

Northgate Park (Ellerbe Creek) Stream Restoration Monitoring Report

DMS Project # 272 Contract#: 6230
USACE Action ID#: 200620453 DWR Project#: N/A
County: Durham
Monitoring Year 04*



Submitted to:

NCDEQ-DMS, 1652 Mail Service Center, Raleigh, NC 27699-1652

Data Collection: 2015
Construction Completed: December 2008
Submitted: December 2015

*Data collected for this report (2015) was collected seven (7) years after construction (7 years elapsed – MY7), but is the 4th year where measurements were made as per the monitoring plan. Measurements were suspended for repairs and repair evaluation in 2011 - 2013

Monitoring Firm



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1.0 EXECUTIVE SUMMARY / PROJECT ABSTRACT

In 2008, the North Carolina Ecosystem Enhancement Program (EEP) restored and enhanced a reach of Ellerbe Creek, an Unnamed Tributary to Ellerbe Creek (UT 3), and stream buffer within Northgate Park in Durham County, NC. The project also included the creation of two stormwater wetlands with outfalls to the project streams. The 5.9-mi² project watershed is located in US Geological Survey Hydrologic Unit 03020201-05-0010 (NC Division of Water Quality Sub-basin 03-04-01) of the Neuse River Basin. This Hydrologic Unit is within EEP's *Ellerbe Creek Local Watershed Plan* (2003) area and is also listed as a Targeted Local Watershed (TLW) in EEP's *Neuse River Basin Priorities Plan* (2010). This project is within the Falls Lake watershed, a drinking supply reservoir for the City of Raleigh. The drainage area for the site is urban residential land. The State has a permanent conservation easement of 7.5 acres and the project is located entirely within Northgate Park, which is a City of Durham public park. The project stream begins at the pedestrian bridge near the baseball diamond and flows 2,284 linear feet to the culvert under Acadia Street. The project goals and objectives are listed below.

Project Goals

- Improving water quality.
- Enhancing flood attenuation.
- Restoring aquatic and riparian habitat.

Project Objectives

- Restoring the Project Reach to a stable urban stream channel that will retain its dimension, pattern, and profile over time, and that is capable of transporting watershed flows and sediment load efficiently.
- Using Priority II restoration to change Ellerbe Creek from a G5c type stream channel to an E type channel.
- Enhancing the capacity of the site to mitigate flood flows by improving the connection of the stream to its floodplain.
- Improving aquatic habitat by establishing a heterogeneous bed morphology with riffle-pool sequences supported by in-stream structures.
- Restoring the riparian buffer from park grasses and herbaceous vegetation to Piedmont Bottomland Forest to provide filtration of nutrients and organic matter inputs into the stream, to improve wildlife habitat, and to provide shade for the stream channel.
- Reducing sediment inputs from localized streambank erosion by re-establishing stream geometry and by stabilizing and revegetating the stream banks.
- Installing three stormwater wetland best management practices (BMPs) to reduce stormwater pollutants (namely nitrogen and phosphorus) and improve water quality prior to discharging into the stream.

Construction was completed at the site in December 2008. In March 2009, live stakes were planted along the stream and the stormwater wetlands were planted. The planting of the riparian buffer was delayed until November 2009 when the rest of the site was planted with tublings and containerized plants. After planting, six vegetation plots were installed following the CVS-EEP vegetation monitoring procedure, five in buffer restoration areas and one in the planted stream riparian zone. Repairs were conducted at the site beginning in late 2013 and ending in March 2014. Once construction was completed, newly repaired banks were planted with live stakes and disturbed construction areas were planted with native transplants.

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. The vegetation monitoring success criterion for the buffer restoration zone is a density of 320 stems/acre after the fifth year of monitoring. Plot 1 is located in the stream riparian zone and Plots 2-6 are located in the buffer enhancement and restoration zones. The

fourth-year vegetation monitoring was based on the Level 2 CVS-EEP vegetation monitoring protocol. The site's average density for this monitoring period was 169 planted stems/acre. Five of the six plots had less than 320 planted stems/acre, with plot 6 being the only one to meet the success criteria. Despite this lack of planted woody vegetation, volunteer species are robust throughout the site and, including volunteers, the site averaged 3,635 total stems/acre, with all plots meeting the success criteria. The easement includes a few isolated areas of managed herbaceous zones for public safety sight line considerations and pedestrian trail access. Invasive species are present throughout the site, but are only scattered in small patches throughout the easement. The 2015 monitoring found some areas with low densities of trees. The streamside vegetation, especially the willows (*Salix spp.*) on the lower half of the site, has also been impacted by beaver, and they have destroyed many of the previously large and healthy trees along the bankfull bench. A beaver lodge is located on-site near stationing 28+75 and two beaver dams are present on site. The first is located at the outlet of stormwater wetland #1 and the second is located at stationing 30+00. DMS will be undertaking a supplemental planting effort in the dormant season of 2015/2016 to address the low planted stem count.

The project as-built survey was conducted in January 2009 and KCI conducted the first-year monitoring survey in January 2010. The longitudinal profile in Appendix D includes the longitudinal profile data from both of these surveys. The as-built profile data are limited in that the survey measurements taken were not annotated in the field and water surface measurements were not taken. As a result, the survey is not detailed enough to generate baseline profile morphology data. The five detailed cross-sections were installed after the as-built survey, so there are no baseline dimensional data, but there are first-year dimensional data. Because of the repair work that occurred in 2013 and 2014, cross-sections 3, 4, and 5 were all reinstalled in October 2014. An effort was made to install these as close to the original cross-sections as possible, but there are slight differences between the first two years and the past two years of monitoring. This year's cross-sectional survey showed general stability at all cross-sections. Cross-sections 1 and 2 continue to trend towards stability. The banks of cross-sections 3 and 5 received vegetated soil lifts and the right bank of cross-section 4 was graded as part of the repair work mentioned above. The live stakes planted along the banks of cross-sections 3, 4, and 5 have grown well since their planting in March 2014. The fourth year of monitoring found both Reach 1 and 2 to be stable and functioning as designed. Although the bed shows areas of significant aggradation along Reach 1 and degradation along Reach 2 compared to the as-built conditions, it shows little change compared to the MY01, 02, and 03 surveys. Areas of bank erosion and structural failure mentioned in previous reports were corrected during the repairs mentioned above. 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 documents available on the DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.

2.0 METHODOLOGY

The survey data were collected with a total station instrument, using control coordinates supplied by URS and the as-built surveyor, Level Cross. The MY04 stream survey was completed on July 22, 2015

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. The MY04 vegetation survey was conducted on June 29, 2015.

3.0 REFERENCES

- DWQ, 2000. Neuse Riparian Buffer Mitigation Rules. 15A NCAC 2B .0242
(<http://ncrules.state.nc.us/ncac/title%2015a%20-%20environment%20and%20natural%20resources/chapter%2002%20-%20environmental%20management/subchapter%20b/15a%20ncac%2002b%20.0242.html>)
- EEP. 2003. Ellerbe Creek Local Watershed Plan.
(http://www.nceep.net/services/lwps/Upper_Neuse/Ellerbe_Creek_Local_Watershed_Plan.pdf)
- EEP. 2010. Neuse River Basin Restoration Priorities.
(draft available:
http://www.nceep.net/services/restplans/DRAFT_RBRP_Neuse_201007.pdf)
- 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>).
- USACE. 2003. Stream Mitigation Guidelines.
(<http://www.saw.usace.army.mil/wetlands/Mitigation/Documents/Stream/>).
- Weakley, A. S. 2006. Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas.
(http://www.herbarium.unc.edu/FloraArchives/WeakleyFlora_2006-Jan.pdf).

Appendix A

Project Vicinity Map and Background Tables

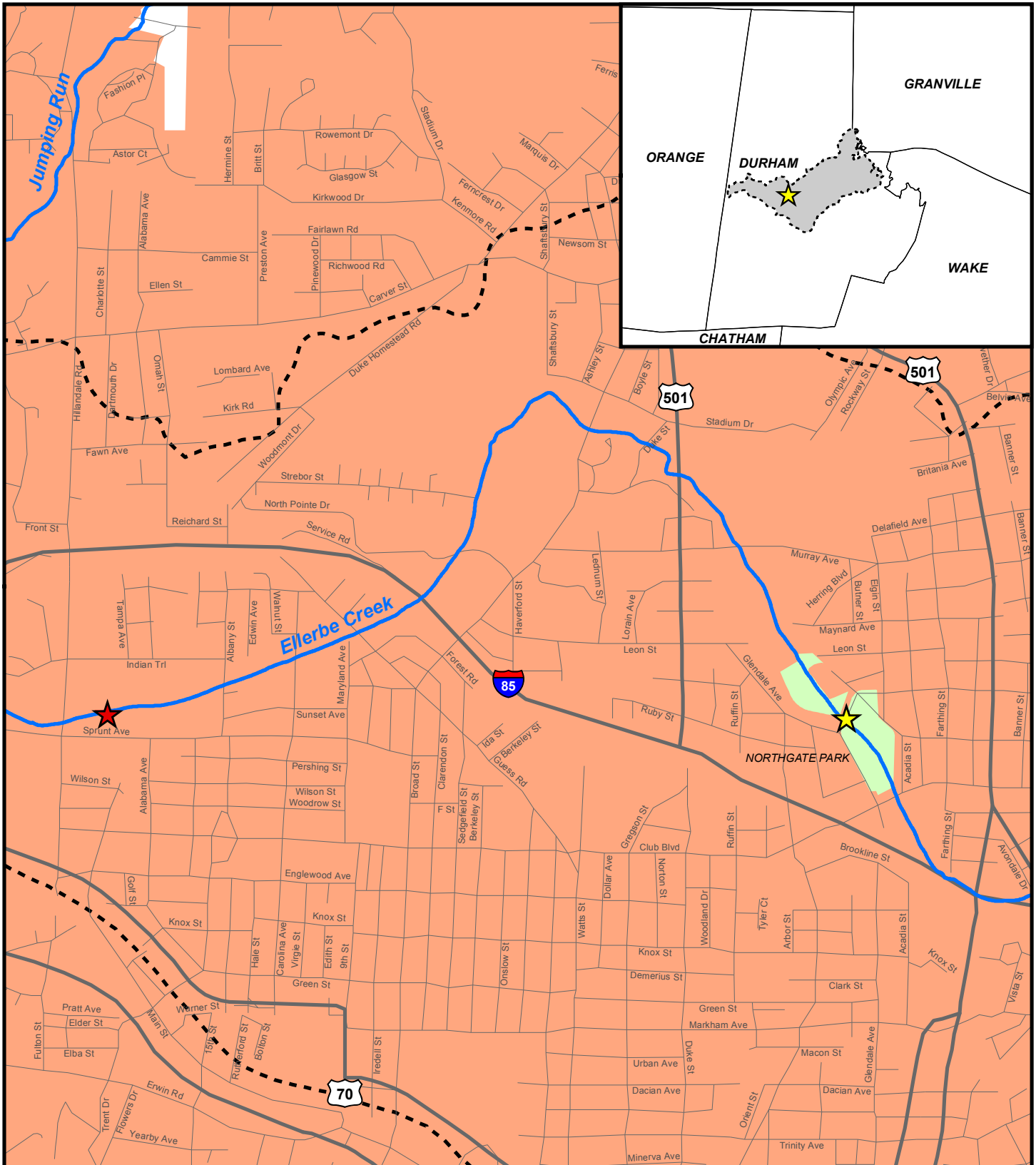


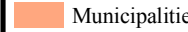
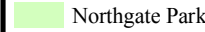
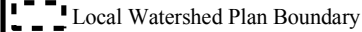
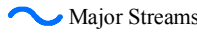



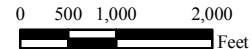


Figure 1. Vicinity Map



-  Roads
-  Counties
-  Municipalities
-  Northgate Park
-  Local Watershed Plan Boundary

-  Major Streams
-  Project Location
-  Hillendale Golf Course Project #127


 1:24,000
 1 inch = 2,000 feet




**Table 1. Project Components and Mitigation Credits
Northgate Park (Ellerbe Creek), DMS Project #272**

Mitigation Credits										
	Stream		Riparian Wetland		Non-riparian Wetland		Buffer		Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE	R	RE		
Length/area	867	1,247					158,172	10,000		
Credits	867	831					158,172	3,333		
TOTAL CREDITS	1,698						161505			
Project Components										
Project Component -or- Reach ID	Stationing/ Location		Existing Footage/ Acreage	Approach (PI, PII etc.)		Restoration -or- Restoration Equivalent		Restoration Footage/Acreage		Mitigation Ratio
Reach 1	10+00 – 25+20		1,520	PII		Enhancement I		1,247*		1.5:1
Reach 2	25+20 – 32+70		646	PII		Restoration		750		1:1
UT 3	100+00 – 101+17		104	PII		Restoration		117		1:1
Buffer						Restoration		3.63		1:1
Buffer						Enhancement		0.23		3:1
Component Summation										
Restoration Level	Stream (linear feet)		Riparian Wetlands (Acres)		Non-Riparian Wetlands (Acres)		Buffer (square feet)		Upland (Acres)	
Restoration	867						158,172			
Enhancement I	1,247						10,000			
Enhancement II										
TOTAL SMU	1,698									
TOTAL RBMU							161,505			

*The stream length for Reach 1 does not include the following easement exceptions: stream with one-sided easement, Lavender Street Road right-of-way, pedestrian bridge crossing

Table 2. Project Activity and Reporting History		
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)		
Elapsed Time Since Grading Complete: 6 yr 11 months		
Elapsed Time Since Planting Complete: 6 yr 0 months		
Number of Reporting Years: 4		
Activity or Report	Data Collection Complete	Actual Completion or Delivery
Concept Plan		Jan 06
Restoration Plan		Jun 06
Final Design - 90%		May 07
Construction		Dec 08
As-Built Survey		Jan 09
Live Stake Planting		Mar 09
Riparian Buffer Planting		Nov 09
Year 1 Monitoring	Nov 09 - Jan 10	May 10
Year 2 Monitoring	Sept 10 - Dec 10	Dec 10
Repair		Mar 14
Year 3 Monitoring	Jan 15	Jan 15
Year 4 Monitoring	Jul 15	Dec 15

Table 3. Project Contacts Table	
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)	
Design Firm	URS 1600 Perimeter Park Drive, Suite 400 Morrisville, North Carolina 27560 Contact: Ms. Kathleen McKeithan Phone: (919) 461-1597
Construction Contractor	Environmental Quality Resources, LLC 1405 Benson Court, Suite C Arbutus, MD 21227 Contact: Mr. John Talley Phone: (443) 304-3310 ext.110 Fax: (443) 304-3315
Planting Contractor	HARP 301 McCullough Drive, 4th Floor Charlotte, North Carolina 28262 Contact: Mr. Alan Peoples Phone: (704) 841-2841
Repair Design Firm	KCI Associates of NC Landmark Center II, Suite 220 4601 Six Forks Rd. Raleigh, NC 27609 Contact: Mr. Adam Spiller Phone: (919) 278-2514 Fax: (919) 783-9266
Repair Construction Contractor	Carolina Environmental Contracting, Inc. PO Box 1905 Mount Airy, NC 27030-6905 Contact: Ms. Joanne Cheatham Phone: (336) 320-3849
Monitoring Performers	
MY-00 - 04	KCI Associates of NC Landmark Center II, Suite 220 4601 Six Forks Rd. Raleigh, NC 27609 Contact: Mr. Adam Spiller Phone: (919) 278-2514 Fax: (919) 783-9266

Table 4. Project Attribute Table			
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)			
Project County	Durham County		
Physiographic Region	Piedmont		
Ecoregion	Triassic Basin		
Project River Basin	Neuse		
USGS HUC for Project (14 digit)	03020201050010		
NCDWQ Sub-basin for Project	03-04-01		
Within extent of EEP Watershed Plan?	Yes - Ellerbe Creek LWP		
WRC Class (Warm, Cool, Cold)	Warm		
% of project easement demarcated	100%		
Beaver activity observed during design phase?	No		
Restoration Component Attribute Table			
	Reach 1	Reach 2	UT 3
Drainage Area	5.9 sq.mi.	5.9 sq.mi.	-
Stream Order	Third	Third	First
Restored length (feet)	1,466	690	117
Perennial or Intermittent	Perennial	Perennial	Perennial
Watershed Type (Rural, Urban, Developing, etc.)	Urban		
Watershed LULC Distribution			
Urban	38%		
Ag-Row Crop	0%		
Ag-Livestock	0%		
Forested	62%		
Water/Wetlands	<1%		
Watershed impervious cover (%)	-		
NCDWQ AU/Index Number	27-5-(0.7)		
NCDWQ Classification	WS-IV; NSW		
303d listed?	Yes		
Upstream of a 303d listed segment?	Yes		
Reasons for 303d Listing or Stressor	impaired biological integrity		
Total acreage of easement	7.5 Acres		
Total vegetated acreage within the easement	1.0 Acre		
Total planted acreage as part of the restoration	6.4 Acres		
Rosgen Classification of pre-existing	G5c	G5c	-
Rosgen Classification of As-built	C5	C5	-
Valley Type	U	U	U
Valley Slope	0.0006	0.0005	U
Valley side slope range (e.g. 2-3%)	U	U	U
Valley toe slope range (e.g. 2-3%)	U	U	U
Trout waters designation	No		
Species of concern, endangered etc.? (Y/N)	No		
Dominant soil series and characteristics			
Series	Chewacla and Wehadkee		
Depth 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



MATCHLINE - SEE SHEET 2

MATCHLINE - SEE SHEET 2

NO.	DATE	REVISIONS

NCDEQ DIVISION OF
MITIGATION SERVICES

KCI
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4601 SIX FORKS ROAD
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NORTHGATE PARK (ELLERBE CREEK)
PROJECT #272 - MONITORING YEAR 04
DURHAM, DURHAM COUNTY, NORTH CAROLINA
ELLERBE CREEK: STATION 10+00 TO STATION 17+40

DATE: DEC 2015
SCALE: GRAPHIC
CURRENT
CONDITION
PLAN VIEW
SHEET 1 OF 3

LEGEND

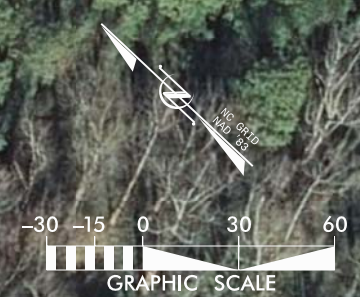
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- AS-BUILT STATIONED.....
- PHOTO POINT (PP).....
- CROSS-SECTION (XS).....
- BMP.....

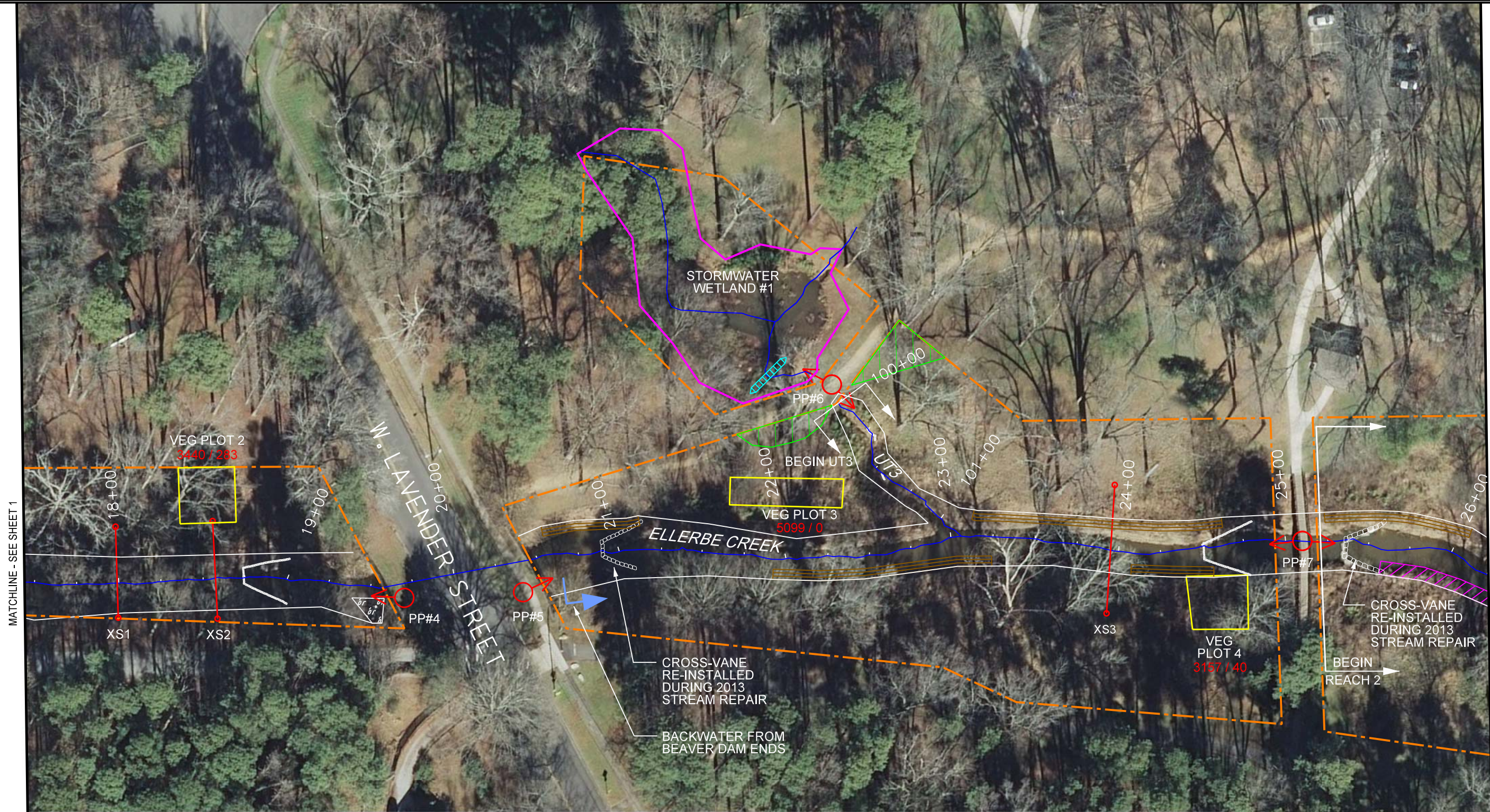
PROJECT CONDITION

- VEG PLOT ABOVE PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT BELOW PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT TOTAL / PLANTED STEM DENSITY..... 3629 / 169
- MOWING INSIDE EASEMENT.....
- BEAVER DAM.....

2013 REPAIR ITEMS

- SOIL LIFT.....
- GRADED BANK.....
- RIFFLE GRADE CONTROL.....





MATCHLINE - SEE SHEET 1

MATCHLINE - SEE SHEET 3

LEGEND

- EASEMENT BOUNDARY.....
- AS-BUILT STATIONED.....
- PHOTO POINT (PP).....
- CROSS-SECTION (XS).....
- BMP.....

PROJECT CONDITION

- VEG PLOT ABOVE PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT BELOW PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT TOTAL / PLANTED STEM DENSITY..... 3629 / 169
- MOWING INSIDE EASEMENT.....
- BEAVER DAM.....

2013 REPAIR ITEMS

- SOIL LIFT.....
- GRADED BANK.....
- RIFFLE GRADE CONTROL.....

REV	DESCRIPTION	DATE

NCDEQ DIVISION OF MITIGATION SERVICES

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 ENGINEERS • PLANNERS • SCIENTISTS
 4601 SIX FORKS ROAD
 RALEIGH, NORTH CAROLINA 27609

**NORTHGATE PARK (ELLERBE CREEK)
 PROJECT #272 - MONITORING YEAR 04**
 DURHAM, DURHAM COUNTY, NORTH CAROLINA
 ELLERBE CREEK: STATION 17+40 TO STATION 26+25

DATE: DEC 2015
 SCALE: GRAPHIC
CURRENT CONDITION PLAN VIEW
 SHEET 2 OF 3



MATCHLINE - SEE SHEET 2

LEGEND

- EASEMENT BOUNDARY.....
- AS-BUILT STATIONED.....
- PHOTO POINT (PP).....
- CROSS-SECTION (XS).....
- BMP.....

PROJECT CONDITION

- VEG PLOT ABOVE PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT BELOW PLANTED STEM SUCCESS CRITERIA.....
- VEG PLOT TOTAL / PLANTED STEM DENSITY..... 3629 / 169
- MOWING INSIDE EASEMENT.....
- BEAVER DAM.....

2013 REPAIR ITEMS

- SOIL LIFT.....
- GRADED BANK.....
- RIFFLE GRADE CONTROL.....



NO.	DATE	DESCRIPTION	REVISIONS

NCDEQ DIVISION OF
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NORTHGATE PARK (ELLERBE CREEK)
PROJECT #272 - MONITORING YEAR 04
DURHAM, DURHAM COUNTY, NORTH CAROLINA
ELLERBE CREEK: STATION 26+25 TO STATION 32+70

DATE: DEC 2015
SCALE: GRAPHIC
CURRENT
CONDITION
PLAN VIEW
SHEET 3 OF 3

Table 5. Visual Stream Morphology Stability Assessment										
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)										
Reach 1 Assessed Length 1520										
Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%			
		2. <u>Degradation</u> - Evidence of downcutting			0	0	100%			
	2. Riffle Condition	1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate	2	8			25%			
		3. Meander Pool Condition ⁺	1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth \geq 1.6)	7			13			
			2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	7			13			
	4. Thalweg Position ⁺	1. Thalweg centering at upstream of meander bend (Run)	0	0			N/A			
2. Thalweg centering at downstream of meander (Glide)		0	0	N/A						
Totals										
2. Bank	1. Scoured/ Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
Totals										
3. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	6	6			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	6	6			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	6	6			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	6	6			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio \geq 1.6 Rootwads/logs providing some cover at base-flow.	6	6			100%			

+This is not a meandering reach, so all pools are associated with structures.

Table 5. Visual Stream Morphology Stability Assessment

Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

Reach 2 Assessed Length 750

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation	
1. Bed	1. Vertical Stability (Riffle and Run units)	1. <u>Aggradation</u> - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%				
		2. <u>Degradation</u> - Evidence of downcutting			0	0	100%				
	2. Riffle Condition	1. <u>Texture/Substrate</u> - Riffle maintains coarser substrate	2	5							40%
		3. Meander Pool Condition	1. <u>Depth</u> Sufficient (Max Pool Depth : Mean Bankfull Depth \geq 1.6)	3							6
			2. <u>Length</u> appropriate (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	3							6
	4. Thalweg Position	1. Thalweg centering at upstream of meander bend (Run)	5	5							100%
2. Thalweg centering at downstream of meander (Glide)		5	5	100%							
2. Bank	1. Scoured/Eroding	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion						0	0	100%	0
	2. Undercut	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%	0	0	100%	
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%	
Totals					0	0	100%	0	0	100%	
3. Engineered Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	4	4							
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	4	4							100%
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	2	2							100%
	3. Bank Protection	Bank erosion within the structures extent of influence does <u>not</u> exceed 15%. (See guidance for this table in EEP monitoring guidance document)	2	2							100%
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio \geq 1.6 Rootwads/logs providing some cover at base-flow.	2	2							100%

Table 6. Vegetation Condition Assessment

Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

		Planted Acreage 6.4		Easement Acreage 7.5		
Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres	Pattern and Color	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres	Pattern and Color	0	0.00	0.0%
Total				0	0.00	0.0%
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25 acres	Pattern and Color	0	0.00	0.0%
Cumulative Total				0	0.00	0.0%
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale).	1000 SF	Pattern and Color	0	0.00	0.0%
Cumulative Total				0	0.00	0.0%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	Pattern and Color	2	0.03	0.4%

Stream Station Photos



PP#1 – MY01 – 1/19/10



PP#1 – MY04 – 12/2/15



PP#2A – MY01 – 1/19/10



PP#2A – MY04 – 12/2/15



PP#2B – MY01 – 1/19/10



PP#2B – MY04 – 12/2/15



PP#3A – MY01 – 1/19/10



PP#3A – MY04 – 12/2/15



PP#3B – MY01 – 1/19/10



PP#3B – MY04 – 12/2/15



PP#4 – MY01 – 1/19/10



PP#4 – MY04 – 12/2/15



PP#5 – MY01 – 1/19/10



PP#5 – MY04 – 12/2/15



PP#6A – MY01 – 1/19/10



PP#6A – MY04 – 12/2/15



PP#6B – MY01 – 1/19/10



PP#6B – MY04 – 12/2/15



PP#7A – MY01 – 1/19/10



PP#7A – MY04 – 12/2/15



PP#7B – MY01 – 1/19/10



PP#7B – MY04 – 12/2/15



PP#8A – MY01 – 1/19/10



PP#8A – MY04 – 12/2/15



PP#8B – MY01 – 1/19/10



PP#8B – MY04 – 12/2/15



PP#9A – MY01 – 1/19/10



PP#9A – MY04 – 12/2/15



PP#9B – MY01 – 1/19/10



PP#9B – MY04 – 12/2/15



PP#9C – MY01 – 1/19/10



PP#9C – MY04 – 12/2/15



PP#10 – MY01 – 1/19/10



PP#10 – MY04 – 12/2/15

Vegetation Monitoring Plot Photos



Plot 1 Photo – Taken looking southeast from the plot origin. MY04 – 6/29/15



Plot 4 Photo – Taken looking south from the plot origin. MY04 – 6/29/15



Plot 2 Photo – Taken looking south from the plot origin. MY04 – 6/29/15



Plot 5 Photo – Taken looking east from the plot origin. MY04 – 6/29/15



Plot 3 Photo – Taken looking east from the plot origin. MY04 – 6/29/15



Plot 6 Photo – Taken looking south from the plot origin. MY04 – 6/29/15

Problem Area Photos



Beaver dam at Station 30 + 00. 12/2/2015



Beaver lodge at Station 28 + 75. 6/29/2015

Appendix C

Vegetation Plot Data

Table 7. Vegetation Plot Criteria Attainment	
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)	
Vegetation Plot ID	Vegetation Survival Threshold Met?
1	No
2	No
3	No
4	No
5	No
6	Yes

Table 8. CVS Vegetation Plot Metadata	
Project Number and Name: 272 - Northgate Park (Ellerbe Creek)	
Report Prepared By	Bethany Williams
Date Prepared	7/24/2015 11:39
database name	KCI-2014-Elerbe.mdb
database location	M:\2014\16146867_NGP Monitoring
computer name	12-3ZV4FP1
file size	48521216
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.
Planted Stems by Plot and Spp	A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.
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	272
project Name	Ellerbe Creek
Description	Stream and Buffer Restoration and Enhancement
River Basin	Neuse
length(ft)	2200
stream-to-edge width (ft)	40
area (sq m)	16349.28
Required Plots (calculated)	6
Sampled Plots	6

Table 9. CVS Stem Count Total and Planted by Plot and Species

Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

			Current Plot Data (MY3 2015)																		Annual Means																	
Scientific Name	Common Name	Species Type	E272-A-0001			E272-A-0002			E272-A-0003			E272-A-0004			E272-A-0005			E272-A-0006			MY3 (2015)			MY2 (2014)			MY1 (2010)			MY0 (2009)								
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T						
<i>Acer</i>	maple	Tree																																	5	5	5	
<i>Acer negundo</i>	boxelder	Tree										1							1			2			1													
<i>Acer rubrum</i>	red maple	Tree																1			2			3			6						1					
<i>Acer saccharum</i>	sugar maple	Tree			2		3	3	3									1				3	3	6	3	3	6	4	4	5								
<i>Alnus serrulata</i>	hazel alder	Shrub										3			13							16	1	1	15								54	3	3	3		
<i>Aronia arbutifolia</i>	Red Chokeberry	Shrub																								1	1	1				1	1	1				
<i>Baccharis</i>	baccharis	Shrub																																				
<i>Baccharis halimifolia</i>	eastern baccharis	Shrub																																				
<i>Betula nigra</i>	river birch	Tree			1							1																										
<i>Celtis laevigata</i>	sugarberry	Tree																																				
<i>Cercis canadensis</i>	eastern redbud	Tree																2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2			
<i>Comus</i>	dogwood	Shrub or Tree																																	3	3	3	
<i>Comus amomum</i>	silky dogwood	Shrub																																				
<i>Diospyros virginiana</i>	common persimmon	Tree					3	3	3																													
<i>Fraxinus pennsylvanica</i>	green ash	Tree																																				
<i>Ilex comuta</i>	Chinese holly	Exotic																																				
<i>Juglans nigra</i>	black walnut	Tree																																				
<i>Juniperus virginiana</i>	eastern redcedar	Tree	1	1	2																																	
<i>Liquidambar styraciflua</i>	sweetgum	Tree																																				
<i>Liriodendron tulipifera</i>	tuliptree	Tree																																				
<i>Morus rubra</i>	red mulberry	Tree																																				
<i>Oxydendrum arboreum</i>	sourwood	Tree																																				
<i>Physocarpus</i>	ninebark	Shrub																																				
<i>Pinus taeda</i>	loblolly pine	Tree																																				
<i>Platanus occidentalis</i>	American sycamore	Tree																																				
<i>Prunus serotina var. serotina</i>	black cherry	Tree																																				
<i>Prunus virginiana</i>	chokecherry	Shrub																																				
<i>Quercus</i>	oak	Tree																																				
<i>Quercus coccinea</i>	scarlet oak	Tree																																				
<i>Quercus lyrata</i>	overcup oak	Tree																																				
<i>Quercus michauxii</i>	swamp chestnut oak	Tree	2	2	2																																	
<i>Quercus pagoda</i>	cherrybark oak	Tree																																				
<i>Quercus phellos</i>	willow oak	Tree																																				
<i>Quercus rubra</i>	northern red oak	Tree																																				
<i>Salix nigra</i>	black willow	Tree																																				
<i>Sambucus canadensis</i>	Common Elderberry	Shrub																																				
<i>Spiraea</i>	spirea	Shrub																																				
<i>Symphoricarpos orbiculatus</i>	coralberry	Shrub																																				
<i>Taxodium distichum</i>	bald cypress	Tree																																				
<i>Ulmus</i>	elm	Tree																																				
<i>Ulmus americana</i>	American elm	Tree																																				
<i>Ulmus parvifolia</i>	Chinese elm	Tree																																				
<i>Unknown</i>		Shrub or Tree																																				
Stem count			3	3	135	7	7	86	0	0	126	1	1	78	6	6	45	8	8	69	25	25	539	27	27	540	57	57	361	85	89	89						
size (ares)			1			1			1			1			1			1			6			6			6			6								
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02			0.15			0.15			0.15			0.15								
Species count			2	2	13	3	3	16	0	0	15	1	1	9	2	2	9	4	4	11	9	9	30	10	10	31	17	17	26	20	22	22						
Stems per ACRE			121.4	121.4	5463	283.3	283.3	3480	0	0	5099	40.47	40.47	3157	242.8	242.8	1821	323.7	323.7	2792	168.6	168.6	3635	182.1	182.1	3642	384.5	384.5	2435	573.3	600.3	600.3						

Appendix D

Stream Survey Data

Cross-Section Plots

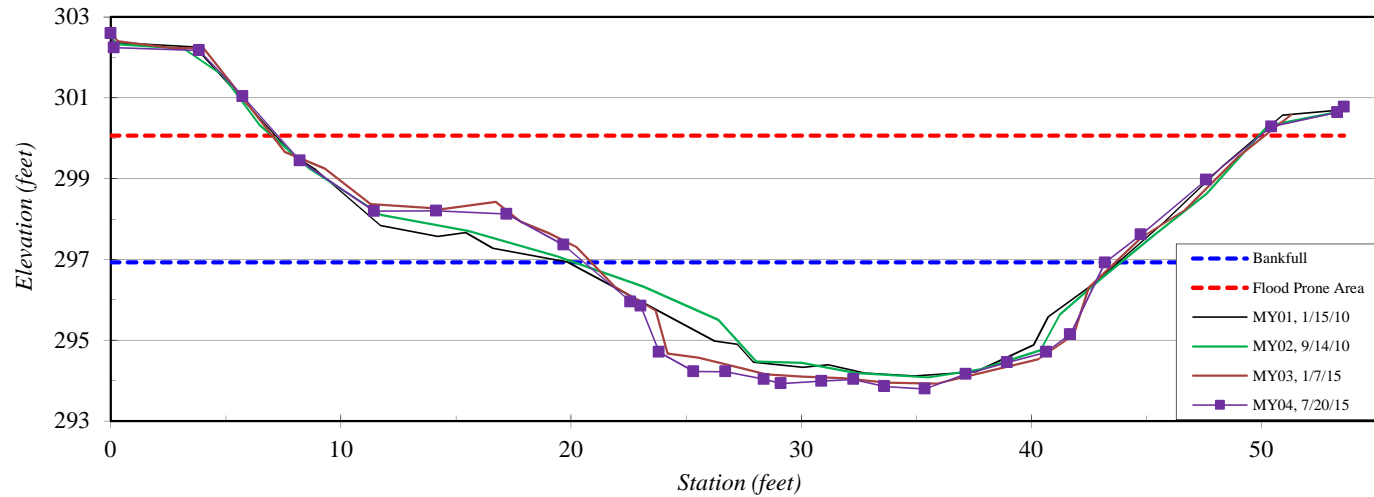
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY04
XS ID	XS - 1, Reach 1, Riffle
Drainage Area (sq mi):	5.9
Date:	7/20/2015
Field Crew:	T. Seelinger, B. Williams



Station	Elevation
0.0	302.59
0.1	302.24
3.8	302.17
5.7	301.04
8.2	299.44
11.4	298.19
14.1	298.20
17.2	298.12
19.7	297.36
22.6	295.95
23.0	295.85
23.8	294.71
25.3	294.22
26.7	294.22
28.4	294.03
29.1	293.93
30.9	293.99
32.3	294.03
33.6	293.86
35.4	293.80
37.2	294.16
39.0	294.45
40.6	294.70
41.7	295.14
43.2	296.92
44.8	297.61
47.6	298.97
50.4	300.29
53.3	300.64
53.6	300.77

SUMMARY DATA	
Bankfull Elevation:	296.9
Bankfull Cross-Sectional Area:	53.4
Bankfull Width:	22.7
Flood Prone Area Elevation:	300.1
Flood Prone Width:	42.8
Max Depth at Bankfull:	3.1
Mean Depth at Bankfull:	2.4
W / D Ratio:	9.6
Entrenchment Ratio:	1.9
Bank Height Ratio:	1.0

Neuse River Basin, Ellerbe Creek, MY04, XS - 1, Reach 1, Riffle



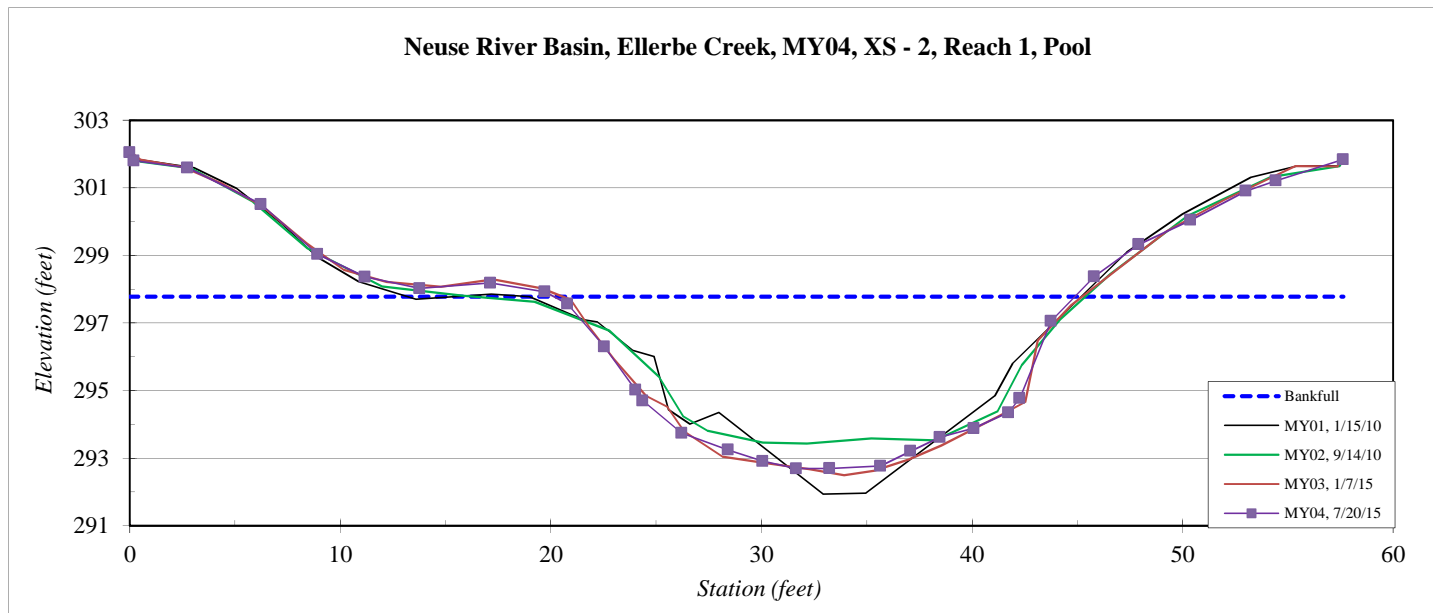
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY04
XS ID	XS - 2, Reach 1, Pool
Drainage Area (sq mi):	5.9
Date:	7/20/2015
Field Crew:	T. Seelinger, B. Williams

Station	Elevation
0.0	302.0
0.2	301.8
2.7	301.6
6.2	300.5
8.9	299.0
11.2	298.4
13.8	298.0
17.1	298.2
19.7	297.9
20.8	297.6
22.5	296.3
24.0	295.0
24.4	294.7
26.2	293.7
28.4	293.2
30.1	292.9
31.7	292.7
33.2	292.7
35.7	292.8
37.1	293.2
38.5	293.6
40.1	293.9
41.7	294.3
42.3	294.8
43.8	297.1
45.8	298.4
47.9	299.3
50.4	300.0
53.0	300.9
54.4	301.2
57.6	301.8

SUMMARY DATA	
Bankfull Elevation:	297.8
Bankfull Cross-Sectional Area:	88.1
Bankfull Width:	24.7
Flood Prone Area Elevation:	-
Flood Prone Width:	-
Max Depth at Bankfull:	5.1
Mean Depth at Bankfull:	3.6
W / D Ratio:	-
Entrenchment Ratio:	-
Bank Height Ratio:	-



Neuse River Basin, Ellerbe Creek, MY04, XS - 2, Reach 1, Pool



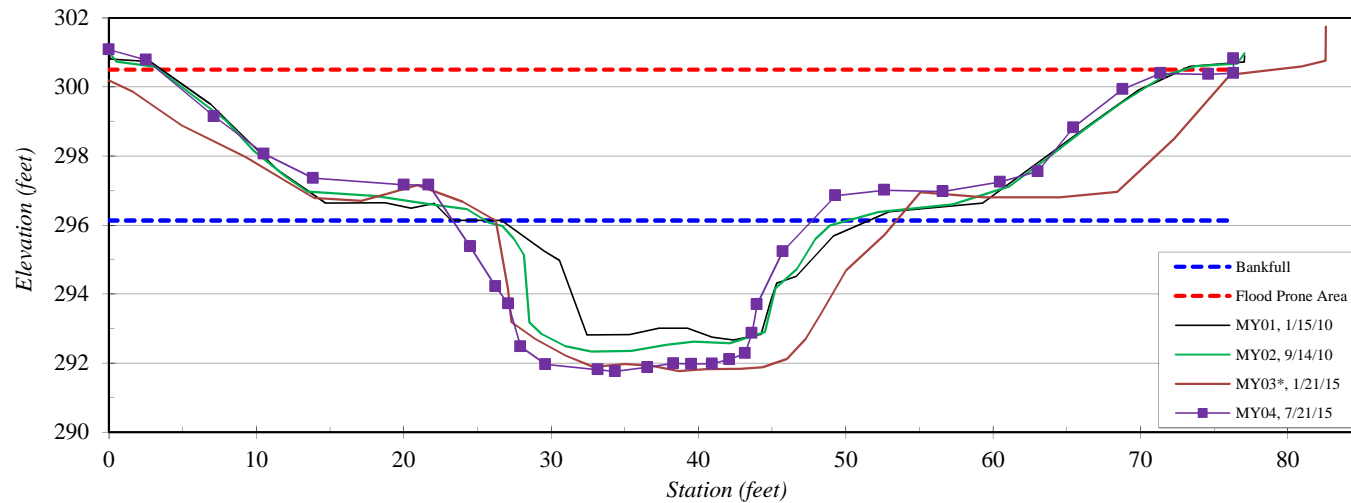
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY04
XS ID	XS - 3, Reach 1, Riffle
Drainage Area (sq mi):	5.9
Date:	7/21/2015
Field Crew:	T. Seelinger, B. Williams



Station	Elevation
0.0	301.08
2.5	300.78
7.1	299.15
10.5	298.06
13.9	297.36
20.0	297.16
21.7	297.16
24.5	295.38
26.2	294.22
27.1	293.72
27.9	292.48
29.6	291.96
33.2	291.81
34.3	291.76
36.5	291.88
38.3	291.99
39.5	291.97
40.9	291.98
42.1	292.11
43.2	292.28
43.6	292.87
44.0	293.71
45.7	295.23
49.3	296.85
52.6	297.01
56.6	296.97
60.5	297.25
63.0	297.55
65.5	298.82
68.8	299.93
71.4	300.39
74.6	300.36
76.3	300.40
76.3	300.82

SUMMARY DATA	
Bankfull Elevation:	296.1
Bankfull Cross-Sectional Area:	77.2
Bankfull Width:	24.4
Flood Prone Area Elevation:	300.5
Flood Prone Width:	76.3
Max Depth at Bankfull:	4.4
Mean Depth at Bankfull:	3.2
W / D Ratio:	7.7
Entrenchment Ratio:	3.1
Bank Height Ratio:	1.0

Neuse River Basin, Ellerbe Creek, MY04, XS - 3, Reach 1, Riffle



*=pins reset for MY03 due to construction activity on site

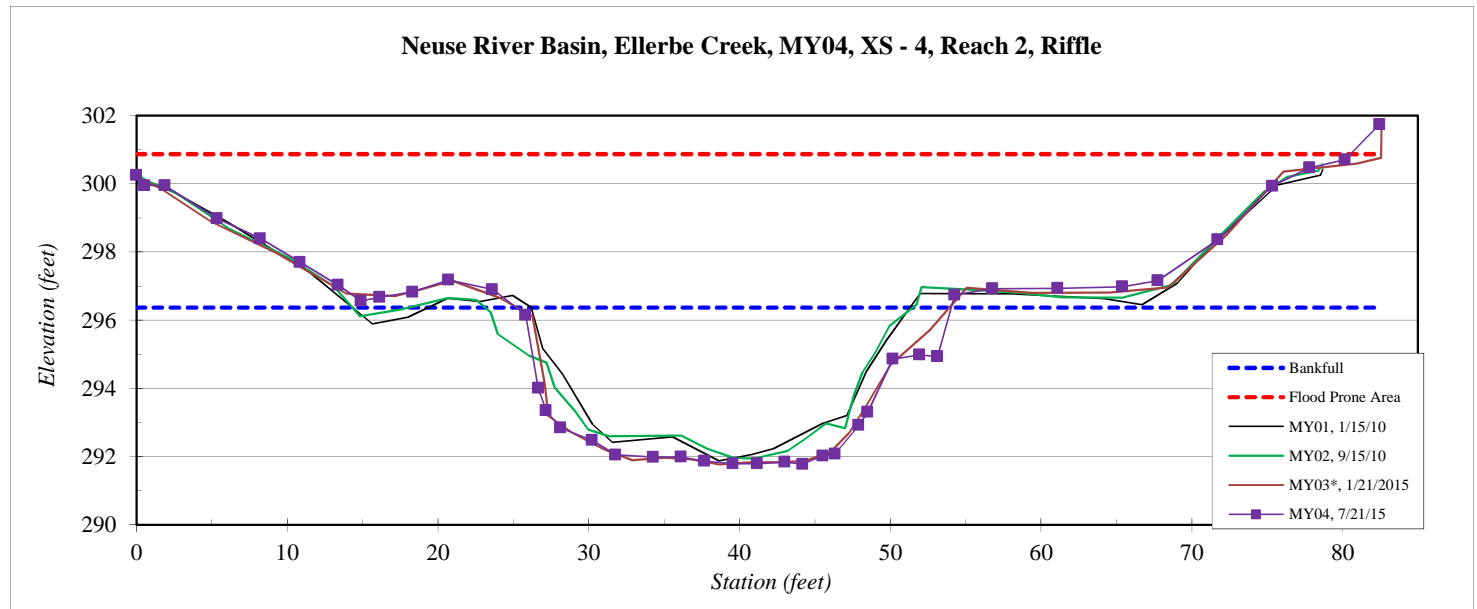
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY04
XS ID	XS - 4, Reach 2, Riffle
Drainage Area (sq mi):	5.9
Date:	7/21/2015
Field Crew:	T. Seelinger, B. Williams



Station	Elevation
0.0	300.25
0.5	299.95
1.9	299.95
5.3	298.99
8.2	298.40
10.8	297.70
13.4	297.03
14.9	296.56
16.1	296.67
18.3	296.83
20.7	297.18
23.6	296.90
25.8	296.15
26.7	294.01
27.2	293.35
28.1	292.84
30.2	292.48
31.8	292.05
34.3	291.99
36.1	291.99
37.7	291.87
39.6	291.79
41.2	291.79
43.0	291.84
44.2	291.78
45.5	292.02
46.3	292.07
47.9	292.92
48.5	293.30
50.2	294.86
51.9	294.98
53.1	294.93
54.3	296.75
56.8	296.92
61.1	296.93

SUMMARY DATA	
Bankfull Elevation:	296.4
Bankfull Cross-Sectional Area:	101.8
Bankfull Width:	28.9
Flood Prone Area Elevation:	300.9
Flood Prone Width:	82.9
Max Depth at Bankfull:	4.6
Mean Depth at Bankfull:	3.5
W / D Ratio:	8.2
Entrenchment Ratio:	2.9
Bank Height Ratio:	1.0

Neuse River Basin, Ellerbe Creek, MY04, XS - 4, Reach 2, Riffle



*=pins reset for MY03 due to construction activity on site

Station	Elevation	Station	Elevation
65.4	296.98	77.8	300.48
67.7	297.16	80.2	300.71
71.7	298.36	82.5	301.75

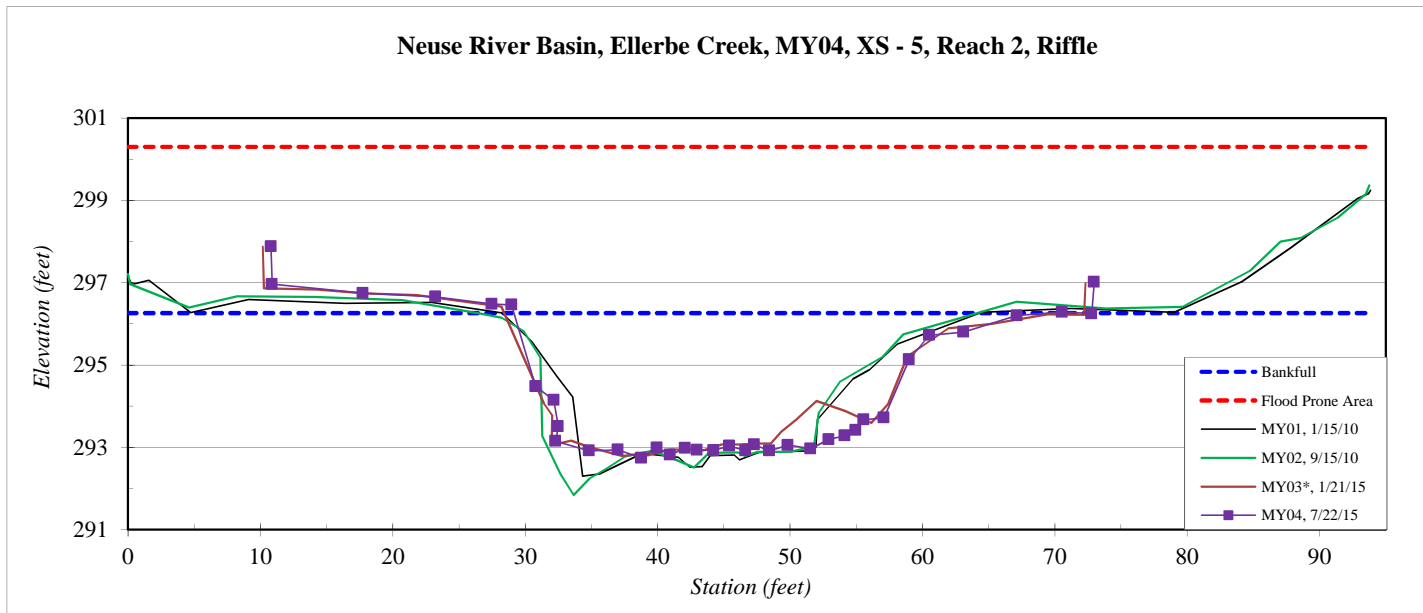
River Basin:	Neuse
Watershed:	Ellerbe Creek, MY04
XS ID	XS - 5, Reach 2, Riffle
Drainage Area (sq mi):	5.9
Date:	7/22/2015
Field Crew:	T. Seelinger, B. Williams

Station	Elevation
0.0	297.88
0.1	296.96
7.0	296.74
12.4	296.66
16.7	296.48
18.2	296.46
20.0	294.48
21.4	294.14
21.7	293.51
21.5	293.15
24.0	292.92
26.2	292.94
28.0	292.74
29.2	292.99
30.2	292.82
31.3	292.98
32.2	292.93
33.4	292.93
34.6	293.03
35.8	292.92
36.5	293.06
37.6	292.91
39.0	293.05
40.8	292.97
42.1	293.19
43.3	293.28
44.2	293.41
44.8	293.67
46.3	293.72
48.2	295.14
49.7	295.72
52.3	295.80
56.3	296.20
59.8	296.28
62.0	296.25
62.2	297.02

SUMMARY DATA	
Bankfull Elevation:	296.3
Bankfull Cross-Sectional Area:	90.1
Bankfull Width:	33.9
Flood Prone Area Elevation:	300.3
Flood Prone Width:	62.2
Max Depth at Bankfull:	3.5
Mean Depth at Bankfull:	2.7
W / D Ratio:	12.8
Entrenchment Ratio:	1.8
Bank Height Ratio:	1.0

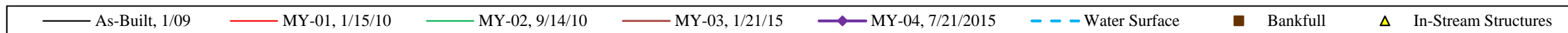
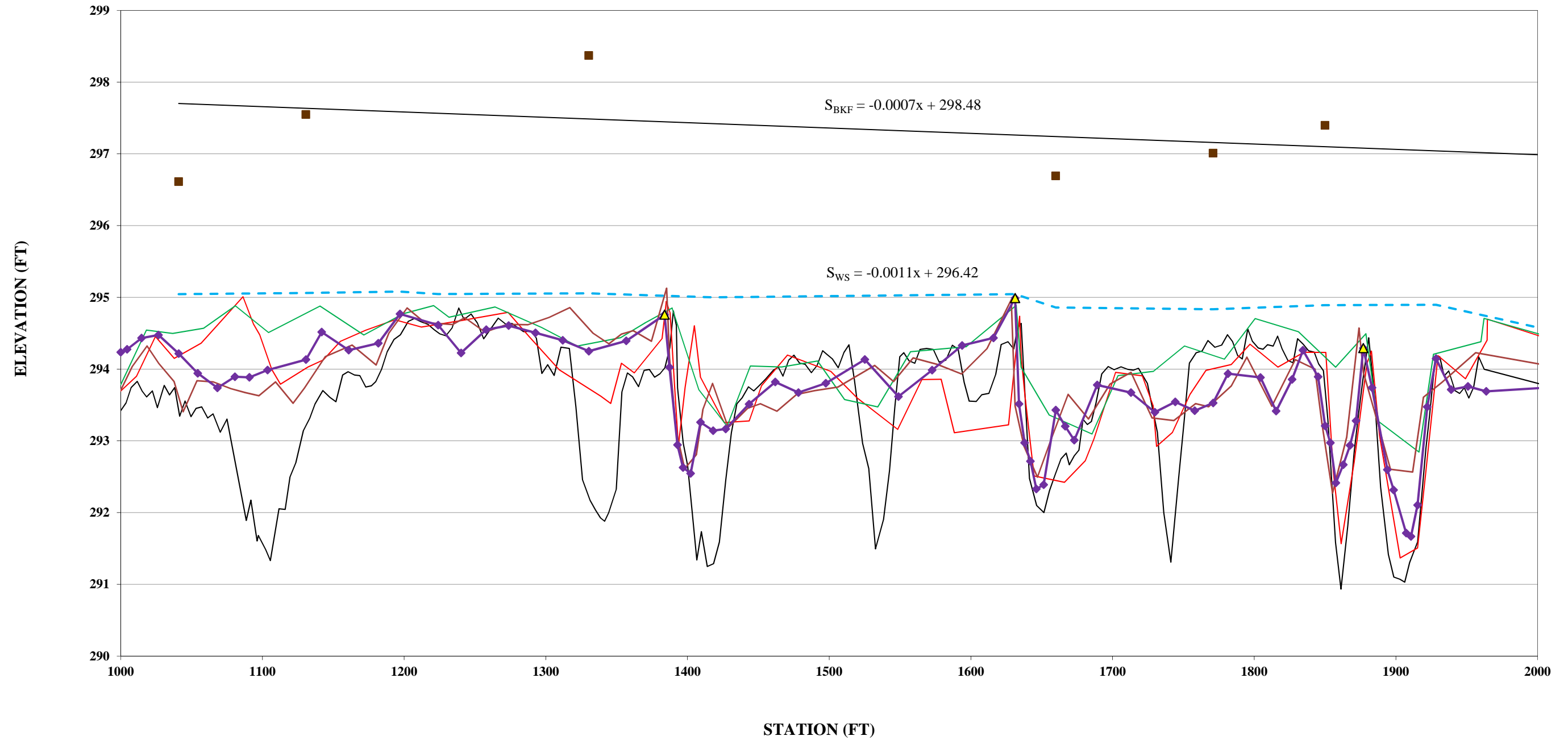


Neuse River Basin, Ellerbe Creek, MY04, XS - 5, Reach 2, Riffle

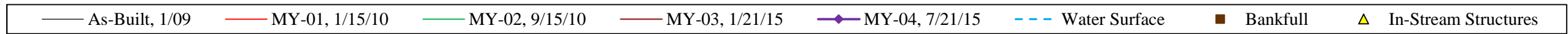
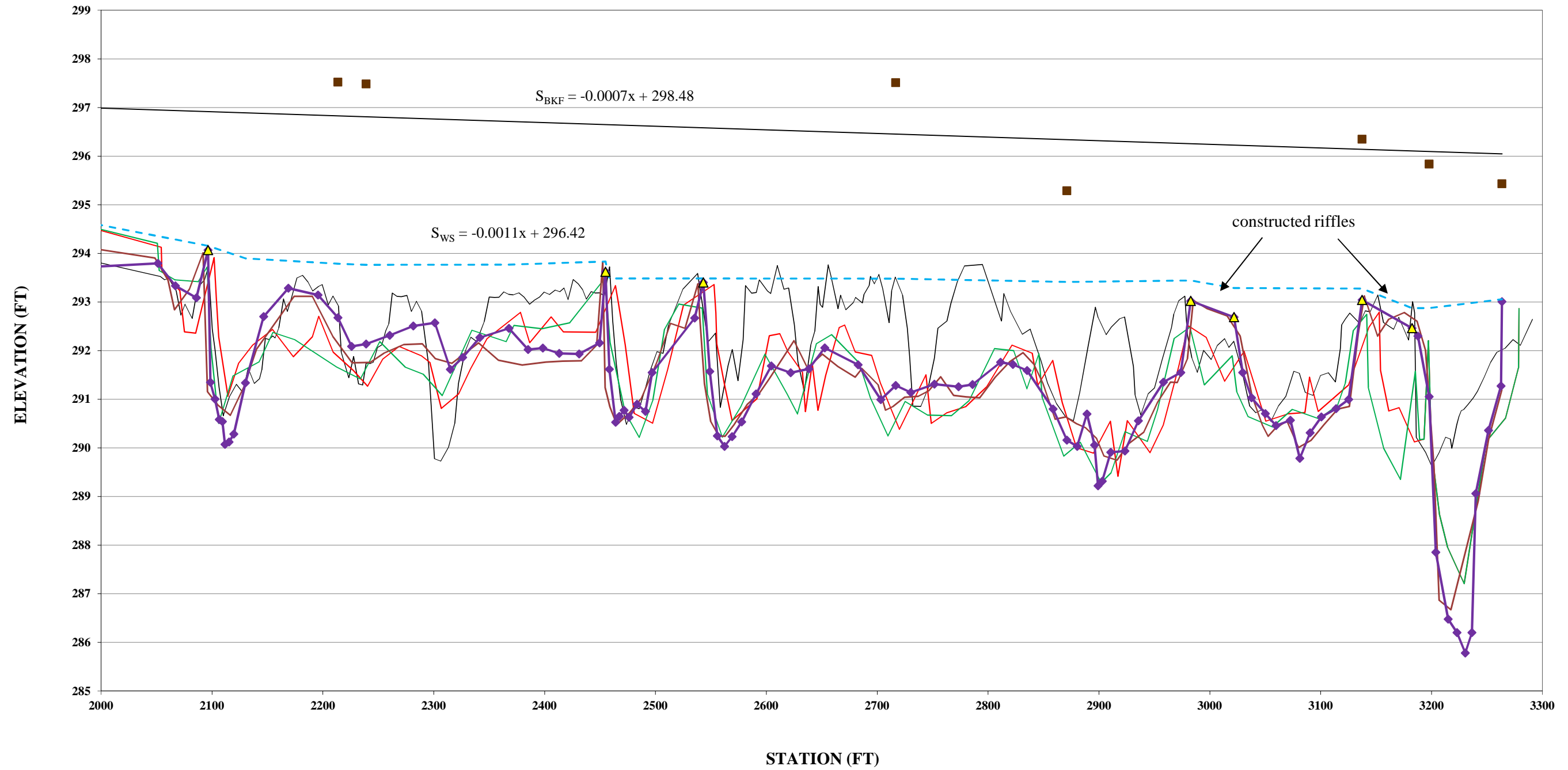


*=pins reset for MY03 due to construction activity on site

**Longitudinal Profile
 Ellerbe Creek
 EEP Project Number 272- MY04
 Stations 10+00 - 20+00**

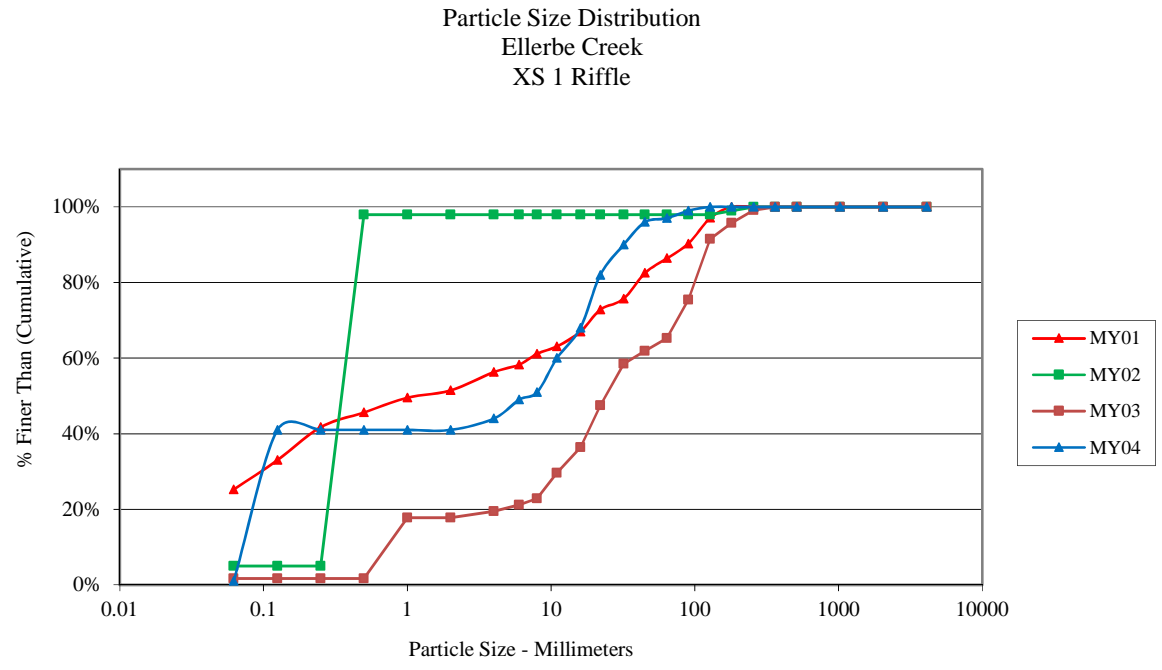


**Longitudinal Profile
 Ellerbe Creek
 EEP Project Number 272- MY04
 Stations 20+00 - 33+00**



Pebble Count Plots

Cross-Section 1 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	40
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	
Very Fine	2 - 4		3
Fine	4 - 5.7	G	5
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	9
Medium	11.3 - 16	V	8
Coarse	16 - 22.6	E	14
Coarse	22.6 - 32	L	8
Very Coarse	32 - 45	S	6
Very Coarse	45 - 64		1
Small	64 - 90	C	2
Small	90 - 128	O	1
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	
		Total	100
Note:			

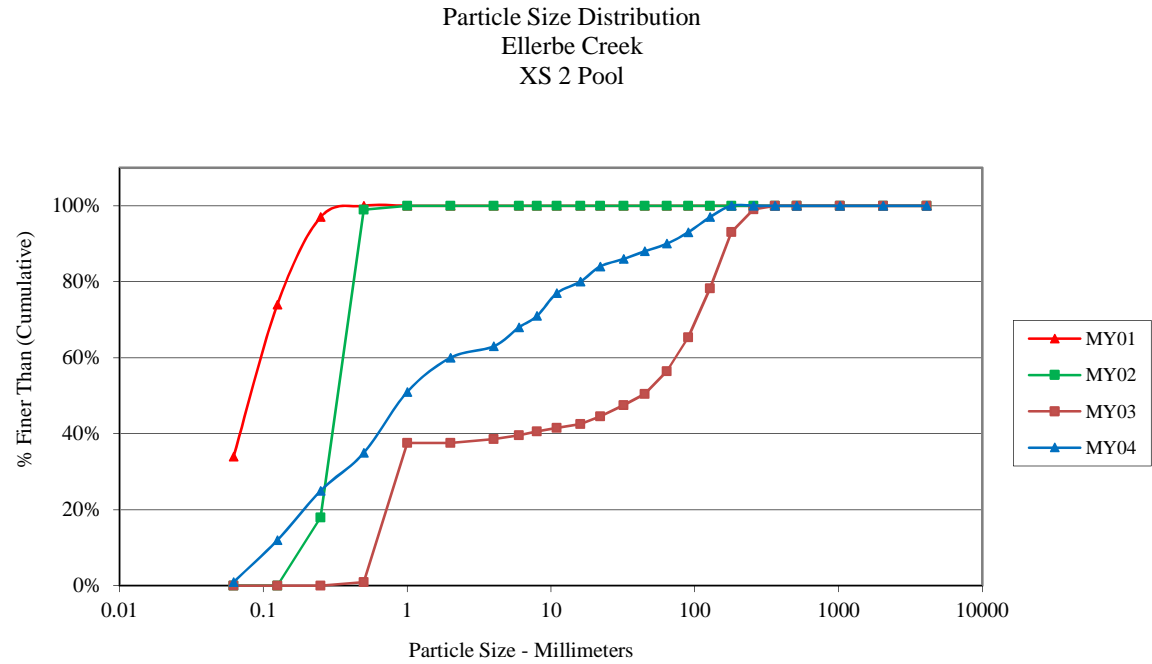


Size (mm)	
D16	0.081
D35	0.11
D50	6.9
D65	14
D84	24
D95	43

Size Distribution	
mean	1.4
dispersion	44.3
skewness	-0.44

Type	
silt/clay	1%
sand	40%
gravel	56%
cobble	3%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 2 Pool - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	1
Very Fine	.062 - .125	S	11
Fine	.125 - .25	A	13
Medium	.25 - .50	N	10
Coarse	.50 - 1	D	16
Very Coarse	1 - 2	S	9
Very Fine	2 - 4		3
Fine	4 - 5.7	G	5
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	6
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	4
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	2
Very Coarse	45 - 64		2
Small	64 - 90	C	3
Small	90 - 128	O	4
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	
		Total	100
Note:			

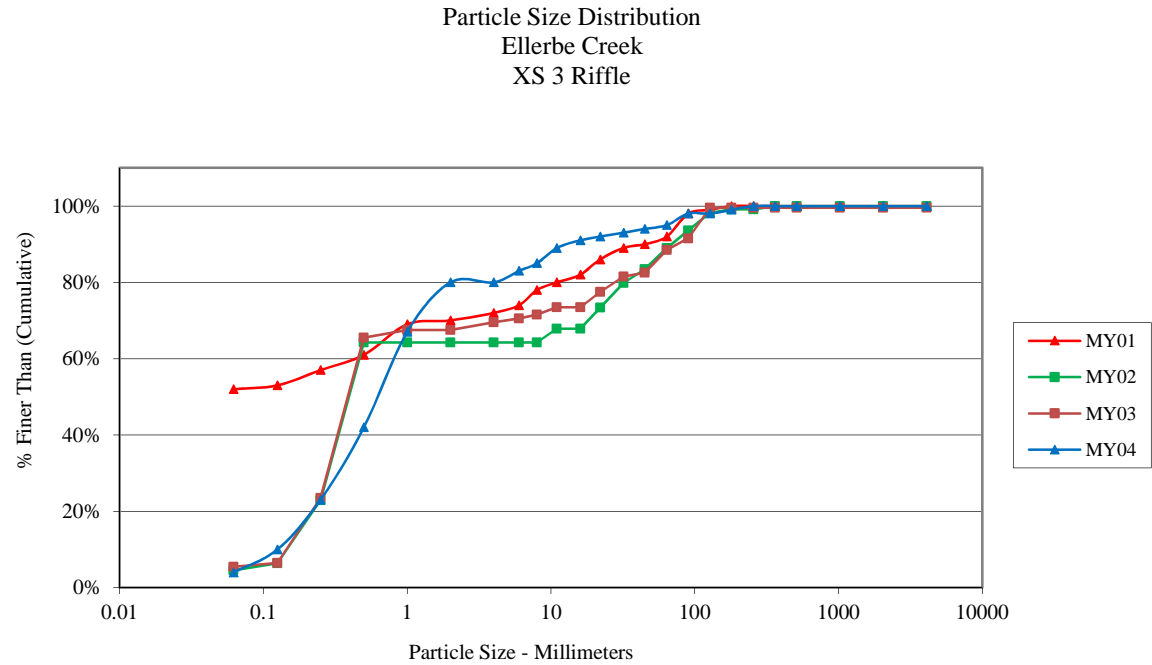


Size (mm)	
D16	0.15
D35	0.5
D50	0.96
D65	4.7
D84	22
D95	110

Size Distribution	
mean	1.8
dispersion	14.7
skewness	0.19

Type	
silt/clay	1%
sand	59%
gravel	30%
cobble	10%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 3 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	4
Very Fine	.062 - .125	S	6
Fine	.125 - .25	A	13
Medium	.25 - .50	N	19
Coarse	.50 - 1	D	25
Very Coarse	1 - 2	S	13
Very Fine	2 - 4		
Fine	4 - 5.7	G	3
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	4
Medium	11.3 - 16	V	2
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	1
Very Coarse	45 - 64		1
Small	64 - 90	C	3
Small	90 - 128	O	
Large	128 - 180	B	1
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	
		Total	100
Note:			

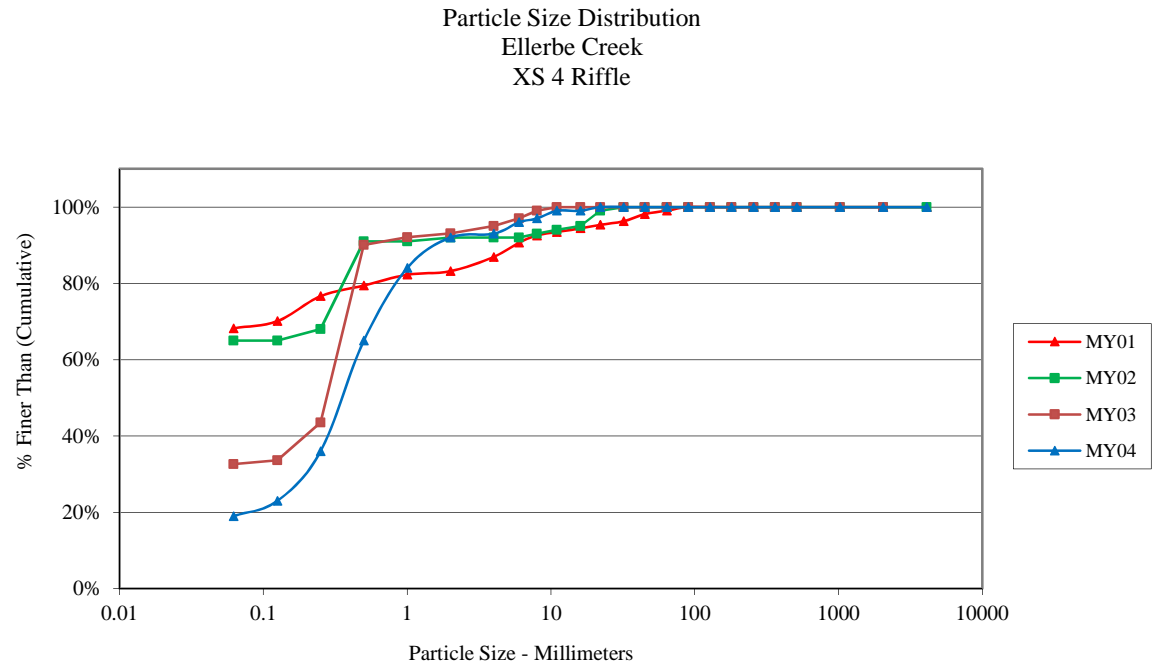


Size (mm)	
D16	0.17
D35	0.39
D50	0.62
D65	0.95
D84	6.9
D95	64

Size Distribution	
mean	1.1
dispersion	7.4
skewness	0.19

Type	
silt/clay	4%
sand	76%
gravel	15%
cobble	5%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 4 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	19
Very Fine	.062 - .125	S	4
Fine	.125 - .25	A	13
Medium	.25 - .50	N	29
Coarse	.50 - 1	D	19
Very Coarse	1 - 2	S	8
Very Fine	2 - 4		1
Fine	4 - 5.7	G	3
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	2
Medium	11.3 - 16	V	
Coarse	16 - 22.6	E	1
Coarse	22.6 - 32	L	
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	
		Total	100
Note:			

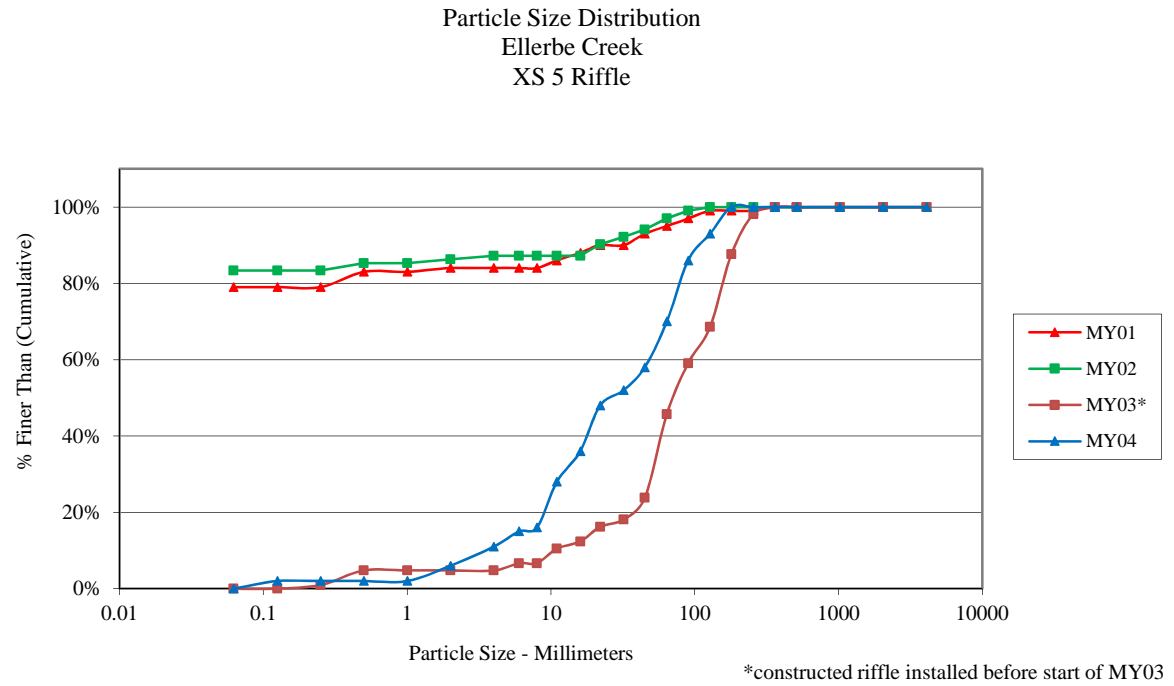


Size (mm)	
D16	0.062
D35	0.24
D50	0.35
D65	0.5
D84	1
D95	5.2

Size Distribution	
mean	0.2
dispersion	4.3
skewness	-0.13

Type	
silt/clay	19%
sand	73%
gravel	8%
cobble	0%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross-Section 5 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	2
Fine	.125 - .25	A	
Medium	.25 - .50	N	
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	4
Very Fine	2 - 4		5
Fine	4 - 5.7	G	4
Fine	5.7 - 8	R	1
Medium	8 - 11.3	A	12
Medium	11.3 - 16	V	8
Coarse	16 - 22.6	E	12
Coarse	22.6 - 32	L	4
Very Coarse	32 - 45	S	6
Very Coarse	45 - 64		12
Small	64 - 90	C	16
Small	90 - 128	O	7
Large	128 - 180	B	7
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	
		Total	100
Note:			



Size (mm)	
D16	8
D35	15
D50	27
D65	55
D84	86
D95	140

Size Distribution	
mean	26.2
dispersion	3.3
skewness	-0.01

Type	
silt/clay	0%
sand	6%
gravel	64%
cobble	30%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Table 10. Baseline - Stream Data Summary Table
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)
Segment Reach: Reach 1 (1,520 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)							30.8			13.5			30.0					
Floodprone Width (ft)							60			300								
Bankfull Cross-Sectional Area (ft ²)							118.6			30.8			54.6					
Bankfull Mean Depth (ft)							3.9			2.3			1.8					
Bankfull Maximum Depth (ft)							4.6			3.8			2.5					
Width/Depth Ratio							8.0			5.9			16.7					
Entrenchment Ratio							1.9			22.2								
Bank Height Ratio							1.7			0.9			1.0					
Pattern																		
Channel Beltwidth (ft)							50	100		50	125		40	60				
Radius of Curvature (ft)							150	180		16	30		165	180				
Meander Wavelength (ft)							700	1000		115	200		700	1000				
Meander Width Ratio							1.6	3.2		3.7	9.3		1.3	2.0				
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)							0.014			0.005			0.002					
Pool Length (ft)																		
Pool Spacing (ft)							45	521		45	93		83	172				
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)							1,466						1,466					
Sinuosity							1.02			1.33			1.01					
Water Surface Slope (ft/ft)							0.0009			0.0019			0.0006					
BF Slope (ft/ft)																		
Rosgen Classification							G5c			E5			C5					

Note: The Pre-Existing Condition and Project Reference Stream Data are the same for both reaches and are from the Restoration Plan document. The Design data are also from the Restoration Plan, except for the Dimension Parameter, which is from the Construction Plans. As-Built data were not taken due to project delays.

Table 10. Baseline - Stream Data Summary Table																			
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)																			
Segment Reach: Reach 2 (750 ft.)																			
Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built			
	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	
Bankfull Width (ft)							30.8			13.5			40.0						
Floodprone Width (ft)							60			300									
Bankfull Cross-Sectional Area (ft ²)							118.6			30.8			75.6						
Bankfull Mean Depth (ft)							3.9			2.3			1.9						
Bankfull Maximum Depth (ft)							4.6			3.8			2.8						
Width/Depth Ratio							8.0			5.9			21.1						
Entrenchment Ratio							1.9			22.2									
Bank Height Ratio							1.7			0.9			1.0						
Pattern																			
Channel Beltwidth (ft)							50	100		50	125		80	100					
Radius of Curvature (ft)							150	180		16	30		63	100					
Meander Wavelength (ft)							700	1000		115	200		260	300					
Meander Width Ratio							1.6	3.2		3.7	9.3		3.2	4.0					
Profile																			
Riffle Length (ft)																			
Riffle Slope (ft/ft)							0.014			0.005			0.001						
Pool Length (ft)																			
Pool Spacing (ft)							45	521		45	93		83	172					
Substrate																			
d50 (mm)																			
d84 (mm)																			
Additional Reach Parameters																			
Valley Length (ft)																			
Channel Length (ft)								1,466						690					
Sinuosity								1.02			1.33			1.02					
Water Surface Slope (ft/ft)								0.0009			0.0019			0.0005					
BF Slope (ft/ft)																			
Rosgen Classification								G5c			E5			C5					

Note: The Pre-Existing Condition and Project Reference Stream Data are the same for both reaches and are from the Restoration Plan document. The Design data are also from the Restoration Plan, except for the Dimension Parameter, which is from the Construction Plans. As-Built data were not taken due to project delays.

Table 10. Baseline - Stream Data Summary Table
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)
Segment Reach: UT 3 (117 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)										13.5			3.2					
Floodprone Width (ft)										300								
Bankfull Cross-Sectional Area (ft ²)										30.8			1.5					
Bankfull Mean Depth (ft)										2.3			0.5					
Bankfull Maximum Depth (ft)										3.8			0.7					
Width/Depth Ratio										5.9			6.4					
Entrenchment Ratio										22.2								
Bank Height Ratio										0.9			1.0					
Pattern																		
Channel Beltwidth (ft)										50	125							
Radius of Curvature (ft)										16	30							
Meander Wavelength (ft)										115	200							
Meander Width Ratio										3.7	9.3							
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)										0.005								
Pool Length (ft)																		
Pool Spacing (ft)										45	93							
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)													117					
Sinuosity												1.33						
Water Surface Slope (ft/ft)												0.0019						
BF Slope (ft/ft)																		
Rosgen Classification												E5			E5			

Note: The Project Reference Stream Data are from the Restoration Plan document. The Design data are from the Construction Plans. There were no Pattern or Profile data for UT3 in the Restoration Plan.

Table 11a. Monitoring - Cross-Section Morphology Data Tables

Project Number and Name: 272 – Northgate Park (Ellerbe Creek)

Segment Reach: Reach 1 (1,520 ft.) and Reach 2 (750 ft.)

Parameter	Cross-Section 1 Riffle - Reach 1						Cross-Section 2 Pool - Reach 1						Cross-Section 3 Riffle - Reach 1					
	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3*	MY4	MY5
Record Elevation (datum) used		296.9	296.9	296.9	296.9			297.8	297.8	297.8	297.8			296.1	296.1	296.1	296.1	
Bankfull Width (ft)		24.0	23.8	22.8	22.7			28.5	29.2	24.7	24.7			25.0	23.8	28.7	24.4	
Floodprone Width (ft)		42.0	42.0	42.7	42.8			-	-	-	-			62.0	62.0	74.6	76.3	
Bankfull Cross-Sectional Area (ft ²)		45.0	43.1	51.4	53.4			82.4	77.3	89.1	88.1			53.4	63.4	98.5	77.2	
Bankfull Mean Depth (ft)		1.9	1.8	2.3	2.4			2.9	2.6	3.6	3.6			2.1	2.7	3.4	3.2	
Bankfull Maximum Depth (ft)		2.8	2.8	3.0	3.1			5.8	4.3	5.3	5.1			3.4	3.8	4.4	4.4	
Width/Depth Ratio		12.8	13.1	10.1	9.6			-	-	-	-			11.7	8.9	8.4	7.7	
Entrenchment Ratio		1.8	1.8	1.9	1.9			-	-	-	-			2.5	2.6	2.6	3.1	
Bank Height Ratio		1.0	1.0	1.0	1.0			-	-	-	-			1.0	1.0	1.0	1.0	
Cross-Sectional Area Between End Pins (ft ²)		-	188.5	178.6	190.4			-	250.3	262.5	258.4			-	327.4	326.1	321.4	
d50 (mm)		1.2	0.35	24	6.90			0.08	0.33	43	0.96			0.06	0.39	0.38	0.62	

Parameter	Cross-Section 4 Riffle - Reach 2						Cross-Section 5 Riffle - Reach 2					
	MY0	MY1	MY2	MY3*	MY4	MY5	MY0	MY1	MY2	MY3*	MY4	MY5
Record Elevation (datum) used		296.4	296.4	296.4	296.4			296.3	296.3	296.3	296.3	
Bankfull Width (ft)		25.2	28.4	28.7	28.9			36.1	26.9	33.5	33.9	
Floodprone Width (ft)		>75	>75	>75	>75			>90	>90	>90	62.2	
Bankfull Cross-Sectional Area (ft ²)		80.2	84.9	98.5	101.8			82.0	81.2	87.4	90.1	
Bankfull Mean Depth (ft)		3.2	3.0	3.4	3.5			2.3	3.0	2.6	2.7	
Bankfull Maximum Depth (ft)		4.5	4.4	4.6	4.6			4.0	4.4	3.5	3.5	
Width/Depth Ratio		7.9	9.5	8.4	8.2			15.9	8.9	12.8	12.8	
Entrenchment Ratio		>3.0	>3.0	>3.0	2.9			>2.5	>2.5	>2.5	1.8	
Bank Height Ratio		1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0	
Cross-Sectional Area Between End Pins (ft ²)		-	326.9	330.7	333.9			-	151.8	124.7	130.0	
d50 (mm)		0.06	0.06	0.28	0.35			0.06	0.06	71	27	

*=Cross-sections 3, 4, and 5 reset in October 2014, before MY3 survey

Table 11b. Monitoring - Stream Reach Morphology Data Table																														
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)																														
Segment Reach: Reach 1 (1,520 ft.)																														
Parameter	MY - 01 (2009)						MY - 02 (2010)						MY - 03 (2014)						MY - 04 (2015)						MY - 05 (2016)					
Dimension	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
Bankfull Width (ft)	24.0	24.5		25.0		2	23.8	23.8		23.8		2	22.8	25.8		28.7		2	22.7	24.4	24.4	88.1	37.3	3						
Floodprone Width (ft)	42.0	52.0		62.0		2	42.0	52.0		62.0		2	42.7	58.7		74.6		2	42.8	59.6		76.3		2						
Bankfull Mean Depth (ft)	1.9	2.0		2.1		2	1.8	2.3		2.7		2	2.3	2.8		3.4		2	2.4	3.2	3.2	3.6	0.6	3						
Bankfull Max Depth (ft)	2.8	3.1		3.4		2	2.8	3.3		3.8		2	3.0	3.7		4.4		2	3.1	4.4	4.4	5.1	1.0	3						
Bankfull Cross-Sectional Area (ft ²)	45.0	49.2		53.4		2	43.1	53.3		63.4		2	51.4	75.0		98.5		2	53.4	77.2	77.2	88.1	17.7	3						
Width/Depth Ratio	11.7	12.3		12.8		2	8.9	11.0		13.1		2	8.4	9.2		10.1		2	7.7	8.7		9.6		2						
Entrenchment Ratio	1.8	2.2		2.5		2	1.8	2.2		2.6		2	1.9	2.2		2.6		2	1.9	2.5		3.1		2						
Bank Height Ratio	1.0	1.0		1.0		2	1.0	1.0		1.0		2	1.0	1.0		1.0		2	1.0	1.0		1.0		2						
Pattern																														
Channel Beltwidth (ft)	*	*	*	*	*	*																								
Radius of Curvature (ft)	*	*	*	*	*	*																								
Rad. of Curv. : Bankfull Width (ft/ft)	*	*	*	*	*	*																								
Meander Wavelength (ft)	*	*	*	*	*	*																								
Meander Width Ratio	*	*	*	*	*	*																								
Profile																														
Riffle Length (ft)	24.5		34.6	84.6			33.0	34.0		34.0		2	45.0	89.0	75.1	146.8	52.3	3	26.8	26.9		27.0		2						
Riffle Slope (ft/ft)	0.0000		0.0006	0.0010			0.0011	0.0010		0.0008		2	0.001	0.002	0.002	0.004	0.002	3	0.001	0.003		0.004		2						
Pool Length (ft)	10.1		36.7	52.8			29.0	36.4	36.0	43.5	25.6	5	17.5	34.5	33.7	53.9	12.4	8	23.7	33.8	33.7	47.5	8.5	7						
Pool Max Depth (ft)							1.6	2.4	2.4	3.2	0.65	6	1.7	2.7	2.6	3.4	0.6	8	2.5	3.0	3.0	4.0	0.6	7						
Pool Spacing (ft)	28.9		89.3	211.4			92.7	257.0	212.0	479.3	136.0	5	29.3	199.8	217.7	358.7	108.8	8	88.3	226.3	198.1	358.4	114.2	5						
Additional Reach Parameters																														
Valley Length (ft)			1,518						1,518						1,518						1,518									
Channel Thalweg Length (ft)			1,580						1,580						1,580						1,580									
Sinuosity			1.04						1.04						1.04						1.04									
Water Surface Slope (ft/ft)			0.0014						0.0014						0.0011						0.0011									
Bankfull Slope (ft/ft)									0.0060						0.0008						0.0007									
Rosgen Classification			C5						C5						C5						C5									
Ri% / Ru% / P% / G% / S%									10 / 35 / 20 / 35 / 0						17 / 54 / 17 / 11 / 1						3 / 67 / 14 / 15 / 1									
SC% / Sa% / G% / C% / B% / Be%			25 / 26 / 35 / 14 / 0 / 0						5 / 60 / 25 / 10 / 0 / 0						3 / 39 / 29 / 29 / 1 / 0						2 / 58 / 34 / 6 / 0 / 0									
d16 / d35 / d50 / d84 / d95			0.062 / 0.15 / 1.2 / 51 / 110						0.019 / 0.3 / 0.39 / 44 / 94						0.6 / 5.4 / 23 / 51 / 103 / 158						0.1 / 0.3 / 2.8 / 17.6 / 72.3									
% of Reach with Eroding Banks									15%						0%						0%									

*Reach 1 was enhanced, and is not a meandering channel

Table 11b. Monitoring - Stream Reach Morphology Data Table																														
Project Number and Name: 272 – Northgate Park (Ellerbe Creek)																														
Segment Reach: Reach 2 (750 ft.)																														
Parameter	MY - 01 (2009)						MY - 02 (2010)						MY - 03 (2014)						MY - 04 (2015)						MY - 05 (2016)					
	Dimension	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
Bankfull Width (ft)	25.2	30.7		36.1		2	23.8	25.4		28.4		2	28.7	31.1		33.5		2	28.9	31.4		33.9		2						
Floodprone Width (ft)	36.1	55.55		75		2	42.0	68.5		90.0		2	>75			>90		2	62.2	72.6		82.9		2						
Bankfull Mean Depth (ft)	2.3	2.7		3.2		2	1.8	2.8		3.0		2	2.6	3.0		3.4		2	2.7	3.1		3.5		2						
Bankfull Max Depth (ft)	4.0	4.3		4.5		2	2.8	4.1		4.4		2	3.5	4.0		4.6		2	3.5	4.1		4.6		2						
Bankfull Cross-Sectional Area (ft ²)	80.2	81.1		82.0		2	43.1	72.3		84.9		2	87.4	93.0		98.5		2	90.1	96.0		101.8		2						
Width/Depth Ratio	7.9	11.9		15.9		2	8.9	9.2		13.1		2	8.4	10.6		12.8		2	8.2	10.5		12.8		2						
Entrenchment Ratio	2.5	2.8		3.0		2	1.8	2.6		3.0		2	>2.5			>3.0		2	1.8	2.4		2.9		2						
Bank Height Ratio	1.0	1.0		1.0		2	1.0	1.0		1.0		2	1.0	1.0		1.0		2	1.0	1.0		1.0		2						
Pattern																														
Channel Beltwidth (ft)	59.0		74.0	94.0																										
Radius of Curvature (ft)	51.0		68.0	107.0																										
Rad. of Curv. : Bankfull Width (ft/ft)																														
Meander Wavelength (ft)	237.0		276.0	303.0																										
Meander Width Ratio	2.1		2.7	3.4																										
Profile																														
Riffle Length (ft)	9.2		16.1	29.2			12.1		15.8	25.0		3	30.6	39.1		47.6		2	39.1	42.1		45		2						
Riffle Slope (ft/ft)	0.001		0.001	0.003			0.001	0.001	0.002	0.003		3	0.003	0.006		0.009		2	0.004	0.006		0.009		2						
Pool Length (ft)	18.4		66.9	91.3			64.0	80.0	73.0	104.0		3	57.1	71.9	71.9	98.5	23.1	3	64.4	70.1	70.1	74.9	5.3	3						
Pool Max Depth (ft)							2.5	2.9	2.7	3.6		3	2.7	4.1	3.4	6.3	1.9	3	3.5	5	4.2	7.3	2.0	3						
Pool Spacing (ft)	67.7		156.6	183.7			154.8	170.0		185.7		2	167.2	254.1		341.0		2	158.0	158.3		158.6		2						
Additional Reach Parameters																														
Valley Length (ft)			658						658						658						658									
Channel Thalweg Length (ft)			710						710						710						710									
Sinuosity			1.08						1.08						1.08						1.08									
Water Surface Slope (ft/ft)			0.00017						0.0009						0.001						0.0011									
Bankfull Slope (ft/ft)									0.0005						0.0019						0.0007									
Rosgen Classification			C5						C5						C5						C5									
Ri% / Ru% / P% / G% / S%									10 / 30 / 20 / 40 / 0						11 / 17 / 32 / 39 / 1						13 / 44 / 31 / 13 / 0									
SC% / Sa% / G% / C% / B% / Be%			68 / 15 / 16 / 1 / 0 / 0						65 / 27 / 8 / 0 / 0 / 0						16 / 33 / 24 / 26 / 1 / 0						10 / 40 / 36 / 15 / 0 / 0									
d16 / d35 / d50 / d84 / d95			0.062 / 0.062 / .0062 / 2.3 / 20						0.062 / 0.062 / 0.062 / 0.4 / 16						11 / 27 / 36 / 55 / 85 / 117						4.0 / 7.6 / 13.7 / 43.5 / 72.6									
% of Reach with Eroding Banks									41%						0%						0%									

Appendix E

Hydrologic Data

Table 12. Verification of Bankfull Events

Project Number and Name: 272 - Northgate Park (Ellerbe Creek)

Date of Data Collection	Date of Occurrence	Method	Photo Number
6/14/2009	6/11/2009	Site visit to evaluate indicators of stage after storm event	N/A
11/11/2009	11/11/2009	Site visit to evaluate indicators of stage after storm event	N/A
12/25/2009	12/25/2009	Eye-witness account	N/A
1/25/2010	1/25/2010	Site visit to evaluate indicators of stage after storm event	N/A
5/17/2010	5/17/2010	Site visit to evaluate indicators of stage after storm event	N/A
9/30/2010	9/30/2010	Site visit to evaluate indicators of stage after storm event	N/A
6/30/2013	6/30/2013	Site visit to evaluate indicators of stage after storm event	1-2
9/24/2014	9/24/2014	Site visit to evaluate indicators of stage during storm event	3-4
12/23/2015	12/23/2015	Site visit to evaluate indicators of stage during storm event	5-6



Photo 1. Bankfull event 6/30/2013



Photo 2. Bankfull event 6/30/2013



Photo 3. Bankfull event 9/24/2014



Photo 4. Bankfull event 9/24/2014



Photo 5. Bankfull event 12/23/2015



Photo 6. Bankfull event 12/23/2015