

**Paschal Golf Course (Richland Creek)  
Stream Restoration Monitoring Report**

**EEP Project # 276  
EEP Contract # 004927  
Monitoring Year 04**



Submitted to:



NCEEP, 1652 Mail Service Center, Raleigh, NC 27699-1652

**Construction Completed: May 2010  
Data Collection: June 2014  
Submitted: January 2015**

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## 1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

The Paschal Golf Course (Richland Creek) Stream Restoration Site, completed in May 2010, restored a total of 2,919 linear feet of stream and 167,092 square feet of buffer restoration in the Neuse River Basin. The project is located in the USGS Hydrologic Unit 03020201-07-0060. This HU is within the EEP's Neuse River Basin Local Watershed Plan and is also listed as a Targeted Local Watershed (TLW) in EEP's *Neuse River Basin Restoration Priorities 2010*. The project goals and objectives are listed below.

### *Project Goals*

- Restore a stable channel morphology and floodplain to the project stream that is capable of moving the flows and sediment provided by its watershed.
- Improve water quality by reducing bank erosion and bed degradation.
- Provide a riparian management zone that is compatible with the surrounding uses (golf course and electrical transmission corridor) and yet retains the ecological function of the riparian zone.
- Enhance aquatic and terrestrial habitat in the stream corridor.

### *Project Objectives*

- Restore 2,919 linear feet of stable stream channel with the appropriate pattern, profile, and dimension that can support efficient sediment transport.
- Plant native trees and shrubs throughout the site.
- Grade a floodplain adjacent to the stream.

The vegetation monitoring success criterion for the planted stream riparian zone is a density of 320 stems/acre after the third year of monitoring and an allowance for 10% mortality in the fourth and fifth years with a final density of 260 stems/acre. Before the start of the MY-04 growing season the site was replanted in areas of low stem density. The fourth-year vegetation monitoring followed the Level 2 CVS-EEP vegetation monitoring protocol. The site's average density for this monitoring period was 410 planted stems/acre, including live stakes, and 387 planted stems/acre, excluding live stakes. Including volunteers, the site averaged 6,122 total stems/acre. Both of the vegetation monitoring plots in the streamside planting area (Plots 1 and 6) had planted stem densities below the fourth-year success criterion of 288 stems/acre. Of the plots in the buffer restoration area (Plots 2, 3, 4, 5, and 7), Plot 7 had a planted stem density below the fourth-year success criterion of 288 stems/acre. There were many loblolly pine and sweetgum volunteers throughout the easement; in certain areas these volunteers were extremely dense. In late summer of 2013, after the vegetation monitoring, the loblolly pine density was reduced to improve the condition of the site for the planted vegetation. Autumn olive (*Elaeagnus umbellata*) is scattered throughout the lower half of the site. This species appears to be a remnant left over from the pre-restoration conditions of the site as well as new volunteer stems from the nearby wooded area. See Figure 3, Current Condition Plan View, for further information on the occurrence of invasive species within the site.

Fourth-year monitoring found Richland Creek to be mostly stable, with only minor changes from the baseline conditions. The stream has three areas of localized bank erosion since construction (2% of all banks), and five areas displaying signs of mass wasting (1% of all banks). There is currently one headcut located approximately at Station 5+75, with one area along the stream experiencing bed deposition. Please see Appendix B Problem Area Photos. A repair plan for these isolated areas of instability is being prepared for implementation in 2015. The longitudinal and cross-sectional data also reflect the overall stability in the project streams. As a part of the stream success criterion, the stream must experience at least two bankfull events, each in separate monitoring years. The site has experienced multiple bankfull events since construction.

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

## **2.0 METHODOLOGY**

The survey data were collected with a total station instrument.

The stationing for the longitudinal profile is based on the thalweg stationing and has been adjusted to match grade control structures from previous longitudinal profiles.

The CVS-EEP protocol, Level 2 (<http://cvs.bio.unc.edu/methods.htm>) was used to collect vegetation data from the site.

## **3.0 REFERENCES**

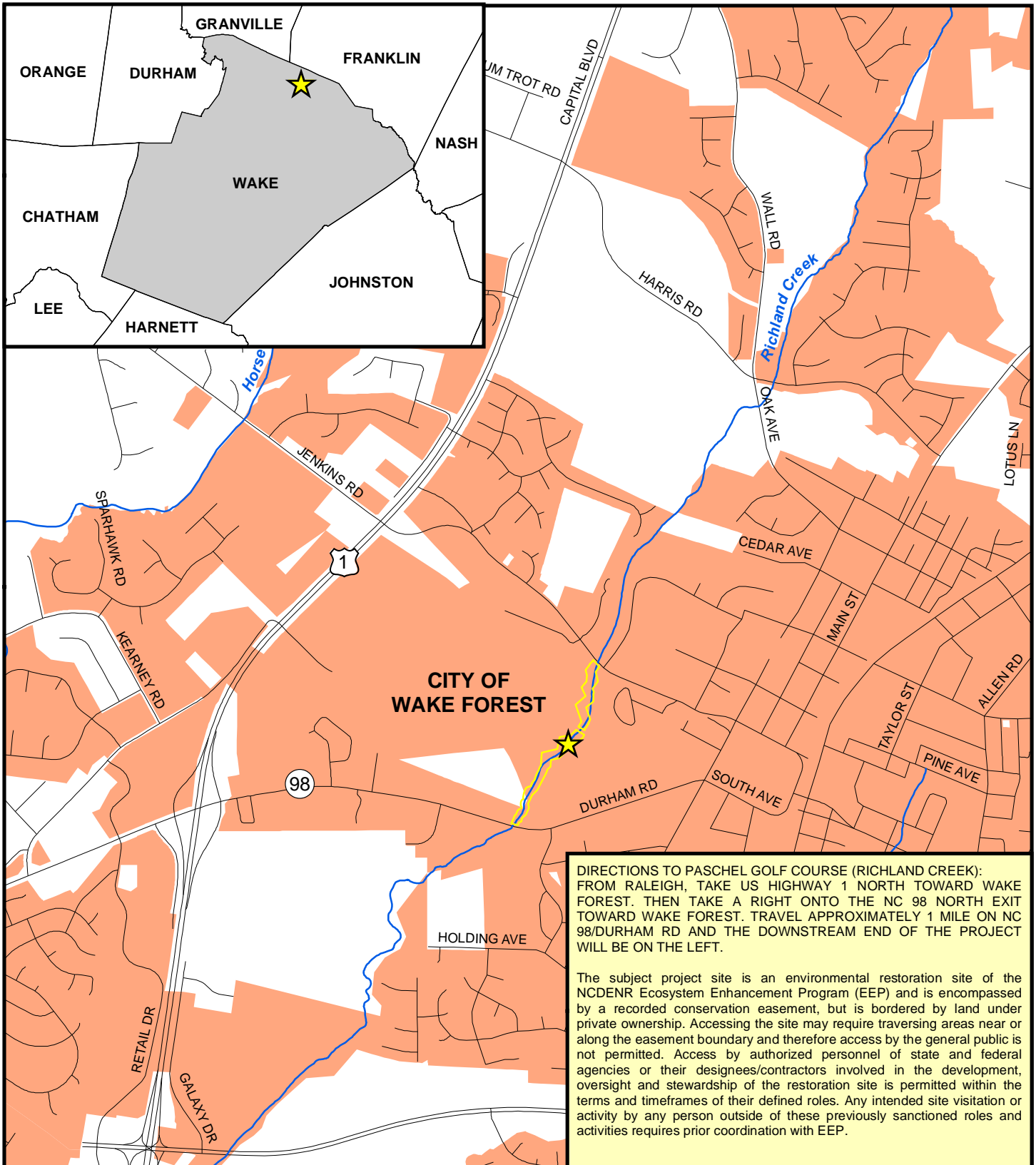
Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2006. CVS-EEP Protocol for Recording Vegetation, Version 4.0 (<http://cvs.bio.unc.edu/methods.htm>)

NCEEP. 2010. Neuse River Basin Restoration Priorities. ([http://portal.ncdenr.org/c/document\\_library/get\\_file?uuid=665be84c-cf93-477b-918c-1993778ef11f&groupId=60329](http://portal.ncdenr.org/c/document_library/get_file?uuid=665be84c-cf93-477b-918c-1993778ef11f&groupId=60329))

USACE. 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.






# **Appendix A**

## **Project Vicinity Map and Background Tables**



**Figure 1. Vicinity Map - Paschal Golf Course (Richland Creek), Project No. 276**



-  Project Location
-  Roads
-  Major Streams and Rivers
-  Municipalities
-  Project Easement

N  
 W — O — E  
 S

1:24,000

0.2 0.1 0 0.2  
 Miles



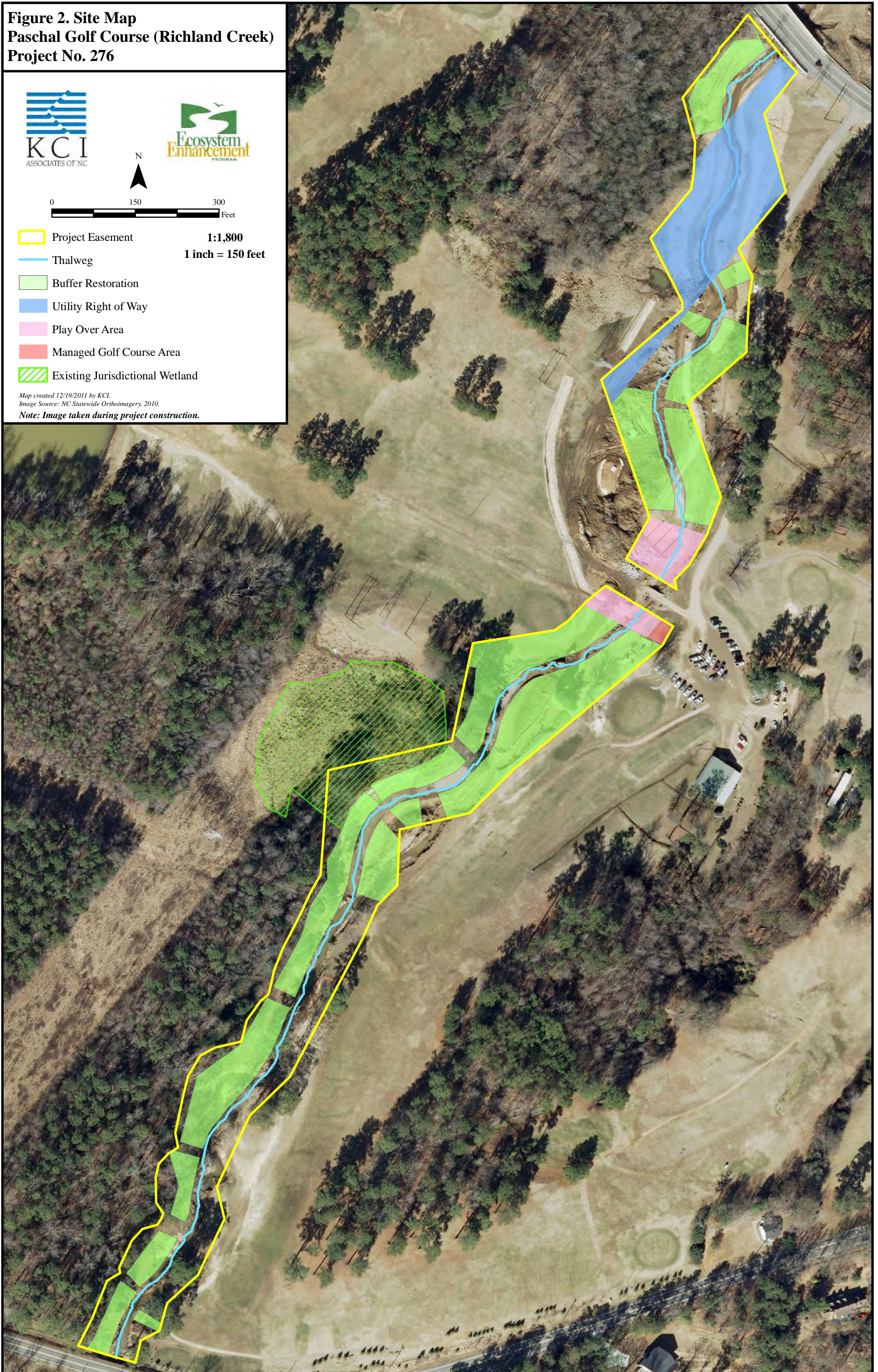
**Figure 2. Site Map**  
**Paschal Golf Course (Richland Creek)**  
**Project No. 276**



0 150 300  
 Feet

- 1:1,800**  
**1 inch = 150 feet**
- Project Easement
  - Thalweg
  - Buffer Restoration
  - Utility Right of Way
  - Play Over Area
  - Managed Golf Course Area
  - Existing Jurisdictional Wetland

*Map created 12/19/2011 by KCI.*  
*Image Source: NC Statewide Orthoimagery, 2010.*  
*Note: Image taken during project construction.*





**Table 1a. Project Components  
Paschal Golf Course (Richland Creek) / Project No. 276**

Project Component or Reach ID	Existing Feet/Acres	Restoration Level	Approach	Linear Footage or Square Feet*	Stationing	Mitigation Ratio	Mitigation Credits <sup>+</sup>	BMP Elements	Comment
Richland Creek	N/A	R	P2	2,919	10+00 - 39+80	1:1	2,766		In-stream structures, including offset rock cross vanes, riffle grade controls, and rock sills, were used to stabilize restored channel. Planted a riparian buffer.
Buffer		R		167,092.2		1:1	167,092.2		Buffer was planted with native vegetation.

\*Linear footage does not include the stream length that runs under a golf cart bridge through an easement exception. Square feet of buffer are limited to the areas of the buffer that meet the regulatory criteria for buffer restoration credit. See Figure 2 for the locations of the creditable buffer.

<sup>+</sup>The credits have been reduced to account for areas where the stream flows through vegetation management zones within the easement. These management areas are depicted on Figure 2. They include a utility right of way and a play over area for the golf course. Under the utility right of way the buffer will be allowed to grow to a height of 12'. Due to this restriction the 309 mitigation credits that would be generated by the stream in the right of way is reduced by 25% to 231 stream credits. The vegetation in the play over area will be trimmed to a few feet high. Due to this restriction, the 151 mitigation credits that would be generated by the stream in the play over area are reduced by 50% to 76 stream credits. There is 2,459 lf of stream that does not have any reductions and will generate 2,459 credits.

**Table 1b. Component Summations  
Paschal Golf Course (Richland Creek) / Project No. 276**

Restoration Level	Stream (lf)	Riparian Wetland (Ac)		Non-Ripar (Ac)	Upland (Ac)	Buffer (Ac)	BMP
		Riverine	Non-Riverine				
Restoration	2,919					3.84	
Enhancement							
Enhancement I							
Enhancement II							
Creation							
Preservation							
HQ Preservation							
		0	0				
<b>Totals (Feet/Acres)</b>	<b>2,919</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3.84</b>	<b>0</b>
<b>MU Totals</b>	<b>2,766</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>3.84</b>	<b>0</b>

<b>Table 2. Project Activity &amp; Reporting History</b> <b>Paschal Golf Course (Richland Creek) / Project No. 276</b>		
Elapsed Time Since Grading Complete: 4 yr 7 months Elapsed Time Since Planting Complete: 4 yr 7 months Number of Reporting Years: 4		
Activity or Report	Data Collection Complete	Actual Completion or Delivery
Restoration Plan	2004	June 2007
Final Design - Construction Plans		Sept 2007
Construction		May 2010
Planting		May 2010
Baseline Monitoring/Report	Aug 2010	Dec 2010
Year 1 Monitoring	Aug 2011	Dec 2011
Year 2 Monitoring	Aug 2012	Nov 2012
Year 3 Monitoring	Jun 2013	Dec 2013
Supplemental Planting		Feb 2014
Year 4 Monitoring	Jun 2014	Nov 2014

<b>Table 3. Project Contacts</b> <b>Paschal Golf Course (Richland Creek) / Project No. 276</b>	
<b>Designer</b>	EcoLogic Associates, P.C. 3808 Clifton Road Greensboro, NC 27407
Primary Project Design POC	Mark Taylor, PE (336) 632-4441
<b>Construction Contractor</b>	River Works 8000 Regency Parkway, Suite 200 Cary, NC 27518
Construction Contractor POC	William Pedersen (919) 459-9034
<b>Planting Contractor</b>	H + J Forest Service
Planting Contractor POC	Matt Hitch (910) 264-1612
<b>Monitoring Performers</b>	KCI Associates of North Carolina 4601 Six Forks Road, Suite 220 Raleigh, NC 27609
Monitoring POC	Adam Spiller (919) 278-2514

**Table 4. Project Attributes  
Paschal Golf Course (Richland Creek) / Project No. 276**

Project County	Wake County
Physiographic Region	Piedmont
Ecoregion	Northern Outer Piedmont
River Basin	Neuse
USGS HUC	03020201
NCDWQ Sub-Basin	03-04-02
Within Extent of EEP Watershed Plan	Yes - Draft - Neuse River Basin Restoration Priorities 2010
WRC Class	Warm
% of Project Easement Demarcated	70%, with wooden bollards
Beaver Activity Observed During Design Phase	Yes
<b>Restoration Component Attributes</b>	
Drainage Area (sq.mi.)	7.8
Stream Order	Second
Restored Length (feet)	2,919
Perennial or Intermittent	Perennial
Watershed Type	Suburban
Watershed LULC Distribution	
Forest/Wetland	35%
Agricultural/Managed Herbaceous	35%
Developed	30%
Watershed Impervious Cover	10%
NCDWQ AU/Index Number	27-21
NCDWQ Classification	C; NSW
303d Listed	U
Upstream of 303d Listed Segment	U
Reasons for 303d Listing or Stressor	U
Total Acreage of Easement	8.5
Total Vegetated Acreage within Easement	1.3
Total Planted Acreage as Part of Restoration	7.2
Rosgen Classification of Pre-Existing	C4/F4
Rosgen Classification of As-Built	C4
Valley Type	-
Valley Slope	0.002
Valley Side Slope Range	-
Valley Toe Slope Range	-
Cowardin Classification	-
Trout Waters Designation	No
Species of Concern, Endangered, Etc.	None
Dominant Soil Series and Characteristics	
Series	Chewacla
Depth	Deep
Clay%	-
K	-
T	-

"N/A" is for items that do not apply.

"-" is for items that are unavailable.

"U" is for items that are unknown.

# **Appendix B**

## **Visual Assessment Data**



**LEGEND**

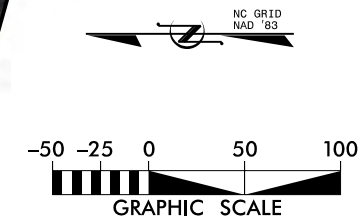
- EASEMENT BOUNDARY.....
- AS-BUILT STATIONED CENTERLINE, TOP OF BANK, AND TOP OF TERRACE.....
- PHOTO POINT.....
- CROSS-SECTION.....
- OLD STREAM CHANNEL.....

**PROJECT CONDITION**

- STREAM BED DEGRADATION.....
- STREAM BED DEPOSITION.....
- BANK EROSION.....
- MASS WASTING OF BANK.....
- VEG PLOT ACHIEVING DENSITY CRITERION.....
- VEG PLOT BELOW DENSITY CRITERION.....
- INVASIVE SPECIES.....

**PROJECT CONDITION DETAILS**

VEG PLOT TOTAL / PLANTED STEM DENSITY ..... **6122/387**  
 STRUCTURE PIPING..... **P**  
 STRUCTURE NOT PROTECTING BANK..... **B**



NO.	DATE	APPROVED

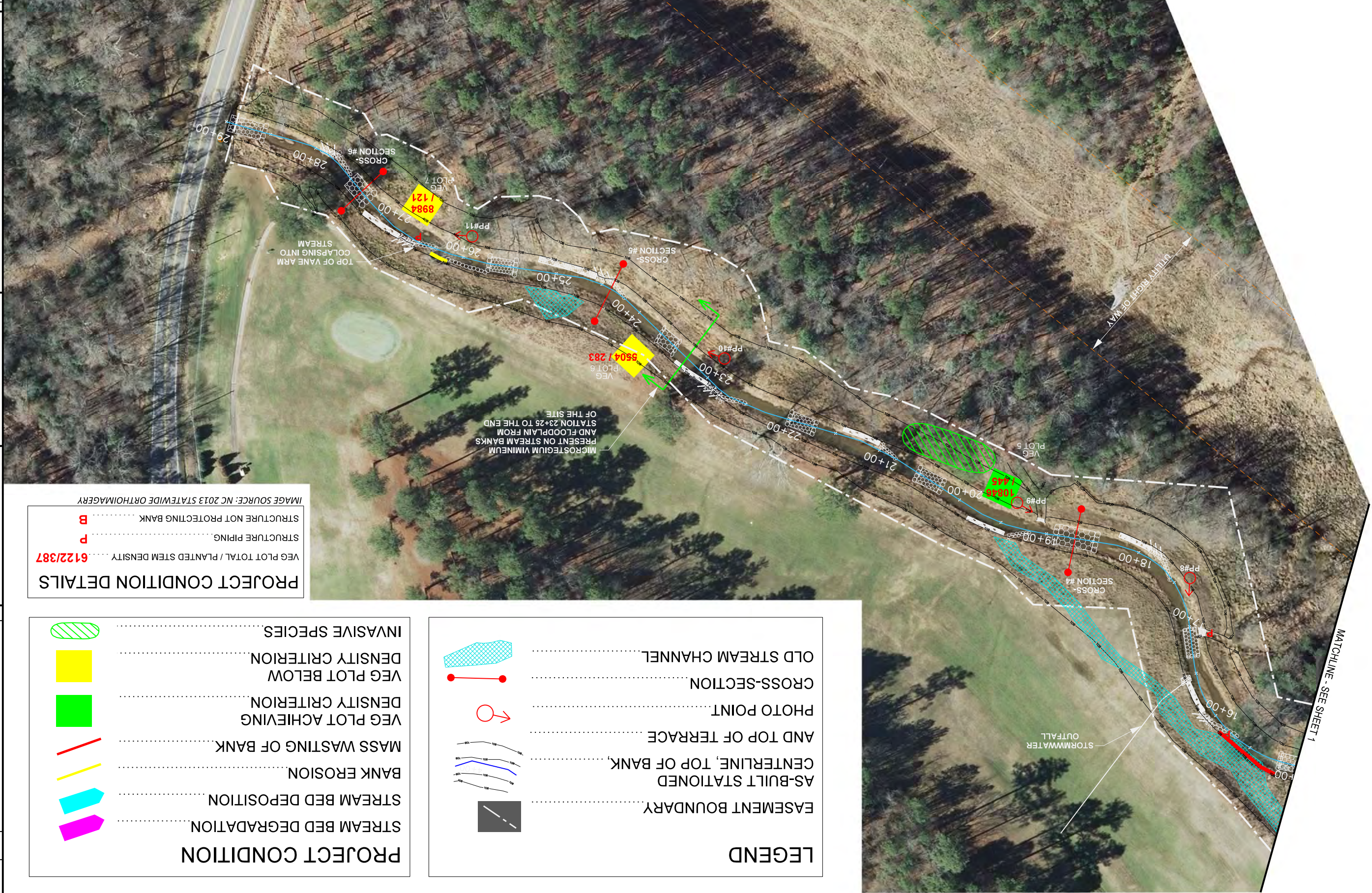


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PASCHAL GOLF COURSE (RICHLAND CREEK)  
 PROJECT #276 - MONITORING YEAR 4  
 WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

DATE: NOV 2014
SCALE: 1" = 100'
FIGURE 3
CURRENT CONDITION PLAN VIEW
SHEET 1 OF 2

IMAGE SOURCE: NC 2013 STATEWIDE ORTHOIMAGERY



### LEGEND

- EASEMENT BOUNDARY
- AS-BUILT STATIONED CENTERLINE, TOP OF BANK AND TOP OF TERRACE
- PHOTO POINT
- CROSS-SECTION
- OLD STREAM CHANNEL

### PROJECT CONDITION

- STREAM BED DEGRADATION
- STREAM BED DEPOSITION
- BANK EROSION
- MASS WASTING OF BANK
- VEG PLOT ACHIEVING DENSITY CRITERION
- VEG PLOT BELOW DENSITY CRITERION
- INVASIVE SPECIES

### PROJECT CONDITION DETAILS

VEG PLOT TOTAL / PLANTED STEM DENSITY ..... 6122/387

STRUCTURE PIPING ..... P

STRUCTURE NOT PROTECTING BANK ..... B

IMAGE SOURCE: NC 2013 STATEWIDE ORTHOIMAGERY



DATE: NOV 2014  
 SCALE: 1" = 100'  
 FIGURE 3  
 CURRENT CONDITION  
 PLAN VIEW  
 SHEET 2 OF 2

PASCHAL GOLF COURSE (RICHLAND CREEK)  
 PROJECT #276 - MONITORING YEAR 4  
 WAKE FOREST, WAKE COUNTY, NORTH CAROLINA

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 RALEIGH, NORTH CAROLINA 27609

**Ecosystem**  
 Environmental  
 PROGRAM

NO.	DATE	DESCRIPTION	APPROVED

MATCHLINE - SEE SHEET 1

<b>Table 5. Visual Stream Morphology Stability Assessment</b>							
<b>Project Number and Name: 276 - Paschal Golf Course (Richland Creek)</b>							
<b>Assessed Length 2,919</b>				<b>Reach - Richland Creek</b>			
<b>Major Channel Category</b>	<b>Channel Sub-Category</b>	<b>Metric</b>	<b>Number Stable, Performing as Intended</b>	<b>Total Number in As-built</b>	<b>Number of Unstable Segments</b>	<b>Amount of Unstable Footage</b>	<b>% Stable, Performing as Intended</b>
<b>1. Bed</b>	<b>1. Vertical Stability</b> (Riffle and Run units)	1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			1	30	99%
		2. <u>Degradation</u> - Evidence of downcutting			0	0	100%
	<b>2. Riffle Condition</b>	1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate	17	17			100%
	<b>3. Meander Pool Condition</b>	1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth $\geq$ 1.6) 2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	13	13			100%
			13	13			100%
	<b>4. Thalweg Position</b>	1. Thalweg centering at upstream of meander bend (Run) 2. Thalweg centering at downstream of meander (Glide)	17	17			100%
17			17			100%	
<b>2. Bank</b>	<b>1. Scoured/Eroding</b>	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			3	60	99%
	<b>2. Undercut</b>	Banks undercut/overhanging to the extent that mass wasting appears likely. Does <u>NOT</u> include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%
	<b>3. Mass Wasting</b>	Bank slumping, calving, or collapse			5	185	97%
<b>Totals</b>					<b>8</b>	<b>245</b>	<b>96%</b>
<b>3. Engineered Structures</b>	<b>1. Overall Integrity</b>	Structures physically intact with no dislodged boulders or logs.	16	16			100%
	<b>2. Grade Control</b>	Grade control structures exhibiting maintenance of grade across the sill.	15	15			100%
	<b>2a. Piping</b>	Structures lacking any substantial flow underneath sills or arms.	1	2			50%
	<b>3. Bank Protection</b>	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	14	16			88%
	<b>4. Habitat</b>	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio $\geq$ 1.6 Rootwads/logs providing some cover at base-flow.	16	16			100%

<b>Table 6. Vegetation Condition Assessment</b>						
<b>Project Number and Name: 276 - Paschal Golf Course (Richland Creek)</b>						
<b>Planted Acreage 7.2</b>			<b>Easement Acreage 8.5</b>			
<b>Vegetation Category</b>	<b>Definitions</b>	<b>Mapping Threshold</b>	<b>CCPV Depiction</b>	<b>Number of Polygons</b>	<b>Combined Acreage</b>	<b>% of Planted Acreage</b>
<b>1. Bare Areas</b>	Very limited cover of both woody and herbaceous material.	0.1 acre	Pattern and Color	0	0.00	0.0%
<b>2. Low Stem Density Areas</b>	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acre	Pattern and Color	0	0.00	0.0%
<b>Total</b>				<b>0</b>	<b>0.00</b>	<b>0.0%</b>
<b>3. Areas of Poor Growth Rates or Vigor</b>	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acre	Pattern and Color	0	0.00	0.0%
<b>Cumulative Total</b>				<b>0</b>	<b>0.00</b>	<b>0.0%</b>
<b>4. Invasive Areas of Concern</b>	Areas or points (if too small to render as polygons at map scale).	1,000 SF	Pattern and Color	2	1.35	15.9%
<b>5. Easement Encroachment Areas</b>	Areas or points (if too small to render as polygons at map scale).	none	Pattern and Color	0	0.00	0.0%



## Stream Station Photos



Photo Point #1 – Looking upstream at fish ramp 8/6/2010– Baseline



Photo Point #1 – Looking upstream at fish ramp 11/10/2014 MY-04



Photo Point #2 – Looking downstream 8/6/2010– Baseline



Photo Point #2 – Looking downstream 11/10/2014 MY-04



Photo Point #2 – Looking upstream 8/6/2010– Baseline



Photo Point #2 – Looking upstream 11/10/2014 MY-04



Photo Point #3 – Looking downstream 8/6/2010– Baseline



Photo Point #3 – Looking downstream 11/10/2014 MY-04



Photo Point #3 – Looking upstream 8/6/2010– Baseline



Photo Point #3 – Looking upstream 11/10/2014 MY-04



Photo Point #4 – Looking downstream 8/6/2010– Baseline



Photo Point #4 – Looking downstream 11/10/2014 MY-04



Photo Point #4 – Looking upstream 8/6/2010– Baseline



Photo Point #4 – Looking upstream 11/10/2014 MY-04



Photo Point #5 – Looking upstream from bridge 8/6/2010– Baseline



Photo Point #5 – Looking upstream from bridge 11/10/2014 MY-04



Photo Point #6 – 8/6/2010 – Baseline



Photo Point #6 – 11/10/2014 MY-04



Photo Point #7 – 8/6/2010 – Baseline



Photo Point #7 – 11/10/2014 MY-04



Photo Point #8 – 8/6/2010 – Baseline



Photo Point #8 – 11/10/2014 MY-04



Photo Point #9 – 8/6/2010 – Baseline



Photo Point #9 – 11/10/2014 MY-04



Photo Point #10 – 8/6/2010 – Baseline



Photo Point #10 – 11/10/2014 MY-04



Photo Point #11 – 8/6/2010– Baseline



Photo Point #11 – 11/10/2014 MY-04

## Problem Area Photos



Station 1+00 Right Bank – 11/10/2014



Station 11+75 – 11/15/2013



Station 15+65 Right Bank – 11/15/2013

## Vegetation Plot Photos



Veg Plot #1 – 6/13/2014



Veg Plot #2 – 6/13/2014



Veg Plot #3 – 6/16/2014



Veg Plot #4 – 6/13/2014

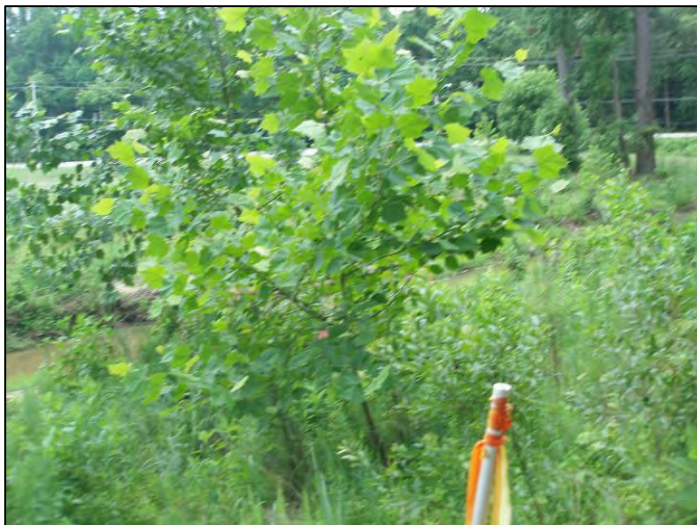


Veg Plot #5 – 6/13/2014



Veg Plot #6 – 6/13/2014





Veg Plot #7 – 6/13/2014

# **Appendix C**

## **Vegetation Plot Data**

<b>Table 7. Vegetation Plot Criteria Attainment</b>				
<b>Paschal Golf Course (Richland Creek) / Project No. 276</b>				
<b>Stream Vegetation Totals (per acre)</b>				
<b>Plot ID</b>	<b><sup>1</sup>Stream Stems</b>	<b><sup>2</sup>Volunteers</b>	<b><sup>3</sup>Total</b>	<b>Success Criteria Met?</b>
1	162	162	688	No
6	283	283	5,504	Yes
Project Avg	223	223	3,177	
<b>Buffer Vegetation Totals (per acre)</b>				
<b>Plot ID</b>	<b><sup>4</sup>Buffer Stems</b>	<b>Success Criteria Met?</b>		
2	647	Yes		
3	567	Yes		
4	486	Yes		
5	445	Yes		
7	122	No		
Project Avg	387			

<sup>1</sup>Stream Stems Native planted woody stems. Includes shrubs, does NOT include live stakes.

<sup>2</sup>Volunteers Native woody stems. NOT planted.

<sup>3</sup>Total Planted + volunteer native woody stems. Includes live stakes.

<b>Table 8. CVS Vegetation Plot Metadata Paschal Golf Course (Richland Creek ) / Project No. 276</b>	
<b>Report Prepared By</b>	Dale Pihoda
<b>Date Prepared</b>	6/16/2014 15:52
<b>database name</b>	KCI-2013-R.mdb
<b>database location</b>	M:\2012\16122606_Richland Creek Monitoring\Veg
<b>computer name</b>	12-3ZV4FP1
<b>DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT-----</b>	
<b>Metadata</b>	Description of database file, the report worksheets, and a summary of project(s) and project data.
<b>Proj, planted</b>	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
<b>Proj, total stems</b>	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.
<b>Plots</b>	List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).
<b>Vigor</b>	Frequency distribution of vigor classes for stems for all plots.
<b>Vigor by Spp</b>	Frequency distribution of vigor classes listed by species.
<b>Damage</b>	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
<b>Damage by Spp</b>	Damage values tallied by type for each species.
<b>Damage by Plot</b>	Damage values tallied by type for each plot.
<b>Planted Stems by Plot and Spp</b>	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
<b>PROJECT SUMMARY-----</b>	
<b>Project Code</b>	304
<b>project Name</b>	Richland Creek
<b>Description</b>	
<b>River Basin</b>	Neuse
<b>length(ft)</b>	
<b>stream-to-edge width (ft)</b>	
<b>area (sq m)</b>	
<b>Required Plots (calculated)</b>	

**Table 9. CVS Stem Count Total and Planted by Plot and Species**  
**Paschal Golf Course (Richland Creek ) / Project No. 276**

			Current Plot Data (MY4 2014)																	
Scientific Name	Common Name	Species Type	E304-01-0001			E304-01-0002			E304-01-0003			E304-01-0004			E304-01-0005			E304-01-0006		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree			2														1	
Alnus serrulata	hazel alder	Shrub				4	4	4	1	1	1			1						
Aronia arbutifolia	Red Chokeberry	Shrub							1	1	1	2	2	2	1	1	1	3	3	3
Baccharis	baccharis	Shrub																		
Baccharis halimifolia	eastern baccharis	Shrub									3			7		2			1	
Betula nigra	river birch	Tree											107			8				
Celtis	hackberry	Tree																		
Celtis laevigata	sugarberry	Tree										1	1	1	1	1	1			
Celtis occidentalis	common hackberry	Tree																		
Cephalanthus occidentalis	common buttonbush	Shrub				1	1	1	1	1	1				1	1	1		1	
Clethra alnifolia	coastal sweetpepperbush	Shrub	1	1	1	2	2	2												
Cornus amomum	silky dogwood	Shrub	3	3	3		1	1	1	1	1	1	1	1		1	2			
Diospyros virginiana	common persimmon	Tree				1	1	4				1	1	1			1		1	
Fraxinus pennsylvanica	green ash	Tree			1				4	4	4	2	2	2	2	2	2	1	1	2
Juniperus virginiana	eastern redcedar	Tree												7						
Liquidambar styraciflua	sweetgum	Tree			8			15			3			6			125		64	
Liriodendron tulipifera	tuliptree	Tree				3	3	3	1	1	1						4		2	
Morella cerifera	wax myrtle	shrub															2		1	
Nyssa sylvatica	blackgum	Tree																		
Pinus taeda	loblolly pine	Tree			2			69			35			101			103		55	
Platanus occidentalis	American sycamore	Tree				4	4	7	5	5	5	5	5	7			2	2	3	
Quercus laurifolia	laurel oak	Tree													1	1	1			
Quercus michauxii	swamp chestnut oak	Tree																1	1	1
Quercus nigra	water oak	Tree																		
Quercus palustris	pin oak	Tree													1	1	1			
Quercus phellos	willow oak	Tree						1							4	4	11			
Salix nigra	black willow	Tree						3			1									
Salix sericea	silky willow	Shrub				1	3	3												
Sambucus canadensis	Common Elderberry	Shrub																		
Ulmus alata	winged elm	Tree																		
Ulmus americana	American elm	Tree						4									1		1	
Unknown		Shrub or Tree																		
Viburnum dentatum	southern arrowwood	Shrub																		
<b>Stem count</b>			4	4	17	16	19	117	14	14	56	12	12	243	11	12	268	7	7	136
<b>size (ares)</b>			1			1			1			1			1			1		
<b>size (ACRES)</b>			0.02			0.02			0.02			0.02			0.02			0.02		
<b>Species count</b>			2	2	6	7	8	13	7	7	11	6	6	12	7	8	17	4	4	13
<b>Stems per ACRE</b>			162	162	688	647	769	4735	567	567	2266	486	486	9834	445	486	10846	283	283	5504



# **Appendix D**

## **Stream Survey Data**

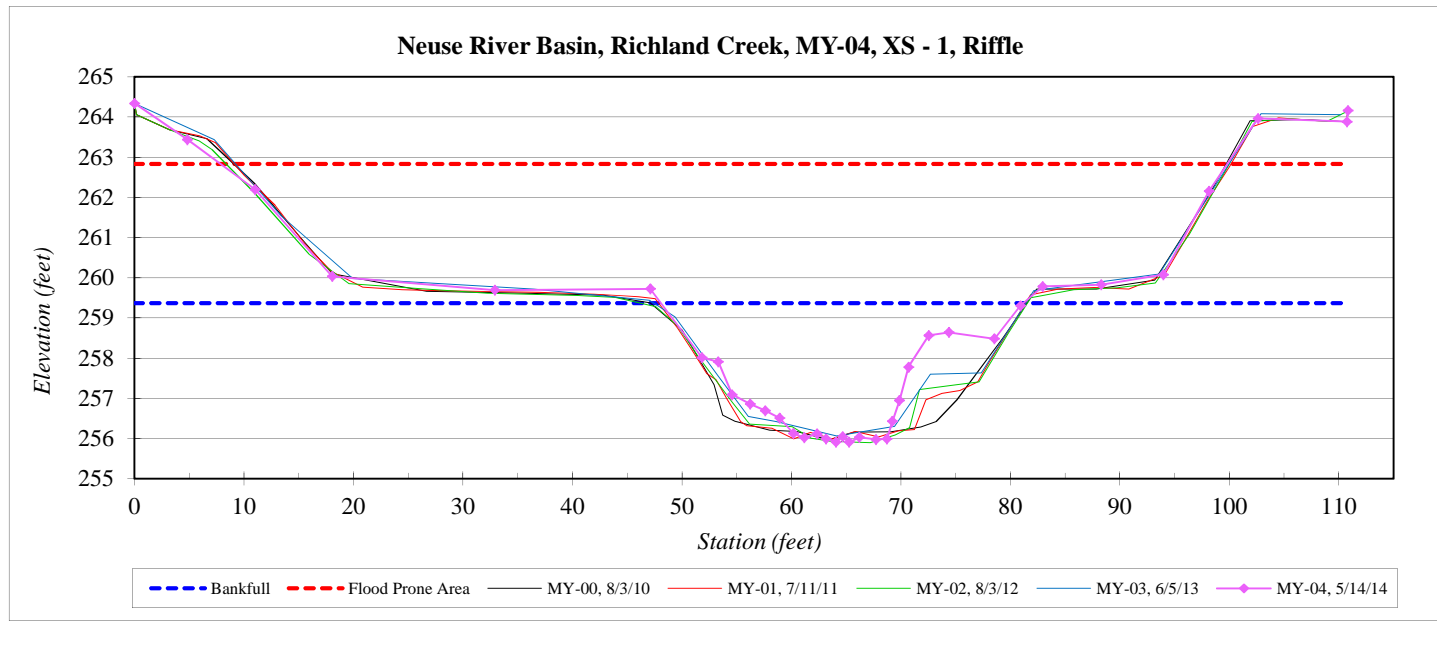
## Cross-Section Plots

<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 1, Riffle
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/13/2014
<b>Field Crew:</b>	T. Seelinger, D. Prihoda



Station	Elevation
0.0	264.34
4.8	263.44
11.0	262.20
18.1	260.04
32.9	259.69
47.1	259.73
51.8	258.01
53.3	257.91
54.6	257.09
56.2	256.86
57.6	256.69
58.9	256.51
60.2	256.12
61.2	256.02
62.3	256.11
63.2	255.99
64.1	255.91
64.7	256.04
65.3	255.91
66.2	256.03
67.7	255.97
68.7	255.99
69.2	256.43
69.9	256.94
70.7	257.77
72.6	258.57
74.4	258.64
78.6	258.48
80.9	259.31
83.0	259.78
88.3	259.83
94.0	260.08
98.1	262.15
102.6	263.97
110.7	263.89
110.8	264.16

SUMMARY DATA	
<b>Bankfull Elevation:</b>	259.4
<b>Bankfull Cross-Sectional Area:</b>	63.8
<b>Bankfull Width:</b>	33.1
<b>Flood Prone Area Elevation:</b>	262.8
<b>Flood Prone Width:</b>	92.1
<b>Max Depth at Bankfull:</b>	3.5
<b>Mean Depth at Bankfull:</b>	1.9
<b>W / D Ratio:</b>	17.2
<b>Entrenchment Ratio:</b>	2.8
<b>Bank Height Ratio:</b>	1.1



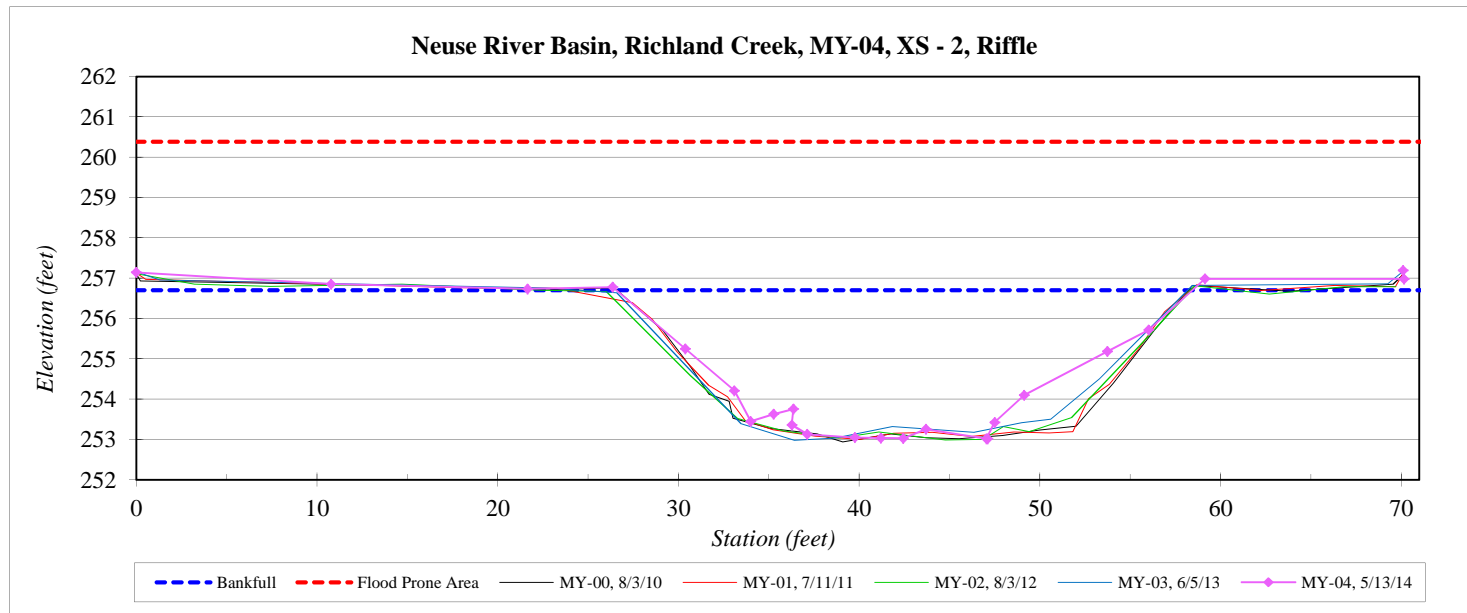


<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 2, Riffle
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/13/2014
<b>Field Crew:</b>	T. Seelinger, D. Pihoda



Station	Elevation
0.0	257.14
0.0	256.85
10.9	256.73
15.6	256.78
19.6	255.25
22.3	254.21
23.2	253.45
24.5	253.63
25.6	253.75
25.5	253.36
26.4	253.13
29.0	253.05
30.4	253.04
31.7	253.03
32.9	253.25
36.3	253.02
36.3	253.01
36.7	253.42
38.4	254.10
43.0	255.18
45.2	255.71
48.4	256.98
59.4	256.98
59.3	257.19

SUMMARY DATA	
<b>Bankfull Elevation:</b>	256.7
<b>Bankfull Cross-Sectional Area:</b>	76.3
<b>Bankfull Width:</b>	31.9
<b>Flood Prone Area Elevation:</b>	260.4
<b>Flood Prone Width:</b>	92.1
<b>Max Depth at Bankfull:</b>	3.7
<b>Mean Depth at Bankfull:</b>	2.4
<b>W / D Ratio:</b>	13.3
<b>Entrenchment Ratio:</b>	2.9
<b>Bank Height Ratio:</b>	1.0

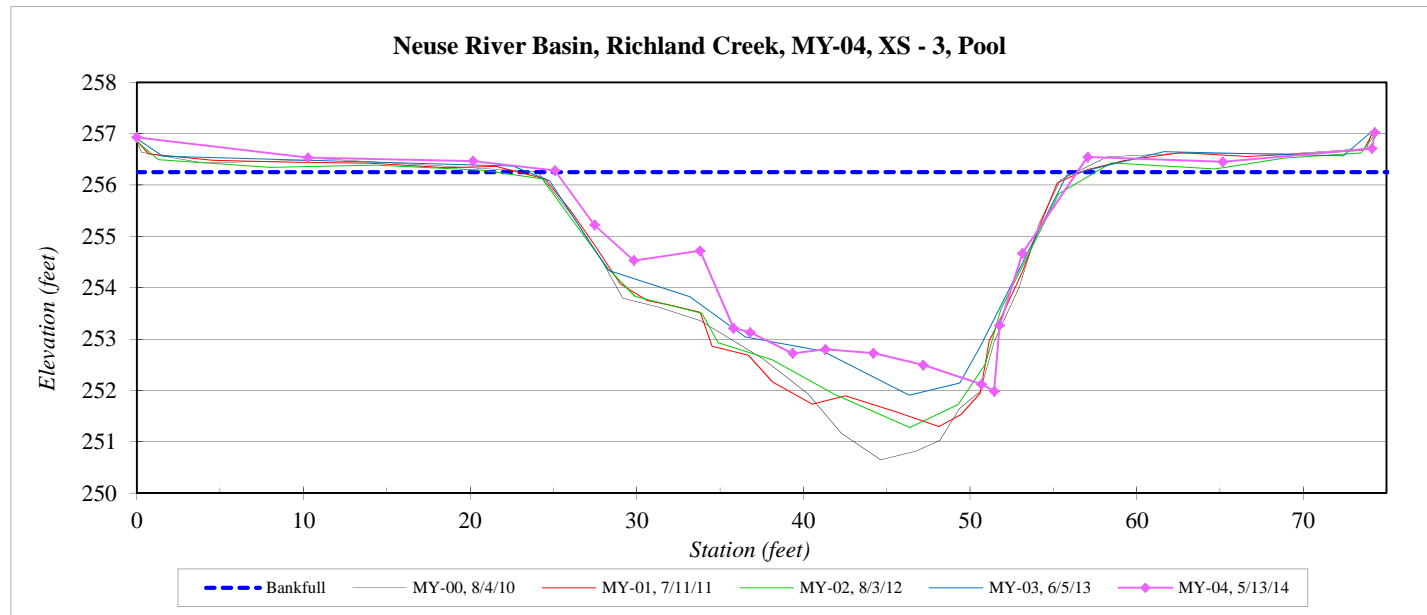


<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 3, Pool
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/13/2014
<b>Field Crew:</b>	T. Seelinger, D. Prihoda



Station	Elevation
0.0	256.93
10.3	256.53
20.2	256.47
25.1	256.29
27.5	255.22
29.8	254.53
33.8	254.72
35.8	253.21
36.8	253.13
39.4	252.72
41.3	252.80
44.2	252.72
47.2	252.49
50.7	252.12
51.5	251.98
51.8	253.26
53.1	254.67
57.1	256.55
65.2	256.45
74.1	256.71
74.3	257.02

SUMMARY DATA	
<b>Bankfull Elevation:</b>	256.3
<b>Bankfull Cross-Sectional Area:</b>	78.9
<b>Bankfull Width:</b>	31.3
<b>Flood Prone Area Elevation:</b>	-
<b>Flood Prone Width:</b>	-
<b>Max Depth at Bankfull:</b>	4.3
<b>Mean Depth at Bankfull:</b>	2.5
<b>W / D Ratio:</b>	12.4
<b>Entrenchment Ratio:</b>	-
<b>Bank Height Ratio:</b>	-

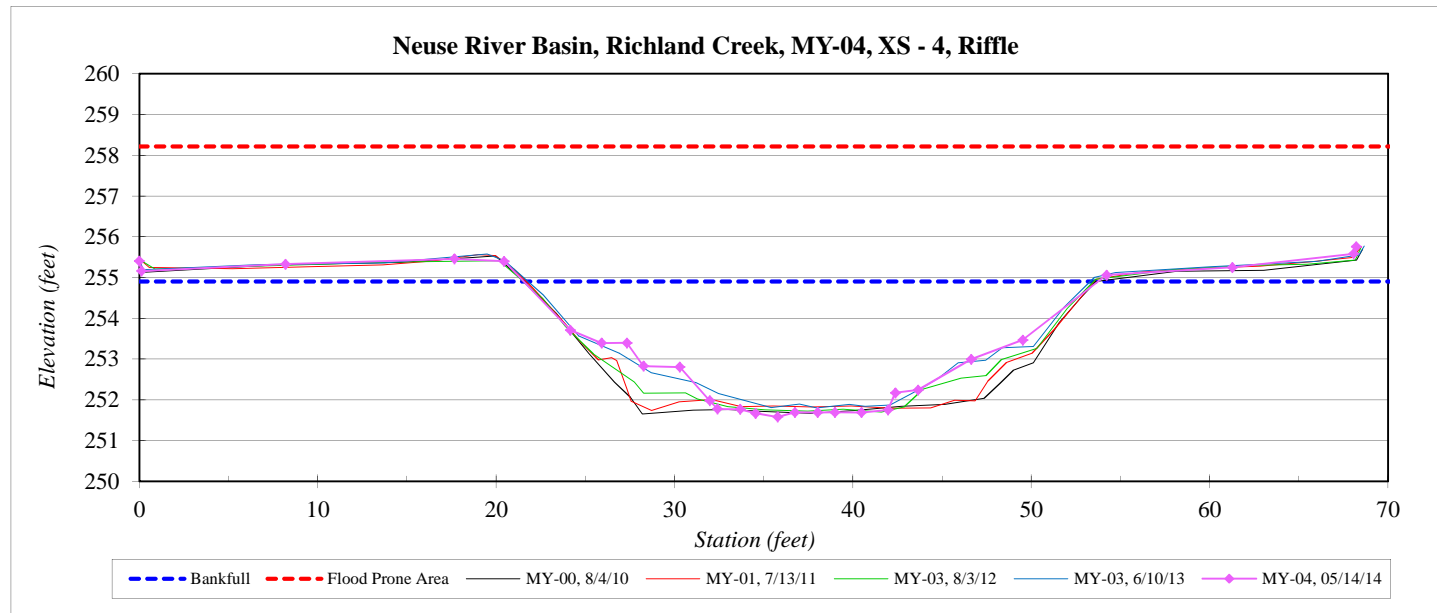


<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 4, Riffle
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/14/2014
<b>Field Crew:</b>	T. Seelinger, D. Prihoda



Station	Elevation
0.0	255.40
0.1	255.16
8.2	255.33
17.7	255.46
20.5	255.40
24.2	253.71
25.9	253.39
27.3	253.40
28.3	252.83
30.3	252.80
32.0	251.98
32.4	251.78
33.7	251.77
34.5	251.67
35.8	251.58
36.8	251.69
38.0	251.69
39.0	251.69
40.5	251.69
42.0	251.75
42.4	252.17
43.7	252.24
46.6	253.00
49.5	253.47
54.2	255.06
61.3	255.25
68.1	255.58
68.2	255.76

SUMMARY DATA	
<b>Bankfull Elevation:</b>	254.9
<b>Bankfull Cross-Sectional Area:</b>	67.2
<b>Bankfull Width:</b>	32.2
<b>Flood Prone Area Elevation:</b>	258.2
<b>Flood Prone Width:</b>	70.0
<b>Max Depth at Bankfull:</b>	3.3
<b>Mean Depth at Bankfull:</b>	2.1
<b>W / D Ratio:</b>	15.4
<b>Entrenchment Ratio:</b>	2.2
<b>Bank Height Ratio:</b>	1.0

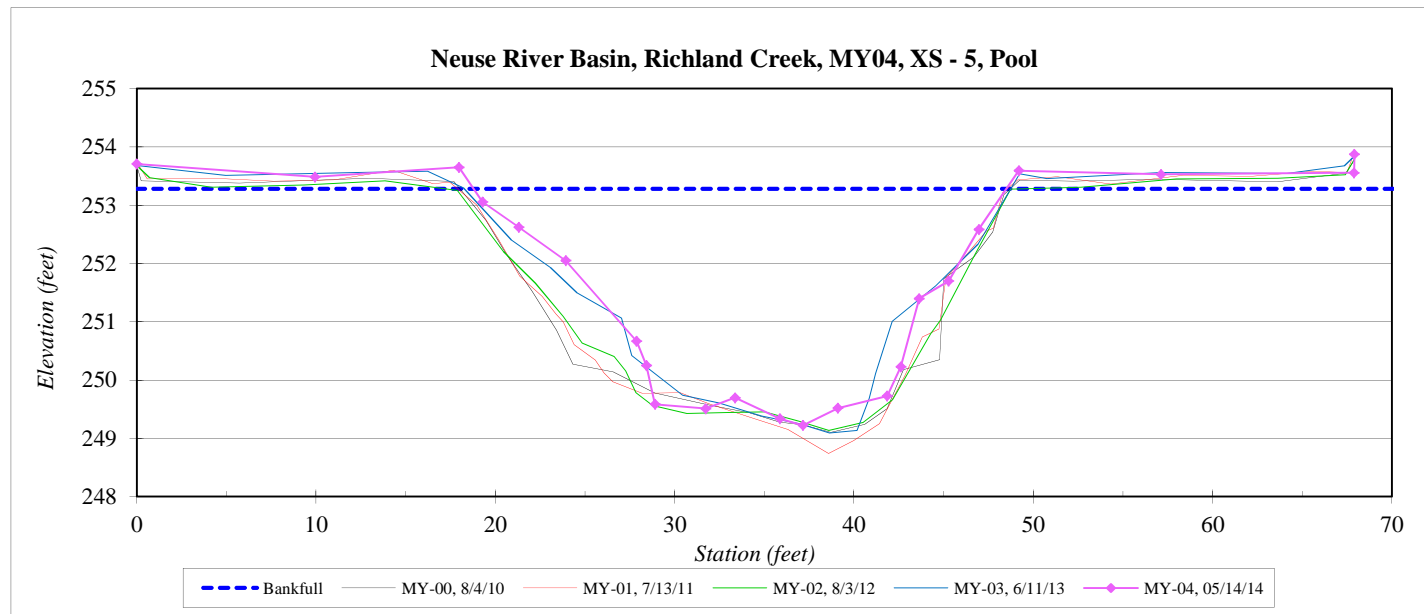


<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 5, Pool
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/14/2014
<b>Field Crew:</b>	T. Seelinger, D. Prihoda



Station	Elevation
0.0	253.71
9.9	253.49
18.0	253.65
19.3	253.06
21.3	252.62
23.9	252.05
27.9	250.67
28.4	250.25
28.9	249.58
31.7	249.51
33.4	249.70
35.9	249.34
37.2	249.22
39.1	249.52
41.8	249.73
42.6	250.23
43.6	251.40
45.3	251.70
47.0	252.59
49.2	253.59
57.1	253.53
67.9	253.56
67.9	253.87

SUMMARY DATA	
<b>Bankfull Elevation:</b>	253.3
<b>Bankfull Cross-Sectional Area:</b>	73.3
<b>Bankfull Width:</b>	29.7
<b>Flood Prone Area Elevation:</b>	-
<b>Flood Prone Width:</b>	-
<b>Max Depth at Bankfull:</b>	4.1
<b>Mean Depth at Bankfull:</b>	2.5
<b>W / D Ratio:</b>	-
<b>Entrenchment Ratio:</b>	-
<b>Bank Height Ratio:</b>	-

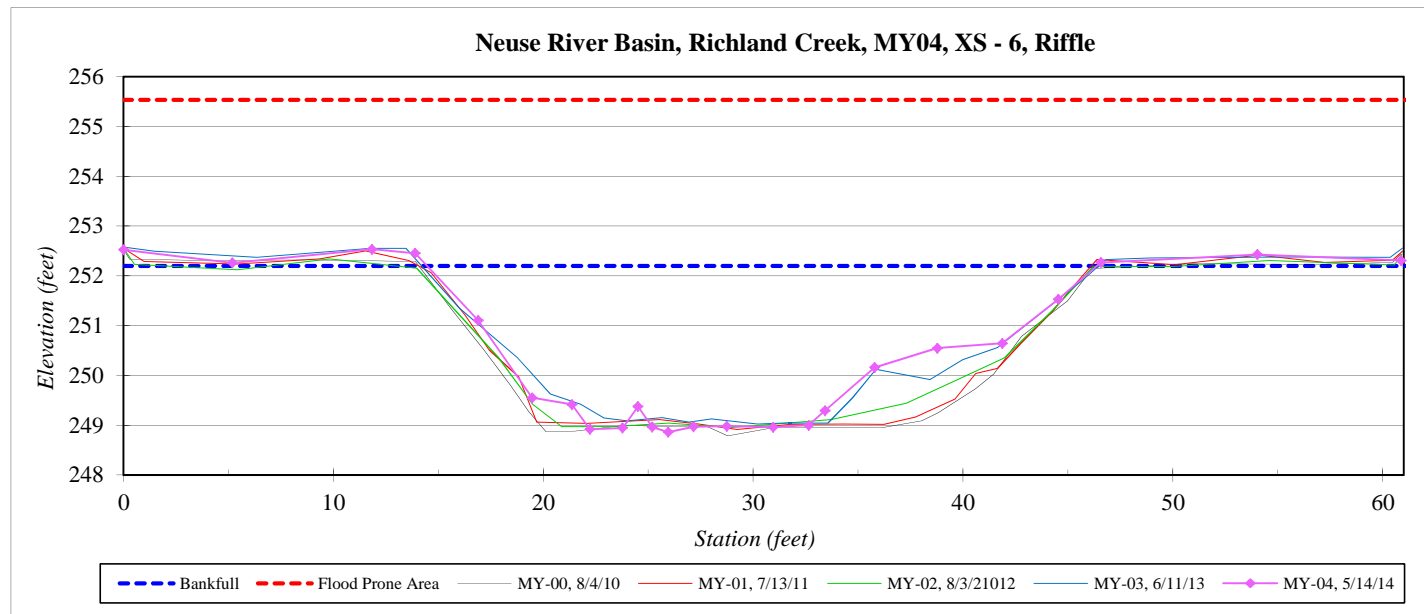


<b>River Basin:</b>	Neuse
<b>Watershed:</b>	Richland Creek, MY-04
<b>XS ID</b>	XS - 6, Riffle
<b>Drainage Area (sq mi):</b>	7.8
<b>Date:</b>	5/14/2014
<b>Field Crew:</b>	T. Seelinger, D. Prihoda

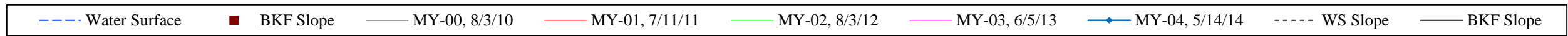
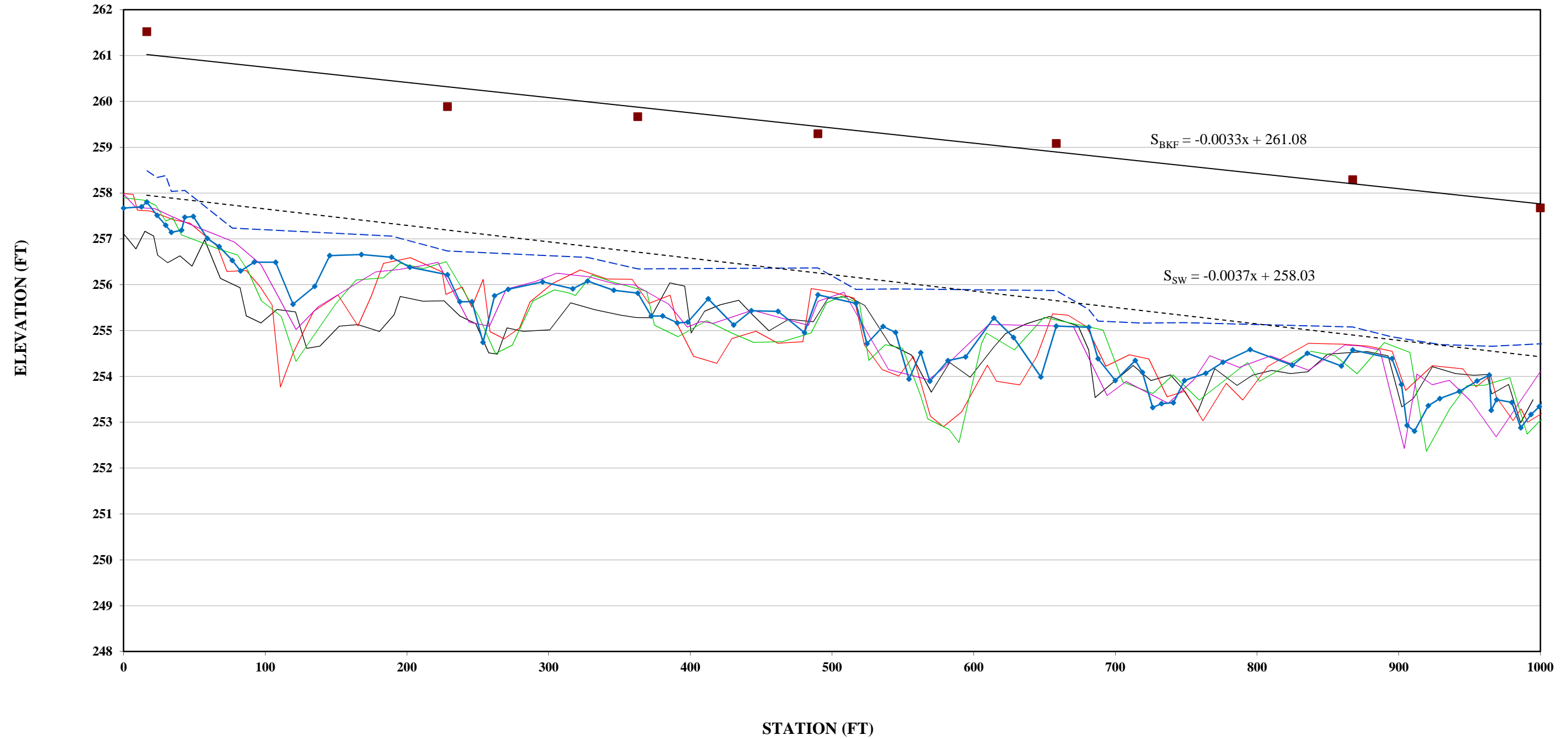


Station	Elevation
0.0	252.52
5.2	252.26
11.8	252.54
13.9	252.45
16.9	251.11
19.5	249.55
21.4	249.42
22.2	248.92
23.8	248.94
24.5	249.38
25.2	248.96
26.0	248.86
27.2	248.97
28.7	248.98
31.0	248.96
32.6	249.00
33.4	249.29
35.8	250.16
38.8	250.55
41.9	250.65
44.5	251.53
46.6	252.27
54.0	252.43
60.9	252.31
61.0	252.47

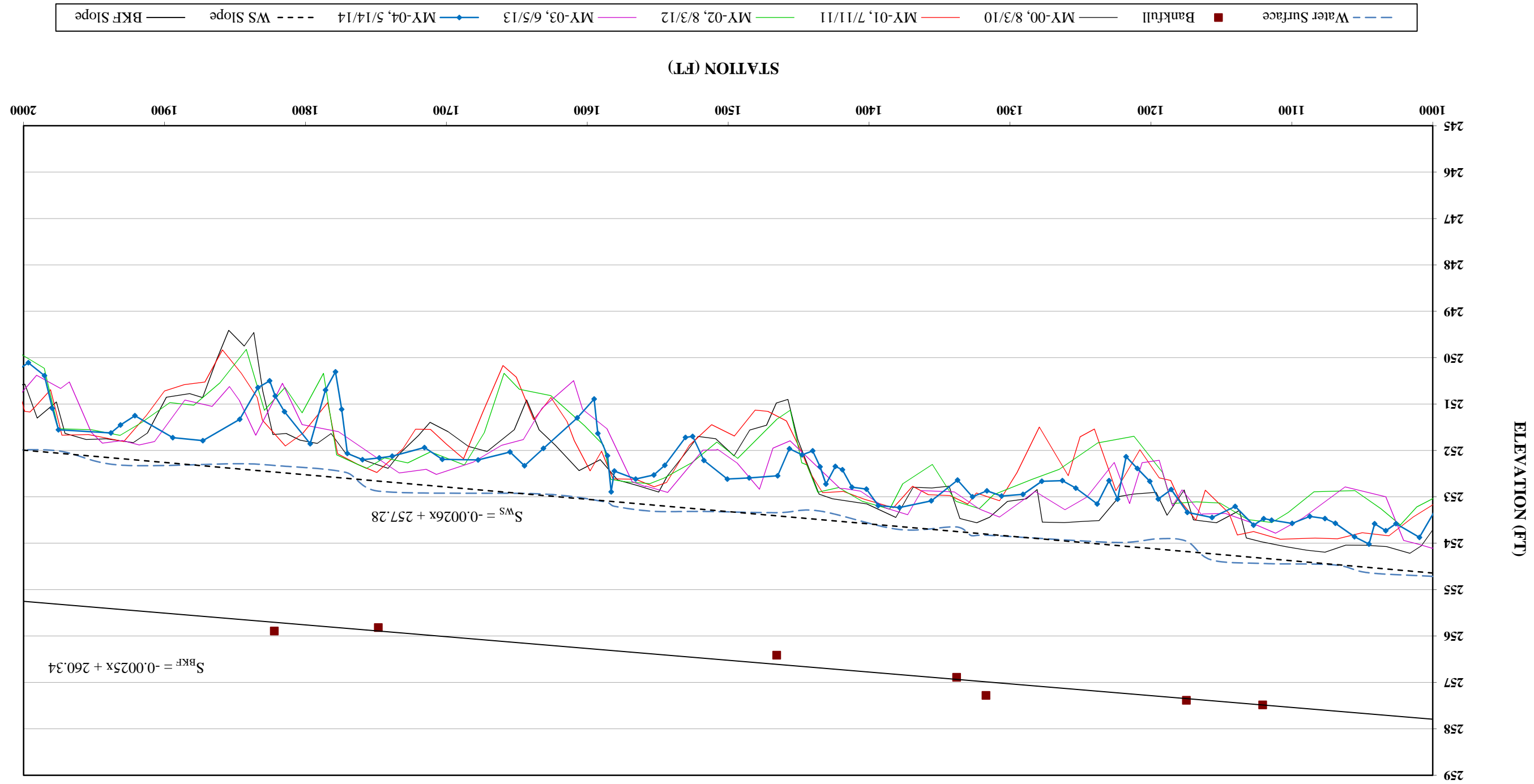
SUMMARY DATA	
<b>Bankfull Elevation:</b>	252.2
<b>Bankfull Cross-Sectional Area:</b>	69.7
<b>Bankfull Width:</b>	31.9
<b>Flood Prone Area Elevation:</b>	255.5
<b>Flood Prone Width:</b>	61.0
<b>Max Depth at Bankfull:</b>	3.3
<b>Mean Depth at Bankfull:</b>	2.2
<b>W / D Ratio:</b>	14.6
<b>Entrenchment Ratio:</b>	1.9
<b>Bank Height Ratio:</b>	1.0



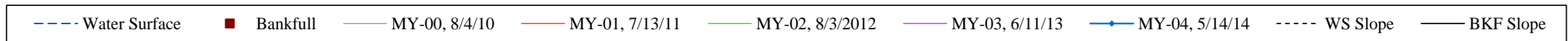
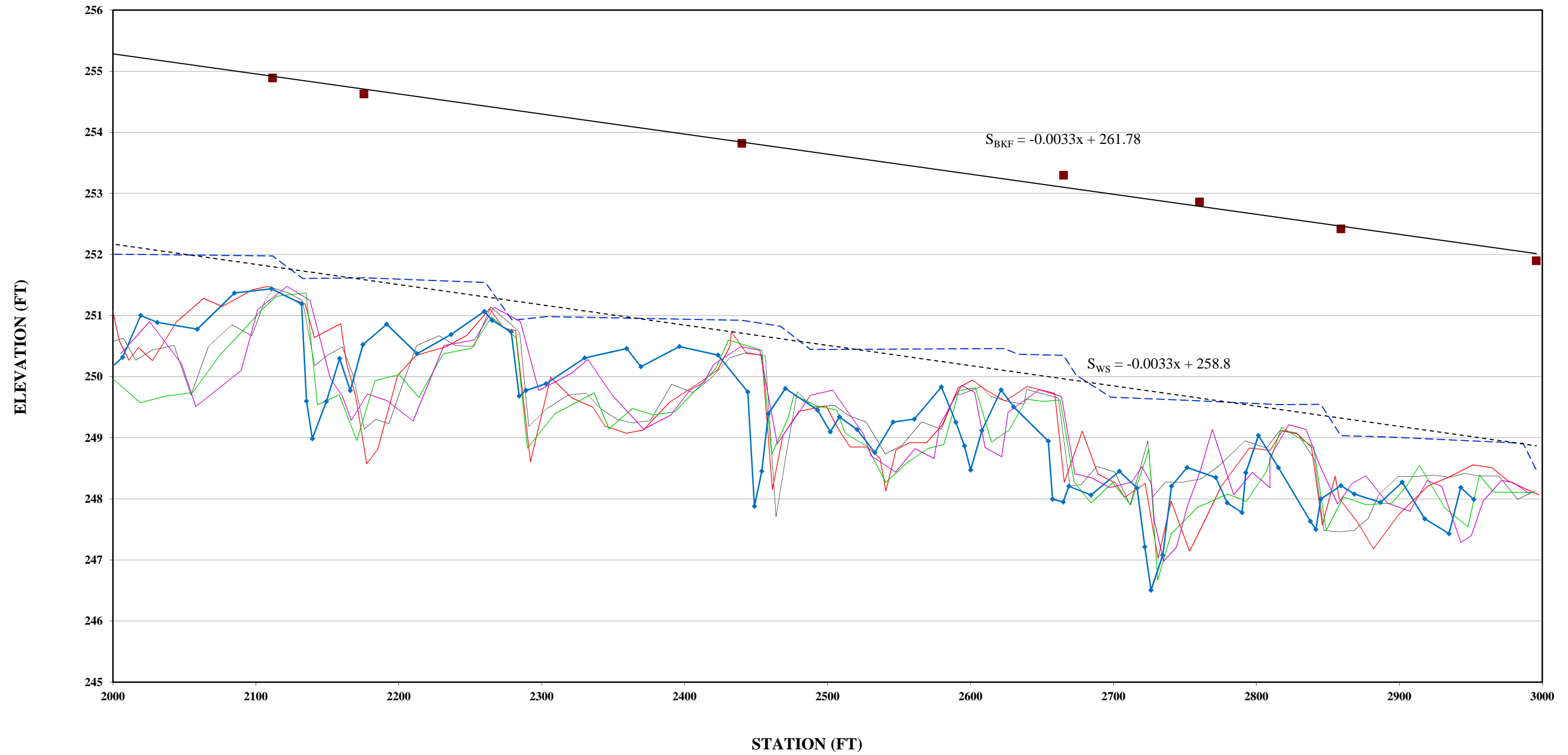
**Longitudinal Profile  
Richland Creek  
EEP Project Number 304- MY-04  
Stations 0+00 - 10+00**



**Longitudinal Profile  
 Richland Creek  
 EFP Project Number 304- MY-04  
 Stations 10+00 - 20+00**



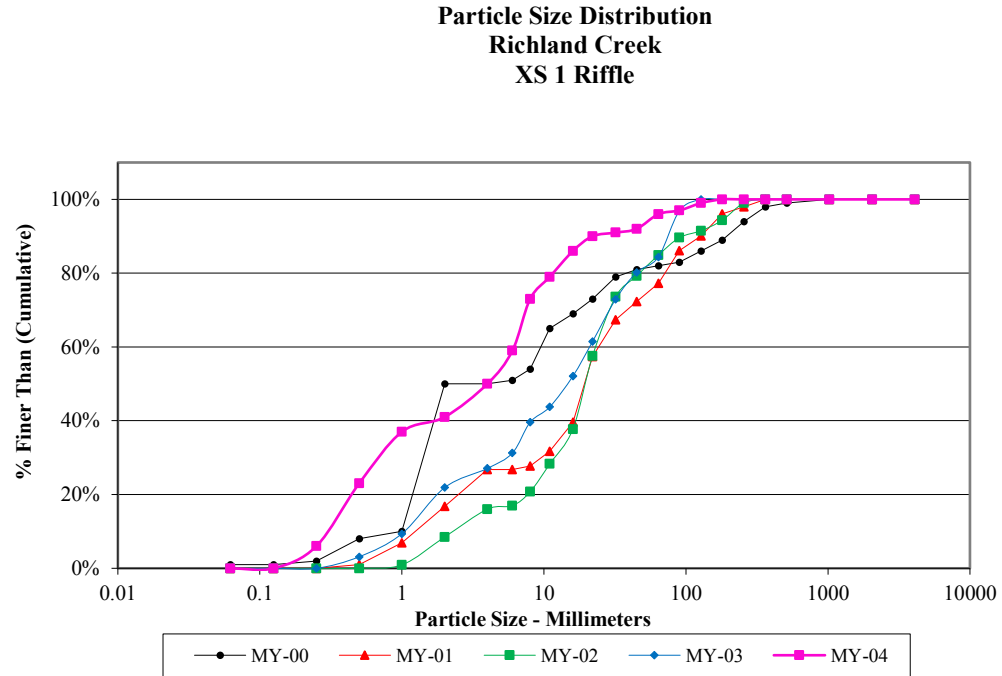
**Longitudinal Profile  
Richland Creek  
EEP Project Number 304- MY-04  
Stations 20+00 - 30+00**





# Pebble Count Plots

Cross-Section 1 Riffle - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	6
Coarse	.50 - 1	D	17
Very Coarse	1 - 2	S	14
Very Fine	2 - 4		4
Fine	4 - 5.7	G	9
Fine	5.7 - 8	R	9
Medium	8 - 11.3	A	14
Medium	11.3 - 16	V	6
Coarse	16 - 22.6	E	7
Coarse	22.6 - 32	L	4
Very Coarse	32 - 45	S	1
Very Coarse	45 - 64		1
Small	64 - 90	C	4
Small	90 - 128	O	1
Large	128 - 180	B	2
Large	180 - 256	L	1
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	100
Note:			

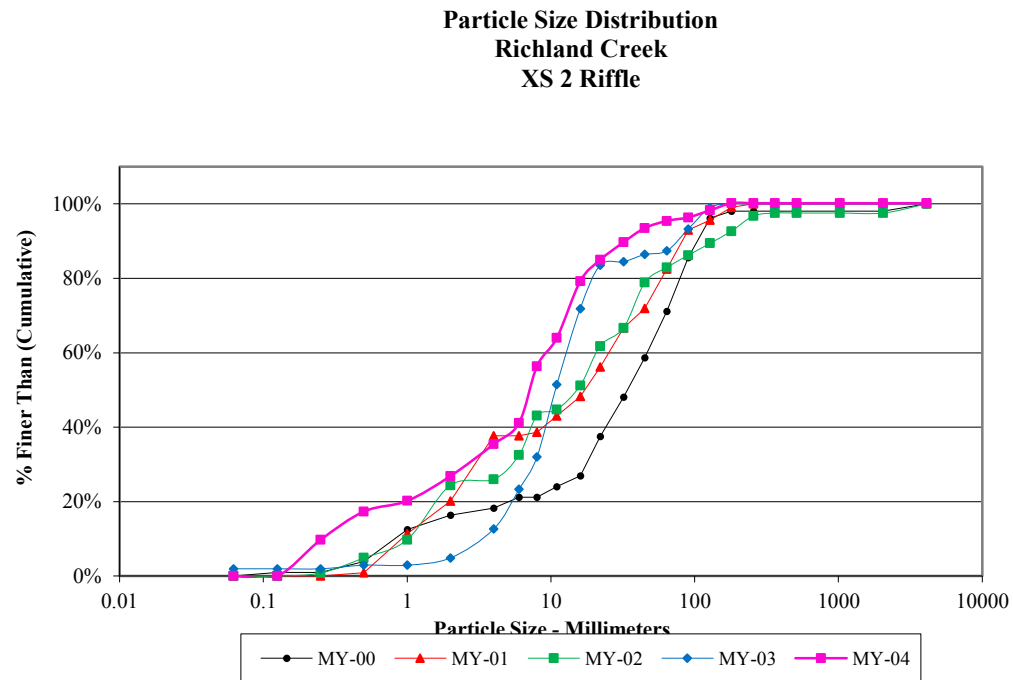


Size (mm)	
D16	0.75
D35	1.8
D50	6
D65	9.2
D84	20
D95	83

Size Distribution	
mean	3.9
dispersion	5.7
skewness	-0.16

Type	
silt/clay	0%
sand	37%
gravel	55%
cobble	8%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Riffle - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	10
Coarse	.50 - 1	D	8
Very Coarse	1 - 2	S	3
Very Fine	2 - 4		7
Fine	4 - 5.7	G	9
Fine	5.7 - 8	R	6
Medium	8 - 11.3	A	16
Medium	11.3 - 16	V	8
Coarse	16 - 22.6	E	16
Coarse	22.6 - 32	L	6
Very Coarse	32 - 45	S	5
Very Coarse	45 - 64		4
Small	64 - 90	C	2
Small	90 - 128	O	1
Large	128 - 180	B	2
Large	180 - 256	L	2
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	105
Note:			

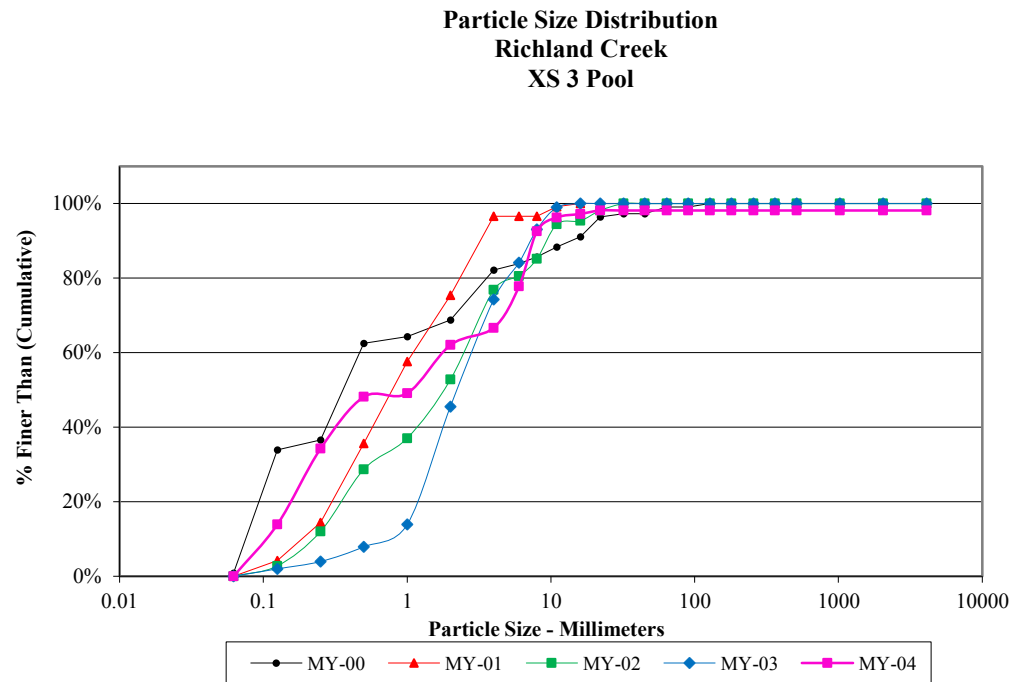


Size (mm)	
D16	0.45
D35	3.9
D50	7.1
D65	11
D84	21
D95	61

Size Distribution	
mean	3.1
dispersion	9.4
skewness	-0.28

Type	
silt/clay	0%
sand	27%
gravel	69%
cobble	5%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Pool - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	15
Medium	.25 - .50	N	22
Coarse	.50 - 1	D	15
Very Coarse	1 - 2	S	1
Very Fine	2 - 4		14
Fine	4 - 5.7	G	5
Fine	5.7 - 8	R	12
Medium	8 - 11.3	A	16
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	106
Note:			

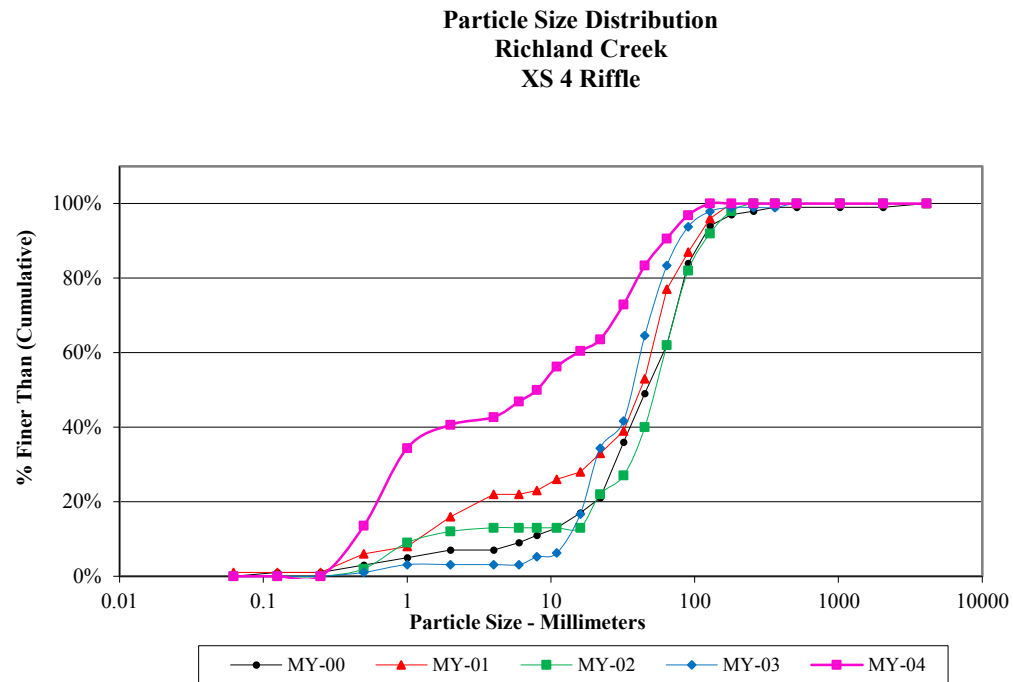


Size (mm)	
D16	0.13
D35	0.25
D50	1
D65	2.6
D84	6.6
D95	8.5

Size Distribution	
mean	0.9
dispersion	7.1
skewness	-0.03

Type	
silt/clay	0%
sand	63%
gravel	37%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Riffle - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	13
Very Coarse	1 - 2	S	20
Very Fine	2 - 4		6
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	4
Medium	8 - 11.3	A	3
Medium	11.3 - 16	V	6
Coarse	16 - 22.6	E	4
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	9
Very Coarse	45 - 64		10
Small	64 - 90	C	7
Small	90 - 128	O	6
Large	128 - 180	B	3
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	96
Note:			

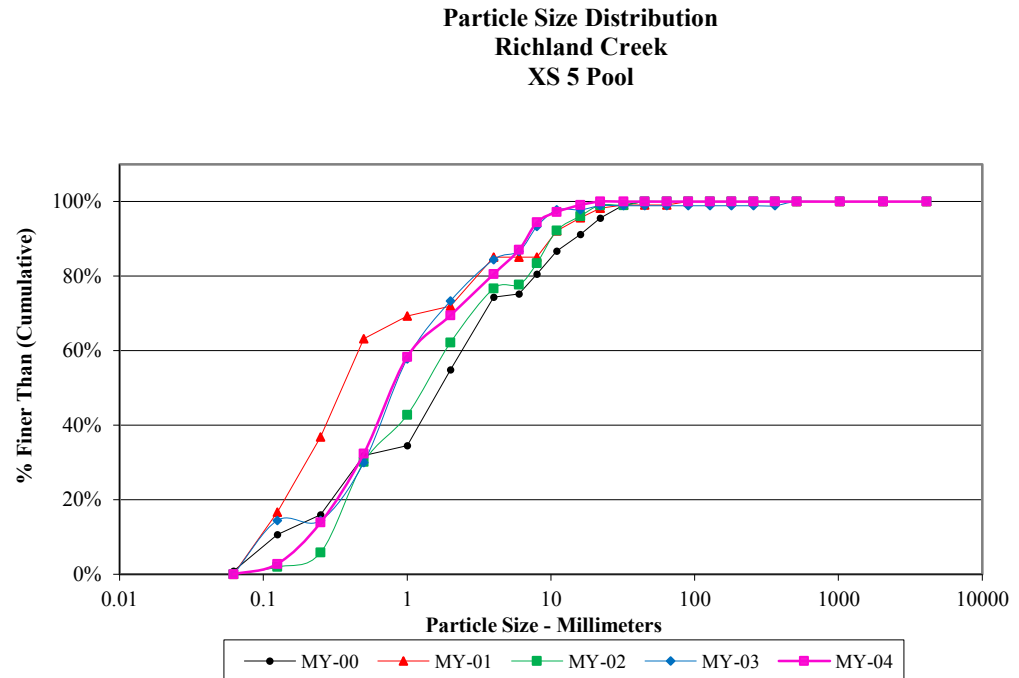


Size (mm)	
D16	0.54
D35	1.1
D50	8
D65	23
D84	46
D95	81

Size Distribution	
mean	5.0
dispersion	10.3
skewness	-0.15

Type	
silt/clay	0%
sand	41%
gravel	50%
cobble	9%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Pool - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	3
Medium	.25 - .50	N	12
Coarse	.50 - 1	D	20
Very Coarse	1 - 2	S	28
Very Fine	2 - 4		12
Fine	4 - 5.7	G	12
Fine	5.7 - 8	R	7
Medium	8 - 11.3	A	8
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	2
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	108
Note:			

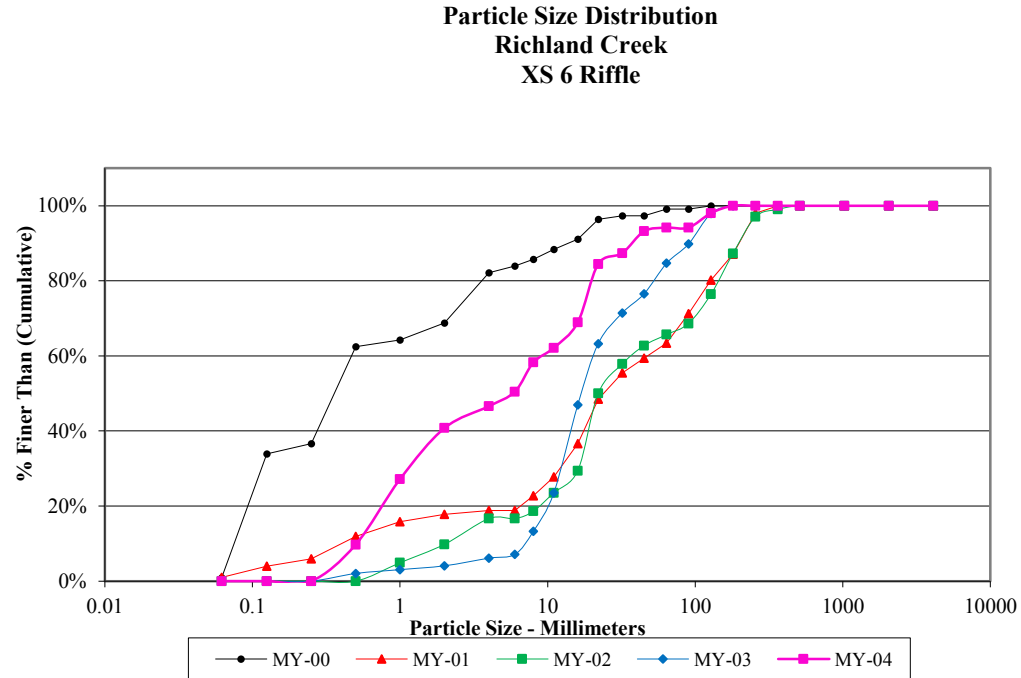


Size (mm)	
D16	0.27
D35	0.54
D50	0.8
D65	1.5
D84	5
D95	8.5

Size Distribution	
mean	1.2
dispersion	4.6
skewness	0.14

Type	
silt/clay	0%
sand	69%
gravel	31%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 6 Riffle - MY-04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	10
Coarse	.50 - 1	D	18
Very Coarse	1 - 2	S	14
Very Fine	2 - 4		6
Fine	4 - 5.7	G	4
Fine	5.7 - 8	R	8
Medium	8 - 11.3	A	4
Medium	11.3 - 16	V	7
Coarse	16 - 22.6	E	16
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	6
Very Coarse	45 - 64		1
Small	64 - 90	C	
Small	90 - 128	O	4
Large	128 - 180	B	2
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		<b>Total</b>	103
Note:			



Size (mm)	
D16	0.64
D35	1.5
D50	5.7
D65	13
D84	22
D95	97

Size Distribution	
mean	3.8
dispersion	6.4
skewness	-0.15

Type	
silt/clay	0%
sand	41%
gravel	53%
cobble	6%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

**Table 10. Baseline Stream Data Summary: Richland Creek - 2,919 lf  
Paschal Golf Course (Richland Creek) / Project No. 276**

Parameter	Regional Curve			Pre-Existing Condition						Reference Reach Data (Upper Richland Creek)						Design			As-built					
	LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
<b>Dimension and Substrate - Riffle</b>																								
Bankfull Width (ft)				22			35.0			28.0			32.0				33.0		31.9	32.7	32.2	34.4	1.2	4
Floodprone Width (ft)				28			60				>100						100		>60	>72	>69	>90	12.8	4
Bankfull Mean Depth (ft)				1.4			2.8			2.3			2.4				2.6		2.4	2.6	2.6	2.8	0.2	4
Bankfull Max Depth (ft)				3.4			3.8				3.75						3.4		3.3	3.5	3.5	3.8	0.2	4
Bankfull Cross-Sectional Area (ft <sup>2</sup> )				48			72			67			75				85.0		80.2	84.2	83.7	89.3	4.1	4
Width/Depth Ratio				12.0			13.8			12.2			13.3				12.1		11.4	12.7	12.5	14.5	1.3	4
Entrenchment Ratio				1.7			1.9			3.1			3.6				3.0		>1.9	>2.0	>2.0	>2.0	0.0	4
Bank Height Ratio					1.2						1.1						1.0		1.0	1.0	1.0	1.0	0.0	4
d50 (mm)					12.0												12.0		4.1	12.7	14.0	20.0	8.0	4
<b>Profile</b>																								
Riffle Length (ft)																			14	48	30	177	42	20
Riffle Slope (ft/ft)				0.0200			0.0370			0.0050			0.0090				0.0056		0.0011	0.0089	0.0075	0.0212	0.0067	20
Pool Length (ft)				23			96			5			25				41		8	74	82	150	42	19
Pool Max Depth					4.0						4.6						5.5		4.3	5.0		5.6	0.92	2
Pool Spacing (ft)				38			258			25			90			150		230	63	153	155	216	49	19
Pool Volume (ft <sup>3</sup> )																								
<b>Pattern</b>																								
Channel Beltwidth (ft)				22			71			100			300			60		300	37	78	83	116	25	9
Radius of Curvature (ft)				32			98			37			70			80		100	80	90	90	100	10	14
Rc:Bankfull width (ft/ft)					1.34					1.1			2.1				2.4		2.5	2.8	2.8	3.1		
Meander Wavelength (ft)				110			300			110			200			220		330	259	321	312	395	45	11
Meander Width Ratio					1.59					9.3			10.7				9.0		1.1	2.4	2.5	3.5		
<b>Substrate, bed and transport parameters</b>																								
Ri%/Ru%/P%/G%/S%																								
SC%/ Sa% / G% / C% / B% / Be%																								
d16 / d35 / d50 / d84 / d95 / di <sup>p</sup> / di <sup>sp</sup> (mm)							1.5 / 7.3 / 12 / 35 / 49 / - / -																	
Reach Shear Stress (competency) lb/ft <sup>2</sup>							0.35										0.40							
Max part size (mm) mobilized at bankfull							20-80										20-90							
Stream Power (transport capacity) W/m <sup>2</sup>																								
<b>Additional Reach Parameters</b>																								
Drainage Area (SM)						7.8						4.8					7.8							
Impervious cover estimate						10%											10%							
Rosgen Classification						F4/1						C4					C4/1							
Bankfull Velocity (fps)						3.1 - 7.0						3.6 - 5.0					5.0							
Bankfull Discharge (cfs)						305 - 400						260 - 280					425							
Valley length (ft)						2,710																	2,710	
Channel thalweg length (ft)																							2,919	
Sinuosity						1.22						1.1					1.20						1.10	
Water Surface Slope (Channel) (ft/ft)						0.0028						0.0040					0.0028						0.0028	
BF slope (ft/ft)																	0.0028						0.0027	
Bankfull Floodplain Area (acres)																								
Proportion over wide (%)																								
Entrenchment Class (ER Range)																								
Incision Class (BHR Range)																								
BEHI VL% / L% / M% / H% / VH% / E%																								
Channel Stability or Habitat Metric																								
Biological or Other																								

Dimension and Substrate		Cross-Section 1 (Riffle)					Cross-Section 2 (Riffle)					Cross-Section 3 (Pool)					Cross-Section 4 (Riffle)					Cross-Section 5 (Pool)								
	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
Bankfull Width (ft)	34.4	33.6	35.4	34.0	33.1	31.9	31.9	35.2	35.6	33.6	31.9	31.4	33.9	36.1	33.2	31.3	32.1	31.9	31.9	31.5	32.2	32.2	31.5	32.5	31.5	32.5	31.9	30.5	29.7	
Floodprone Width (ft)	>90	>90	>90	>90	>90	>70	>70	>70	>70	>70	>70	-	-	-	-	>68	>68	>68	>68	>68	>68	>68	>68	-	-	-	-	-	-	
Bankfull Mean Depth (ft)	2.4	2.4	2.2	2.1	1.9	2.8	2.5	2.5	2.5	2.4	3.3	3.3	2.9	2.7	2.6	2.5	2.5	2.4	2.3	2.1	2.1	3.3	4.3	2.9	2.9	2.8	2.7	2.4	2.5	
Bankfull Max Depth (ft)	3.4	3.4	3.5	3.3	3.5	3.8	3.8	3.7	3.7	3.7	3.7	5.6	5.0	5.0	4.3	4.3	3.3	3.2	3.2	3.1	3.3	4.3	90.8	4.3	4.7	4.1	4.2	4.1		
Bankfull Cross-Sectional Area (ft <sup>2</sup> )	81.7	79.9	78.5	72.1	63.8	89.3	88.5	87.6	84.0	76.3	104.0	99.2	97.8	86.3	78.9	80.2	76.5	73.1	66.6	67.2	90.8	90.6	90.8	90.8	90.8	85.0	74.4	73.3		
Bankfull Width/Depth Ratio	14.5	14.1	16.0	16.0	17.2	11.4	14.0	14.5	13.5	13.3	-	-	-	-	-	12.8	13.3	13.9	14.9	15.4	90.8	90.6	90.8	90.8	90.8	85.0	74.4	73.3		
Bankfull Entrenchment Ratio	>2.0	>2.0	>2.2	>2.2	>2.8	>2.0	>1.8	>2.0	>2.0	>2.0	-	-	-	-	-	>2.0	>2.1	>2.2	>2.2	>2.2	90.8	90.6	90.8	90.8	90.8	85.0	74.4	73.3		
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	-	-	-	-	-	1.0	1.0	1.0	1.0	1.0	90.8	90.6	90.8	90.8	90.8	85.0	74.4	73.3		
Cross-Sectional Area Between End Pins (ft <sup>2</sup> )	477.5	478.0	477.4	460.5	479.8	111.4	108.6	114.4	110.9	85.4	135.7	134.2	135.6	123.3	123.0	100.1	100.6	96.2	105.9	100.1	106.4	110.6	107.4	106.4	106.4	110.6	107.4	99.8	102.8	
d50 (mm)	2.0	19.0	20.0	20.0	6.0	34.0	17.0	15.0	7.9	7.1	0.4	0.8	1.7	2.2	2.0	46.0	42.0	53.0	51.0	11.0	106.4	110.6	107.4	106.4	110.6	107.4	99.8	102.8		

Based on fixed baseline elevation															
	Base	MY1	MY2	MY3	MY4	MY5	MY+		Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	32.2	32.6	33.3	32.3	31.9				32.2	32.6	33.3	32.3	31.9		
Floodprone Width (ft)	>60	>60	>60	>60	>61				>60	>60	>60	>60	>61		
Bankfull Mean Depth (ft)	2.7	2.5	2.3	2.2	2.2				2.7	2.5	2.3	2.2	2.2		
Bankfull Max Depth (ft)	3.5	3.4	3.2	3.2	3.3				3.5	3.4	3.2	3.2	3.3		
Bankfull Cross-Sectional Area (ft <sup>2</sup> )	85.6	82.2	77.9	70.2	69.7				85.6	82.2	77.9	70.2	69.7		
Bankfull Width/Depth Ratio	12.1	12.9	14.2	14.8	14.6				12.1	12.9	14.2	14.8	14.6		
Bankfull Entrenchment Ratio	>1.9	>1.8	>1.9	>1.9	>1.9				>1.9	>1.8	>1.9	>1.9	>1.9		
Bankfull Bank Height Ratio	1.0	1.0	1.0	1.0	1.0				1.0	1.0	1.0	1.0	1.0		
Cross-Sectional Area Between End Pins (ft <sup>2</sup> )	94.3	94.1	92.1	87.1	81.2				94.3	94.1	92.1	87.1	81.2		
d50 (mm)	44.0	24.0	22.0	23.0	7.7				44.0	24.0	22.0	23.0	7.7		

Table 11a. Monitoring - Cross-Section Morphology Data  
Paschal Golf Course (Richland Creek) / Project No. 276



**Table 11b. Monitoring - Stream Reach Morphology Data Table**  
**Paschal Golf Course (Richland Creek) / Project No. 276**  
**Richland Creek (2,919 ft.)**

Parameter	MY01 (2011)						MY02 (2012)						MY03 (2013)						MY04 (2014)						MY05 (2015)					
	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
<b>Dimension</b>																														
Bankfull Width (ft)	31.9	34.2	33.1	35.2	3.031	4	31.9	34.1	34.4	35.6	1.771	4	30.5	32.5	32.8	34.0	1.341	4	31.9	32.3	32.1	33.1	0.568	4						
Floodprone Width (ft)	68	72	69	90	12.754	4	60	72	69	89	12.285	4	61	73	69	92	13.367	4	61	79	81	92	15.791	4						
Bankfull Mean Depth (ft)	2.3	2.4	2.4	2.5	0.082	4	2.2	2.3	2.3	2.5	0.126	4	2.1	2.3	2.3	2.6	0.214	4	1.9	2.2	2.2	2.4	0.208	4						
Bankfull Max Depth (ft)	3.2	3.5	3.4	3.8	0.252	4	3.2	3.4	3.4	3.7	0.245	4	3.1	3.6	3.5	4.3	0.520	4	3.3	3.5	3.4	3.7	0.191	4						
Bankfull Cross-Sectional Area (ft <sup>2</sup> )	76.5	81.8	81.1	88.6	5.102	4	73.1	79.3	78.2	87.6	6.053	4	66.6	75.6	73.3	86.3	7.860	4	63.8	69.3	68.5	76.3	5.286	4						
Width/Depth Ratio	12.9	14.3	13.7	16.8	1.756	4	13.9	14.7	14.4	16.0	0.933	4	13.5	14.8	14.9	16.0	1.023	4	13.3	15.1	15.0	17.2	1.632	4						
Entrenchment Ratio	1.8	1.9	1.9	2.1	0.150	4	1.8	2.1	2.1	2.6	0.340	4	1.9	2.2	2.2	2.7	0.340	4	1.9	2.5	2.5	2.9	0.480	4						
Bank Height Ratio	1.0	1.0	1.0	1.0	0.000	4	1.0	1.0	1.0	1.0	0.000	4	1.0	1.0	1.0	1.0	1.0	4	1.0	1.0	1.0	1.0	0.050	4						
<b>Pattern</b>																														
Channel Beltwidth (ft)	37	78	83	116	25	9																								
Radius of Curvature (ft)	80	91.1	90	100	9	9																								
Rad. of Curv. : Bankfull Width (ft/ft)	2.5	2.7	2.7	2.6																										
Meander Wavelength (ft)	259	321	312	395	45	11																								
Meander Width Ratio	1.2	2.3	2.5	3.0																										
<b>Profile</b>																														
Riffle Length (ft)	18	41	30	103	23	17	17	33	26	65	16	18	14	29	25	78	11	16	9	25	23	56	13	21						
Riffle Slope (ft/ft)	0.001	0.010	0.008	0.019	0.006	17	0.002	0.013	0.010	0.025	0.008	18	0.001	0.023	0.008	0.010	0.006	16	0.001	0.016	0.009	0.048	0.013	21						
Pool Length (ft)	31	72	74	122	24	17	12	68	78	120	31	17	9	129	74	78	32	14	7	25	25	45	10	19						
Pool Max Depth (ft)	1.5	1.5		1.5		1	1.5	1.5		1.5		1	3.3	3.3		3.3		1	3.1	3.1		3.1		1						
Pool Spacing (ft)	86	172	169	262	45	16	51	161	159	256	54	16	130	278	165	185	47	13	47	127	150	245	65	19						
<b>Additional Reach Parameters</b>																														
Valley Length (ft)	2,710						2,710						2,710						2,710											
Channel Thalweg Length (ft)	2,919						2,919						2,919						2,919											
Sinuosity	1.1						1.1						1.1						1.1											
Water Surface Slope (ft/ft)	0.0032						0.0034						0.0034						0.0034											
Bankfull Slope (ft/ft)	0.0029						0.0025						0.0025						0.0025											
Rosgen Classification	C4						C4						C5						C5											
SC% / Sa% / G% / C% / B% / Be%	0.33%/36%/47%/16%/0.67%						0%/29%/54%/16%/1%						0%/25%/67%/12%/0%/0%						0%/39%/55%/6%/0%/0%											
d16 / d35 / d50 / d65/ d84 / d95	1.1/10/17/65/110						4.6/13/19/31/66/135						6.7/12/18/25/50/86						0.7/21/5.9/13.3/25.8/71.3											
% of Reach with Eroding Banks	1%						2%						5%						3%											

# **Appendix E**

## **Hydrology Data**

**Table 12. Verification of Bankfull Events  
Paschal Golf Course (Richland Creek) / Project No. 276**

<b>Date of Data Collection</b>	<b>Date of Occurrence</b>	<b>Method</b>	<b>Photo #</b>
5/17/2010	5/17/2010	Photographed on site	1, See Below
9/28/2011	9/16/2011	Crest gauge	None
11/5/2012	unknown	Crest gauge and indicators of storm event	None
6/10/2013	6/7/2013	Photographed on site	2, see below
11/15/2013	unknown	Photographed on site	3, see below
5/28/2014	unknown	Photographed on site	4, see below



Photo #1 - Bankfull Event, 5/17/2010



Photo #2 – Bankfull Evidence (wrack lines), 6/10/2013



Photo #3 – Bankfull Evidence (wrack lines), 11/15/2013



Photo #4 – Bankfull Evidence (wrack lines), 5/28/2014



Photo #5 – Bankfull Evidence (wrack lines), 11/10/2014