	0.0173	0.0306		0.0258	0.0532	0.0308	0.0115	0.0451	0.0213	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	No Flow	0.0191	0.0405	0.0301	No Flow	No Flow	No Flow
Pool Length (ft)				12.0	29.1	21.2	25.0	26.9		19.4	51.1	25.8	23.7	41.0	30.1	28.9	42.8	36.5	28.0	44.3	34.0	33.6	43.0	38.1	29.6	46.5	37.5	29.6	46.5	37.5
Pool Spacing (ft)				33.4	43.7	38.6			141.2	42.0	64.3	51.9	35.6	70.0	49.3	35.0	60.3	46.4	39.7	64.0	54.9	26.2	56.9	45.7	32.5	53.0	44.6	32.5	53.0	44.6
Substrate																														
D50 (mm)						69.2			7.8			7.8			90.0			39.8			65.5			55.4			117.8			112.8
D84 (mm)						140.1			21.6			21.6			210.4			104.6			138.4			105.2			180.0			183.1
Additional Reach Parameters																														
Valley Length (ft)						974			200			194			191			191			191			191			191			191
Channel Length (ft)						1129			203			282			284			284			284			284			284			284
Sinuosity						1.2			1.02			1.45			1.49			1.49			1.49			1.49			1.49			1.49
Water Surface Slope (ft/ft)						0.0311			0.0171			0.0054			0.0075			0.0065			0.0070			0.0062			0.0069			0.0065
BF Slope (ft/ft)						0.0326			0.0192			0.0054			0.0062			0.0061			0.0034			0.0034			0.0065			0.0064
Rosgen Classification						E3/1b**			E4			E4			C3/1			C4/1			C4/1			C4/1			C3/1			C3/1
Bankfull Discharge (cfs)			73.1			77.6			10.4			10.4			10.4			10.4			10.4			10.4			10.4			10.4
Bankfull Velocity (ft/sec)			4.9			5.0			3.6			2.4			2.5			3.0			3.3			3.0			3.7			3.1

Notes: Blank fields = Historic project documentation necessary to provide these data were collected/compiled.
Where no min/max values is provided, and only one value was measured or computed, that value is presented as the mean or median value.
* Inclusion will be project specific and determined primarily by As-built monitoring plan/success criteria
E3/1b ("E3/1"** E stream type channel morphology, large cobble substrate with bedrock control; E3/1**"b"** bankfull slope greater than 0.02 ft/ft.)
The water surface slope in years 1, 2, 3 and 5 represents the "channel slope" since the channel was dry.

Table XIIIa: Baseline Geomorphic and Hydraulic Summary - All Cross Sections
Beaverdam Creek and Unnamed Tributaries Stream Restoration / EEP Project No. D06054-C
Reach: Beaverdam Creek Main Stem

Parameter	Cross Section 7 (Pool)						Cross Section 8 (Riffle)					
Dimension	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**
BF Width (ft)	18.08	16.22	14.65	18.14	17.85	20.60	18.43	17.73	17.50	16.38	18.91	18.23
Floodprone Width (ft)	132.38	130.85	127.92	129.72	124.05	128.99	135.63	133.69	132.80	131.26	128.17	133.93
BF Cross Sectional Area (ft²)	21.87	20.32	17.70	21.34	18.82	20.52	18.48	17.91	18.76	17.71	19.63	17.72
BF Mean Depth (ft)	1.21	1.25	1.21	1.18	1.05	1.00	1.00	1.01	1.07	1.08	1.04	0.97
BF Max Depth (ft)	2.67	2.50	2.37	2.53	2.23	2.54	2.30	2.06	2.00	1.93	2.07	2.09
Width/Depth Ratio	14.94	12.98	12.11	15.37	17.00	20.60	18.43	17.55	16.36	15.17	18.18	18.79
Entrenchment Ratio	7.32	8.07	8.73	7.15	6.95	6.26	7.36	7.54	7.59	8.01	6.78	7.35
Bank Height Ratio	1	1	1	1	1	1	1	1	1	1	1	1
Wetted Perimeter (ft)	18.96	17.04	15.48	18.96	18.50	23.07	19.09	18.43	18.14	17.02	19.50	19.19
Hydraulic Radius (ft)	1.15	1.19	1.14	1.13	1.02	0.89	0.97	0.98	1.03	1.04	1.01	0.92
Substrate												
D50 (mm)	0.15	7.42	21.66	16.00	0.06	0.05	40.45	31.01	75.14	28.42	46.91	56.87
D84 (mm)	64.35	31.33	58.29	46.53	40.17	22.98	162.84	60.21	147.06	58.93	146.55	141.50

Table XIIIb: Baseline Geomorphic and Hydraulic Summary - All Cross Sections
Beaverdam Creek and Unnamed Tributaries Stream Restoration/ EEP Project No. D06054-C
Reach: UT1

Parameter	Cross Section 3 (Riffle)						Cross Section 4 (Pool)						Cross Section 5 (Pool)						Cross Section 6 (Riffle)					
Dimension	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**
BF Width (ft)	13.80	11.84	10.00	12.50	12.82	9.21	10.22	10.27	9.47	9.25	11.33	12.48	9.06	9.12	8.78	8.97	8.87	10.32	9.22	9.66	9.12	10.41	11.32	12.22
Floodprone Width (ft)	110.03	107.54	109.58	105.88	106.64	100.60	102.77	102.04	106.63	97.90	99.47	102.67	85.25	84.39	83.71	86.97	83.16	80.90	86.55	83.50	81.42	87.23	84.64	82.84
BF Cross Sectional Area (ft²)	10.19	9.35	6.66	8.07	7.51	5.95	9.28	8.94	9.11	7.99	10.95	10.27	10.44	9.95	11.12	10.39	9.12	11.48	7.49	7.71	7.50	9.64	8.80	8.79
BF Mean Depth (ft)	0.74	0.79	0.58	0.65	0.59	0.65	0.91	0.87	0.96	0.86	0.97	0.82	1.15	1.09	1.27	1.16	1.03	1.11	0.81	0.80	0.82	0.93	0.78	0.72
BF Max Depth (ft)	1.64	1.58	1.61	1.70	1.59	1.42	1.72	1.74	1.79	1.67	1.81	1.72	2.21	2.18	2.25	2.21	2.03	2.09	1.95	1.57	1.88	1.95	1.98	1.69
Width/Depth Ratio	18.65	14.99	19.86	19.23	21.73	14.17	11.23	11.80	9.86	10.76	11.68	15.22	7.88	8.37	6.91	7.73	8.61	9.30	11.38	12.08	11.12	11.19	14.51	16.97
Entrenchment Ratio	7.97	9.08	9.51	8.47	8.32	10.92	10.05	9.93	11.25	10.58	8.78	8.23	9.41	9.25	9.53	9.70	9.38	7.84	9.39	8.64	8.93	8.38	7.48	6.78
Bank Height Ratio	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wetted Perimeter (ft)	14.22	12.25	12.11	13.34	13.68	9.81	10.82	10.87	10.19	9.90	11.95	13.28	10.10	10.11	10.01	10.08	10.58	12.09	9.82	10.16	9.79	11.16	11.74	14.14
Hydraulic Radius (ft)	0.72	0.76	0.55	0.60	0.55	0.61	0.86	0.82	0.89	0.81	0.92	0.77	1.03	0.98	1.11	1.03	0.86	0.95	0.76	0.76	0.77	0.86	0.75	0.62
Substrate																								
D50 (mm)	61.41	28.47	75.37	47.37	40.12	56.40	0.29	0.29	0.06	0.06	0.03	0.03	20.96	7.23	36.34	24.31	21.66	14.43	76.07	32.93	49.38	46.12	32.00	40.67
D84 (mm)	175.48	97.10	143.02	84.80	87.57	148.80	67.46	67.46	103.02	46.91	0.05	0.06	114.83	23.11	87.77	55.77	130.61	79.59	143.58	84.40	100.13	74.40	85.84	93.82

Table XIIIc: Baseline Geomorphic and Hydraulic Summary - All Cross Sections

Beaverdam Creek and Unnamed Tributaries Stream Restoration / EEP Project No. D06054-C

Reach: UT2

Parameter	Cross Section 1 (Pool)						Cross Section 2 (Riffle)					
Dimension	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**	**MY 0**	**MY 1**	**MY 2**	**MY 3**	**MY 4**	**MY 5**
BF Width (ft)	13.77	13.46	10.55	9.82	10.66	9.03	11.55	6.43	6.91	6.99	6.42	7.02
Floodprone Width (ft)	89.76	90.07	85.31	81.23	82.32	72.35	114.79	43.89	82.57	35.55	37.92	35.93
BF Cross Sectional Area (ft²)	16.15	13.52	10.12	7.25	8.43	7.59	6.35	3.51	3.13	3.46	2.79	3.35
BF Mean Depth (ft)	1.17	1.00	0.96	0.74	0.79	0.84	0.55	0.55	0.45	0.49	0.43	0.48
BF Max Depth (ft)	2.41	2.37	1.81	1.70	1.65	1.48	1.31	0.96	1.02	0.91	0.95	1.00
Width/Depth Ratio	11.77	13.46	10.99	13.27	13.49	10.75	21.00	11.69	15.36	14.27	14.93	14.63
Entrenchment Ratio	6.52	6.69	8.09	8.27	7.72	8.01	9.94	6.82	11.95	5.08	5.90	5.12
Bank Height Ratio	1	1	1	1	1	1	1	1	1	1	1	1
Wetted Perimeter (ft)	14.73	14.46	11.34	10.61	11.28	9.72	11.95	6.75	7.42	8.42	7.07	8.18
Hydraulic Radius (ft)	1.10	0.93	0.89	0.68	0.75	0.78	0.53	0.52	0.42	0.41	0.39	0.41
Substrate												
D50 (mm)	33.08	11.12	0.05	0.05	0.03	0.03	90.00	39.80	65.45	55.37	117.77	112.80
D84 (mm)	220.56	70.93	25.61	56.39	0.05	0.05	210.40	104.63	138.39	105.20	180.00	183.05

APPENDIX A

Vegetation Raw Data

1. Vegetation Monitoring Plot Photos
2. Vegetation Data Tables
3. Vegetation Problem Area Photos
4. Vegetation Problem Area Plan View

Vegetation Plot 1
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 2
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 3
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 4
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 5
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 6
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 7
Monitoring Year 5
(EMH&T, 9/5/13)

Vegetation Plot 8
Monitoring Year 5
(EMH&T, 9/5/13)

Table 1. Vegetation Metadata	
Report Prepared By	Marion Wells
Date Prepared	6/26/2013 11:37
database name	cvs-eep-entrytool-v2.2.6.mdb
database location	Q:\ENVIRONMENTAL\Monitoring\EEP Vegetation Database
computer name	2UA602108H
file size	53424128
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Proj, planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Proj, total stems	Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.
Plots	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
Vigor	Frequency distribution of vigor classes for stems for all plots.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
ALL Stems by Plot and spp	A matrix of the count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.
PROJECT SUMMARY----------	
Project Code	D06054C
project Name	Beaverdam Creek
Description	Stream restoration of Beaverdam Creek mainstem and two unnamed tributaries.
River Basin	
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	8

Table 2. Vegetation Vigor by Species								
	Species	**4**	**3**	**2**	**1**	**0**	**Missing**	**Unknown**
	Alnus serrulata	6	5					
	Aronia arbutifolia						1	
	Cephalanthus occidentalis	6	6	6			3	
	Cornus amomum	1	2	2			1	
	Diospyros virginiana		5	2		1	2	
	Fraxinus pennsylvanica						1	
	Quercus bicolor			3			1	
	Quercus palustris			2				
	Sambucus canadensis	1						
	Taxodium distichum		1	2			3	
	Ulmus rubra						1	
	Liriodendron tulipifera	4	1					
	Nyssa sylvatica	2	2					
	Platanus occidentalis	20	13	1			1	
TOT:	**14**	**40**	**35**	**18**		**1**	**14**	

Table 3. Vegetation Damage by Species						
	Species	All Damage Categories	(no damage)	Site Too Dry	Vine Strangulation	(other damage)
	Alnus serrulata	11	11			
	Aronia arbutifolia	1	1			
	Cephalanthus occidentalis	21	20			1
	Cornus amomum	6	4			2
	Diospyros virginiana	10	9			1
	Fraxinus pennsylvanica	1	1			
	Liriodendron tulipifera	5	5			
	Nyssa sylvatica	4	4			
	Platanus occidentalis	35	33		2	
	Quercus bicolor	4	2	1		1
	Quercus palustris	2	1			1
	Sambucus canadensis	1	1			
	Taxodium distichum	6	4	2		
	Ulmus rubra	1	1			
TOT:	**14**	**108**	**97**	**3**	**2**	**6**

Table 4. Vegetation Damage by Plot						
	plot	All Damage Categories	(no damage)	Site Too Dry	Vine Strangulation	(other damage)
	D06054C-01-0001 (year 5)	11	11			
	D06054C-01-0002 (year 5)	15	14			1
	D06054C-01-0003 (year 5)	15	15			
	D06054C-01-0004 (year 5)	21	19			2
	D06054C-01-0005 (year 5)	11	11			
	D06054C-01-0006 (year 5)	8	5	3		
	D06054C-01-0007 (year 5)	13	12			1
	D06054C-01-0008 (year 5)	14	10		2	2
TOT:	**8**	**108**	**97**	**3**	**2**	**6**

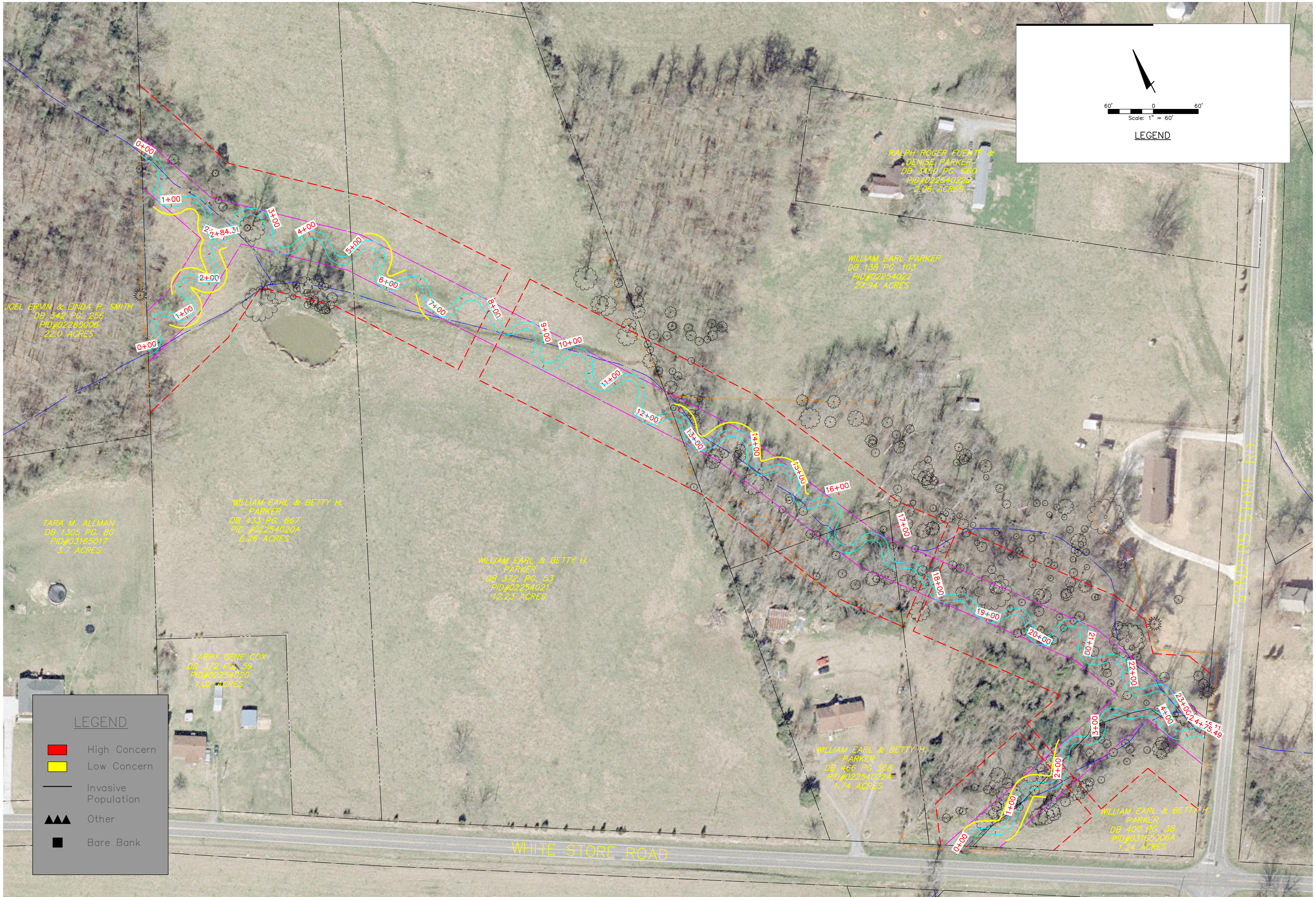
Table 5. Stem Count by Plot and Species - planted stems												
	Species	Total Planted Stems	# plots	avg# stems	plot D06054C-01-0001 (year 5)	plot D06054C-01-0002 (year 5)	plot D06054C-01-0003 (year 5)	plot D06054C-01-0004 (year 5)	plot D06054C-01-0005 (year 5)	plot D06054C-01-0006 (year 5)	plot D06054C-01-0007 (year 5)	plot D06054C-01-0008 (year 5)
	Alnus serrulata	11	6	1.83			4	1	2	2	1	1
	Cephalanthus occidentalis	18	4	4.5		3	4	6	5			
	Cornus amomum	5	2	2.5		1		4				
	Diospyros virginiana	7	1	7							7	
	Liriodendron tulipifera	5	3	1.67	2	2	1					
	Nyssa sylvatica	4	2	2			1		3			
	Platanus occidentalis	34	7	4.86	4	7	2	10		1	1	9
	Quercus bicolor	3	2	1.5						1		2
	Quercus palustris	2	2	1							1	1
	Sambucus canadensis	1	1	1			1					
	Taxodium distichum	3	2	1.5	1					2		
TOT:	**11**	**93**	**11**		**7**	**13**	**13**	**21**	**10**	**6**	**10**	**13**

Table 6. Stem Count by Plot and Species - all stems												
	Species	Total Stems	# plots	avg# stems	D06054C-01-0001 (year 5)	D06054C-01-0002 (year 5)	D06054C-01-0003 (year 5)	D06054C-01-0004 (year 5)	D06054C-01-0005 (year 5)	D06054C-01-0006 (year 5)	D06054C-01-0007 (year 5)	D06054C-01-0008 (year 5)
	Alnus serrulata	11	6	1.83			4	1	2	2	1	1
	Cephalanthus occidentalis	18	4	4.5		3	4	6	5			
	Cornus amomum	5	2	2.5		1		4				
	Diospyros virginiana	8	1	8							8	
	Fraxinus pennsylvanica	47	3	15.67	14	14	19					
	Ilex verticillata	1	1	1							1	
	Liquidambar styraciflua	172	8	21.5	50	16	18	13	13	7	35	20
	Quercus bicolor	5	2	2.5						1		4
	Quercus palustris	2	2	1							1	1
	Sambucus canadensis	6	1	6			6					
	Taxodium distichum	3	2	1.5	1					2		
	Liriodendron tulipifera	5	3	1.67	2	2	1					
	Nyssa sylvatica	4	2	2			1		3			
	Platanus occidentalis	48	7	6.86	4	10	2	10		1	1	20
	Ulmus americana	21	3	7	10		1				10	
TOT:	**15**	**356**	**15**		**81**	**46**	**56**	**34**	**23**	**13**	**57**	**46**

VPA 1

View of the spread of *microstegium* at along UT1, between stations 12+50 and 15+00. This invasive grass is found in various patches along the project corridor, but is most prominent in this area.

(EMH&T, 9/05/13)



UNION COUNTY, NORTH CAROLINA
STREAM RESTORATION PLAN
FOR
BEAVERDAM CREEK
AND UNNAMED TRIBUTARIES
APPENDIX A
VEGETATION PROBLEM AREA PLAN VIEW

Date	Scale	Job No.	Sheet
December, 2013	1" = 60'	2009-0327	1—1

Ecosystem Enhancement PROGRAM

EMH&T
Evans, Mechwart, Hambleton & Tilton, Inc.
Engineers • Surveyors • Planners • Scientists
5500 New Albany Road, Columbus, OH 43054
Phone: 614.775.4500 Fax: 614.775.4800

J:\20090327\20090327env\Dwg\Exhibits\Year 5 - Appendix A.dwg Last Saved By: jcramer, 1/3/2014 2:35 PM Last Printed By: Cramer, James, 1/3/2014 2:35 PM (No Xrefs)

APPENDIX B

Geomorphologic Raw Data

1. Fixed Station Photos
2. Table B1. Qualitative Visual Stability Assessment
3. Cross Section Plots
4. Longitudinal Plots
5. Pebble Count Plots
6. Bankfull Event Photos

Fixed Station 1
Overview of Beaverdam Creek, looking downstream
(EMH&T, 9/5/13).

Fixed Station 2
Overview of UT1, looking upstream near station 19+00
(Top Photo – Year 2: 9/19/10, Bottom Photo – Year 5: 9/5/13).
(EMH&T)

Fixed Station 3
Overview of valley along UT1, looking upstream near station 13+00
(Top Photo – Year 2: 9/19/10, Bottom Photo – Year 5: 9/5/13).
(EMH&T)

Fixed Station 4
Overview of valley along UT1, looking downstream near station 13+00
(Top Photo – Year 2: 9/19/10, Bottom Photo – Year 5: 9/11/13).
(EMH&T)

Fixed Station 5
Overview of UT1, looking downstream from upstream project limits
(Top Photo – Year 2: 9/19/10, Bottom Photo – Year 5: 9/5/13).
(EMH&T)

Fixed Station 6
Overview of UT2, looking downstream
(Top Photo – Year 2: 9/19/10, Bottom Photo – Year 5: 9/5/13).
(EMH&T)

Table B1. Visual Morphological Stability Assessment
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C
Segment/Reach: Main Stem

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	% Perform in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	10	10	0	100	
	2. Armor stable (e.g. no displacement)?	10	10	0	100	
	3. Facet grade appears stable?	10	10	0	100	
	4. Minimal evidence of embedding/fining?	10	10	0	100	
	5. Length appropriate?	10	10	0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	9	9	0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	9	9	0	100	
	3. Length appropriate?	9	9	0	100	**100%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	10	10	0	100	
	2. Downstream of meander (glide/inflection) centering?	10	10	0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	10	10	0	100	
	2. Of those eroding, # w/concomitant point bar formation?	10	10	0	100	
	3. Apparent Rc within spec?	10	10	0	100	
	4. Sufficient floodplain access and relief?	10	10	0	100	**100%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0 feet	100	
	2. Channel bed degradation - areas of increasing downcutting or headcutting?	N/A	N/A	0/0 feet	100	**100%**
F. Vanes	1. Free of back or arm scour?	N/A	0	N/A	N/A	
	2. Height appropriate?	N/A	0	N/A	N/A	
	3. Angle and geometry appear appropriate?	N/A	0	N/A	N/A	
	4. Free of piping or other structural failures?	N/A	0	N/A	N/A	**N/A**
G. Wads/ Boulders	1. Free of scour?	N/A	0	N/A	N/A	
	2. Footing stable?	N/A	0	N/A	N/A	**N/A**

Table B1. Visual Morphological Stability Assessment
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C
Segment/Reach: UT1

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	% Perform in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	43	43	0	100	
	2. Armor stable (e.g. no displacement)?	43	43	0	100	
	3. Facet grade appears stable?	43	43	0	100	
	4. Minimal evidence of embedding/fining?	43	43	0	100	
	5. Length appropriate?	43	43	0	100	**100%**
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	42	42	0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	36	42	60	86	
	3. Length appropriate?	42	42	0	100	**95%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	41	41	0	100	
	2. Downstream of meander (glide/inflection) centering?	41	41	0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	37	41	4	90	
	2. Of those eroding, # w/concomitant point bar formation?	41	41	0	100	
	3. Apparent Rc within spec?	41	41	0	100	
	4. Sufficient floodplain access and relief?	34	41	7	83	**93%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0 feet	100	
	2. Channel bed degradation - areas of increasing downcutting or headcutting?	N/A	N/A	0/0 feet	100	**100%**
F. Vanes	1. Free of back or arm scour?	N/A	0	N/A	N/A	
	2. Height appropriate?	N/A	0	N/A	N/A	
	3. Angle and geometry appear appropriate?	N/A	0	N/A	N/A	
	4. Free of piping or other structural failures?	N/A	0	N/A	N/A	**N/A**
G. Wads/ Boulders	1. Free of scour?	N/A	0	N/A	N/A	
	2. Footing stable?	N/A	0	N/A	N/A	**N/A**

Table B1. Visual Morphological Stability Assessment
Beaverdam Creek Stream Restoration / EEP Project No. D06054-C
Segment/Reach: UT2

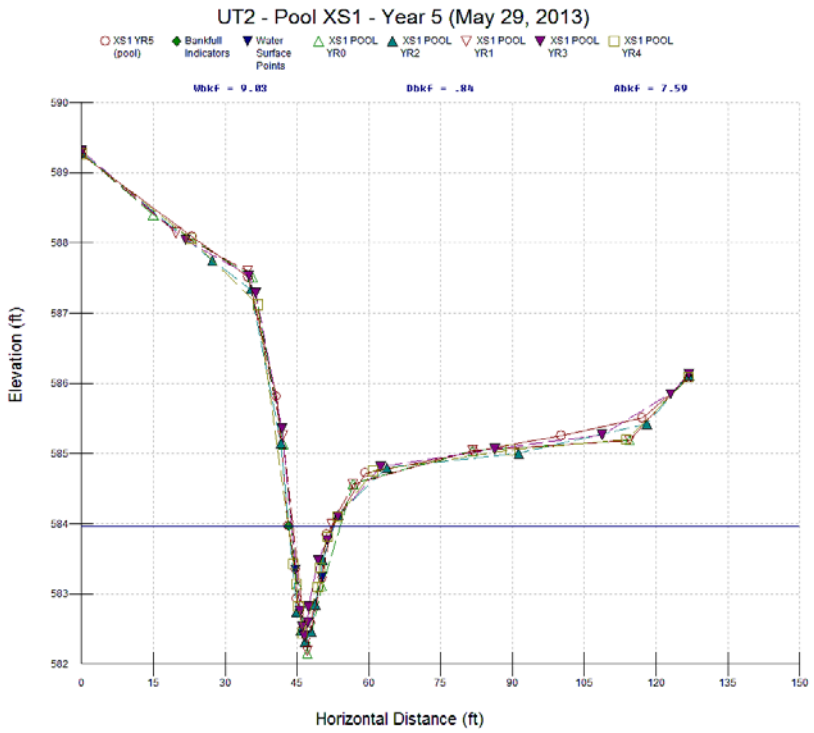
Feature Category	Metric (per As-built and reference baselines	(# Stable) Number Performing as Intended	Total number per As-built	Total Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
A. Riffles	1. Present?	5	5	0	100	
	2. Armor stable (e.g. no displacement)?	5	5	0	100	
	3. Facet grade appears stable?	5	5	0	100	
	4. Minimal evidence of embedding/fining?	4	5	0	60	
	5. Length appropriate?	5	5	0	100	**96%**
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	5	5	0	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	4	5	0	80	
	3. Length appropriate?	5	5	0	100	**93%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	6	6	0	100	
	2. Downstream of meander (glide/inflection) centering?	6	6	0	100	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	6	6	0	100	
	2. Of those eroding, # w/concomitant point bar formation?	6	6	0	100	
	3. Apparent Rc within spec?	6	6	0	100	
	4. Sufficient floodplain access and relief?	5	6	1	83	**96%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	N/A	N/A	0/0 feet	100	
	2. Channel bed degradation - areas of increasing downcutting or headcutting?	N/A	N/A	0/0 feet	100	**100%**
F. Vanes	1. Free of back or arm scour?	N/A	0	N/A	N/A	
	2. Height appropriate?	N/A	0	N/A	N/A	
	3. Angle and geometry appear appropriate?	N/A	0	N/A	N/A	
	4. Free of piping or other structural failures?	N/A	0	N/A	N/A	**N/A**
G. Wads/ Boulders	1. Free of scour?	N/A	0	N/A	N/A	
	2. Footing stable?	N/A	0	N/A	N/A	**N/A**

Summary Data
All dimensions in feet.

Bankfull Area	7.59 ft^2
Bankfull Width	9.03 ft
Mean Depth	0.84 ft
Maximum Depth	1.48 ft
Width/Depth Ratio	10.75
Entrenchment Ratio	8.01
Classification	E

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT2**
DATE	**05/29/2013**
CROSS SECTION:	**1**
FEATURE:	**Pool**

Cross-section photo – looking across channel from left bank to right bank

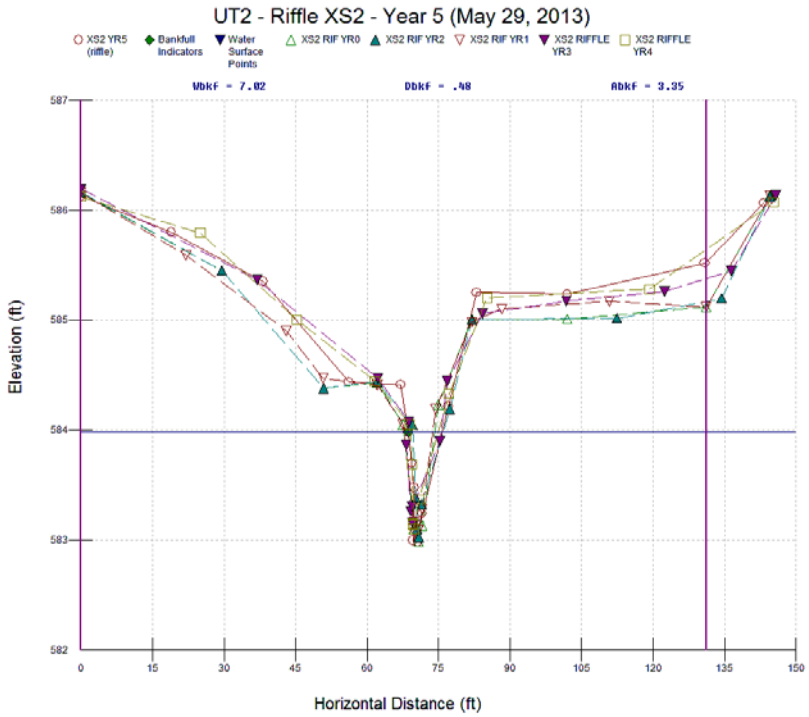


Summary Data
All dimensions in feet.

Bankfull Area	3.35 ft^2
Bankfull Width	7.02 ft
Mean Depth	0.48 ft
Maximum Depth	1.0 ft
Width/Depth Ratio	14.63
Entrenchment Ratio	5.12
Classification	C

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT2**
DATE	**05/29/2013**
CROSS SECTION:	**2**
FEATURE:	**Riffle**

Cross-section photo – looking across channel, from left bank to right bank

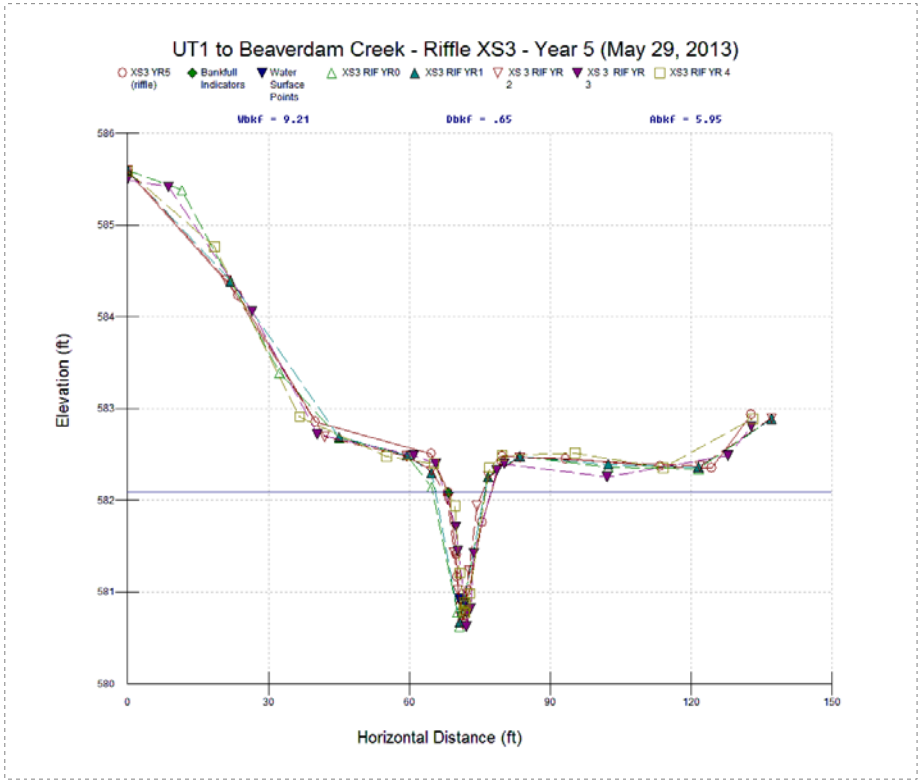


Summary Data
All dimensions in feet.

Bankfull Area	5.95 ft^2
Bankfull Width	9.21 ft
Mean Depth	0.65 ft
Maximum Depth	1.42 ft
Width/Depth Ratio	14.17
Entrenchment Ratio	10.92
Classification	C

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT1**
DATE	**05/29/2013**
CROSS SECTION:	**3**
FEATURE:	**Riffle**

Cross-section photo – looking across channel, from left bank to right bank

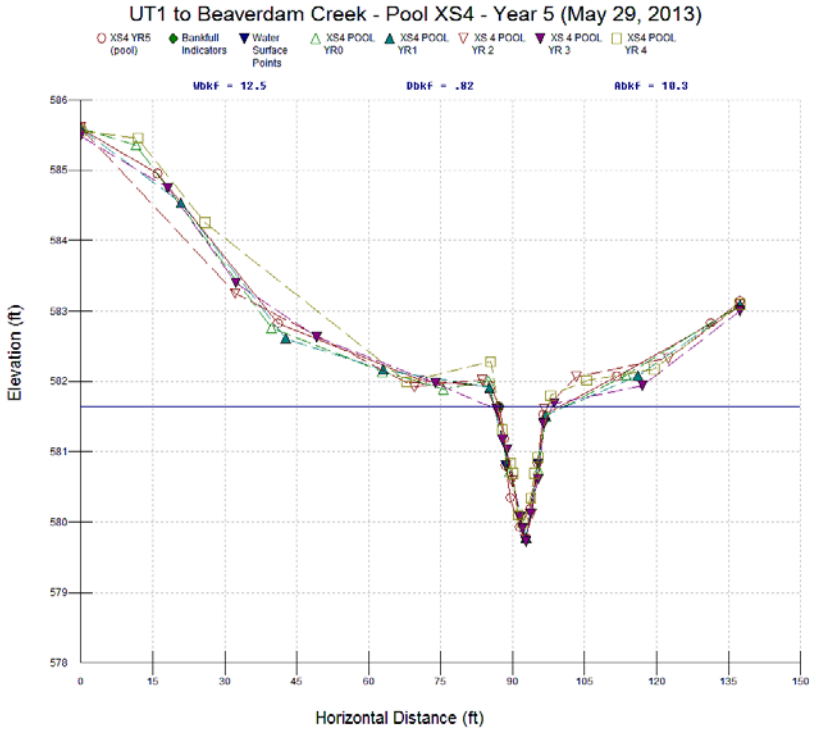


Summary Data
All dimensions in feet.

Bankfull Area	10.27 ft^2
Bankfull Width	12.48 ft
Mean Depth	0.82 ft
Maximum Depth	1.72 ft
Width/Depth Ratio	15.22
Entrenchment Ratio	8.23
Classification	E

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT1**
DATE	**05/29/2013**
CROSS SECTION:	**4**
FEATURE:	**Pool**

Cross-section photo – looking across channel, from right bank to left bank

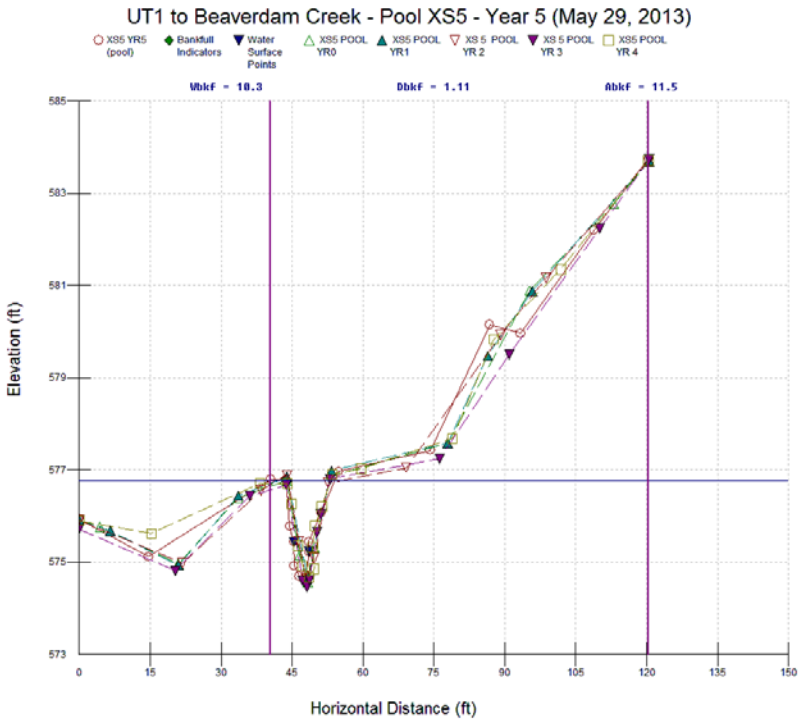


Summary Data
All dimensions in feet.

Bankfull Area	11.48 ft^2
Bankfull Width	10.32 ft
Mean Depth	1.11 ft
Maximum Depth	2.09 ft
Width/Depth Ratio	9.3
Entrenchment Ratio	7.84
Classification	E

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT1**
DATE	**05/29/2013**
CROSS SECTION:	**5**
FEATURE:	**Pool**

Cross-section photo – looking upstream

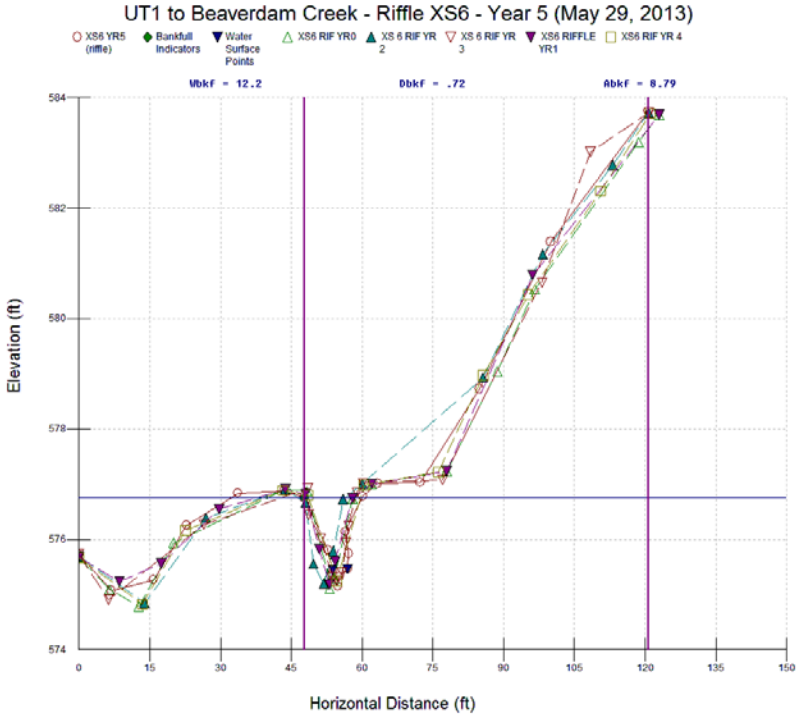


Summary Data
All dimensions in feet.

Bankfull Area	8.79 ft^2
Bankfull Width	12.22 ft
Mean Depth	0.72 ft
Maximum Depth	1.69 ft
Width/Depth Ratio	16.97
Entrenchment Ratio	6.78
Classification	C

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**UT1**
DATE	**05/29/2013**
CROSS SECTION:	**6**
FEATURE:	**Riffle**

Cross-section photo – looking across channel from left bank to right bank

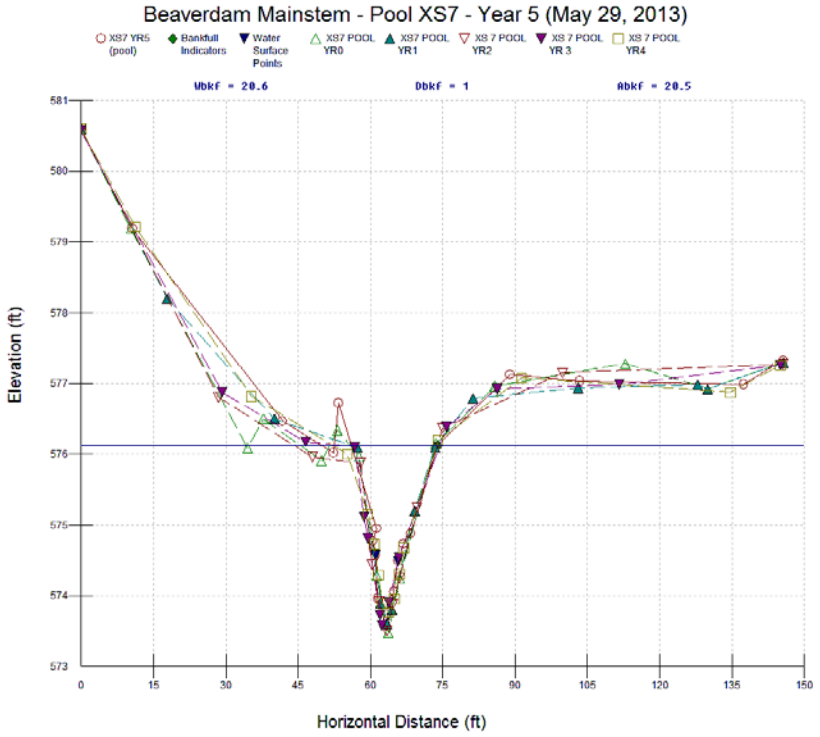


Summary Data
All dimensions in feet.

Bankfull Area	20.52 ft^2
Bankfull Width	20.6 ft
Mean Depth	1.0 ft
Maximum Depth	2.54 ft
Width/Depth Ratio	20.6
Entrenchment Ratio	6.26
Classification	C

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**Main stem**
DATE	**05/29/2013**
CROSS SECTION:	**7**
FEATURE:	**Pool**

Cross-section photo – looking across channel, from left bank to right bank

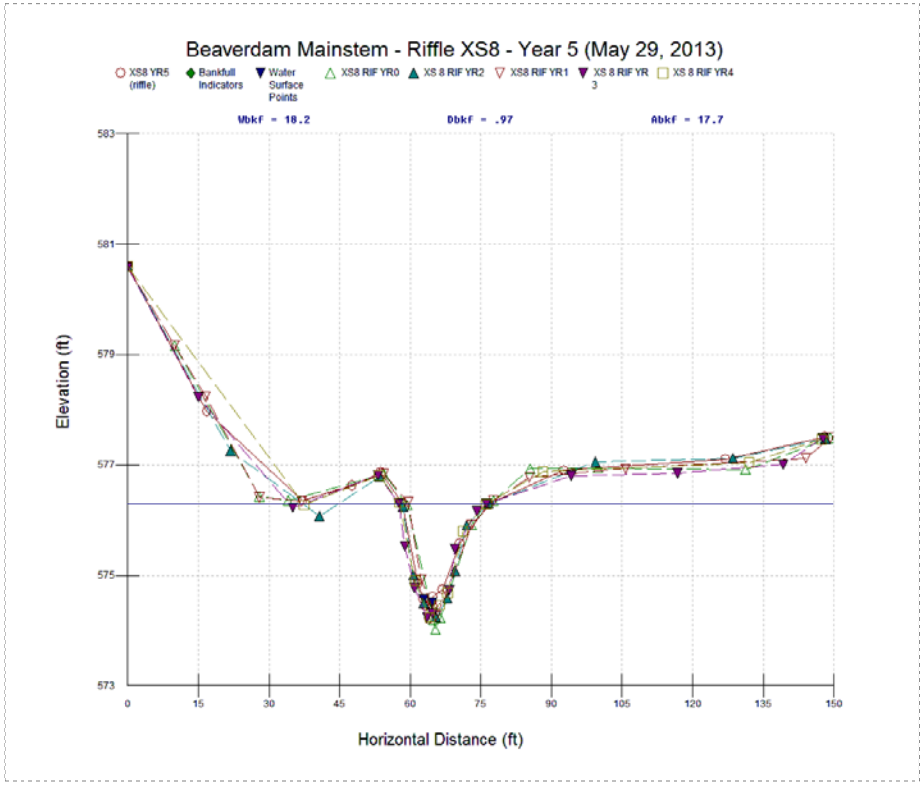


Summary Data
All dimensions in feet.

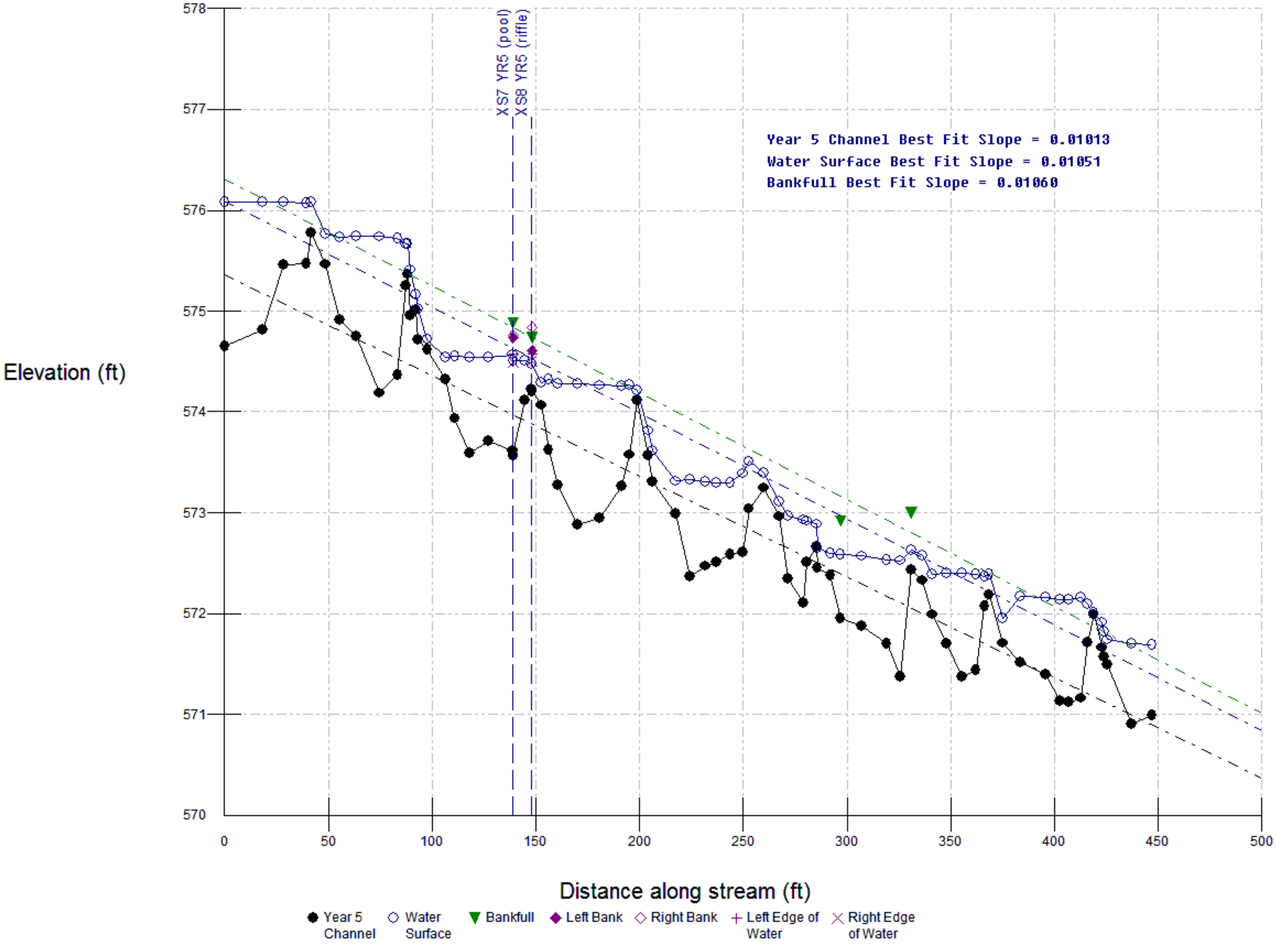
Bankfull Area	17.72 ft^2
Bankfull Width	18.23 ft
Mean Depth	0.97 ft
Maximum Depth	2.09 ft
Width/Depth Ratio	18.79
Entrenchment Ratio	7.35
Classification	C

PROJECT	**Beaverdam Creek**
	D06054-C
	5-YEAR
TASK	**Cross-Section**
REACH	**Main stem**
DATE	**05/29/2013**
CROSS SECTION:	**8**
FEATURE:	**Riffle**

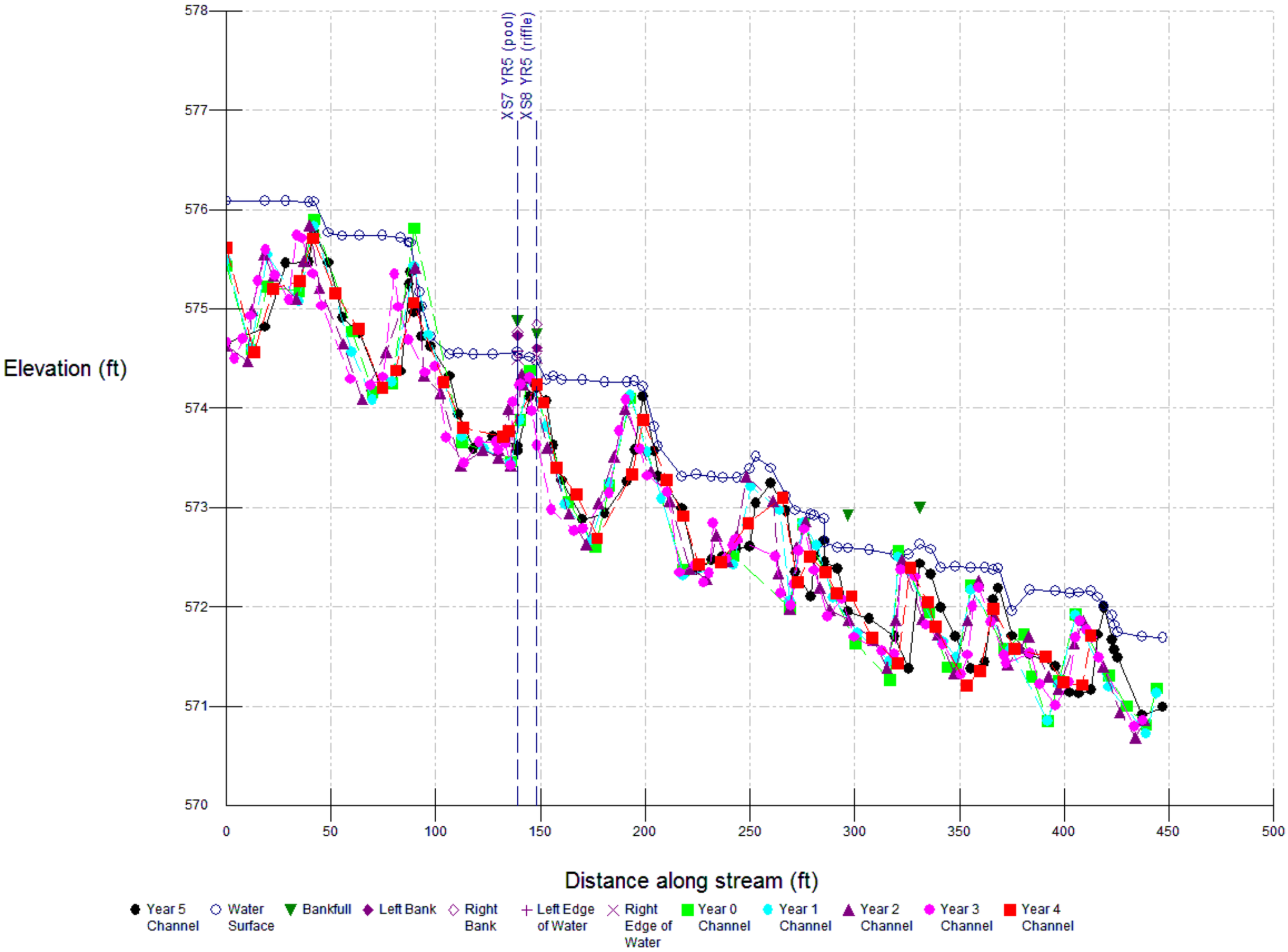
Cross-section photo – looking left bank to right bank



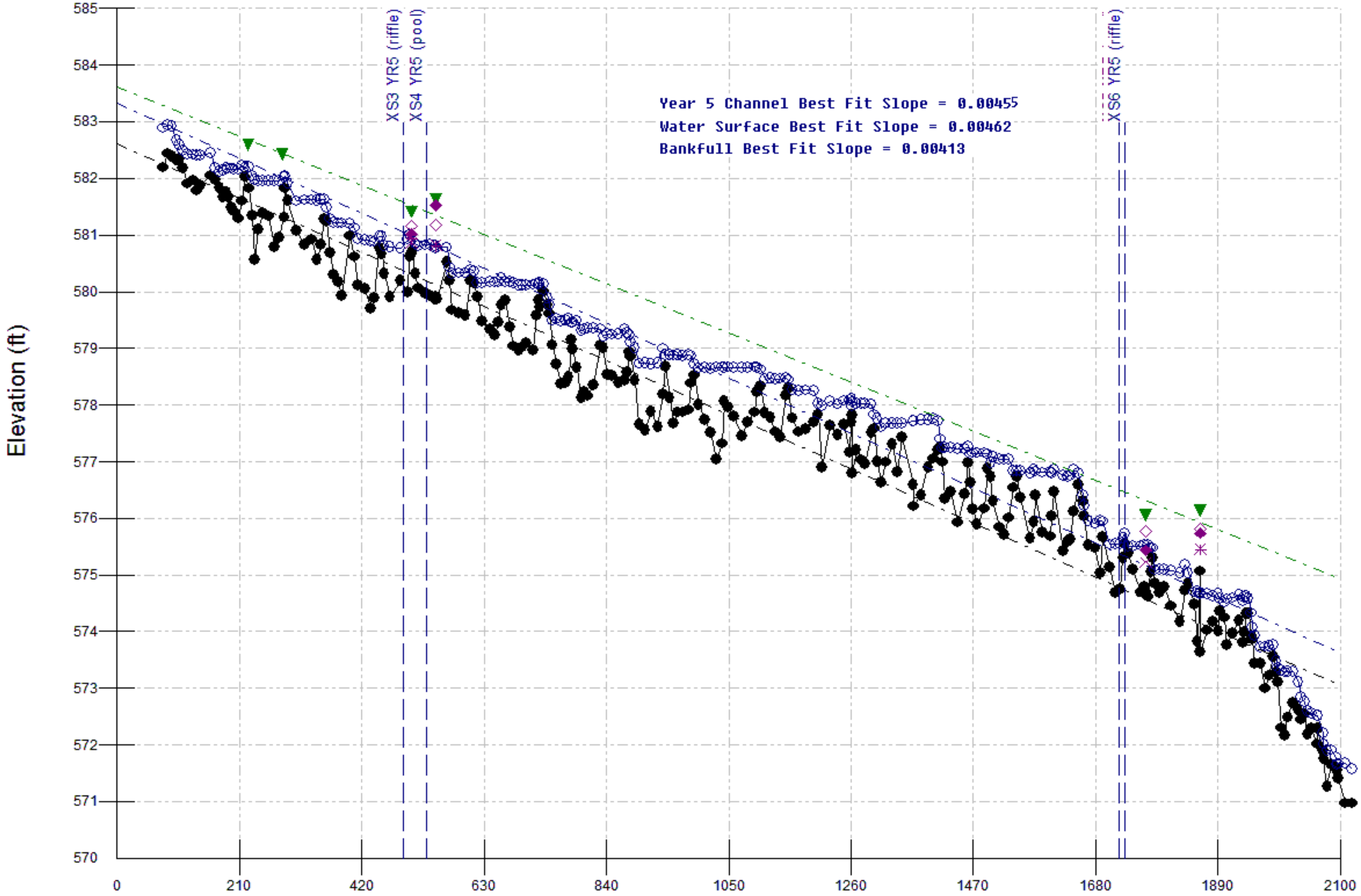
Beaverdam Creek Mainstem - Profile - Year 5 (May 29, 2013)



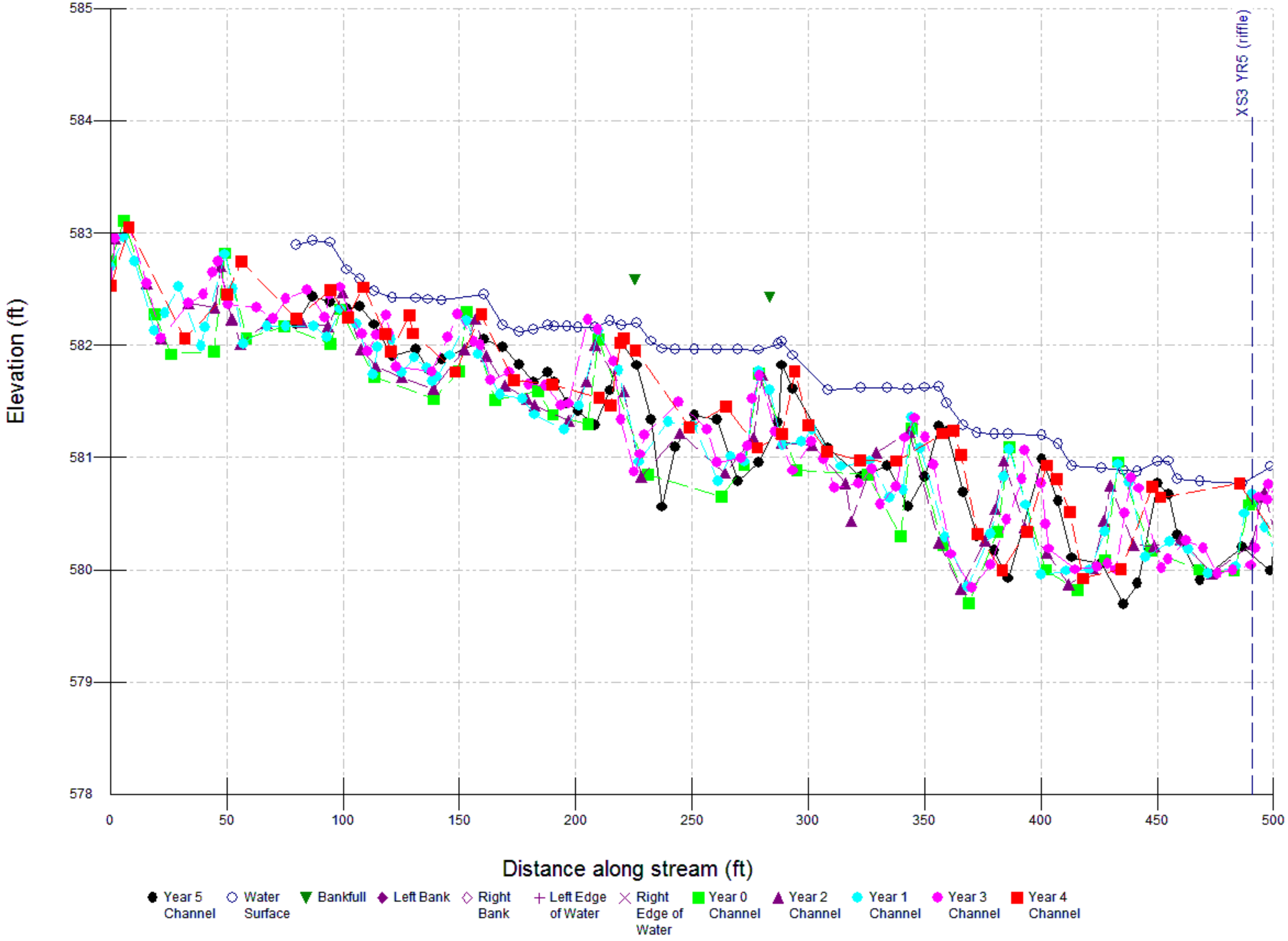
Beaverdam Creek Mainstem - Profile - Year 5 (May 29, 2013)



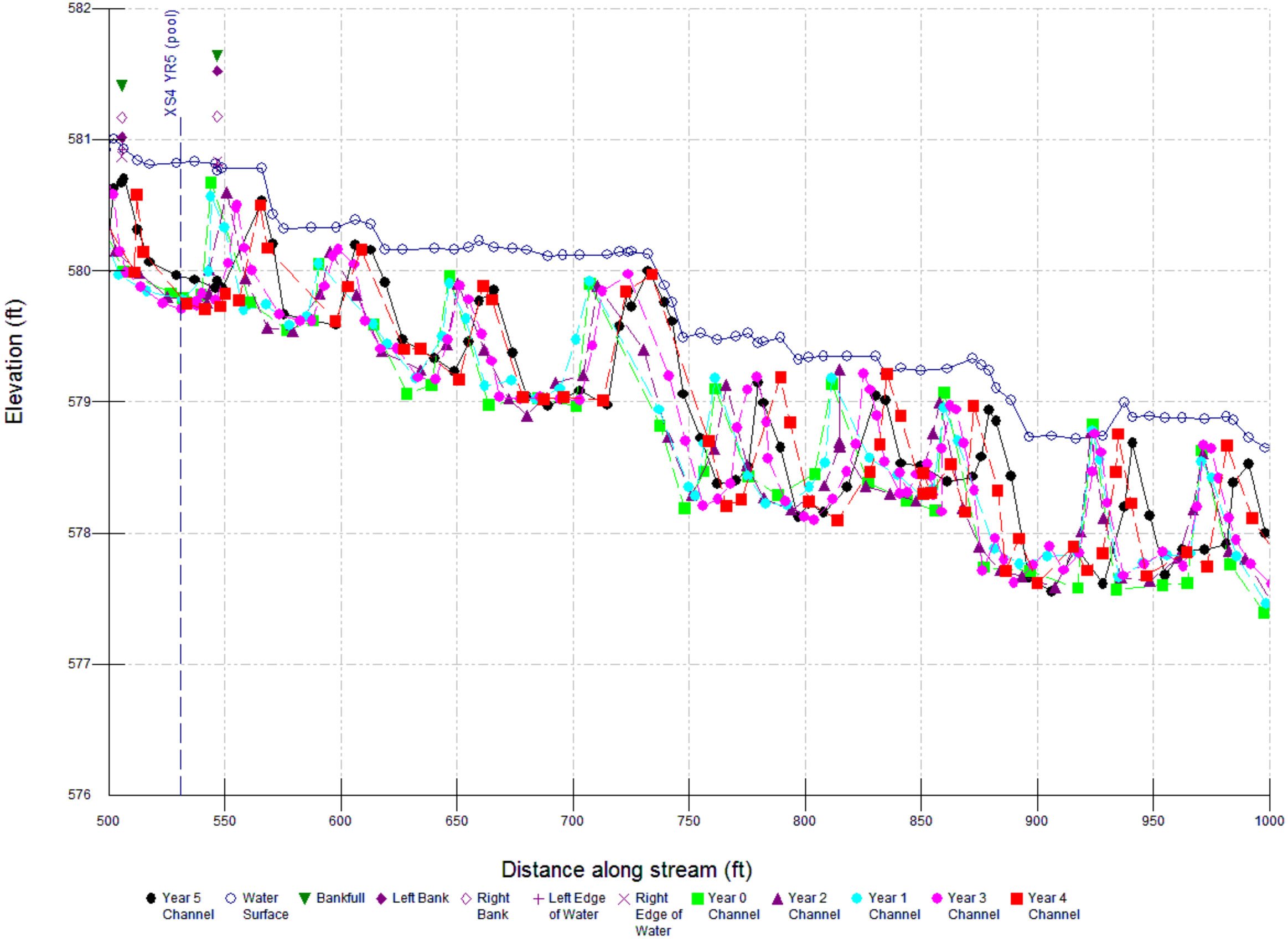
Unnamed Tributary 1 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)



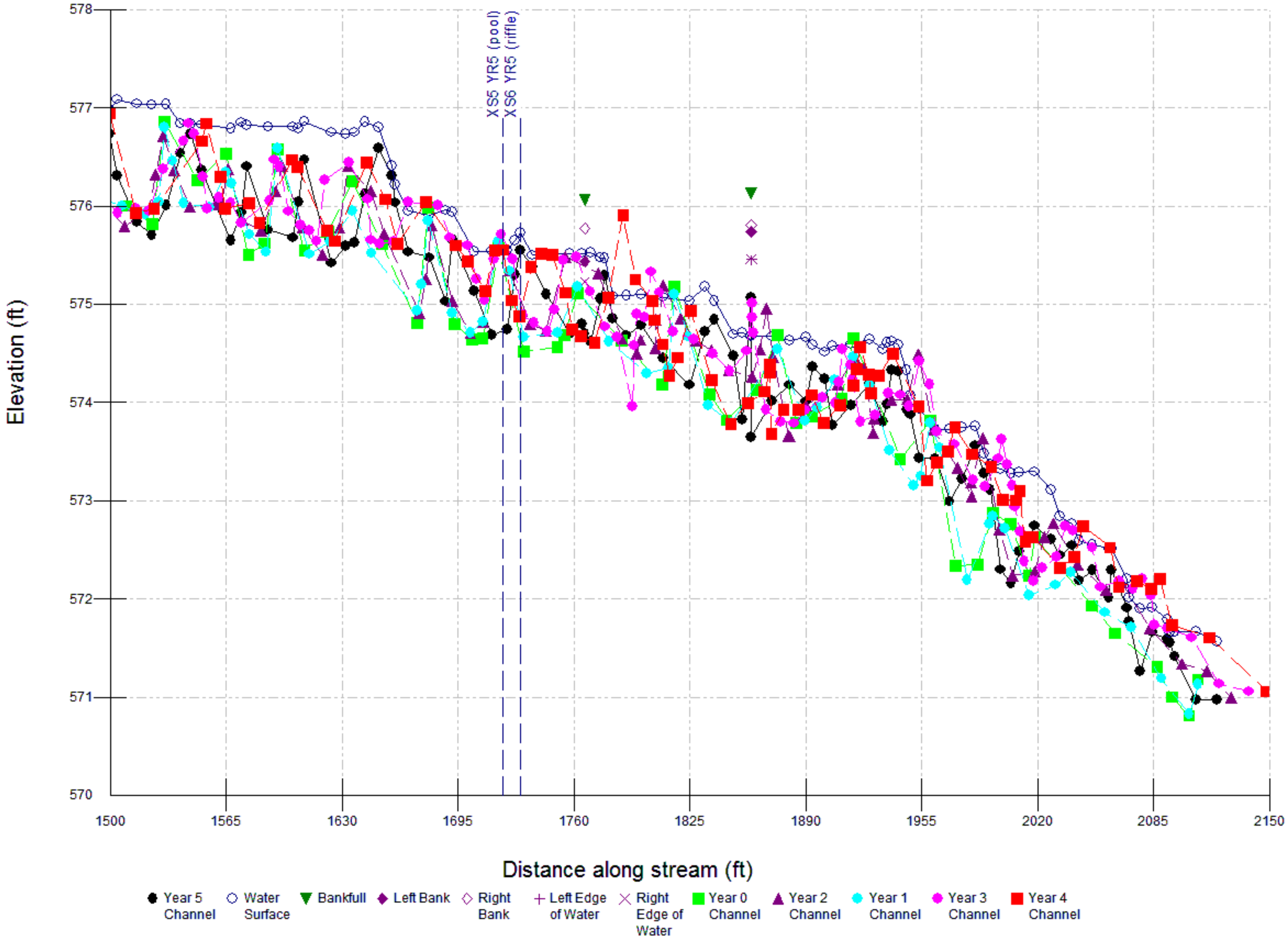
Unnamed Tributary 1 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)



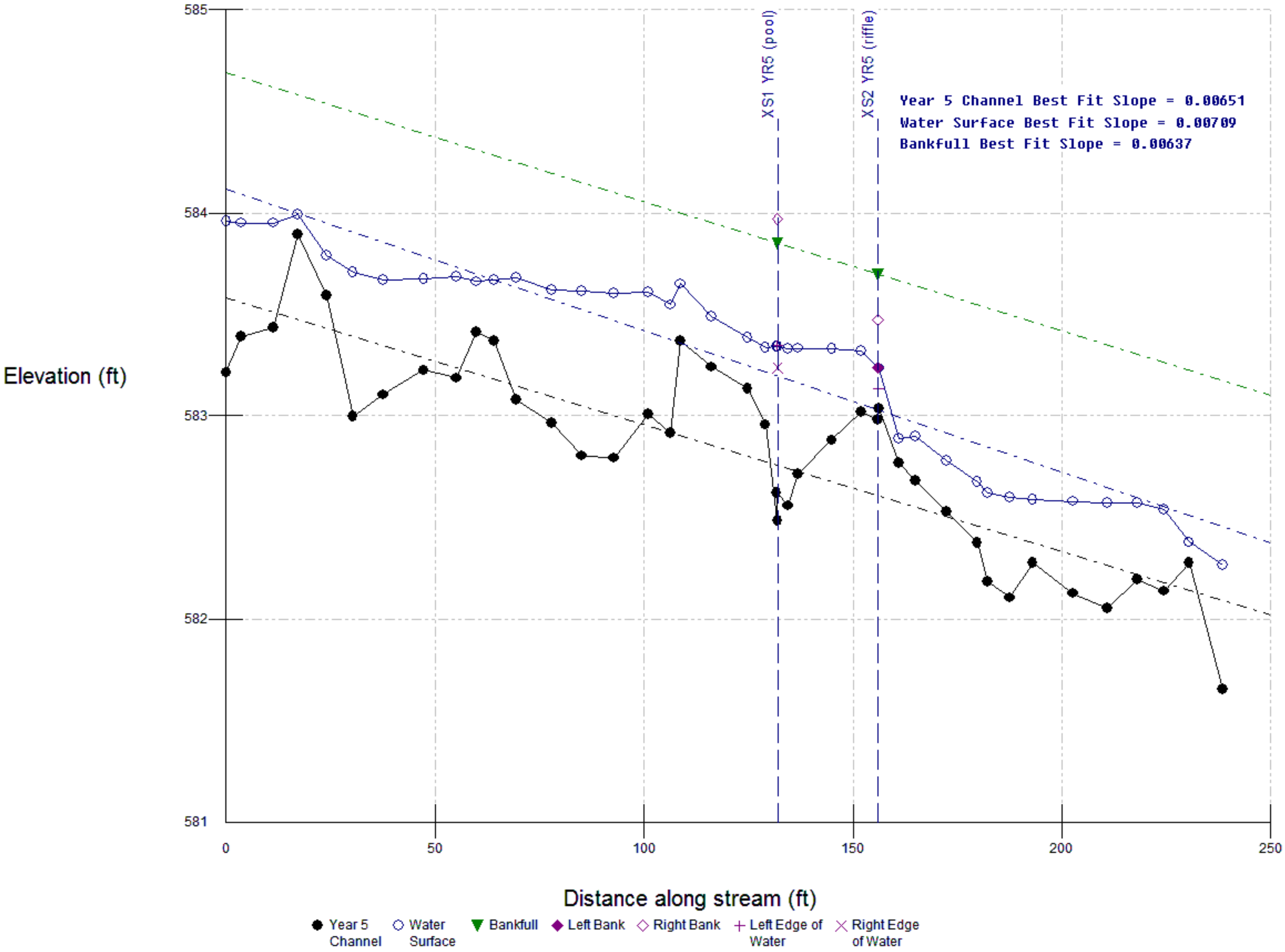
Unnamed Tributary 1 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)



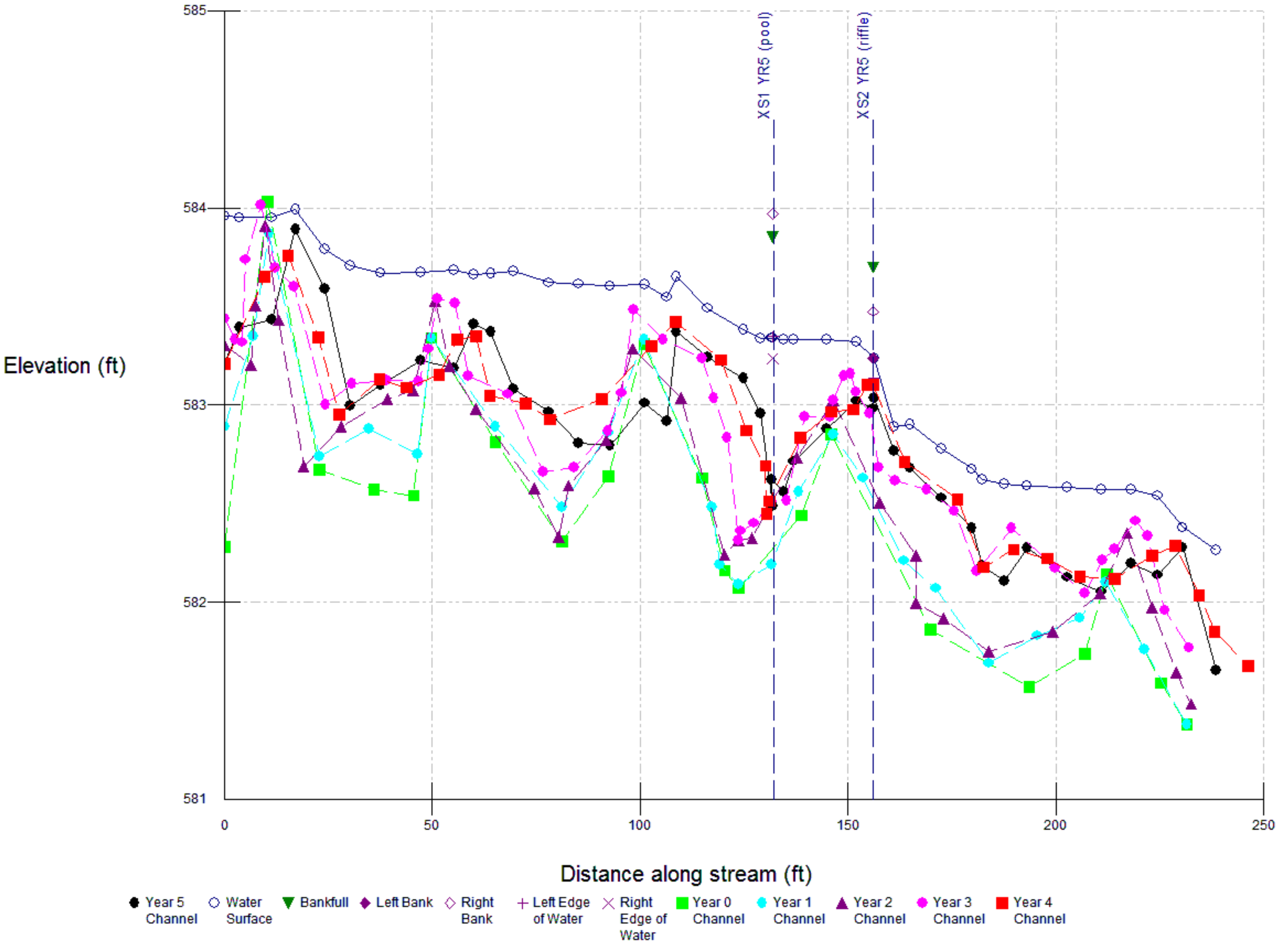
Unnamed Tributary 1 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)



Unnamed Tributary 2 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)

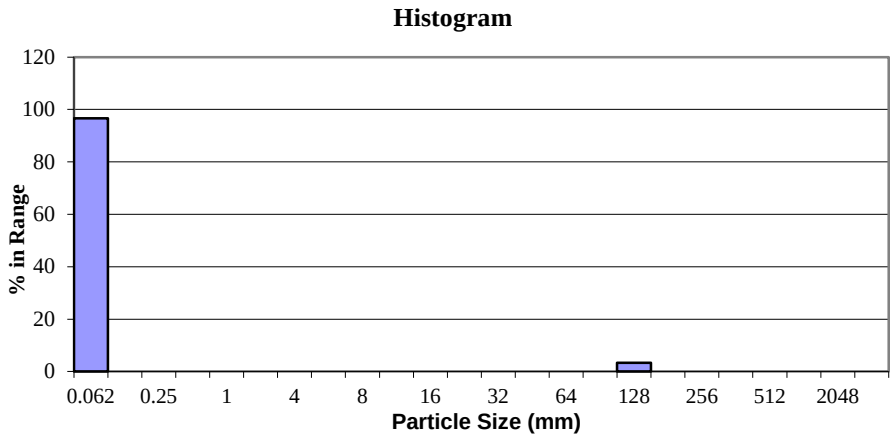


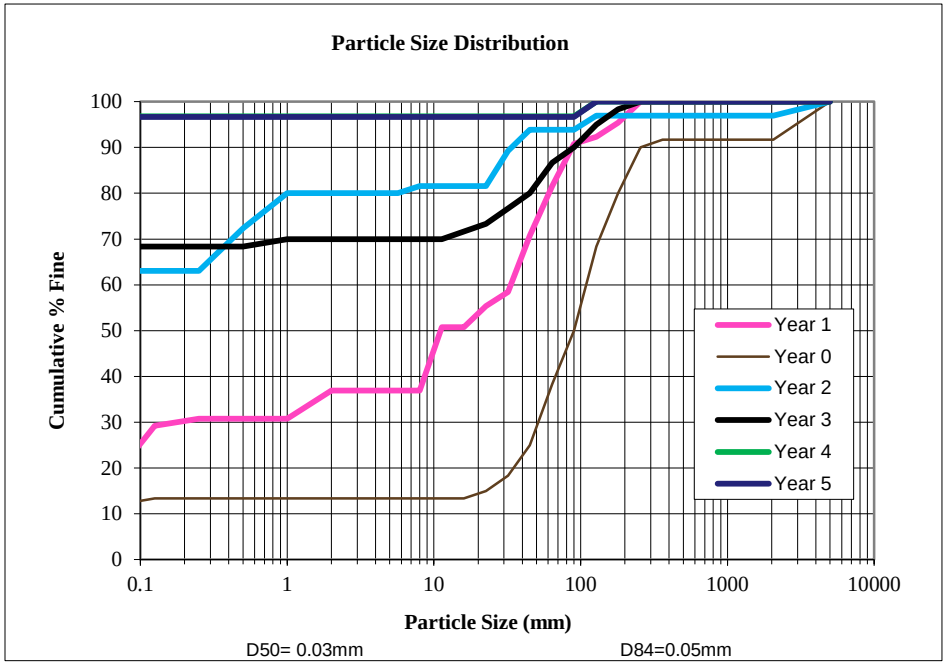
Unnamed Tributary 2 (to Beaverdam Creek) - Profile - Year 5 (May 29, 2013)



Pebble Count - Pool				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	58	97	97
Very Fine Sand	0.062-0.125	0	0	97
Fine Sand	0.125-0.25	0	0	97
Medium Sand	0.25-0.5	0	0	97
Coarse Sand	0.5-1.0	0	0	97
Very Coarse Sand	1.0-2.0	0	0	97
Very Fine Gravel	2.0-4.0	0	0	97
Fine Gravel	4.0-5.7	0	0	97
Fine Gravel	5.7-8.0	0	0	97
Medium Gravel	8.0-11.3	0	0	97
Medium Gravel	11.3-16.0	0	0	97
Coarse Gravel	16.0-22.6	0	0	97
Coarse Gravel	22.6-32	0	0	97
Very Coarse Gravel	32-45	0	0	97
Very Coarse Gravel	45-64	0	0	97
Small Cobble	64-90	0	0	97
Small Cobble	90-128	2	3	100
Large Cobble	128-180	0	0	100
Large Cobble	180-256	0	0	100
Small Boulder	256-362	0	0	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		60	100	

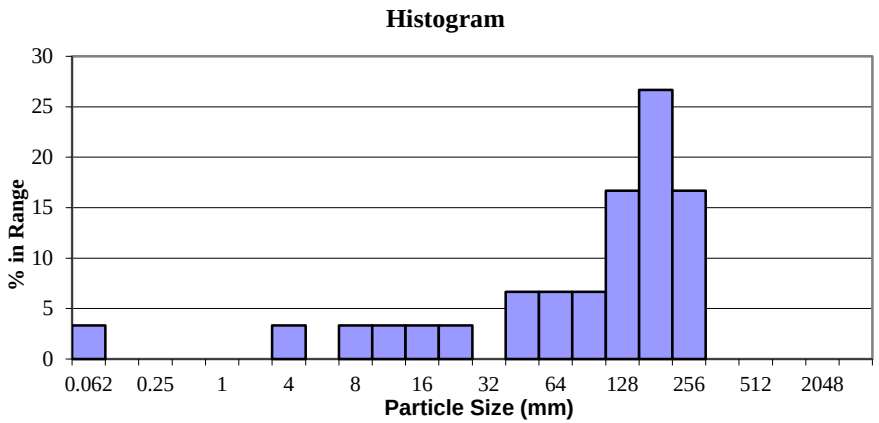
Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT2	**X Sec**	1
Date	05/14/13	**Sta No.**	1+23.57

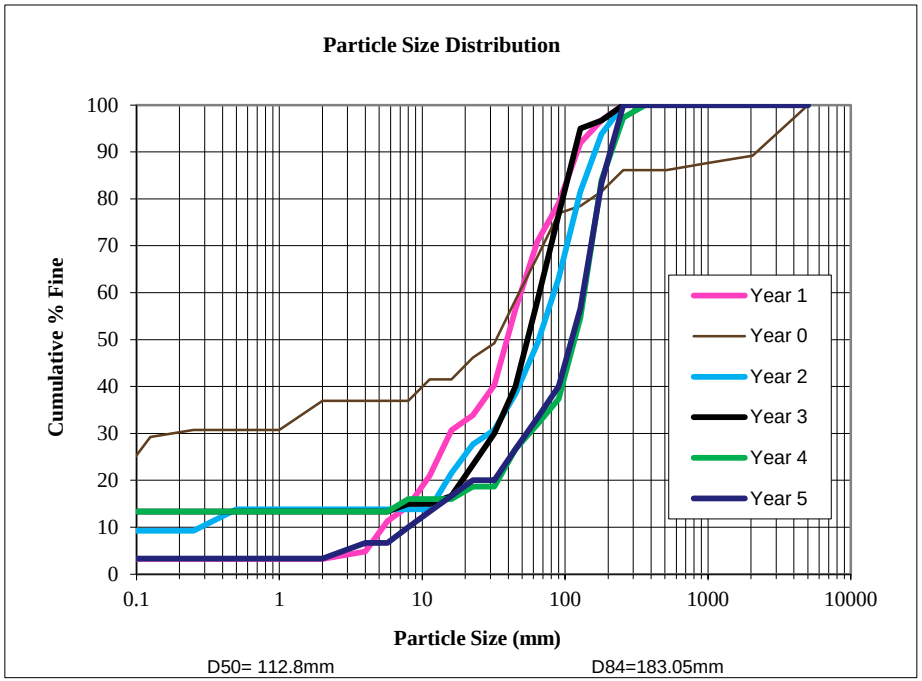




Pebble Count - Riffle				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	2	3	3
Very Fine Sand	0.062-0.125	0	0	3
Fine Sand	0.125-0.25	0	0	3
Medium Sand	0.25-0.5	0	0	3
Coarse Sand	0.5-1.0	0	0	3
Very Coarse Sand	1.0-2.0	0	0	3
Very Fine Gravel	2.0-4.0	2	3	7
Fine Gravel	4.0-5.7	0	0	7
Fine Gravel	5.7-8.0	2	3	10
Medium Gravel	8.0-11.3	2	3	13
Medium Gravel	11.3-16.0	2	3	17
Coarse Gravel	16.0-22.6	2	3	20
Coarse Gravel	22.6-32	0	0	20
Very Coarse Gravel	32-45	4	7	27
Very Coarse Gravel	45-64	4	7	33
Small Cobble	64-90	4	7	40
Small Cobble	90-128	10	17	57
Large Cobble	128-180	16	27	83
Large Cobble	180-256	10	17	100
Small Boulder	256-362	0	0	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		60	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT2	**X Sec**	2
Date	05/14/13	**Sta No.**	1+46.40

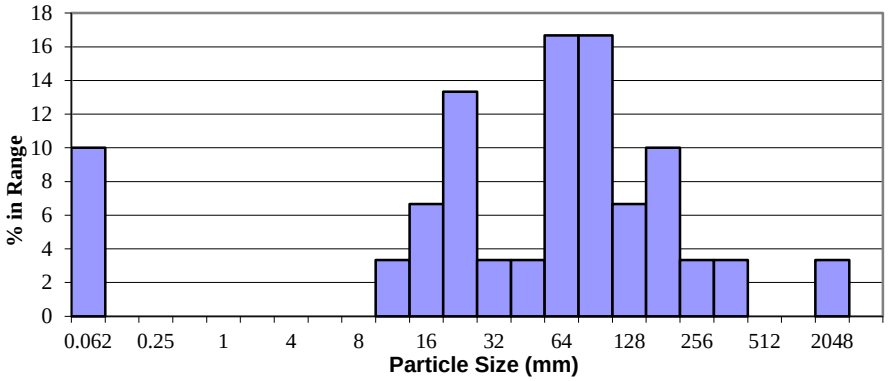


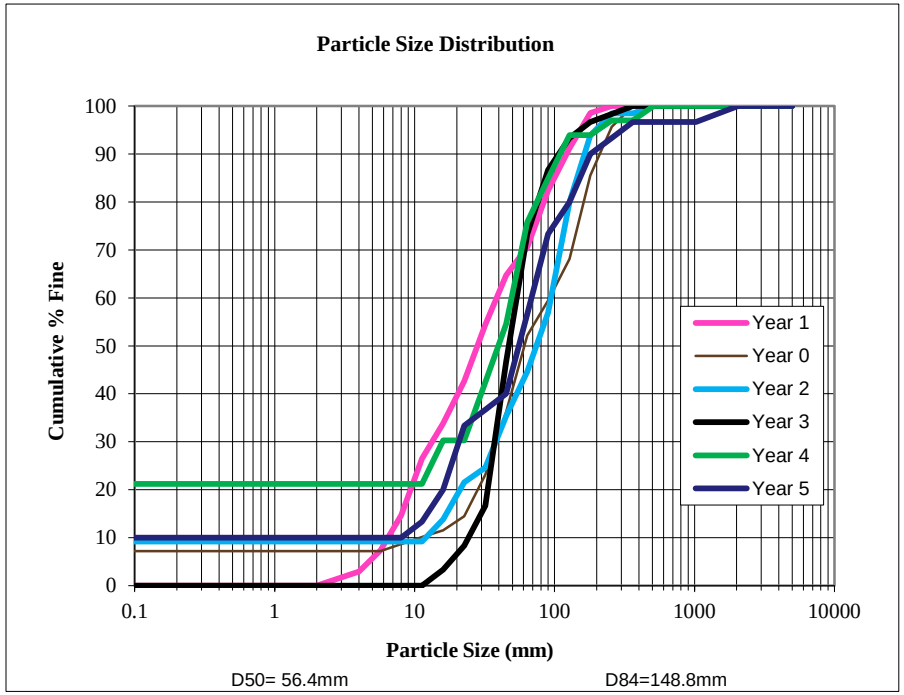


Pebble Count - Riffle				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	6	10	10
Very Fine Sand	0.062-0.125	0	0	10
Fine Sand	0.125-0.25	0	0	10
Medium Sand	0.25-0.5	0	0	10
Coarse Sand	0.5-1.0	0	0	10
Very Coarse Sand	1.0-2.0	0	0	10
Very Fine Gravel	2.0-4.0	0	0	10
Fine Gravel	4.0-5.7	0	0	10
Fine Gravel	5.7-8.0	0	0	10
Medium Gravel	8.0-11.3	2	3	13
Medium Gravel	11.3-16.0	4	7	20
Coarse Gravel	16.0-22.6	8	13	33
Coarse Gravel	22.6-32	2	3	37
Very Coarse Gravel	32-45	2	3	40
Very Coarse Gravel	45-64	10	17	57
Small Cobble	64-90	10	17	73
Small Cobble	90-128	4	7	80
Large Cobble	128-180	6	10	90
Large Cobble	180-256	2	3	93
Small Boulder	256-362	2	3	97
Small Boulder	362-512	0	0	97
Medium Boulder	512-1024	0	0	97
Large Boulder	1024-2048	2	3	100
Bedrock	<2048	0	0	100
Totals		60	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT1	**X Sec**	3
Date	05/14/13	**Sta No.**	4+90.86

Histogram

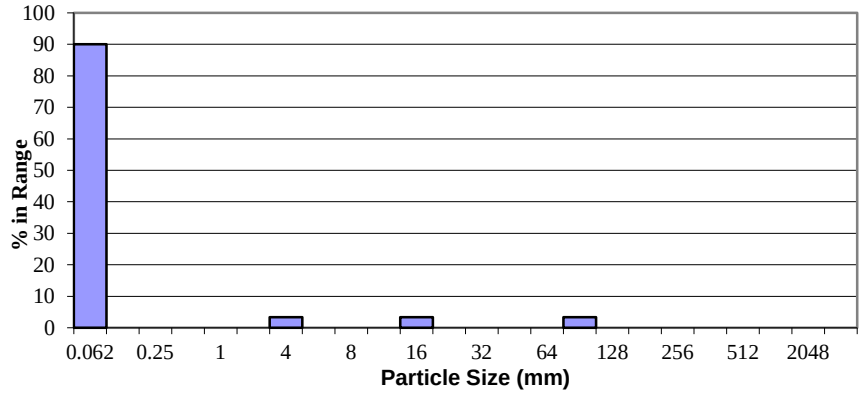


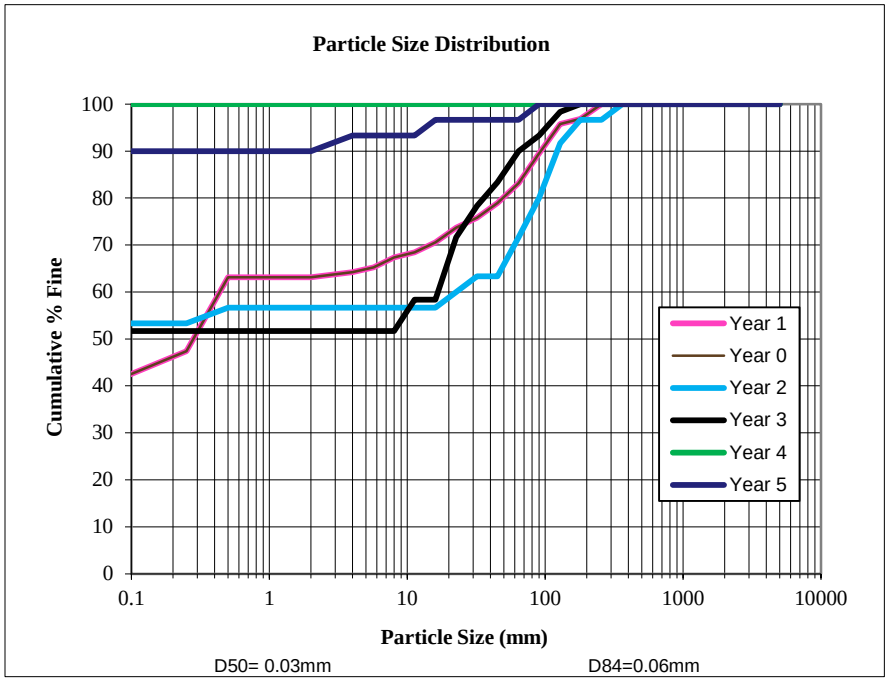


Pebble Count - Pool				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	54	90	90
Very Fine Sand	0.062-0.125	0	0	90
Fine Sand	0.125-0.25	0	0	90
Medium Sand	0.25-0.5	0	0	90
Coarse Sand	0.5-1.0	0	0	90
Very Coarse Sand	1.0-2.0	0	0	90
Very Fine Gravel	2.0-4.0	2	3	93
Fine Gravel	4.0-5.7	0	0	93
Fine Gravel	5.7-8.0	0	0	93
Medium Gravel	8.0-11.3	0	0	93
Medium Gravel	11.3-16.0	2	3	97
Coarse Gravel	16.0-22.6	0	0	97
Coarse Gravel	22.6-32	0	0	97
Very Coarse Gravel	32-45	0	0	97
Very Coarse Gravel	45-64	0	0	97
Small Cobble	64-90	2	3	100
Small Cobble	90-128	0	0	100
Large Cobble	128-180	0	0	100
Large Cobble	180-256	0	0	100
Small Boulder	256-362	0	0	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		60	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT1	**X Sec**	4
Date	05/14/13	**Sta No.**	5+31.80

Histogram

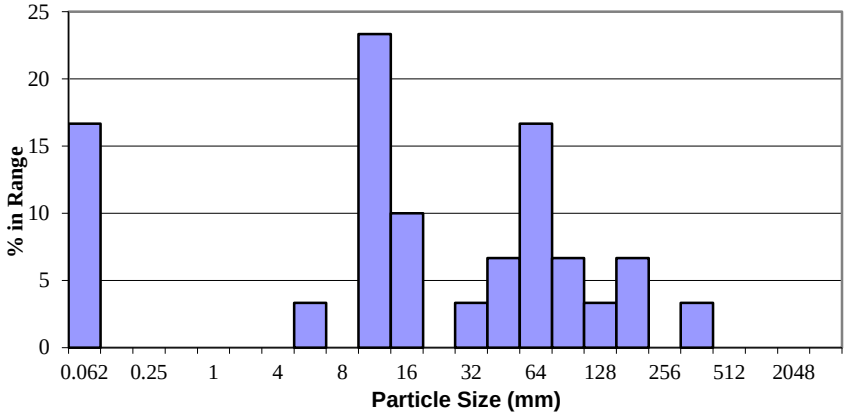


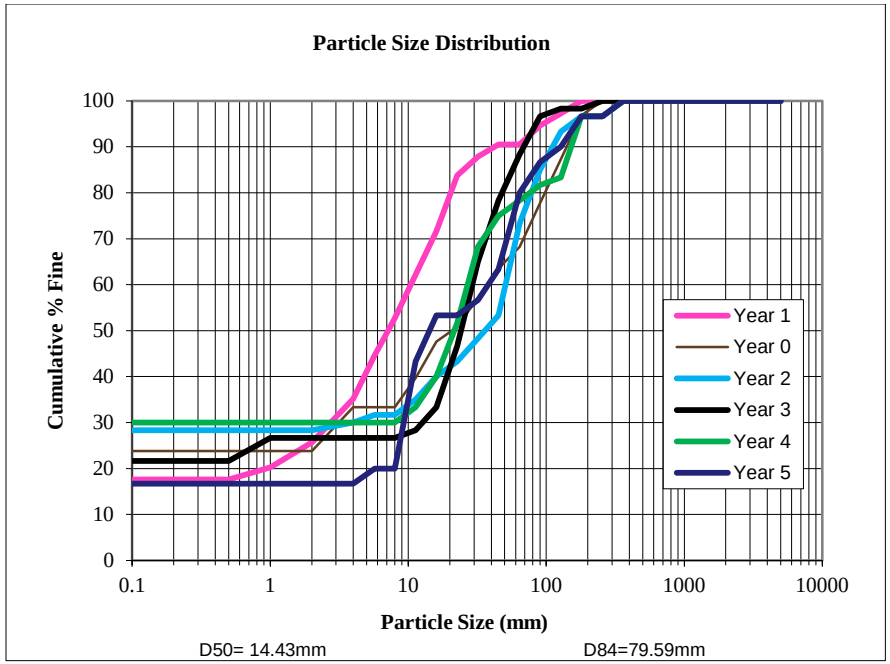


Pebble Count - Pool				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	10	17	17
Very Fine Sand	0.062-0.125	0	0	17
Fine Sand	0.125-0.25	0	0	17
Medium Sand	0.25-0.5	0	0	17
Coarse Sand	0.5-1.0	0	0	17
Very Coarse Sand	1.0-2.0	0	0	17
Very Fine Gravel	2.0-4.0	0	0	17
Fine Gravel	4.0-5.7	2	3	20
Fine Gravel	5.7-8.0	0	0	20
Medium Gravel	8.0-11.3	14	23	43
Medium Gravel	11.3-16.0	6	10	53
Coarse Gravel	16.0-22.6	0	0	53
Coarse Gravel	22.6-32	2	3	57
Very Coarse Gravel	32-45	4	7	63
Very Coarse Gravel	45-64	10	17	80
Small Cobble	64-90	4	7	87
Small Cobble	90-128	2	3	90
Large Cobble	128-180	4	7	97
Large Cobble	180-256	0	0	97
Small Boulder	256-362	2	3	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		60	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT1	**X Sec**	5
Date	05/14/13	**Sta No.**	17+31.58

Histogram

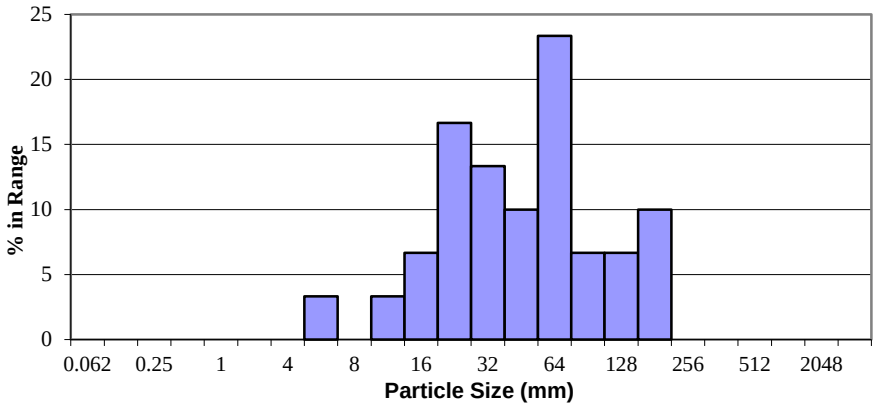


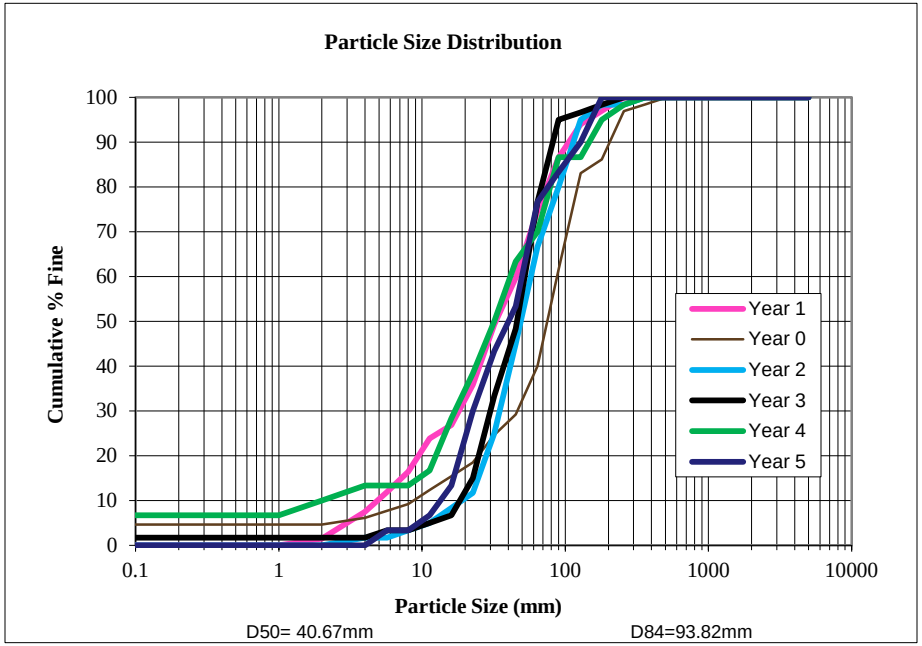


Pebble Count - Riffle				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	0	0	0
Very Fine Sand	0.062-0.125	0	0	0
Fine Sand	0.125-0.25	0	0	0
Medium Sand	0.25-0.5	0	0	0
Coarse Sand	0.5-1.0	0	0	0
Very Coarse Sand	1.0-2.0	0	0	0
Very Fine Gravel	2.0-4.0	0	0	0
Fine Gravel	4.0-5.7	2	3	3
Fine Gravel	5.7-8.0	0	0	3
Medium Gravel	8.0-11.3	2	3	7
Medium Gravel	11.3-16.0	4	7	13
Coarse Gravel	16.0-22.6	10	17	30
Coarse Gravel	22.6-32	8	13	43
Very Coarse Gravel	32-45	6	10	53
Very Coarse Gravel	45-64	14	23	77
Small Cobble	64-90	4	7	83
Small Cobble	90-128	4	7	90
Large Cobble	128-180	6	10	100
Large Cobble	180-256	0	0	100
Small Boulder	256-362	0	0	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		60	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	UT1	**X Sec**	6
Date	05/14/13	**Sta No.**	17+62.09

Histogram

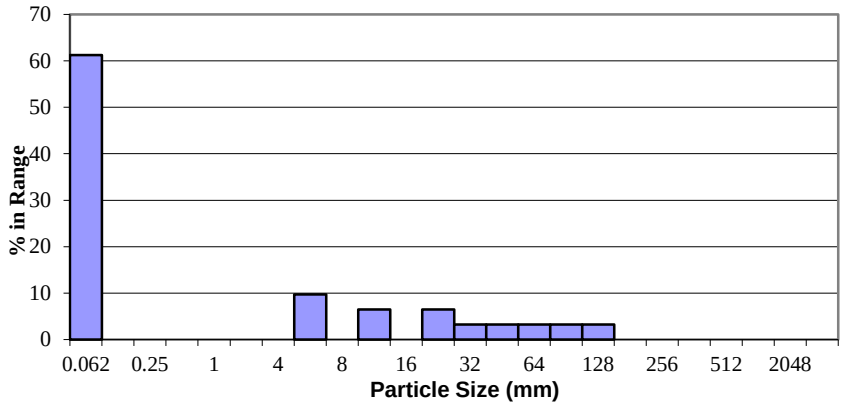


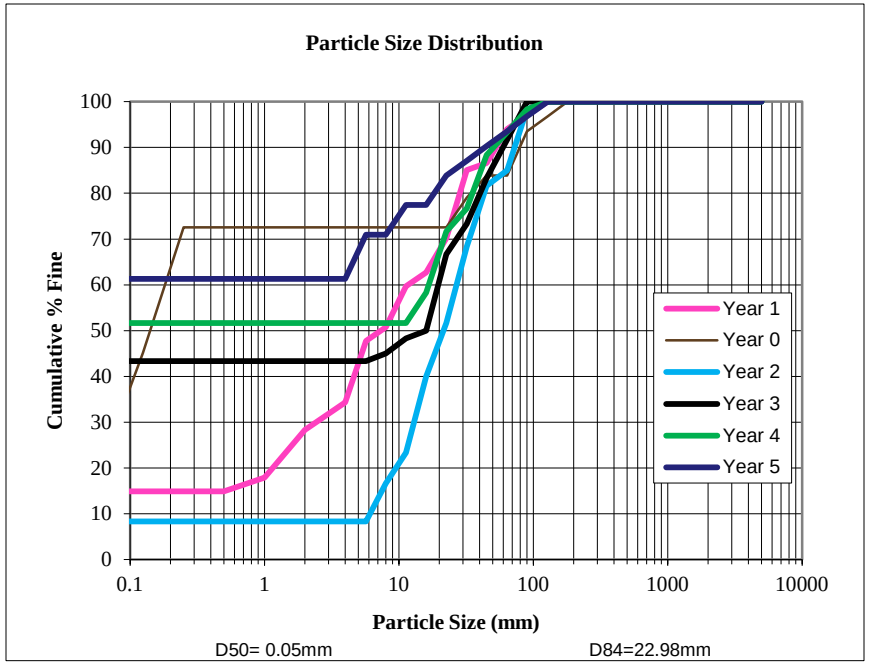


Pebble Count - Pool				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	38	61	61
Very Fine Sand	0.062-0.125	0	0	61
Fine Sand	0.125-0.25	0	0	61
Medium Sand	0.25-0.5	0	0	61
Coarse Sand	0.5-1.0	0	0	61
Very Coarse Sand	1.0-2.0	0	0	61
Very Fine Gravel	2.0-4.0	0	0	61
Fine Gravel	4.0-5.7	6	10	71
Fine Gravel	5.7-8.0	0	0	71
Medium Gravel	8.0-11.3	4	6	77
Medium Gravel	11.3-16.0	0	0	77
Coarse Gravel	16.0-22.6	4	6	84
Coarse Gravel	22.6-32	2	3	87
Very Coarse Gravel	32-45	2	3	90
Very Coarse Gravel	45-64	2	3	94
Small Cobble	64-90	2	3	97
Small Cobble	90-128	2	3	100
Large Cobble	128-180	0	0	100
Large Cobble	180-256	0	0	100
Small Boulder	256-362	0	0	100
Small Boulder	362-512	0	0	100
Medium Boulder	512-1024	0	0	100
Large Boulder	1024-2048	0	0	100
Bedrock	<2048	0	0	100
Totals		62	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	Beaverdam Creek	**X Sec**	7
Date	05/14/13	**Sta No.**	1+35.96

Histogram

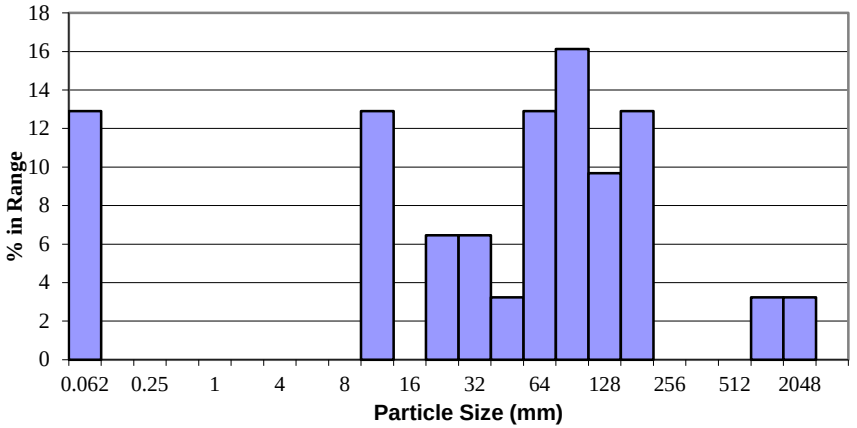




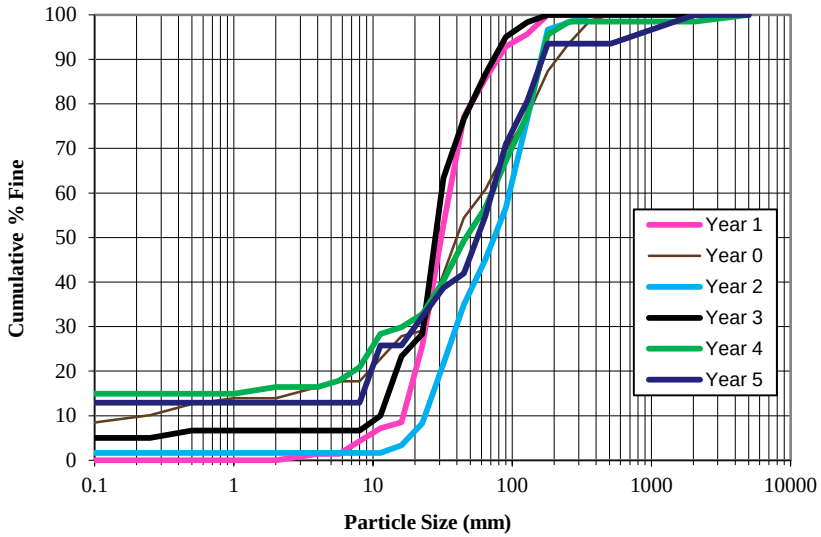
Pebble Count - Riffle				
Material	**Particle Size (mm)**	**Count**	**% in Range**	**% Cumulative**
Silt/Clay	<0.062	8	13	13
Very Fine Sand	0.062-0.125	0	0	13
Fine Sand	0.125-0.25	0	0	13
Medium Sand	0.25-0.5	0	0	13
Coarse Sand	0.5-1.0	0	0	13
Very Coarse Sand	1.0-2.0	0	0	13
Very Fine Gravel	2.0-4.0	0	0	13
Fine Gravel	4.0-5.7	0	0	13
Fine Gravel	5.7-8.0	0	0	13
Medium Gravel	8.0-11.3	8	13	26
Medium Gravel	11.3-16.0	0	0	26
Coarse Gravel	16.0-22.6	4	6	32
Coarse Gravel	22.6-32	4	6	39
Very Coarse Gravel	32-45	2	3	42
Very Coarse Gravel	45-64	8	13	55
Small Cobble	64-90	10	16	71
Small Cobble	90-128	6	10	81
Large Cobble	128-180	8	13	94
Large Cobble	180-256	0	0	94
Small Boulder	256-362	0	0	94
Small Boulder	362-512	0	0	94
Medium Boulder	512-1024	2	3	97
Large Boulder	1024-2048	2	3	100
Bedrock	<2048	0	0	100
Totals		62	100	

Beaverdam Creek Restoration EEP Project No. D06054-C			
Reach	Beaverdam Creek	**X Sec**	8
Date	05/14/13	**Sta No.**	1+44.70

Histogram



Particle Size Distribution



BF 1
Crest gage at 5+50 on UT1 (Year 1).
(EMH&T, 4/8/09)

BF 2
Crest gage at 5+50 on UT1 (Year 2).
(EMH&T, 9/19/10)

BF 3
Crest gage at 5+ 50 on UT1 (Year 3).
(EMH&T, 5/16/11)

BF 4
Crest gage at 5+ 50 on UT1 (Year 5).
(EMH&T, 5/14/13)

BF 5
Crest gage at 3+80 on Beaverdam Creek Mainstem and 22+75 on UT1, at the confluence of the two reaches (Year 1).
(EMH&T, 4/8/09)

BF 6
Crest gage at 3+80 on Beaverdam Creek Mainstem and 22+75 on UT1, at the confluence of the two reaches (Year 2).
(EMH&T, 9/19/10)

BF 7
Crest gage at 3+80 on Beaverdam Creek Mainstem and 22+75 on UT1, at the confluence of the two reaches (Year 3).
(EMH&T, 5/16/11)