Third Fork Creek Stream Restoration – NCEEP Project #139
Durham, North Carolina

Third Annual Monitoring Report -- FINAL
February 2008

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THIRD FORK CREEK STREAM RESTORATION – NCEEP Project #139
2007 MONITORING REPORT – YEAR 3

CONDUCTED FOR THE NORTH CAROLINA DEPARTMENT OF ENVIRONMENT AND NATURAL RESOURCES

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1.0 Executive Summary

The Third Fork Creek stream restoration project is located in southwest-central Durham, North Carolina, in the headwaters of the Third Fork Creek watershed (US Geological Survey14-digit Hydrologic Unit Code 03030002060120) within the New Hope Creek Sub-basin of the Upper Cape Fear River (NC Division of Water Quality Sub-basin 03-06-05). The project has restored approximately 2,900 linear feet of perennial stream in the Cape Fear River Basin. Evaluation and design were initiated during the summer of 2002. Construction was completed in January 2005. The stream restoration project's objectives were: to restore stable channel morphology, which will reduce bank erosion; improve the watershed's sediment transport; improve aquatic habitat diversity; and increase aesthetic value to local stakeholders.

The first 2007 qualitative evaluation was conducted by RJG&A in April. Subsequent qualitative evaluations were conducted during July and October 2007. The third annual vegetation monitoring data were collected during July 2007, using EEP's most-recent monitoring protocol. The third annual geomorphologic monitoring data were collected during July 2007.

Overall, the restoration project has met its design goals. Several major geomorphologic changes were documented during the second monitoring year, but overall the site is relatively stable. The average live planted woody stem density (905 live stems per acre) has exceeded the vegetation success criteria (320 live stems per acre) by 183 percent. Several invasive exotic species are colonizing the site, including *Humulus japonicus*, *Paulownia tomentosa*, and *Albizia julibrissin*. EEP is in the process of initiating an herbicide treatment contract to address these exotic invasive issues.

2.0 Project Background

2.1. Project Objectives

According to the 2003 Restoration Plan (KCI 2003), the stream restoration project's objectives were to:

- restore stable channel morphology with the aim of reducing bank erosion
- improve the watershed's sediment transport
- improve aquatic habitat diversity
- increase aesthetic value to local stakeholders.

2.2. Project Structure, Mitigation Type, and Approach

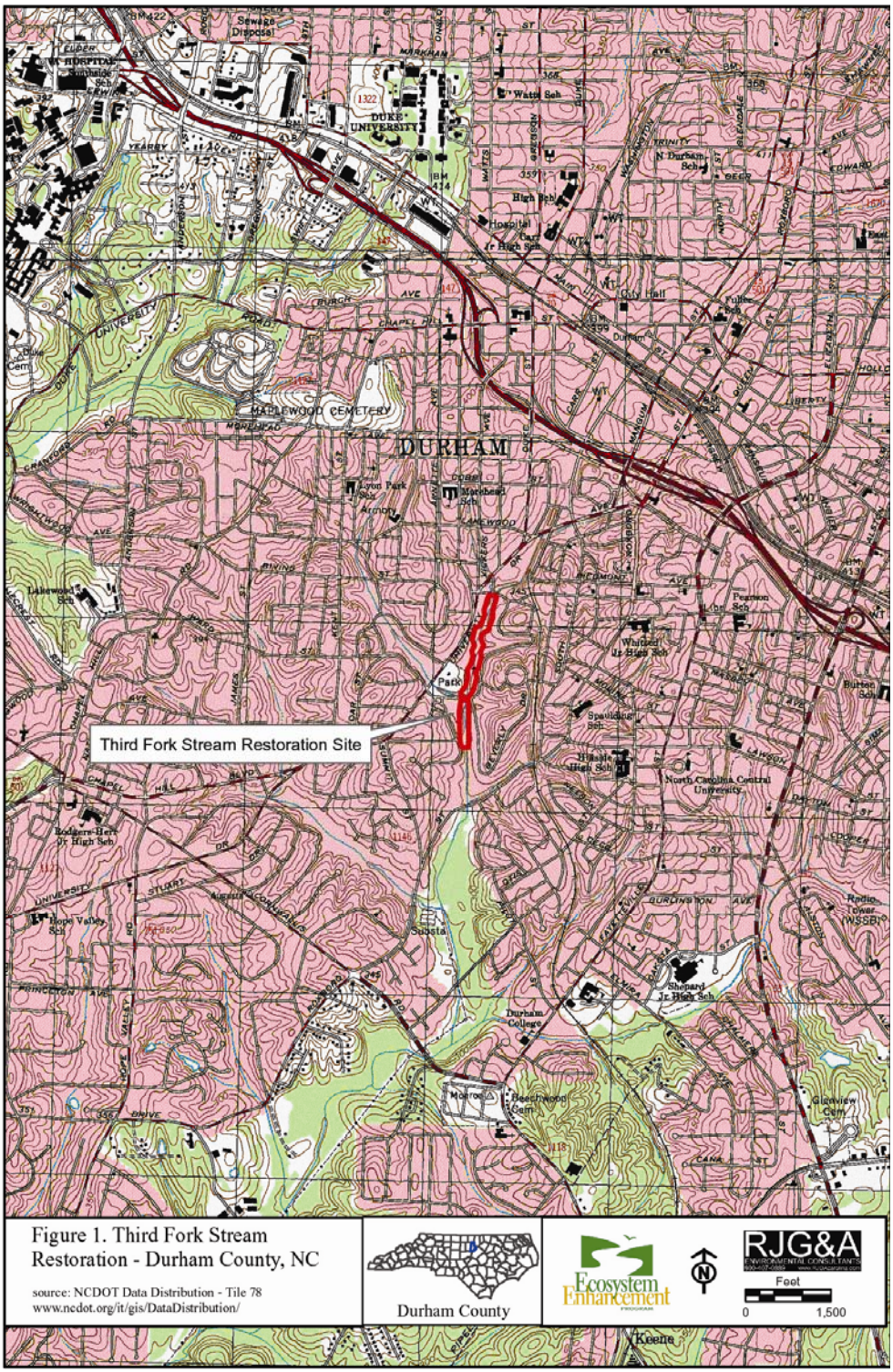
A priority 2 stream restoration approach was used to design and reestablish approximately 3,025 linear feet of meandering, bankfull channel and a new floodplain along Third Fork Creek. The project restored riffle-pool sequencing and used cross-vane and j-hook in-stream structures to provide grade control. The unnamed tributary that enters from the upper reach's left bank (station 20+33) was incorporated and stabilized with a grade control structure to match the grade of the restored channel. Coir fiber matting and live staking were installed/planted to help stabilize the graded stream banks. A 50 foot wide buffer was planted with native species on both sides the restored stream. Space and use needs in the park limited the woody plantings to within 30 feet of the stream. The buffers' outer twenty feet was planted in native grasses and is managed (mowed).

2.3 Location and Setting

The entire restoration site is contained within Forest Hills Park, which is owned by the City of Durham. To get to the Third Fork Creek restoration site from NC 147, take exit 12C. At the end of the off-ramp, drive north on Duke Street. At the next light, take a left on Jackson and then a left on to Vickers. Take Vickers to the intersection with University Drive (US 15/501 Business). Forest Hills Park will be directly in front of you. Take a right on to University and park in the parking lot across from West Forest Hills Boulevard (Figure 1). The upstream boundary of the restoration project is downstream from where Third Fork Creek emerges from the box culvert under the northern stretch East Forest Hills Boulevard. The stream restoration extends downstream along the main channel from this point to the southern edge of the Forest Hills Park. The double box culvert under the southern stretch of the East Forest Hills Boulevard loop divides the restoration into upper and lower reaches. An unnamed tributary to Third Fork Creek joins the lower reach on the downstream end of the culvert. The lower reach therefore has a significantly larger watershed.

Forest Hills Park is dominated by lawn/open space with relatively little mature canopy cover (less than 25 percent). A playground and other facilities with impervious cover (e.g swimming pool, tennis courts, and picnic shelter) are located near the southern portion of

the restoration's upper reach. The surrounding area is highly urbanized. The majority of the land use is dedicated to residential and commercial development and secondary roads. Prior to the restoration, both project reaches were incised and had active bed degradation and channel widening characterized by severe bank erosion.



2.4. History and Background

KCI Associates of North Carolina designed the Third Fork (Forest Hills Park) stream restoration. The restoration plan was completed in February 2003 and construction was completed approximately two years later. As-built data collection occurred in March 2005 and the as-built and year one monitoring reports were submitted in December 2005. Robert J. Goldstein and Associates collected year two monitoring data and submitted the year-two report in December 2006. Year three monitoring data were collected in July 2007.

Exhibit Table I. Mitigation Structure and Objectives - Third Fork Creek Stream Restoration – EEP Project #139 – Durham, NC

Reach ID	Mitigation Type	Approach	Linear Feet	Stationing	Mitigation Credits (ratio)	Comment
Upstream	Restoration	Priority 2	2,900	10+00-26+00	3,792 (1:1)	Realigned channel with restored floodplain to convey stormflow/ sediment and restore aquatidc habitat
Downstream	Restoration	Priority 2		25+00 – 40+25		

Exhibit Table II. Activity and Reporting History - Third Fork Creek Stream Restoration – EEP Project #139– Durham, NC

Activity or Report	Data Collection	Completion
Restoration Plan	2002	February 2003
Construction	NA	January 2005
Temporary S&E mix applied	NA	NA
Permanent seed mix applied	NA	NA
Bare Root Planting	NA	NA
Mitigation Plan	NA	December 2005 (report date)
As-built	March 2005	December 2005 (report date)
Year 1 Monitoring		December 2005 (report date)
Vegetation	September 2005	
Geomorphological	September 2005	
Year 2 Monitoring		December 2006 (report date)
Vegetation	September 2006	
Geomorphological	October 2006	
Year 3 Monitoring		October 2007 (report date)
Vegetation	July 2007	
Geomorphological	July 2007	

Exhibit Table III. Project Contacts - Third Fork Creek Stream Restoration – EEP Project #139 – Durham, NC	
Design:	KCI Associates of North Carolina, P.A. Landmark Center II, Suite 220 4601 Six Forks Road Raleigh, North Carolina 27609 Mr. Joe Pfeiffer (919) 783-9214
Construction Contractor:	NA
Monitoring Performers (2006 and 2007):	RJG&A 1221 Corporation Parkway, Suite 100 Raleigh, NC 27616 Ms. Jessi O'Neal (919) 872-1174

Exhibit Table IV. Project Background - Third Fork Creek Stream – EEP Project #139	
County	Durham
Drainage Area	1,126.4 acres (1.76 square miles)
Drainage Impervious Cover Estimate (%)	44%
Stream Order	Second Order
Physiographic Region	Piedmont
Ecoregion	Triassic Basins
Rosgen Classification of As-built	
Upper Reach	F5, G5, E5
Lower Reach	C5
Dominant Soil Types	
Upstream Reach	Congaree
Downstream Reach	Congaree
Reference Site ID	North Prong Creek
USGS HUC for Project and Reference	03030002060120, 0303002060140
NCDWQ Sub-basin for Project and Reference	03-06-05, 03-06-05
NCDWQ Classification for Project and Reference	C
Any portion of the project segment 303d listed?	Yes
Any portion of the project segment upstream of a 303d listed segment?	Yes
Reasons for 303d Listing or Stressor	Turbidity, low dissolved oxygen, fecal coliform bacteria
% of Project Easement Fenced	0%

2.5. Monitoring Plan View

See Figure 2 for Monitoring Plan View.

Figure 2.1 - 2007 Monitoring. Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

RJG&A ENVIRONMENTAL CONSULTANTS 800-407-0889 www.RJGAcarolina.com

Ecosystem Enhancement PROGRAM

Feet
0 50 100

LEGEND

- 2007 Thalweg
- Vegetation Monitoring Plots
- Cross Sections
- ① Photopoints

As-built Drawings (Supplied by KCI)

- Vanes
- Thalweg
- Edge of water
- Conservation Easement
- Sewer ROW

East Forest Hills Blvd.

Sewer Right of Way

XS1

XS2

Figure 1.1 Match line

Figure 1.2

	Easting	Northing
Vegetation Plots		
1	2026252.522400	812789.657666
2	2026222.941600	812569.691675
3	2025987.289460	812136.701257
4	2025961.194110	811689.362376
Cross-sections		
1-L	2026045.167310	812046.165066
1-R	2026008.863870	812074.268999
2-L	2026019.907700	811829.907400
2-R	2025969.114450	811842.610456
Photopoints		
1	2026280.064630	812942.007941
2	2026245.292230	812638.539733
3	2026224.428790	812585.685687
4	2026034.128930	812393.109820
5	2026035.393380	812128.144141
6	2025987.976480	812046.207724
7	2025968.377490	811836.182435
8	2025926.650610	811606.368490

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Ecosystem Enhancement PROGRAM

Feet
0 50 100

Figure 2.2 - 2007 Monitoring. Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

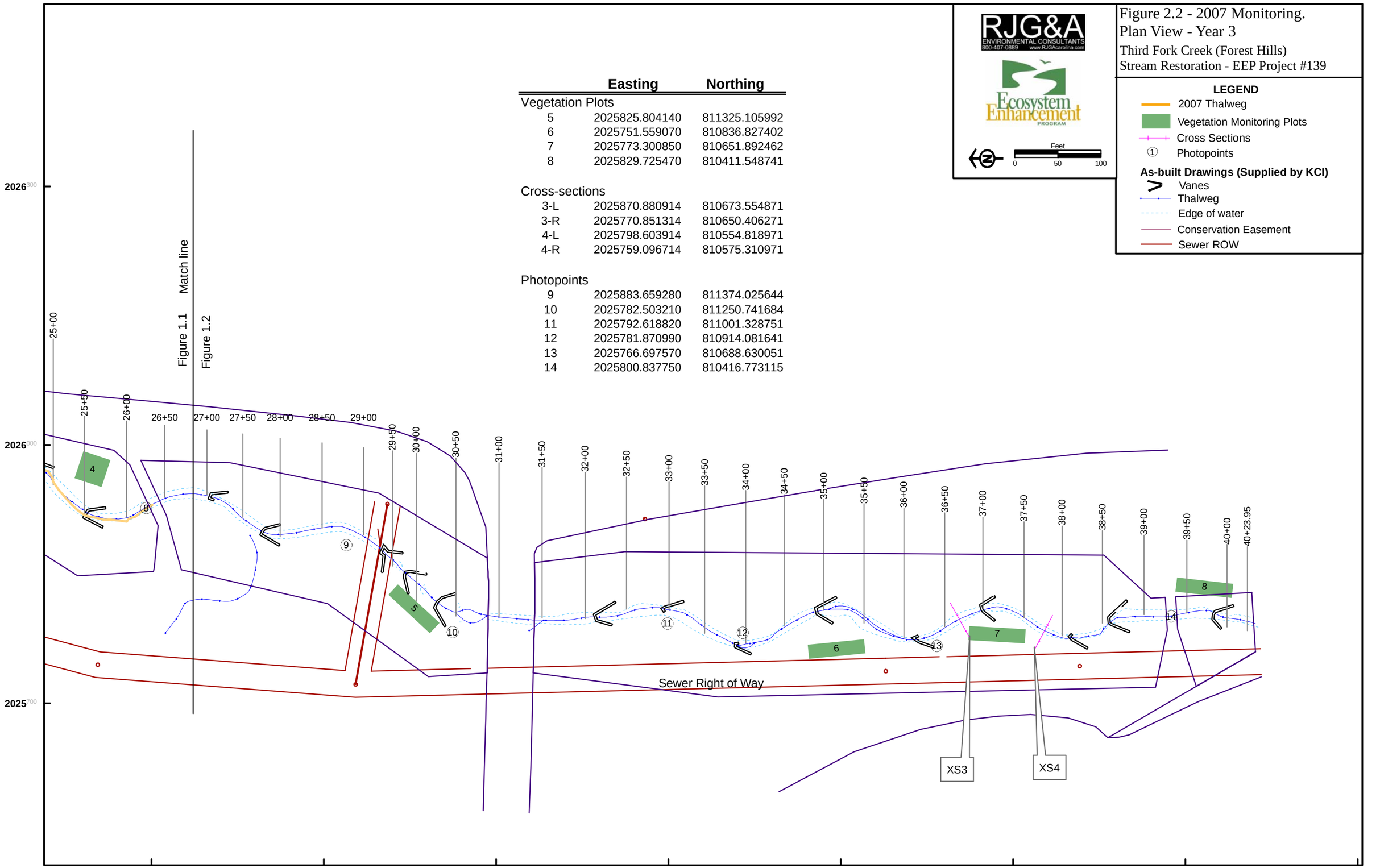
LEGEND

- 2007 Thalweg
- Vegetation Monitoring Plots
- Cross Sections
- ① Photopoints

As-built Drawings (Supplied by KCI)

- Vanes
- Thalweg
- Edge of water
- Conservation Easement
- Sewer ROW

	Easting	Northing
Vegetation Plots		
5	2025825.804140	811325.105992
6	2025751.559070	810836.827402
7	2025773.300850	810651.892462
8	2025829.725470	810411.548741
Cross-sections		
3-L	2025870.880914	810673.554871
3-R	2025770.851314	810650.406271
4-L	2025798.603914	810554.818971
4-R	2025759.096714	810575.310971
Photopoints		
9	2025883.659280	811374.025644
10	2025782.503210	811250.741684
11	2025792.618820	811001.328751
12	2025781.870990	810914.081641
13	2025766.697570	810688.630051
14	2025800.837750	810416.773115



3.0 Project Conditions and Monitoring Results

RJG&A's initial 2007 qualitative evaluation was on 11 April. Quantitative vegetation and geomorphologic data were collected between 12 and 20 July. Another qualitative/quantitative evaluation was conducted on 12 October 2007.

Like in 2006, structural failure and compromise were recorded in a number of specific locations. Exotic invasive woody stem density is relatively low but several species have begun to colonize the restoration area, particularly bankfull benches and floodplain terraces. Planted woody stem density is high, as is success. Exotic invasive vines have had a moderate impact on planted woody stem success on several benches.

Geomorphic problem areas observed in 2006 and April 2007 appear to have stabilized considerably during the 2007 growing season. The restoration project appears to be adequately transporting urban sediment loads and restoring aquatic habitat (i.e. meeting its design functions/goals).

3.1 . Vegetation Assessment

Planted woody vegetation was successful when qualitatively evaluated during October 2007. Planted woody stem success remained high throughout the restoration. Nineteen species are planted at the restoration site. The average live, planted woody stem density for all plots was 22 individuals per plot, which translates to 905 stems per acre, down from 926 stems per acre observed in 2006. The 2007 density exceeds the required 320 live stems per acre by 183 percent. Stem density is highest for *Callicarpa americana*, *Fraxinus pennsylvanica*, and *Viburnum dentatum* (Table 5 Appendix A). As can be seen in Table 2 in Appendix A, 156 of the 179 observed planted stems (87.15%) had a vigor of 4. Mortality in the vegetation plots remains low (less than 2%) and was only observed in plots 3 and 4.

Monitoring plot photos are also located in Appendix A.

3.1.1. Vegetation Problem Areas

Density and size of invasive exotic species increased slightly during the third growing season (2007). The total area of dense invasive exotic vine colonization decreased significantly, from approximately 0.41 acre in 2006, to 0.18 in 2007. Sporadic, low density invasive vines exist throughout the restoration area. Conversely, invasive exotic woody stems were more commonly observed at the end of the 2007 growing season (from approximately 0.03 acre in 2006, to approximately 0.28 acre in 2007).

Dense colonies of Japanese hops (*Humulus japonicus*) and porcelainberry (*Ampelopsis brevipedunculata*) were, like in 2006, observed on floodplain benches. These colonies have migrated from their observed locations in 2006. The 2007 invasive vine colonies are much smaller than 2006. In 2007 they only occupy areas that appear to have been former stands of giant ragweed (*Ambrosia trifida*). The ragweed stands appear to have been cut earlier in the growing season by neighbors adjacent to the Forest Hills Park, likely to address aesthetic and weed migration concerns.

Several small groups of invasive exotic woody stems were also observed in the upper reach. Most woody stems observed were mimosa (*Albisia julibrissin*), which were six to eight feet tall. Several princess tree (*Paulownia tomentosa*) stems were also observed. They were slightly taller (~10 feet).

Invasive exotic woody stems along the downstream reach increased in absolute number, vigor and density during the 2007 growing season.

See Table 6, Figure A1-Vegetative Problem Area Plan View, and Vegetation problem Area Photos in Appendix A.

3.1.2. Current Conditions Plan View (Vegetation)

The Current Conditions Plan View for streams may be found in Appendix A.

3.2. Stream Assessment

3.2.1. Procedural Items

3.2.1.1. Morphometric Criteria

RJG&A personnel qualitatively evaluated the site during early April 2007, during normal flow and October 2007, during low flow. During July 2007 the third annual cross section, pattern, and longitudinal profile data were collected based on the 2003 Stream Mitigation Guidelines (USACE 2003). Four cross-sections were surveyed and longitudinal profiles of approximately 400 linear feet of both the upstream and downstream reaches of the stream restoration were surveyed. Photographs were taken at the four cross sections and at the 14 permanent photo locations that were established by KCI in March 2005.

3.2.1.2. Hydrologic Criteria

A crest gauge with granulated cork was installed along the right bank at station 33+75 on 13 June 2007. The crest gauge was first evaluated on 16 July 2007. The only cork remaining inside the gauge was stuck around the cap, indicating that a bankfull storm event had occurred. Based on NC CRONOS data from the 312515 Durham weather station, these flows could have occurred in response to storm events which occurred on 14 June (0.66 inch), or 11 July (0.62 inch). After this evaluation, the gauge was re-filled with approximately five cubic inches of ground cork. The gauge was again evaluated on 12 October 2007. Again, the only granulated cork remaining inside the gauge was inside the cap at the top, indicating that at least one bankfull event had occurred since 16 July. The bankfull event was in response to precipitation events on 28 July (1.08 inches), 23 August (0.7 inch), or 15 August (0.6 inch).

The evaluation of Third Fork Creek clearly indicates that at least two storm events resulted in flows over the designed/built bankfull elevation.

Exhibit Table V. Verification of Bankfull Events – Third Fork Stream Restoration – EEP Project #139			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo # (if available)**
16 July 2007	13 June-16 July 2007	Crest Gauge Evaluation	NA
12 October 2007	17 July – 12 October 2007	Crest Gauge Evaluation	NA

3.2.1.3. Bank Stability Assessments
A detailed BEHI only applies to Monitoring year 5 and was, therefore, not performed during 2007 (monitoring year 3).

3.2.2. Current Conditions Plan View (Stream)
The Current Conditions Plan View (Streams) can be found in Appendix B.

3.2.3. Problem Areas Table
Overall, the site is maintaining its as-built dimension, pattern, and profile, and planted woody stem success is high. Bank erosion along most of the previously observed problem areas appears to have decreased significantly. The Piedmont's record 2007 drought and the associated lack of flashy storm events have allowed woody and herbaceous plants to colonize most of the *slumps* associated with bank undercutting and lateral channel migration. If woody species become well established, their root systems may provide long-term bank stability.

Only two significant, high priority problem areas were observed in October 2007. The j-hook at station 27+04 has been entirely compromised. Its top three boulders have been entirely undercut, dislodged, and deposited into a deepening pool. No grade control or velocity dissipation are occurring. The bank undercut/lateral migration between stations 34+11 and 34+80 is expanding and appears to be active.

The remaining bank slumps and undercuts are relatively minor and should continue to be monitored to ensure that they continue to equilibrate over time.

Table B1 in Appendix B outlines problem areas by station, along with suspected causes and representative photos.

3.2.4. Numbered Issue Photo Section
Representative problem area photos listed in Table B.1. can be found in Appendix B immediately following Table B.1.

3.2.5. Fixed Station Photos
Permanent photopoint images are located in Appendix B.

3.2.6. Stability Assessment Table

Exhibit Table VI. Categorical Stream Feature Visual Stability Assessment Third Fork Creek Stream Restoration – EEP Project #139 Upstream Reach (1600 Feet)						
Feature	Initial*	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	100%	NA	92	86		
B. Pools	100%	NA	87	87		
C. Thalweg	100%	NA	69	97		
D. Meanders	100%	NA	90	98		
E. Bed General	100%	NA	100	100		
F. Vanes/J Hooks, etc.	100%	NA	93	96		
G. Wads and Boulders	NA	NA	NA	NA		
Downstream Reach (1525 Feet)						
A. Riffles	100%	NA	56	56		
B. Pools	100%	NA	56	56		
C. Thalweg	100%	NA	57	57		
D. Meanders	100%	NA	67	67		
E. Bed General	100%	NA	100	100		
F. Vanes/J Hooks, etc.	100%	NA	89	94		
G. Wads and Boulders	100%	NA	NA	NA		

*These percentages are assumed. Neither the As-built Monitoring Report nor the First Year Monitoring Report contained any visual stability assessment data.

Exhibit Table VII. Baseline Morphology and Hydraulic Summary - Third Fork Creek Stream Restoration– EEP Project #139 – Upstream Reach						
Parameters	**USGS Data**	**Regional Curve Int.**	**Pre-Existing Condition**	**Reference Reach**	**Design**	**As-Built**
Dimension						
Bankfull Width (ft)			21.8-26.8	17.8	27	NA
Floodprone Width (ft)			29.2-400	NA	NA	NA
Bankfull Area (sq ft)			45.1-57.2	26.2	60	NA
Mean Depth (ft)			NA	1.5	2.2	NA
Maximum Depth (ft)			4.7	3.0	4.0	NA
Width/Depth Ratio			8.3-15.9	12.1	12.1	NA
Entrenchment Ratio			1.1-18.3	33.7	2.3-14.8	NA
Bank Height Ratio						
Wetted Perimeter (ft)			NA	NA	NA	NA
Hydraulic Radius (ft)			NA	NA	NA	NA
Pattern						
Channel Beltwidth (ft)			NA	158	120	NA
Radius of Curvature (ft)			NA	37-40	60-75	NA
Meander Wavelength			NA	94-143	160-190	NA
Meander Width ratio				8.9	4.4	NA
Profile						
Riffle length (ft)			NA	NA	NA	NA
Riffle slope (ft/ft)			0.24-0.57	0.2-2.1	0.25-0.29	NA
Pool length (ft)			NA	8-30	27-40	NA
Pool spacing (ft)			NA	40-85.5	60-125	NA
Substrate						
d50 (mm)			0.31-0.38	0.20	0.31-0.38	NA
d84 (mm)			NA	NA	NA	NA
Additional Reach Parameters						
Valley Length (ft)			NA	NA	NA	NA
Channel Length (ft)			1890	407	2083	NA
Sinuosity			1.03	1.28	1.13	NA
Water Surface Slope (ft/ft)			0.25	0.24	0.25	NA
BF slope (ft/ft)			NA	NA	NA	NA
Rosgen Classification			F5, G5, E5	C5	C5	NA
Habitat Index			NA	NA	NA	NA
Macrobenthos			NA	NA	NA	NA

Exhibit Table VII. Baseline Morphology and Hydraulic Summary - Third Fork Creek Stream Restoration– EEP Project #139 – Downstream Reach						
Parameter	**USGS Data**	**Regional Curve Int.**	**Pre-Existing Condition**	**Reference Reach**	**Design**	**As-Built**
Dimension						
Bankfull Width (ft)			29.5	17.8	30	NA
Floodprone Width (ft)			62-400	NA	NA	NA
Bankfull Area (sq ft)			71.4	26.2	75	NA
Mean Depth (ft)			NA	1.5	2.5	NA
Maximum Depth (ft)			5.8	3.0	4.25	NA
Width/Depth Ratio			12.2	12.1	12.0	NA
Entrenchment Ratio			6.8	33.7	6.7	NA
Bank Height Ratio						
Wetted Perimeter (ft)			NA	NA	NA	NA
Hydraulic Radius (ft)			NA	NA	NA	NA
Pattern						
Channel Beltwidth (ft)			NA	158	90	NA
Radius of Curvature (ft)			NA	37-40	60-80	NA
Meander Wavelength			NA	94-143	180-210	NA
Meander Width ratio				8.9	3.0	NA
Profile						
Riffle length (ft)			NA	NA	NA	NA
Riffle slope (ft/ft)			0.25-0.29	0.2-2.1	0.25	NA
Pool length (ft)			NA	8-30	30-45	NA
Pool spacing (ft)			NA	40-85.5	70-140	NA
Substrate						
d50 (mm)			0.41	0.20	0.41	NA
d84 (mm)			NA	NA	NA	NA
Additional Reach Parameters						
Valley Length (ft)			NA	NA	NA	NA
Channel Length (ft)			900	407	925	NA
Sinuosity			1.01	1.28	1.10	NA
Water Surface Slope (ft/ft)			0.20	0.24	0.20	NA
BF slope (ft/ft)			NA	NA	NA	NA
Rosgen Classification			C5	C5	C5	NA
Habitat Index			NA	NA	NA	NA
Macrobenthos			NA	NA	NA	NA

Table VIII. Morphology and Hydraulic Monitoring Summary - Third Fork Creek Stream Restoration - EEP Project #139 Upstream Reach												
	XS 1						XS 2					
Dimension	As-built	MY1	MY2	MY3	MY4	MY5	As-built	MY1	MY2	MY3	MY4	MY5
Floodprone Width (ft)	240.00	240.00	240.00	240.00			240.00	240.00	240.00	240.00		
Bankfull Width (ft)	20.40	27.11	28.63	24.45			26.43	26.39	27.62	27.39		
Bankfull Area (sq ft)	61.87	61.37	62.47	30.12			70.07	72.88	76.71	77.42		
Mean Depth (ft)	3.03	2.26	2.18	2.23			2.65	2.76	2.78	2.83		
Maximum Depth (ft)	3.91	3.95	4.19	12.30			4.81	5.11	5.45	5.59		
Width/Depth Ratio	6.70	12.00	13.12	61.28			9.97	NA	9.94	9.69		
Entrenchment Ratio	11.76	8.85	8.38	8.74			9.08	NA	8.69	8.67		
Bank Height Ratio		1.00		1.02				1.03		1.03		
Wetted Perimeter (ft)	NA	NA	30.91	11.80			NA	NA	31.70	31.14		
Hydraulic Radius (ft)	NA	NA	2.02	39.25			NA	NA	2.42	2.49		
Substrate												
d50 (mm)		0.06	0.04	0.36				0.06	0.09	0.14		
d84 (mm)		0.06	0.06	1.88				0.10	0.78	1.63		
Pattern		**As-built**		**MY1**		**MY2**		**MY3**		**MY4**		**MY5**
Channel Beltwidth (ft)		NA		NA		33.88		29.28				
Radius of Curvature (ft)		NA		NA		69.42		60.58				
Meander Wavelength		NA		NA		177.65		182.45				
Meander Width ratio		NA		NA		1.20		2.12				
Profile												
Riffle length (ft)		NA		NA		51.43		55.57				
Riffle slope (ft/ft)		NA		NA		0.002		0.002				
Pool length (ft)		NA		NA		28.60		47.39				
Pool spacing (ft)		NA		NA		35.95		21.96				
Additional Reach Parameters												
Valley Length (ft)		NA		NA		310		310				
Channel Length (ft)		NA		NA		350		350				
Sinuosity		NA		NA		1.13		1.13				
Water Surface Slope (ft/ft)		NA		NA		0.0018		0.0018				
BF slope (ft/ft)		NA		NA		0.0007		0.0007				
Rosgen Classification		NA		NA		C5		C5				
Habitat Index		NA		NA		NA		NA				
Macrobenthos		NA		NA		NA		NA				

Table VIII. Morphology and Hydraulic Monitoring Summary - Third Fork Creek Stream Restoration - EEP Project #139 Downstream Reach

	XS 3						XS 4					
Dimension	As-built	MY1	MY2	MY3	MY4	MY5	As-built	MY1	MY2	MY3	MY4	MY5
Floodprone Width (ft)	240.00	240.00	240.00	240.00			240.00	240.00	240.00	240.00		
Bankfull Width (ft)	17.50	29.00	25.97	22.32			17.50	23.29	20.47	24.28		
Bankfull Area (sq ft)	54.61	53.46	47.67	55.42			61.50	60.40	57.34	68.79		
Mean Depth (ft)	3.12	1.84	1.84	2.48			3.51	2.59	2.80	2.83		
Maximum Depth (ft)	3.28	3.48	3.84	4.26			4.51	4.97	4.56	4.77		
Width/Depth Ratio	5.61	15.70	14.51	8.99			4.98	NA	7.31	8.57		
Entrenchment Ratio	13.71	8.28	9.24	10.75			13.71	NA	11.72	9.89		
Bank Height Ratio		1.04		1.15				0.96		1.09		
Wetted Perimeter (ft)	NA	NA	28.31	25.04			NA	NA	23.99	27.91		
Hydraulic Radius (ft)	NA	NA	1.68	2.21			NA	NA	2.39	2.46		
Substrate												
d50 (mm)		0.49	6.27	0.76				1.00	0.85	0.78		
d84 (mm)		1.50	16.60	9.65				2.00	11.30	3.17		
Pattern		**As-built**		**MY1**		**MY2**		**MY3**		**MY4**		**MY5**
Channel Beltwidth (ft)		NA		NA		35.77		47.47				
Radius of Curvature (ft)		NA		NA		57.96		56.59				
Meander Wavelength		NA		NA		162.56		183.76				
Meander Width ratio		NA		NA		1.54		1.61				
Profile												
Riffle length (ft)		NA		NA		14.24		8.45				
Riffle slope (ft/ft)		NA		NA		0.021		0.031				
Pool length (ft)		NA		NA		101.45		51.15				
Pool spacing (ft)		NA		NA		23.28		30.45				
Additional Reach Parameters												
Valley Length (ft)		NA		NA		308		310				
Channel Length (ft)		NA		NA		350		350				
Sinuosity		NA		NA		1.14		1.13				
Water Surface Slope (ft/ft)		NA		NA		0.0009		0.001				
BF slope (ft/ft)		NA		NA		0.0003		0.0046				
Rosgen Classification		NA		NA		C5b		E5				
Habitat Index		NA		NA		NA		N/A				
Macrobenthos		NA		NA		NA		N/A				

IV. Methodology

Monitoring methodologies follow the current EEP-provided templates and guidelines (Lee *et al* 2006). Photographs were taken digitally. A Trimble Geo XT handheld mapping-grade unit was used to collect cross section, vegetation corner, photopoint, and problem area locations. Additional notations were written on the as-built plan sheets.

4.1. Stream Methodology

Methods employed were a combination those specified in the Mitigation Plan, the First Annual Monitoring Report, and standard regulatory guidance and procedures documents. Stream monitoring data was collected using the techniques described in US ACE Stream Mitigation Guidelines, US Forest Service's Stream Channel Reference Sites, and Applied River morphology (USACE, 2003; Harrelson et al., 1994; Rosgen, 1996). A South Total Station and Nikon automatic level were used for collecting all geomorphic data. Photographs facing downstream were taken at each cross section.

4.2. Vegetation Methodology

Eight representative vegetation survey plots were selected and installed in the upstream and downstream reaches during September 2006. Where appropriate, the new monitoring plots were co-located with the first year monitoring plots. All plots measure 100 square meters in area and are either 10 meters by 10 meters, or five meters by 20 meters. Pursuant to the guidelines, the four corners of each plot (e.g. 0,0; 0,10; 10,0; and 10,10; or 0,0; 0,20; 5,0; and 5,20.) marked with 18 inch long one half inch diameter galvanized steel conduit were relocated in 2007. Within each plot, each planted woody stem location (x and y) recorded in 2006 was relocated. No mortality was observed.

Level 1 (planted woody stems) and Level 2 (volunteer woody stems) data collection was performed in all plots, pursuant to the most recent CVS/EEP protocol (Lee *et al* 2006). Within each plot, each planted woody stem location (x and y) was recorded, and height and live stem diameter were recorded for each stem location. All planted stems were identified with pink flagging. Vegetation was identified using Weakley (Weakley 2007). Photos were taken of each vegetation plot from the 0,0 corner. Because the dimensions of the plots installed in 2006 are different than the first annual vegetation monitoring plots, direct comparison with the first year data is inappropriate.

Tables 1 through 5 in Appendix A contain the data from the vegetation monitoring. Monitoring plot photos can also be found in Appendix A.

References

Harrelson, Cheryl, C. L. Rawlins, and John Potpondy. (1994). *Stream Channel Reference Sites: An Illustrated Guide to Field Technique.* USDA, Forest Service. General Technical Report RM-245.

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Appendix A Vegetation Data

Table 1. Vegetation Metadata

Report Prepared By Jessi O'Neal
Date Prepared 3/14/2008 11:45

database name RJGA-2007-B.mdb
database location C:\Documents and Settings\Owner\Desktop\2007 CVS veg data entry\Third_Fork

DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------

Metadata	This worksheet, which is a summary of the project and the project data.
Plots	List of plots surveyed.
Vigor	Frequency distribution of vigor classes.
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.
Stem Count by Plot and Spp	Count of living stems of each species for each plot; dead and missing stems are excluded.

PROJECT SUMMARY----------

Project Code	Project Name	Description	length(ft)	stream-to-edge width (ft)	area (sq m)	Required Plots (calculated)	Sampled Plots
001	3rd fork creek	stream restoration					1
3fk	Third Fork Creek	Stream Restoration					7

Table 2. Vegetation Vigor by Species

	Species	4	3	2	1	0	Missing
	Albizia julibrissin						
	Alnus serrulata	16		1			
	Amelanchier arborea	1					
	Betula nigra	11	1				
	Callicarpa americana	22	1				
	Cephalanthus occidentalis						
	Clethra alnifolia	1					
	Cornus amomum	15					1
	Fraxinus pennsylvanica	20	3				
	Itea virginica	12	1				
	Liquidambar styraciflua						
	Paulownia tomentosa						
	Pinus taeda						
	Quercus phellos						
	Salix nigra	2					
	Sambucus canadensis	1	2	1			
	Symphoricarpos orbiculatus	14	2				
	Taxodium distichum						
	Ulmus rubra						
	Viburnum nudum	1	1				
	Morella cerifera	9					
	Viburnum dentatum	7					
	Ilex decidua	4					
	Ilex opaca	2	1	1			
	Vaccinium						
	Cercis canadensis	1					1
	Hamamelis virginiana	5	2				
	Platanus occidentalis	12	5	1			
	Prunus serotina						
	Acer negundo						
	Acer rubrum						
TOT:	**31**	**156**	**19**	**4**			**2**

Table 3. Damage by Species

	Species	All Damage Categories	(no damage)	Insects	Other/Unknown Animal
	Acer negundo	1	1		
	Acer rubrum	1	1		
	Albizia julibrissin	2	2		
	Alnus serrulata	19	17	2	
	Amelanchier arborea	2	2		
	Betula nigra	13	11	1	1
	Callicarpa americana	25	25		
	Cephalanthus occidentalis	1	1		
	Cercis canadensis	2	2		
	Clethra alnifolia	1	1		
	Cornus amomum	16	16		
	Fraxinus pennsylvanica	25	25		
	Hamamelis virginiana	8	5	3	
	Ilex decidua	4	4		
	Ilex opaca	4	4		
	Itea virginica	15	14	1	
	Liquidambar styraciflua	5	5		
	Morella cerifera	10	10		
	Paulownia tomentosa	2	2		
	Pinus taeda	1	1		
	Platanus occidentalis	22	13	9	
	Prunus serotina	2	2		
	Quercus phellos	1	1		
	Salix nigra	2	2		
	Sambucus canadensis	6	5	1	
	Symphoricarpos orbiculatus	17	17		
	Taxodium distichum	1	1		
	Ulmus rubra	2	2		
	Vaccinium	1	1		
	Viburnum dentatum	7	7		
	Viburnum nudum	2	2		
TOT:	**31**	**220**	**202**	**17**	**1**

Table 4. Damage by Plot

	plot	All Damage Categories	(no damage)	Insects	Other/Unknown Animal
	001-jo,sd-0005-year:1	12	12		
	3fk-jo, sd-0007-year:1	21	16	5	
	3fk-sd-0008-year:1	12	10	1	1
	3fk-wjs-0001-year:1	40	39	1	
	3fk-WJS-0002-year:1	31	30	1	
	3fk-wjs-0003-year:1	41	40	1	
	3fk-wjs-0004-year:1	17	14	3	
	3fk-WM-0006-year:1	46	41	5	
TOT:	**8**	**220**	**202**	**17**	**1**

Table 5. Stem Count by Plot and Species

	Species	Total Stems	# plots	avg# stems	plot 001-jo,sd-0005-year:1	plot 3fk-jo, sd-0007-year:1	plot 3fk-sd-0008-year:1	plot 3fk-wjs-0001-year:1	plot 3fk-WJS-0002-year:1	plot 3fk-wjs-0003-year:1	plot 3fk-wjs-0004-year:1	plot 3fk-WM-0006-year:1
	Alnus serrulata	17	7	2.43	1	2		3	1	6	1	3
	Amelanchier arborea	1	1	1			1					
	Betula nigra	12	7	1.71	1	2	1		2	1	2	3
	Callicarpa americana	23	7	3.29	1	2	1	4	8	4		3
	Cercis canadensis	1	1	1				1				
	Clethra alnifolia	1	1	1				1				
	Cornus amomum	15	8	1.88	2	1	1	3	3	2	1	2
	Fraxinus pennsylvanica	23	6	3.83	1		2		3	3	2	12
	Hamamelis virginiana	7	5	1.4		1	2	1	1			2
	Ilex decidua	4	4	1	1			1	1	1		
	Ilex opaca	4	3	1.33				1			2	1
	Itea virginica	13	5	2.6		2		6	1	3		1
	Morella cerifera	9	4	2.25		3		2		1		3
	Platanus occidentalis	18	7	2.57		2	1	7	2	1	2	3
	Salix nigra	2	1	2	2							
	Sambucus canadensis	4	3	1.33		1		1				2
	Symphoricarpos orbiculatus	16	8	2	1	1	1	1	3	5	2	2
	Viburnum dentatum	7	2	3.5					3	4		
	Viburnum nudum	2	2	1					1			1
TOT:	**19**	**179**	**19**		**10**	**17**	**10**	**32**	**29**	**31**	**12**	**38**

Table 6. Vegetation Problem Areas – Third Fork Creek Stream – EEP Project #139 – Durham, NC			
Feature/Issue	**Station/Range**	**Suspected Cause**	**Photo #**
Exotic Invasive Vines and Woody Stems	11+70-14+06	Colonization of floodplain by air and waterborne seeds	VP1
Exotic Invasive Vines	13+42-15+00	Colonization of floodplain by waterborne seeds	VP2
Exotic Invasive Woody Stems	13+57-35+25	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	15+84-16+29	Colonization by air and water borne seeds	VP3
Exotic Invasive Vines	17+67-19+33	Colonization of floodplain by waterborne seeds	VP2
Exotic Invasive Vines	19+23-19+59	Colonization of floodplain by waterborne seeds	VP2
Exotic Invasive Woody Stems	19+32-19+42	Colonization by air and water borne seeds	VP3
Exotic Invasive Vines and Woody Stems	22+06-23+50	Colonization of floodplain by air and waterborne seeds	VP1
Exotic Invasive Woody Stems	26+84-27+50	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	28+9-29+38	Colonization by air and water borne seeds	VP3
Disturbed area	30+14-30+85	Diseased tree removal by City of Durham maintenance crew – no replanting	VP4
Exotic Invasive Vines and Woody Stems	30+15-30+54	Colonization of floodplain by air and waterborne seeds	VP1
Exotic Invasive vines	30+28-30+90	Colonization of floodplain by waterborne seeds	VP2
Exotic Invasive Woody Stems	31+23-32+33	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	31+44-32+38	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	34+74-35+30	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	35+51-35+72	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	36+3-36+67	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	37+44-38+37	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	38+52-38+97	Colonization by air and water borne seeds	VP3
Exotic Invasive Woody Stems	38+97-39+14	Colonization by air and water borne seeds	VP3

Appendix A2. Representative Vegetation Problem Area Photos - 2007 - Third Fork Stream Restoration - Project 139

VP1. Exotic Invasive Vines and Woody Stems

VP2. Exotic Invasive Vines

VP3. Exotic Invasive Woody Stems

VP4. Disturbed Area - not replanted

Appendix A3. Vegetation Monitoring Plot Photographs - 2007 - Third Fork Creek Stream Restoration

Plot 1 (September 2006)

Plot 1 (July 2007)

Plot 2 (September 2006)

Plot 2 (July 2007)

Appendix A3. Vegetation Monitoring Plot Photographs - 2007 - Third Fork Creek Stream Restoration

Plot 3 (September 2006)

Plot 3 (July 2007)

Plot 4 (September 2006)

Plot 4 (July 2007)

Appendix A3. Vegetation Monitoring Plot Photographs - 2007 - Third Fork Creek Stream Restoration

Plot 5 (September 2006)

Plot 5 (July 2007)

Plot 6 (September 2006)

Plot 6 (July 2007)

Appendix A3. Vegetation Monitoring Plot Photographs - 2007 - Third Fork Creek Stream Restoration

Plot 7 (September 2006)

Plot 7 (July 2007)

Plot 8 (September 2006)

Plot 8 (July 2007)

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Feet
0 50 100

Ecosystem Enhancement Program

Figure A1 - 2007 Current Conditions Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

LEGEND

- 2007 Thalweg
- Vegetation Monitoring Plots
- Cross Sections
- ① Photopoints

As-built Drawings (Supplied by KCI)

- Vanes
- Thalweg
- Edge of water
- Conservation Easement
- Sewer ROW

East Forest Hills Blvd.

Figure 1.1 Match line

Figure 1.2

	Easting	Northing
Vegetation Plots		
1	2026252.522400	812789.657666
2	2026222.941600	812569.691675
3	2025987.289460	812136.701257
4	2025961.194110	811689.362376
Cross-sections		
1-L	2026045.167310	812046.165066
1-R	2026008.863870	812074.268999
2-L	2026019.907700	811829.907400
2-R	2025969.114450	811842.610456
Photopoints		
1	2026280.064630	812942.007941
2	2026245.292230	812638.539733
3	2026224.428790	812585.685687
4	2026034.128930	812393.109820
5	2026035.393380	812128.144141
6	2025987.976480	812046.207724
7	2025968.377490	811836.182435
8	2025926.650610	811606.368490

Vegetation Problem Areas 07

- Disturbed

Invasive/Exotic Colonization

- Vines and Woody Stems
- Vines
- Woody Stems

Sewer Right of Way

XS1

XS2

2026300
2026000
2025700

8130000 8128000 8126000 8124000 8122000 8120000 8118000 8116000

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Feet
0 50 100

Ecosystem Enhancement PROGRAM

Figure A2 - 2007 Current Conditions Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

	Easting	Northing
Vegetation Plots		
5	2025825.804140	811325.105992
6	2025751.559070	810836.827402
7	2025773.300850	810651.892462
8	2025829.725470	810411.548741
Cross-sections		
3-L	2025870.880914	810673.554871
3-R	2025770.851314	810650.406271
4-L	2025798.603914	810554.818971
4-R	2025759.096714	810575.310971
Photopoints		
9	2025883.659280	811374.025644
10	2025782.503210	811250.741684
11	2025792.618820	811001.328751
12	2025781.870990	810914.081641
13	2025766.697570	810688.630051
14	2025800.837750	810416.773115

Vegetation Problem Areas 07

Disturbed

Invasive/Exotic Colonization

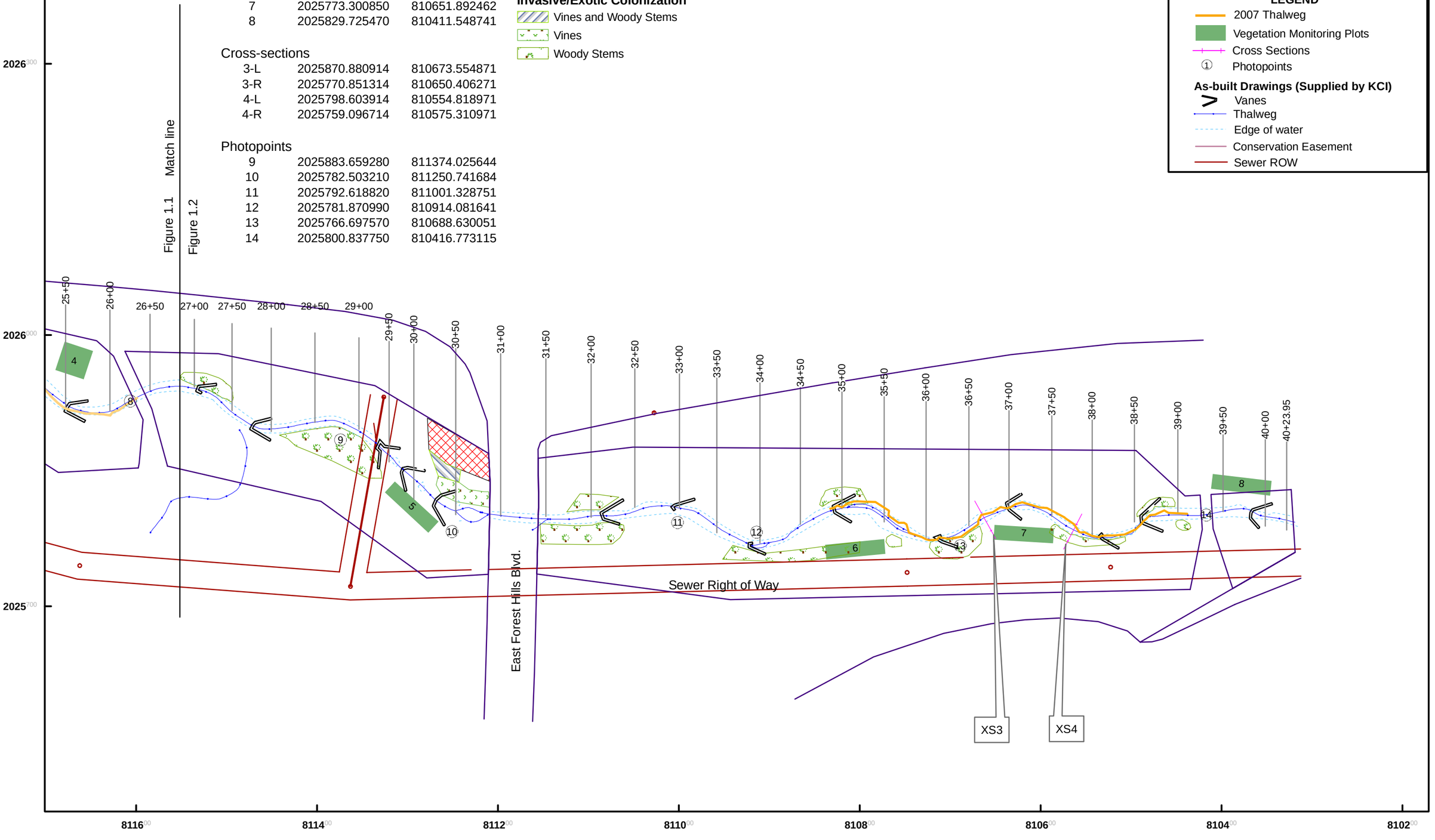
Vines and Woody Stems
Vines
Woody Stems

LEGEND

2007 Thalweg
Vegetation Monitoring Plots
Cross Sections
① Photopoints

As-built Drawings (Supplied by KCI)

Vanes
Thalweg
Edge of water
Conservation Easement
Sewer ROW



Appendix B Geomorphologic Raw Data

Figure B1. Current Conditions Plan View

B2. Stream Problem Areas Table

B3. Representative Stream Problem Area Photos

B4. Stream Photo-station Photos

B5. Qualitative Visual Stability Assessment Table

B6. Cross section Plots and Raw Data Tables

B7. Longitudinal Plots and Raw Data Tables

B8. Pebble Counts

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Feet
0 50 100

Ecosystem Enhancement Program

Figure B1 - 2007 Current Conditions - Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

LEGEND

- 2007 Thalweg
- Vegetation Monitoring Plots
- Cross Sections
- ① Photopoints

As-built Drawings (Supplied by KCI)

- Vanes
- Thalweg
- Edge of water
- Conservation Easement
- Sewer ROW

Figure 1.1 Match line

Figure 1.2

East Forest Hills Blvd.

Sewer Right of Way

XS1

XS2

	Easting	Northing
Vegetation Plots		
1	2026252.522400	812789.657666
2	2026222.941600	812569.691675
3	2025987.289460	812136.701257
4	2025961.194110	811689.362376
Cross-sections		
1-L	2026045.167310	812046.165066
1-R	2026008.863870	812074.268999
2-L	2026019.907700	811829.907400
2-R	2025969.114450	811842.610456
Photopoints		
1	2026280.064630	812942.007941
2	2026245.292230	812638.539733
3	2026224.428790	812585.685687
4	2026034.128930	812393.109820
5	2026035.393380	812128.144141
6	2025987.976480	812046.207724
7	2025968.377490	811836.182435
8	2025926.650610	811606.368490

Stream Problem Areas 07

High Priority

- Bank undercut/slump
- Vane backcut/scour

Low Priority

- Bank undercut/slump
- Vane backcut/scour
- Aggradation (pool)
- Aggradation (bar)
- UT/Stormwater Headcut

2026300
2026000
2025700

8130000 8128000 8126000 8124000 8122000 8120000 8118000 8116000

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Feet
0 50 100

Ecosystem Enhancement PROGRAM

Figure B2 - 2007 Current Conditions Plan View - Year 3

Third Fork Creek (Forest Hills)
Stream Restoration - EEP Project #139

	Easting	Northing
Vegetation Plots		
5	2025825.804140	811325.105992
6	2025751.559070	810836.827402
7	2025773.300850	810651.892462
8	2025829.725470	810411.548741
Cross-sections		
3-L	2025870.880914	810673.554871
3-R	2025770.851314	810650.406271
4-L	2025798.603914	810554.818971
4-R	2025759.096714	810575.310971
Photopoints		
9	2025883.659280	811374.025644
10	2025782.503210	811250.741684
11	2025792.618820	811001.328751
12	2025781.870990	810914.081641
13	2025766.697570	810688.630051
14	2025800.837750	810416.773115

Stream Problem Areas 07

High Priority
- Bank undercut/slump
- Vane backcut/scour

Low Priority
- Bank undercut/slump
- Vane backcut/scour
- Aggradation (pool)
- Aggradation (bar)
- UT/Stormwater Headcut

LEGEND
- 2007 Thalweg
- Vegetation Monitoring Plots
- Cross Sections
- Photopoints

As-built Drawings (Supplied by KCI)
- Vanes
- Thalweg
- Edge of water
- Conservation Easement
- Sewer ROW

Match line
Figure 1.1
Figure 1.2
East Forest Hills Blvd.
Sewer Right of Way
XS3
XS4

B2. Stream Problem Areas - Third Fork Stream Restoration – EEP Project #139

Feature/Issue	Station	Probable Cause	Photo
Aggradation (bar)	10+57	Offsite/upstream	SP1
Aggradation (pool)	10+68	Offsite/upstream	SP2
Aggradation (bar)	10+75	Offsite/upstream	SP1
Aggradation (pool)	11+10	Offsite/upstream	SP2
Headcut-stormwater dist.	14+29	Insufficient armor	SP5
Bank undercut/slump	25+85-26+19	No armor/rootwad	SP3
Vane backcut/scour	27+04	Insufficient/no coarse backfill	SP4
Aggradation (bar)	30+75	Offsite/upstream	SP1
Aggradation (bar)	31+48	Offsite/upstream	SP1
Bank undercut/slump	34+11-34+80	No armor/rootwad	SP3
Bank undercut/slump	35+46-35+75	No armor/rootwad	SP3
Bank undercut/slump	36+30-36+56	No armor/rootwad	SP3
Bank undercut/slump	37+12-37+87	No armor/rootwad	SP3
Bank undercut/slump	37+14-38+10	No armor/rootwad	SP3
Aggradation (pool)	38+14	Offsite/upstream	SP2
Vane backcut/scour	38+68	Insufficient/no coarse backfill	SP4

Appendix B3. Representative Stream Problem Area Photos - 2007 - Third Fork Stream Restoration - Project 139

SP1. Aggradation (bar)

SP2. Aggradation (pool)

SP3. Bank Undercut/Slump

SP4. Vane Backcut/Scour

Appendix B3. Representative Stream Problem Area Photos - 2007 - Third Fork Stream Restoration - Project 139

SP5. Headcut

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #1 – Looking Upstream (11/20/06)

PP #1 – Looking Upstream (07/16/07)

PP #2 – Looking Upstream (11/20/06)

PP #2 – Looking Upstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #3 – Ditch Entering Stream (11/20/06)

PP #3 – Ditch Entering Stream (07/16/07)

PP #4 – Looking Downstream (11/20/06)

PP #4 – Looking Downstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #5 – UT Entering Stream (11/20/06)

PP #5 – UT Entering Stream (07/16/07)

PP #6 – Looking Downstream (11/20/06)

PP #6 – Looking Downstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #7 – Looking Downstream (11/20/06)

PP #7 – Looking Downstream (07/16/07)

Not Available

PP #8 – Looking Upstream (11/20/06)

PP #8 – Looking Upstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #9 – Looking Upstream (11/20/06)

PP #9 – Looking Upstream (07/16/07)

PP #10 – Looking Downstream (11/20/06)

PP #10 – Looking Downstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #11 – Looking Upstream (11/20/06)

PP #11 – Looking Upstream (07/16/07)

PP #12 – Looking Upstream (11/20/06)

PP #12 – Looking Upstream (07/16/07)

Appendix B4. Permanent Photopoint Photographs - Third Fork Creek Stream Restoration

PP #13 – Looking Upstream (11/20/06)

PP #13 – Looking Upstream (07/16/07)

PP #14 – Looking Upstream (11/20/06)

PP #14 – Looking Upstream (07/16/07)

Table B5. Visual Morphological Assessment Third Fork Stream Restoration Project - Upstream Reach - Project #139

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total Number per As-built	Total Number/ feet in Unstable State	Percent Performing in Stable Condition	Feature Performing Mean (%)
A. Riffles	1. Present	10	10	1/20	100	
	2. Armor stable	9	10	1/5	90	
	3. Facet grade appears stable	8	10	2/15	80	
	4. Minimal evidence of embedding/fining	7	10	3/25	70	
	5. Length appropriate	9	10	1/5	90	**86**
B. Pools	1. Present	13	15	0	87	
	2. Sufficiently deep	13	15	2/25	87	
	3. Length appropriate	13	15	2/25	87	**87**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	16	16	0	100	
	2. Downstream of meander (glide/inflection) centering	15	16	1/23	94	**97**
D. Meanders	1. Outer bend in state of limited/controlled erosion	15	16	1/23	94	
	2. Of those eroding, # w/concomitant point bar formation	0	NA	0	NA	
	3. Apparent Rc within spec	16	16	0	100	
	4. Sufficient floodplain access and relief	16	16	0	100	**98**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	3	NA	0	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	0	NA	0	100	**100**
F. Vanes	1. Free of back or arm scour	22	23	1/15	96	
	2. Height appropriate	22	23	1/3	96	
	3. Angle and geometry appear appropriate	22	23	1/10	96	
	4. Free of piping or other structural failures	22	23	1/15	96	**96**
G. Wads/Bould	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Table B5. Visual Morphological Assessment Third Fork Stream Restoration Project - Downstream Reach - Project #139

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total Number per As-built	Total Number/ feet in Unstable State	Percent Performing in Stable Condition	Feature Performing Mean (%)
A. Riffles	1. Present	7	10	3/35	70	
	2. Armor stable	6	10	4/30	60	
	3. Facet grade appears stable	5	10	5/60	50	
	4. Minimal evidence of embedding/fining	3	10	7/90	30	
	5. Length appropriate	7	10	3/25	70	**56**
B. Pools	1. Present	6	12	6/25	50	
	2. Sufficiently deep	6	12	6/40	50	
	3. Length appropriate	8	12	4/35	67	**56**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	4	7	3/13	57	
	2. Downstream of meander (glide/inflection) centering	4	7	3/25	57	**57**
D. Meanders	1. Outer bend in state of limited/controlled erosion	4	7	0/0	57	
	2. Of those eroding, # w/concomitant point bar formation	NA	NA	2/4	NA	
	3. Apparent Rc within spec	5	7	0/0	71	
	4. Sufficient floodplain access and relief	5	7	0/0	71	**67**
E. Bed (General)	1. General channel bed aggradation areas (bar formation)	NA	NA	3/25	100	
	2. Channel bed degradation – areas of increasing downcutting or head cutting	NA	NA	4/32	100	**100**
F. Vanes	1. Free of back or arm scour	8	9	1/7	89	
	2. Height appropriate	9	9	0/0	100	
	3. Angle and geometry appear appropriate	9	9	2/11	100	
	4. Free of piping or other structural failures	8	9	1/7	89	**94**
G. Wads/Bould	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	NA

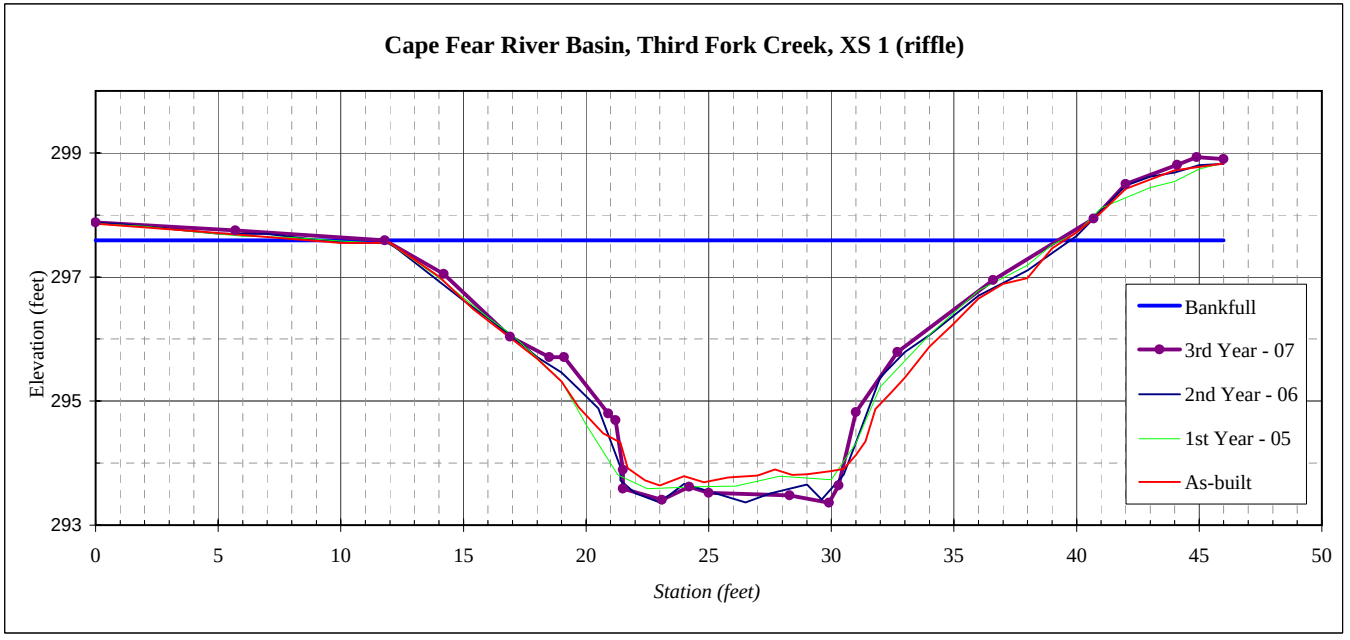
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 1 (riffle)
Reach:	Upstream
Date:	7/16/2007
Field Crew:	S. Doig, K. Barnes

Station	Rod Ht.	Elevation
0.0	6.31	297.88
5.7	6.44	297.75
11.8	6.60	297.59
14.2	7.14	297.05
16.9	8.15	296.04
18.5	8.48	295.71
19.1	8.48	295.71
20.9	9.39	294.80
21.2	9.50	294.69
21.5	10.3	293.89
21.5	10.60	293.59
23.1	10.78	293.41
24.2	10.57	293.62
25.0	10.67	293.52
28.3	10.71	293.48
29.9	10.83	293.36
30.3	10.55	293.64
31.0	9.37	294.82
32.7	8.40	295.79
36.6	7.24	296.95
40.7	6.25	297.94
42.0	5.69	298.50
44.1	5.38	298.81
44.9	5.26	298.93
46.0	5.29	298.90

SUMMARY DATA	
Floodprone Elevation (ft)	301.82
Bankfull Elevation (ft)	297.59
Floodprone Width (ft)	240.00
Bankfull Width (ft)	24.45
Entrenchment Ratio	8.74
Mean Depth (ft)	2.23
Maximum Depth (ft)	12.30
Width/Depth Ratio	61.28
Bankfull Area (sq ft)	30.12
Wetted Perimeter (ft)	11.80
Hydraulic Radius (ft)	39.25

Stream Type:	C5c

View of cross-section #1 looking upstream



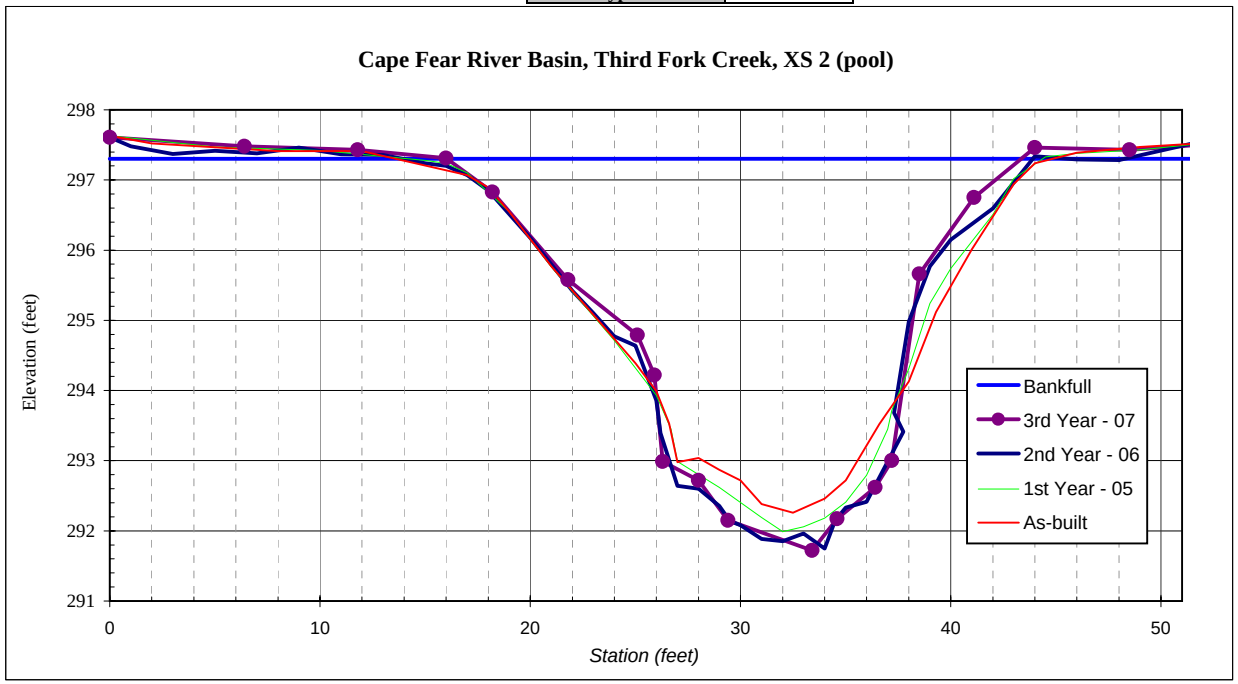
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 2 (pool)
Reach:	Upstream
Date:	7/16/2007
Field Crew:	S. Doig, K. Barnes

Station	Rod Ht.	Elevation
0	5.26	297.61
6.4	5.39	297.48
11.8	5.44	297.43
16	5.56	297.31
18.2	6.04	296.83
21.8	7.29	295.58
25.1	8.08	294.79
25.9	8.65	294.22
26.3	9.88	292.99
28	10.15	292.72
29.4	10.72	292.15
33.4	11.15	291.72
34.6	10.7	292.17
36.4	10.25	292.62
37.2	9.87	293
38.5	7.21	295.66
41.1	6.12	296.75
44	5.41	297.46
48.5	5.44	297.43
51.7	5.37	297.5

SUMMARY DATA	
Floodprone Elevation (ft)	302.9
Bankfull Elevation (ft)	297.31
Floodprone Width (ft)	240
Bankfull Width (ft)	27.39
Entrenchment Ratio	8.67
Mean Depth (ft)	2.83
Maximum Depth (ft)	5.59
Width/Depth Ratio	9.69
Bankfull Area (sq ft)	77.42
Wetted Perimeter (ft)	31.14
Hydraulic Radius (ft)	2.49

View of cross-section #2 looking upstream

Stream Type:	C5c



River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 3 (riffle)
Reach:	Downstream
Date:	7/13/2007
Field Crew:	S. Doig, K. Barnes

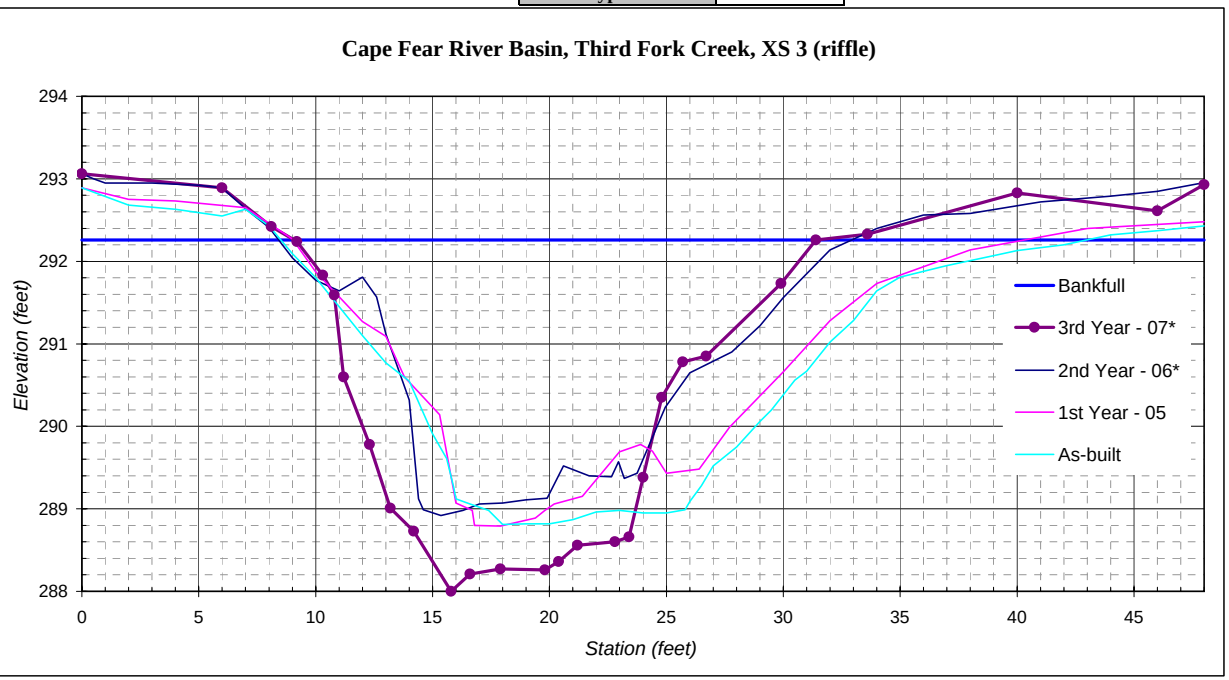
Station	Rod Ht.	Elevation
0	5.09	293.06
6	5.26	292.89
8.1	5.73	292.42
9.2	5.91	292.24
10.3	6.32	291.83
10.8	6.56	291.59
11.2	7.55	290.6
12.3	8.37	289.78
13.2	9.14	289.01
14.2	9.42	288.73
15.8	10.15	288
16.6	9.94	288.21
17.9	9.88	288.27
19.8	9.89	288.26
20.4	9.79	288.36
21.2	9.59	288.56
22.8	9.55	288.6
23.4	9.49	288.66
24	8.77	289.38
24.8	7.8	290.35
25.7	7.37	290.78
26.7	7.3	290.85
29.9	6.42	291.73
31.4	5.89	292.26
33.6	5.82	292.33
40	5.32	292.83
46	5.54	292.61
48	5.22	292.93

SUMMARY DATA	
Floodprone Elevation (ft)	296.52
Bankfull Elevation (ft)	292.26
Floodprone Width (ft)	240.00
Bankfull Width (ft)	22.32
Entrenchment Ratio	10.75
Mean Depth (ft)	2.48
Maximum Depth (ft)	4.26
Width/Depth Ratio	8.99
Bankfull Area (sq ft)	55.42
Wetted Perimeter (ft)	25.04
Hydraulic Radius (ft)	2.21

View of cross-section #3 looking upstream

Stream Type:	E5

*the original (as-built and 1st year) cross section was not relocated in 2006. Subsequent years' data represent relocation based best professional judgment, which appropriately approximates the original location.



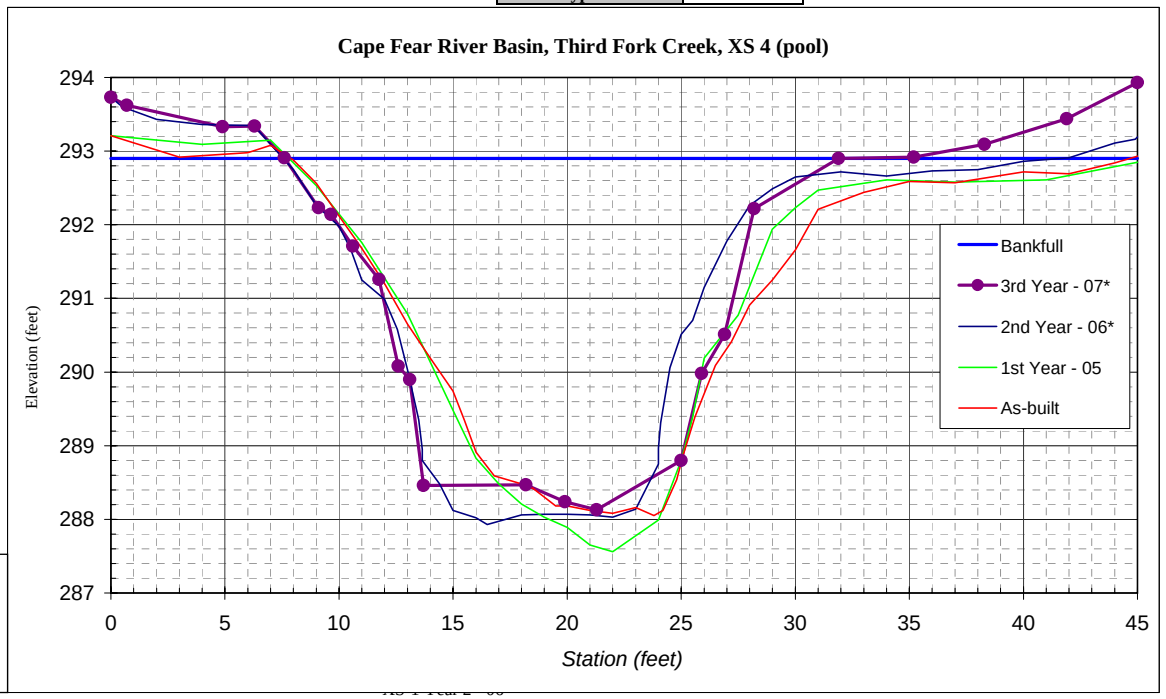
River Basin:	Cape Fear
Watershed:	Third Fork Creek
XS ID	XS 4 (pool)
Reach:	Downstream
Date:	7/12/2007
Field Crew:	S. Doig, K. Barnes

Station	Rod Ht.	Elevation
0	6.12	293.73
0.7	6.23	293.62
4.9	6.52	293.33
6.3	6.51	293.34
7.6	6.94	292.91
9.1	7.62	292.23
9.65	7.71	292.14
10.6	8.14	291.71
11.75	8.59	291.26
12.6	9.77	290.08
13.1	9.95	289.9
13.7	11.39	288.46
18.2	11.38	288.47
19.9	11.61	288.24
21.3	11.72	288.13
25	11.05	288.8
25.9	9.87	289.98
26.9	9.34	290.51
28.2	7.63	292.22
31.9	6.95	292.9
35.2	6.93	292.92
38.3	6.76	293.09
41.9	6.41	293.44
45	5.92	293.93

SUMMARY DATA	
Floodprone Elevation (ft)	297.67
Bankfull Elevation (ft)	292.90
Floodprone Width (ft)	240.00
Bankfull Width (ft)	24.28
Entrenchment Ratio	9.89
Mean Depth (ft)	2.83
Maximum Depth (ft)	4.77
Width/Depth Ratio	8.57
Bankfull Area (sq ft)	68.79
Wetted Perimeter (ft)	27.91
Hydraulic Radius (ft)	2.46

View of cross-section #3 looking upstream

Stream Type:	E5



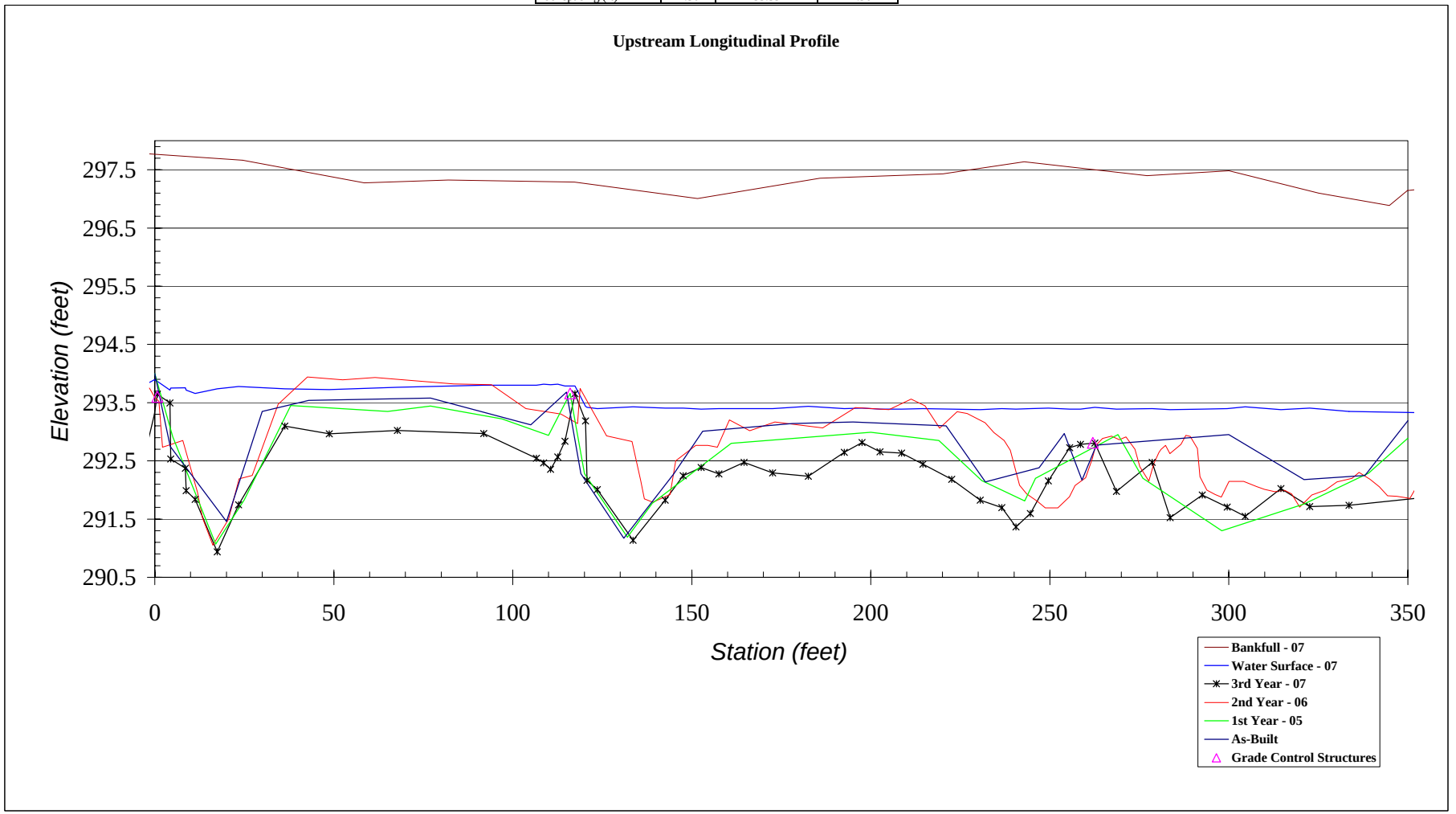
*the original (as-built and 1st year) cross section was not relocated in 2006. Subsequent years' data represent relocation based best professional judgment, which appropriately approximates the original location.

B7. Longitudinal Plots and Raw Data Tables - Third Fork Creek Stream Restoration Monitoring Year 3 (2007) - Durham, NC

River Basin:			Cape Fear
Watershed:			Third Fork Creek
Reach:			Upstream
Profile ID:			Profile 1
Date:			17 July 2007
Field Crew:			S. Doig and K. Brehm

Pattern	min	max	average
Channel Beltwidth (ft)	20.42	42.66	29.28
Radius of Curvature (ft)	27.69	82.19	60.58
Meander Wavelength	161.75	212.61	182.45
Meander Width ratio	2.00	2.59	2.12
Profile	min	max	average
Riffle length (ft)			55.57
Riffle slope (ft/ft)			0.002
Pool length (ft)	22.65	76.80	47.39
Pool spacing (ft)	4.30	55.59	21.96

Additional Reach Parameters	
Valley Length (ft)	310
Channel Length (ft)	350
Sinuosity	1.13
Water Surface Slope (ft/ft)	0.0018
BF slope (ft/ft)	0.0007
Rosgen Classification	C5
Habitat Index	NA
Macrobenthos	NA

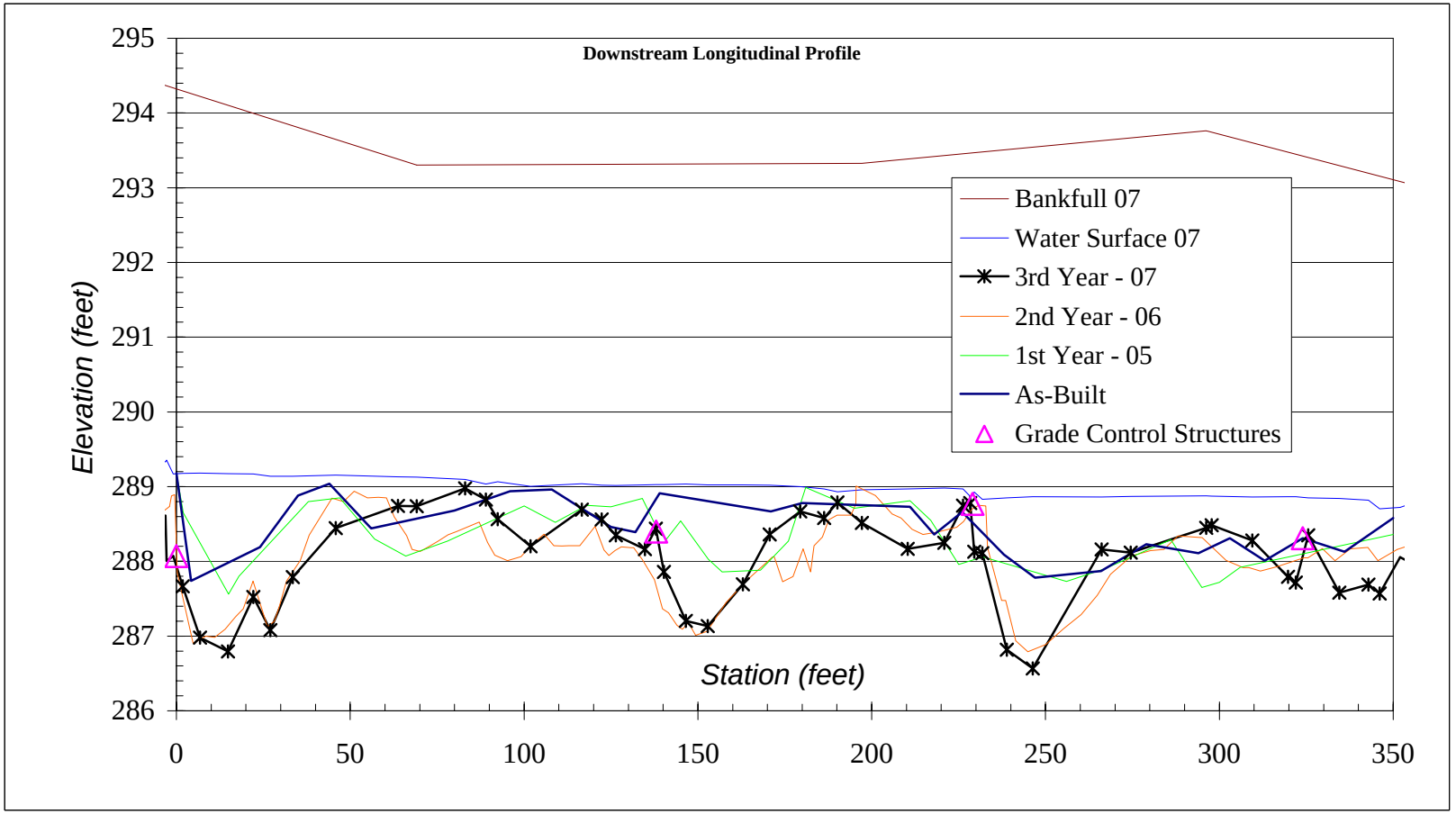


B7. Longitudinal Plots and Raw Data Tables - Third Fork Creek Stream Restoration Monitoring Year 3 (2007) - Durham, NC

River Basin:	Cape Fear
Watershed:	Third Fork Creek
Reach:	Downstream
Profile ID:	Profile 2
Date:	27 July 2007
Field Crew:	J. O'Neal and S. Doig

Pattern	min	max	average
Channel Beltwidth (ft)	45.5	51.4	47.467
Radius of Curvature (ft)	45.20	62.32	56.59
Meander Wavelength	181.6	185.93	183.76
Meander Width ratio	1.75	1.47	1.61
Profile	min	max	average
Riffle length (ft)	5.66	11.70	8.45
Riffle slope (ft/ft)	0.017	0.0441	0.0308
Pool length (ft)	24.21	76.901	51.149
Pool spacing (ft)	21.26	41.407	30.447

Additional Reach Parameters	
Valley Length (ft)	310
Channel Length (ft)	350
Sinuosity	1.13
Water Surface Slope (ft/ft)	0.001
BF slope (ft/ft)	0.005
Rosgen Classification	E5
Habitat Index	**N/A**
Macrobenthos	**N/A**



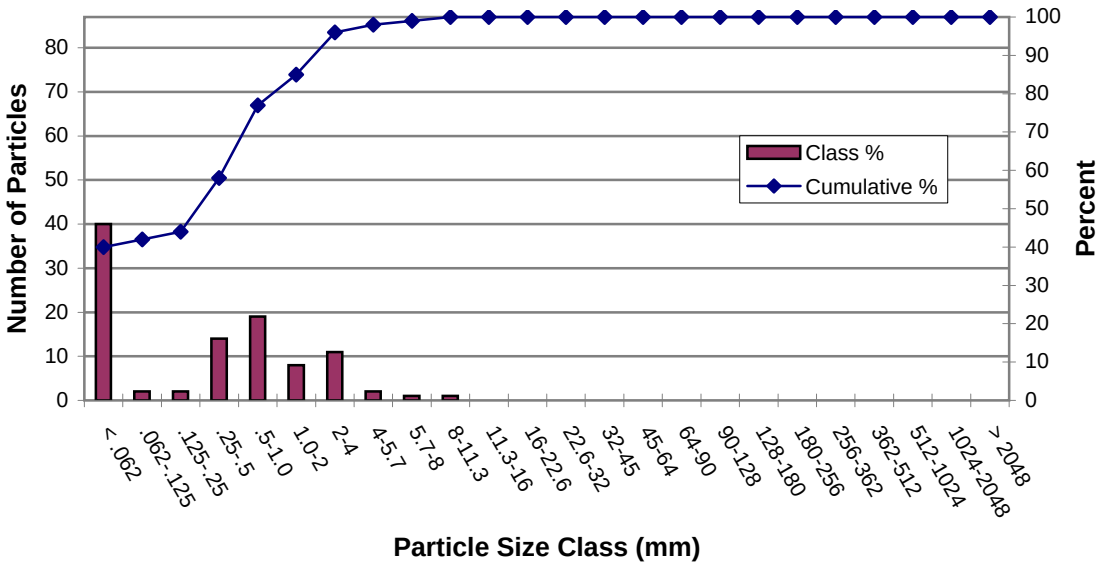
B8. Pebble Count - Third Fork Creek Stream Restoration Third Year Monitoring 07/25/2007

Cross Section One

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	40	40	40
Sand	Very Fine Sand	.062-.125	2	2	42
	Fine Sand	.125-.25	2	2	44
	Medium Sand	.25-.5	14	14	58
	Coarse Sand	.5-1.0	19	19	77
	Very Course Sand	1.0-2	8	8	85
Gravel	Very Fine Gravel	2-4	11	11	96
	Fine Gravel	4-5.7	2	2	98
	Fine Gravel	5.7-8	1	1	99
	Medium Gravel	8-11.3	1	1	100
	Medium Gravel	11.3-16		0	100
	Coarse Gravel	16-22.6		0	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	100
Cobble	Small Cobble	64-90		0	100
	Small Cobble	90-128		0	100
	Medium Cobble	128-180		0	100
	Large Cobble	180-256		0	100
Boulder	Small Boulders	256-362		0	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 0.36 mm

d_{84} = 1.88 mm



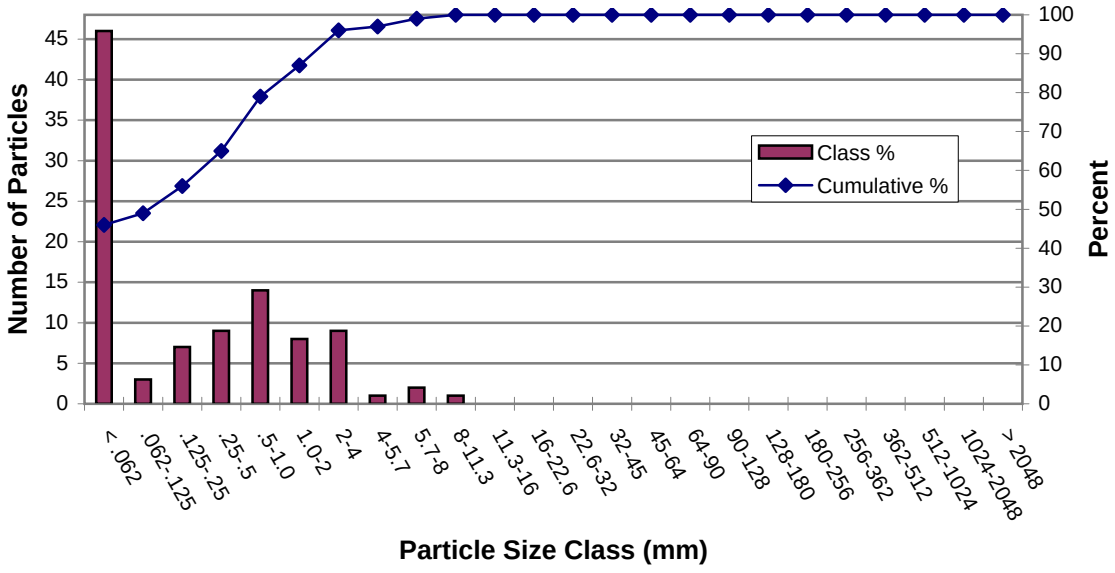
B8. Pebble Count - Third Fork Creek Stream Restoration Third Year Monitoring 07/25/2007

Cross Section Two

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	46	46	46
Sand	Very Fine Sand	.062-.125	3	3	49
	Fine Sand	.125-.25	7	7	56
	Medium Sand	.25-.5	9	9	65
	Coarse Sand	.5-1.0	14	14	79
	Very Course Sand	1.0-2	8	8	87
Gravel	Very Fine Gravel	2-4	9	9	96
	Fine Gravel	4-5.7	1	1	97
	Fine Gravel	5.7-8	2	2	99
	Medium Gravel	8-11.3	1	1	100
	Medium Gravel	11.3-16		0	100
	Coarse Gravel	16-22.6		0	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	100
Cobble	Small Cobble	64-90		0	100
	Small Cobble	90-128		0	100
	Medium Cobble	128-180		0	100
	Large Cobble	180-256		0	100
Boulder	Small Boulders	256-362		0	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 0.14 mm

d_{84} = 1.63 mm



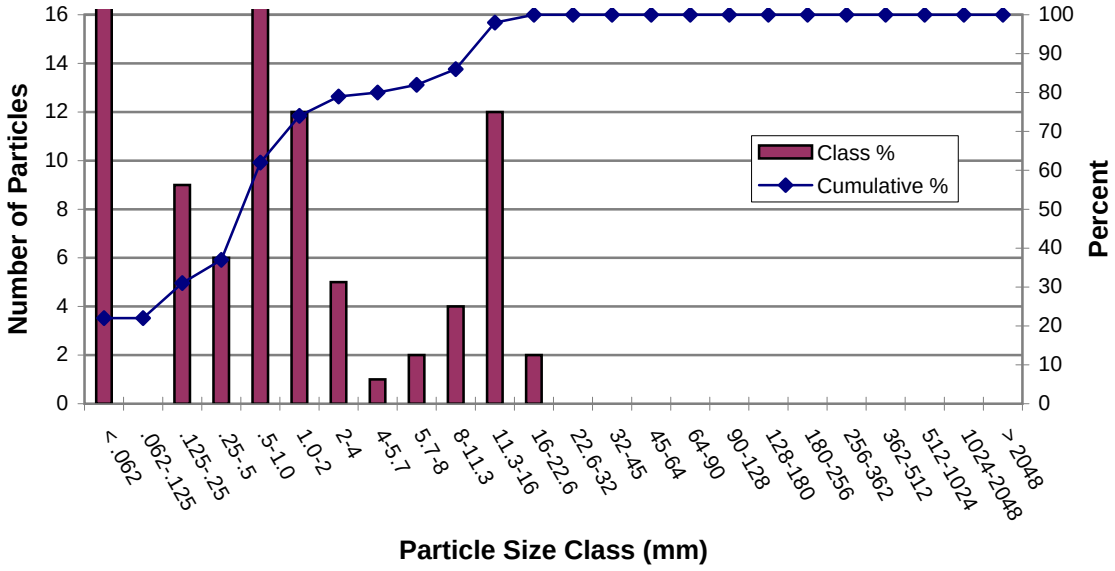
B8. Pebble Count - Third Fork Creek Stream Restoration Third Year Monitoring 07/25/2007

Cross Section Three

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	22	22	22
Sand	Very Fine Sand	.062-.125	0	0	22
	Fine Sand	.125-.25	9	9	31
	Medium Sand	.25-.5	6	6	37
	Coarse Sand	.5-1.0	25	25	62
	Very Course Sand	1.0-2	12	12	74
Gravel	Very Fine Gravel	2-4	5	5	79
	Fine Gravel	4-5.7	1	1	80
	Fine Gravel	5.7-8	2	2	82
	Medium Gravel	8-11.3	4	4	86
	Medium Gravel	11.3-16	12	12	98
	Coarse Gravel	16-22.6	2	2	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	100
Cobble	Small Cobble	64-90		0	100
	Small Cobble	90-128		0	100
	Medium Cobble	128-180		0	100
	Large Cobble	180-256		0	100
Boulder	Small Boulders	256-362		0	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 0.76 mm

d_{84} = 9.65 mm



B8. Pebble Count - Third Fork Creek Stream Restoration Third Year Monitoring 07/25/2007

Cross Section Four

	Particle	Size Range (mm)	Total #	Class %	Cumulative %
S/C	Silt/Clay	< .062	10	10	10
Sand	Very Fine Sand	.062-.125	4	4	14
	Fine Sand	.125-.25	8	8	22
	Medium Sand	.25-.5	12	12	34
	Coarse Sand	.5-1.0	29	29	63
	Very Course Sand	1.0-2	14	14	77
Gravel	Very Fine Gravel	2-4	12	12	89
	Fine Gravel	4-5.7	2	2	91
	Fine Gravel	5.7-8	4	4	95
	Medium Gravel	8-11.3	2	2	97
	Medium Gravel	11.3-16	2	2	99
	Coarse Gravel	16-22.6	1	1	100
	Coarse Gravel	22.6-32		0	100
	Very Course Gravel	32-45		0	100
	Very Course Gravel	45-64		0	100
Cobble	Small Cobble	64-90		0	100
	Small Cobble	90-128		0	100
	Medium Cobble	128-180		0	100
	Large Cobble	180-256		0	100
Boulder	Small Boulders	256-362		0	100
	Small Boulders	362-512		0	100
	Medium Boulders	512-1024		0	100
	Large Boulders	1024-2048		0	100
	Bedrock	> 2048		0	100
	Total		100		

d_{50} = 0.78 mm

d_{84} = 3.17 mm