CROSS CREEK STREAM RESTORATION

MONITORING REPORT (YEAR 2 OF 5)

Cumberland County, North Carolina
NCEEP Project Number 105

Prepared for:
North Carolina Ecosystem Enhancement Program
1652 Mail Service Center
Raleigh, NC 27699-1652

Status of Plan: Final
Submission Date: March 2008

Monitoring Firm:

Stantec Consulting Services Inc
801 Jones Franklin Road, Suite 300
Raleigh, NC 27606

EXECUTIVE SUMMARY

Project Background

The North Carolina Ecosystems Enhancement Program (EEP) restored 2,090 linear feet of the Cross Creek stream channel located within the City of Fayetteville, North Carolina. The site was constructed between the dates of March of 2004 to January 2005. The following report provides the monitoring information for Year 2 of the stream restoration project. The project consists of portions of two tributaries of the Cape Fear River, Little Cross Creek and Cross Creek. Both are located within the city limits of Fayetteville on City property southwest of Fayetteville State University's Campus in Cumberland County, North Carolina. Both creeks have been impacted from development and had lost ecological functions related to water quality and biological habitat.

The Priority 2 restoration involved re-establishing the floodplain at a lower elevation so that the floodplain can be accessed during storm events above bankfull. The natural meander patterns were restored based on reference reach data. Rock grade control vane structures and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability.

Vegetation Assessment

On September 20, 2007 and October 1, 2007 the Year 2 vegetation monitoring was completed using the Carolina Vegetation Survey (CVS) – EEP protocol (version 4.1) on eight monitoring plots previously established by Earth Tech. The Level 2 survey (planted and natural stems) methodology was utilized. While five plots met the 3-year success criteria of 320 trees/acre, three plots (103, 107, and 108) did not. If planted shrubs are used in calculating success then all plots would be successful. Plots 107 and 108 met success criteria last year but are in an area now dense with kudzu. Plots 101 and 105 did not meet success criteria last year but do this year; possibly due to discrepancies in past data collection. Kudzu is a major problem along the majority of the site, primarily along Little Cross Creek. It should be removed as soon as possible with either mechanical and/or chemical treatment to ensure future vegetative success. A few small areas of Chinese privet are also present onsite.

Stream Assessment

On June 28, 2007 and July 4, 2007 Stantec completed the Year 2 monitoring surveys for the two restored reaches. The locations of the cross sections for the riffles and pools set by Earth Tech were unable to be located in the field. With several searches for the cross sections, and with the lack of data, six new cross sections for riffles and pools were placed; 2 for Little Cross Creek and 4 for Cross Creek.

The assessment found Little Cross Creek Tributary to be stable and performing as intended with only small minor problem areas, while the Cross Creek stream reach was found to have major problem areas and is considered at this point to be unstable and currently does not meet the success requirements.

The Cross Creek stream reach major problem areas include a failure of the stormwater channel plunge pool as well as a failure of an adjacent wetland pond located on the right bank near station 21+60. The stormwater channel is undergoing massive erosion and bank migration. Failure has occurred at the outlet entering into the main reach of the stream in the form of a scour hole, depositing sediment directly into the main reach from erosion of the stormwater channel. The construction plans call the channel width of the storm water channel to be 20 feet, however the surveyed measurement was found to be 40 feet. It is clear that the channel cannot currently hold the velocities and flow capacity of the discharge outflowing

from the stormwater pipe. The failure of the wetland pond is directly influenced and caused by the failure of the stormwater channel. A failure from the wetland pond's outlet to the main reach along with overbank flow has occurred producing massive erosion.

It is strongly recommended that this area of the restoration project be re-resigned. The flow exiting the stormdrain (and the energy associated with that flow) is too great for the current design. A flow splitter is recommended to divert large storms around the facility and into a bypass channel. The bypass channel should be designed to convey large flows and should utilize grade control structures for stabilization and for the benefit of the receiving stream reach. Redesigning this area will decrease downstream velocities and restore habitat in the wetland area.

Minor problem areas (SP 1-8, 11-18) were also found across the project and they can be defined into four subcategories: structure failure, root wad failure, toe scour, and bank erosion. These problem areas can be remediated by additional plantings and/or minor hand grading of the banks.

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1.0 Project Background

The project consists of portions of two tributaries to the Cape Fear River, Little Cross Creek and Cross Creek. Both are located within the city limits of Fayetteville on public lands southwest of Fayetteville State University's Campus in Cumberland County, North Carolina.

1.1 PROJECT OBJECTIVES

Project goals and objectives for the Cross Creek and Little Cross Creek Stream Restoration:

- Provide a stable stream channel that neither aggrades nor degrades while maintaining its dimension, pattern, and profile with the capacity to transport its watershed's water and sediment load;
- Provide the stream with a floodplain at the stream's current elevation:
- Improve aquatic habitat with the use of natural material stabilization structures such as root wads, rock vanes, woody debris and a riparian buffer.
- Provide wildlife habitat and bank stability though the creation of a riparian zone.

1.2 PROJECT STRUCTURE

The project consists of portions of two tributaries of the Cape Fear River, Little Cross Creek and Cross Creek. Both are located within the City Limits of Fayetteville on City-owned property southwest of Fayetteville States University's Campus in Cumberland County, North Carolina. The watershed area for this project is 25.5 square miles.

The restoration site is located entirely within a highly developed area of Fayetteville. Land immediately adjacent to the restoration site is undeveloped, grass coved land included in the Martin Luther King Jr. Park expansion. There are both water and sewer utilities within the project limits.

Prior to construction, both Cross Creek and Little Cross Creek had been impacted from development and had lost ecological functions related to water quality and biological habitat. The main factors in the degradation and impairment of the streams were the historical straightening of the channels and the filling of their floodplains. Both reaches within the project limits were classified as G5 type channels.

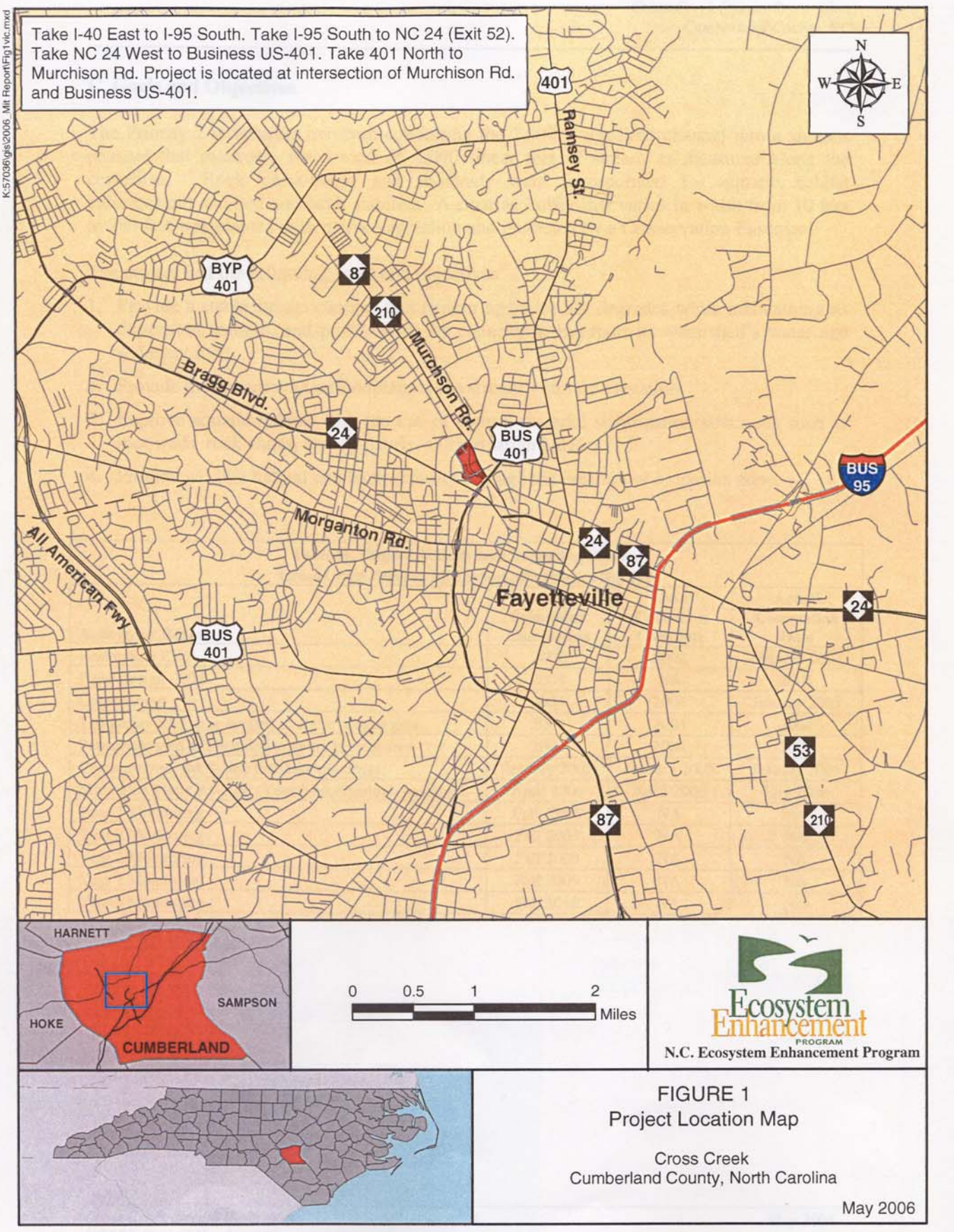
The Priority 2 restoration involved converting the 2,000 ft impaired channel into a sinuous channel that meanders for a total of 2,090 linear feet of stream (Exhibit Table I). The project also involved re-establishing the floodplain at a lower elevation to provide access to high stream flows. Rock grade control vane structures and rootwads were incorporated for aquatic habitat enhancement and bed and bank stability. A riparian buffer that varies in width from 10 feet to 280 feet was planted with native vegetation and protected by a Conservation Easement.

Exhibit Table I. Project Restoration Components Cross Creek Stream Restoration - EEP Project No. 105								
Reach ID	**Existing Feet/Acres**	**Type**	**Approach**	**Footage or Acreage**	**Mitigation Ratio**	**Mitigation Units**	**Stationing**	**Comment**
Cross Creek	1295	R	P2	1376.0	1.0	1376.0	11+4.00 to 25+16.58	Instream structures and vegetated buffers
Little Cross Creek	705	R	P2	714.0	1.0	714.0	10+00 to 17.13.687	Instream structures and vegetated buffers
Mitigation Unit Summations								
Stream (lf)	Riparian Wetland (ac)		Nonriparian Wetland (ac)		Total Wetland (ac)		Buffer (ac)	Comment
2090.0	0.0		0.0		0.0		0.0	

R = Restoration
P2 = Priority 2

1.3 LOCATION AND SETTING

The restoration site is located within the City of Fayetteville, North Carolina on public land. The restoration site is located entirely within a highly developed area of Fayetteville. The property is located off of the Martin Luther King Freeway (formerly the C.B.D. Loop), between Murchison Road and Bragg Boulevard. Washington Drive and Blue Street, both off of Murchison Road, surround the project site. The site can be accessed from either Washington Drive or Blue Street (Figure 1).


K:\57036\gis\2006_Mit Report\Fig1vic.mxd
Take I-40 East to I-95 South. Take I-95 South to NC 24 (Exit 52). Take NC 24 West to Business US-401. Take 401 North to Murchison Rd. Project is located at intersection of Murchison Rd. and Business US-401.
N
W
E
S
401
Ramsey St.
BYP 401
87
210
Murchison Rd.
Bragg Blvd.
24
BUS 401
BUS 95
Morganton Rd.
All American Fwy
Fayetteville
53
HARNETT
SAMPSON
HOKE
CUMBERLAND
0 0.5 1 2
Miles
Ecosystem Enhancement PROGRAM
N.C. Ecosystem Enhancement Program
FIGURE 1
Project Location Map
Cross Creek
Cumberland County, North Carolina
May 2006

1.4 PROJECT HISTORY AND BACKGROUND

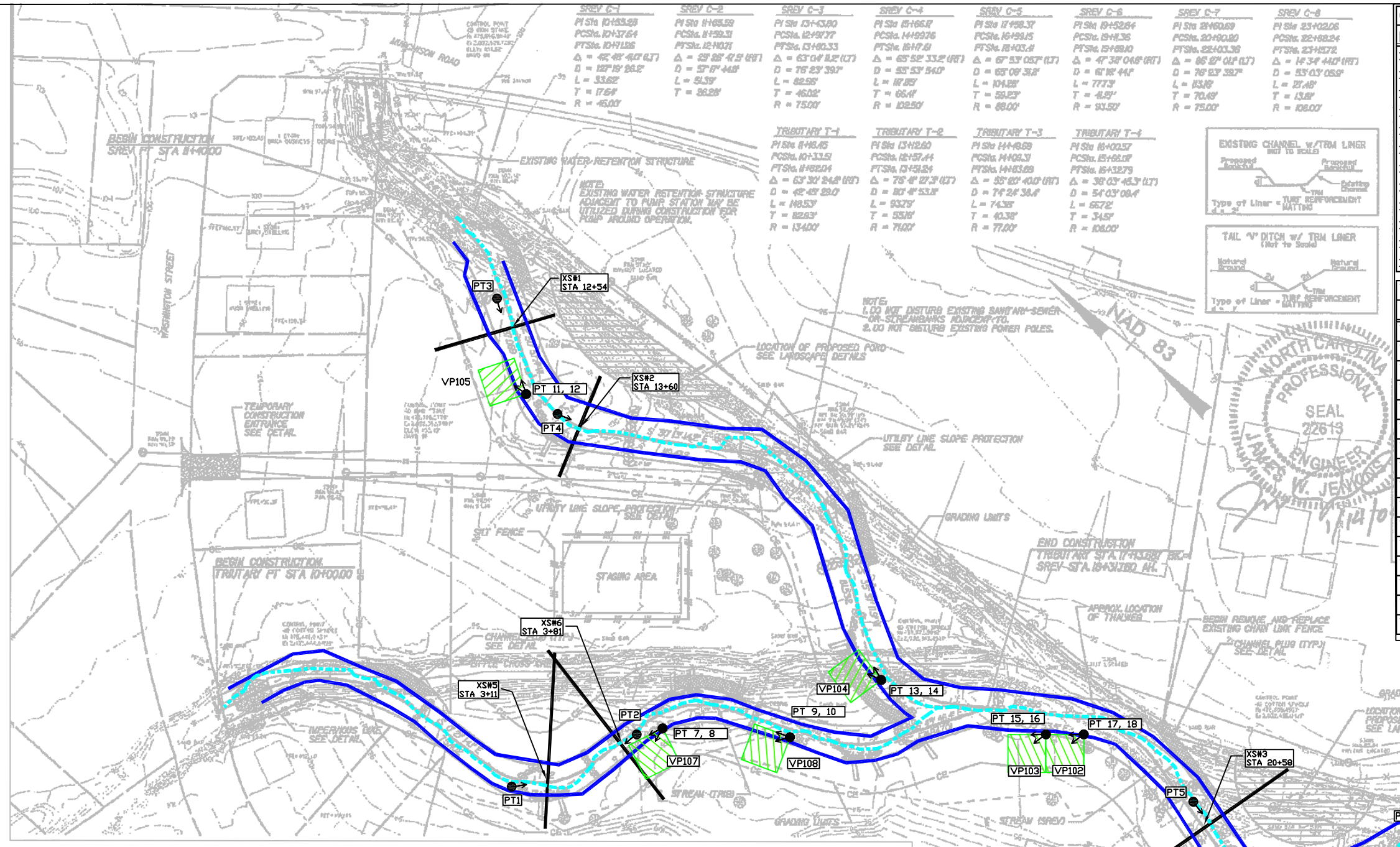
Exhibit Table II. Project Activity and Reporting History Cross Creek Stream Restoration - EEP Project No. 105		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	2002	Oct 2002
Final Design - 90%	NA	2004
Construction	2004	Jan 2005
Temporary S&E mix applied to entire project area	2004	2004
Permanent seed mix applied to entire project area	2004	2004
Containerized and B&B plantings	Jan 2005	Jan 2005
Mitigation Plan / As-built (Year 0 Monitoring - baseline)	Apr 2006	Jul 2006
Year 1 Monitoring	Nov 2006	Dec 2006
Year 2 Monitoring	Oct 2007	Dec 2007
Year 3 Monitoring	NA	NA
Year 4 Monitoring	NA	NA
Year 5 Monitoring	NA	NA

Exhibit Table III. Project Component Table Cross Creek Stream Restoration - EEP Project No. 105	
Designer Primary project design POC	*Earth Tech* 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607 Bill Jenkins, PE (919) 854-6200
Construction Contractor Construction contractor POC	*Backwater Environmental* 2312 New Bern Ave. Raleigh, NC 27610 Wes Newell (919)231-9227
Planting Contractor Planting Contractor POC	*Carolina Silvics, Inc.* 908 Indian Trail Road Edenton, NC 27932 Mary-Margaret McKinney (252)482-8491
Seeding Contractor Seeding Contractor POC	*Backwater Environmental* 2312 New Bern Ave. Raleigh, NC 27610 Wes Newell (919)231-9227
Seed Mix Sources	*Ernst Conservation Seeds* 9006 Mercer Pike Meadville, PA 16335 Stacy Charles (814)336-2404
Nursery Stock Suppliers	*Coastal Plain Conservation Nursery* (container plants) 3067 Conners Drive Edenton, NC 27932 Ellen Colodney (252)482-5707 *Cure Nursery* (container plants) 880 Buteo Road Pittsboro, NC 27312 Jennifer Cure (919)542-6186 *Taylor's Nursery* 3705 New Bern Avenue Raleigh, NC 27610 Richard Taylor (919)231-6161 *International Paper* 55594 Hwy38 S Blenheim, SC 29516 Gary Nelson (1-800-222-1290)
Monitoring Performers (Year 0-1)	*Earth Tech* 701 Corporate Center Drive, Suite 475 Raleigh, NC 27607
Monitoring POC	Ron Johnson (919)854-6210
Monitoring Performers (Year 2)	*Stantec Consulting Services, Inc.* 801 Jones Franklin Road, Ste 300 Raleigh, NC 27606
Stream Monitoring POC Vegetation Monitoring POC Wetland Monitoring POC	David Bidelspach (919)851-6866 Amber Coleman (919)851-6866 NA

Exhibit Table IV. Project Background Table Cross Creek Stream Restoration - EEP Project No. 105	
Project County	Cumberland
Drainage Area	
Little Cross Creek/Cross Creek	10.5/25.5 sq mi
Drainage impervious cover estimate (%)	71%
Stream Order	
Cross Creek/Little Cross Creek	2nd/1st
Physiographic Region	Sandhills/Coastal Plain
Ecoregion	Atlantic Southern Loam Plains
Rosgen Classification of As-built	C
Cowardin Classification	Riverine
Dominant soil types	Chewacla loam Rion fine sandy loam
Reference site ID	Country Club Branch and Little Rockfish Creek
USGS HUC for Project	03030004
USGS HUC for Reference	03030004
NCDWQ Subbasin for Project	03-06-15
NCDWQ Subbasin for Reference	03-07-01
NCDWQ Classification for Project	Cross Creek (C), Little Cross Creek (C)
NCDWQ Classification for Reference	UT Cross Creek (Country Club Branch, C), Little Rockfish Creek C
Any portion of any project segment 303d listed?	Yes
Any portion of any project segment upstream of a 303d listed segment?	Yes
Reasons for 303d listing or stressor	Imparied Biological Activity, fecal coliform
% of project easement fenced	0%

1.5 MONITORING PLAN VIEW

See Figure 2 for the Monitoring Plan View.



LEGEND

- YEAR 02 BANK
- YEAR 02 THALWEG
- YEAR 02 CROSS-SECTIONS
- YEAR 02 PHOTO POINTS
- YEAR 02 VEG PLOTS

CROSS SECTION PIN COORDINATES		
pin	lat	long
xs1lpin	35.067308	-78.891863
xs1rpin	35.06738	-78.891863
xs2lpin	35.067097	-78.891903
xs2rpin	35.067059	-78.892061
xs3lpin	35.065326	-78.891713
xs3rpin	35.065356	-78.891837
xs4lpin	35.064961	-78.891283
xs4rpin	35.064861	-78.891351
xs5lpin	35.066592	-78.892872
xs5rpin	35.066675	-78.89273
xs6lpin	35.066454	-78.892642
xs6rpin	35.066617	-78.892593

VEG PLOT PIN COORDINATES		
Plot	Long	Lat
V101-1	-78.891839	35.065273
V101-2	-78.891942	35.065352
V102-1	-78.891842	35.06573
V102-2	-78.89199	35.065747
V103-1	-78.891908	35.0658
V103-2	-78.892049	35.065808
V104-1	-78.892009	35.066207
V104-2	-78.892083	35.06632
V105-1	-78.891999	35.067242
V105-2	-78.892013	35.067371
V106-1	-78.891299	35.064845
V106-2	-78.891447	35.064824
V107-1	-78.89257	35.066475
V107-2	-78.892703	35.066407
V108-1	-78.892383	35.066258
V108-2	-78.892525	35.066291

NORTH CAROLINA PROFESSIONAL SEAL 22613 ENGINEER JAMES W. JEAVONS

NO.	REVISIONS	DRN	CHK	DAB	TXB	DATE
1	DRAFT REVISION 2 DESIGN					07/10/06

Stantec Consulting Services Inc.
Suite 300, 801 Jones Franklin Rd
Raleigh, NC 27606
Tel. 919.851.6666
Fax. 919.851.7024
www.stantec.com

CROSS CREEK
STREAM RESTORATION (105)
FIGURE 2- MONITORING PLAN VIEW

CROSS CREEK

SOURCE - EARTH TECH
STREAM RESTORATION CONSTRUCTION PLANS
C-3, 12/24/03, UPDATED 1/4/04

DATE	08/03/07
PROJECT NO.	
FILENAME	CROSSCREEK.dwg
SHEET NO.	
DRAWING NO.	

Back of 11x17

2.0 Project Condition and Monitoring Results

2.1 VEGETATION ASSESSMENT

Vegetative sample plots were quantitatively monitored during the first growing season. Eight 100m^2 plots were established throughout the project. In each plot, all four plot corners were permanently located with conduit. Species composition, density, and survival were monitored during Year 0 and Year 1. On September 20, 2007 and October 1, 2007 the Year 2 vegetation monitoring was completed using the Carolina Vegetation Survey (CVS) – EEP protocol (version 4.1). The Level 2 survey (planted and natural stems) methodology was utilized.

As per the mitigation plan, the vegetative success criteria are based on the US Army Corps of Engineers Stream Mitigation Guidelines (USACE, 2003). The final vegetative success criteria will be the survival of 260 5-year old planted trees per acre at the end of the year 5 monitoring period. An interim measure of vegetation planting success will be the survival of at least 320 3-year old planted trees per acre at the end of year 3 of the monitoring period.

The Year 2 stem counts within each of the vegetative monitoring plots are included in Exhibit Tables A1 through A5 in Appendix A.

2.1.1 Vegetation Problem Areas

Kudzu is a major problem along the majority of the site, particularly along Little Cross Creek. It should be removed as soon as possibly with either mechanical and/or chemical treatment to ensure future vegetative success. A few small areas of Chinese privet, mimosa and Johnson grass are also present onsite. For more details see Exhibit Table A6 as well as accompanying photos provided in Appendix A.

Plots 103, 107 and 108 do not meet the success criteria of 320 trees per acre. This is a change from last year when plots 101, 103, and 105 did not meet success criteria. This may possibly be due to discrepancies in past data collection. In at least a few occurrences, plants were found during year 2 that were obviously planted but were not in the table for year 1. Vegetation plots 107 and 108 are suffering the consequences of a heavy kudzu invasion. If both planted shrubs and trees were to be counted in the vegetative success criteria then all of the plots would be well above the required 320 stems per acre.

2.1.2 Vegetation Current Condition Plan View

Vegetative problem areas are shown on the Integrated Current Condition Plan View in Appendix D.

2.2 STREAM ASSESSMENT

2.2.1 Hydrology

The region has been in an extreme drought for much of 2007. No evidence of bankfull flows was observed onsite and flows were not measured with peak stage recorders. According to the Year 1 monitoring report, evidence of at least one bankfull event was observed during last year's monitoring. However, it is unclear if this has been verified. In order to verify bankfull events, a crest gauge should be installed onsite.

Exhibit Table V. Verification of Bankfull Events
Cross Creek Stream Restoration - EEP Project No. 105

Date of Data Collection	Date of Occurrence	Method	Photo #
2007	None	NA	NA

2.2.2 Bank Stability

According to the NCEEP guidelines for monitoring, bank stability assessments will be performed during year 5 monitoring. Bank stability will be assessed using the near bank stress (NBS) assessment and bank erodibility hazard index (BEHI).

Exhibit Table VI. BEHI and Sediment Export Estimates
Cross Creek Stream Restoration - EEP Project No. 105

Bank stability will be assessed in monitoring Year 5

2.2.3 Stream Problem Areas

The major problem areas for this project are a failure of a stormwater channel plunge pool [Stream Problem Area (SP) 9] and a failure of a wetland pond (SP 10). This pond lies adjacent to the stormwater channel in the lower reach of Cross Creek (Photo 1 in Appendix B3 of Appendix B and Appendix D. Integrated Problem Areas Plan View). The stormwater channel has produced massive erosion and bank migration (Appendix B3. Photo 2). Failure has occurred at the confluence of the stormwater channel and Cross Creek in the form of a blow hole. Sediment is being deposited directly into the main reach from erosion of the stormwater channel (Appendix B3. Photo 3). The original design for this feature called for a plunge basin, field observation indicates that this was either improperly designed or not constructed properly. The channel cannot currently hold the velocities and flow capacity of the discharge from the stormwater pipe. The grade that the stormwater channel approaches the stream channel is too steep. The failure of the stormwater channel has in turn caused failure to the wetland pond (Appendix B3. Photos 4 and 5). Currently, the wetland is receiving overflow from the stormwater channel and the increased flow has caused erosion and channel migration in the wetland much like that in the stormwater channel. A failure at the wetland pond's outlet to the main reach and overbank flow has also occurred.

It is strongly recommended that this area of the restoration project be re-resigned. The flow exiting the stormdrain (and the energy associated with that flow) is too great for the current design. A flow splitter is

recommended to divert large storms around the facility and into a bypass channel. The bypass channel should be designed to convey large flows and should utilize grade control structures for stabilization and for the benefit of the receiving stream reach. Redesigning this area will decrease downstream velocities and restore habitat in the wetland area. See Exhibit Table B1 as well as accompanying photos provided in Appendix B.

Minor problem areas (SP 1-8, 11-18) were also found across the project and they can be defined into four subcategories: structure failure, root wad failure, toe scour, and bank erosion. These problem areas can be remediated by additional plantings and/or minor hand grading. See Exhibit Table B1 and representative photos in Appendix B as well as the map in Appendix D for more information.

2.2.4 Stream Current Condition Plan View

Stream problem areas are shown on the Integrated Current Condition Plan View in Appendix D.

2.2.5 Stability Assessment

Exhibit Table VII-A. Categorical Stream Feature Visual Stability Assessment
Cross Creek Stream Restoration - EEP Project No. 105
(Cross Creek)

Feature	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	95%	60%	83%			
B. Pools	100%	100%	79%			
C. Thalweg	100%	90%	94%			
D. Meanders	100%	NA	81%			
E. Bed General	95%	95%	86%			
F. Bank Condition	NA	NA	82%			
G. Vanes / J Hooks, etc.	95%	100%	70%			
H. Wads and Boulders	100%	90%	25%			

Exhibit Table VII-B. Categorical Stream Feature Visual Stability Assessment
Cross Creek Stream Restoration - EEP Project No. 105
(Little Cross Creek)

Feature	Initial	MY-01	MY-02	MY-03	MY-04	MY-05
A. Riffles	95%	60%	92%			
B. Pools	100%	100%	92%			
C. Thalweg	100%	90%	100%			
D. Meanders	100%	NA	100%			
E. Bed General	95%	95%	94%			
F. Bank Condition	NA	NA	73%			
G. Vanes / J Hooks, etc.	95%	100%	71%			
H. Wads and Boulders	100%	90%	67%			

**Initial and MY1 data are for the entire project. MY2 data is broken out by reach.*

2.2.6 Quantitative Measures Summary

Exhibit Table VIII-A. Baseline Morphology and Hydraulics Summary
Cross Creek Stream Restoration - EEP Project No. 105
Reach: Cross Creek (1376 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Stream Reference			Design			As-Built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)				16.0	52.0	29.4	26.0	30.0	27.4	14.5	27.4				34.2	34.2	49.6	38.6
Flood Prone Width (ft)																		
BF Cross Sectional Area (SF)				11.6	115.0	88.6	68.8	77.1	73.2	21.1	49.1				73	67.8	113.6	70.8
BF Mean Depth (ft)				1.3	6.3	2.9	2.5	3.0	2.65	0.8	2.3				2.14	1.8	2.3	2.0
BF Max Depth (ft)							3.3	4.1	3.7	2.1	3.5				3.2	3.2	4.3	3.4
Width/Depth Ratio							8.8	10.3	10.0	8.4	34				16	17.3	21.7	21.0
Entrenchment Ratio							1.25	1.9	1.6	10.5	14.9				2.7			
Bank Height Ratio																		
Wetted Perimeter (ft)																		
Hydraulic Radius (ft)																		
Pattern																		
Channel Beltwidth (ft)									27.4	20	36		70	170		28	87	70
Radius of Curvature (ft)									0	7	36		70	120		75	120	93.5
Meander Wavelength (ft)									0	32	325		240	479		283	377	354
Meander Width ratio									1.0	0.67	1.8		2.0	5.0		0.82	1.75	1.81
Profile																		
Riffle Length													38	177	92	10.99	60.86	27.84
Riffle Slope													0.004	0.004	0	0.0019	0.0285	0.0045
Pool Length													11.0	42.7	30.5	4.34	43.35	16.43
Pool Spacing							77	167	132	19	123		152	228	187	12.65	340.56	80.28
Substrate																		
d50 (mm)																<0.62	.5-1.0	
d84 (mm)																.25-.5	2.0-4.0	
Additional Reach Parameters																		
Valley Length																		1215.3
Channel Length (ft)																		1442
Sinuosity							1.0	1.0	1.0	1.3	1.5				1.1			1.19
Water Surface Slope							0	0	0	0	0				0			0.0030
BF Slope																		0.0021
Rosgen Classification									G5,E5			C5,E5			C5			C
*Habitat Index																		
*Macro-benthos																		

*Inclusion will be project specific and determined primarily by As-built monitoring plan/success criteria

Exhibit Table VIII-B. Baseline Morphology and Hydraulics Summary
Cross Creek Stream Restoration - EEP Project No. 105
Reach: Little Cross Creek (714 feet)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Stream Reference			Design			As-Built		
Dimension	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
BF Width (ft)				14.0	49.0	25.1	17.3	23.0	20.2	14.5	27.4				24.7	23.3	36.4	29.9
Flood Prone Width (ft)																		
BF Cross Sectional Area (SF)				11.5	200.0	66.4	33.5	43.6		21.1	49.1				38	35.5	50.1	42.8
BF Mean Depth (ft)				1.2	5.9	2.6			1.9	0.8	2.3				1.54	1.4	1.5	1.5
BF Max Depth (ft)							2.5	2.9		2.1	3.5				N/A	2.3	3.0	2.65
Width/Depth Ratio							8.9	12.1		8.4	34				16	15.3	26.5	20.9
Entrenchment Ratio									1.6	10.5	14.9				3.3			
Bank Height Ratio																		
Wetted Perimeter (ft)																		
Hydraulic Radius (ft)																		
Pattern																		
Channel Beltwidth (ft)									20.2	20	36		50	124		32	90	61
Radius of Curvature (ft)									0	7	36		50	86		71	134	91.5
Meander Wavelength (ft)									0	32	325		173	346		210	380	295
Meander Width ratio									1.0	0.67	1.8		2.0	5.0		1.37	2.47	2.04
Profile																		
Riffle Length													58	81	76	12.9	45.4	26.4
Riffle Slope													0.006	0.006	0.006	0.0016	0.0202	0.0029
Pool Length													24.3	37.3	27.7	20.3	128.5	52.2
Pool Spacing							36	131	83	19	123		90	172	118	8.0	43.3	14.2
Substrate																		
d50 (mm)																.5-1.0	1.0-2.0	
d84 (mm)																1.0-2.0	16.0-22.6	
Additional Reach Parameters																		
Valley Length																		661
Channel Length (ft)																		714
Sinuosity									1.0	1.3	1.5				1.12			1.08
Water Surface Slope									0	0	0				0.003			0.0030
BF Slope																		0.0099
Rosgen Classification									G5			C5,E5			C5			C
*Habitat Index																		
*Macro-benthos																		

*Inclusion will be project specific and determined primarily by As-built monitoring plan/success criteria

Exhibit Table IXA. Morphology and Hydraulic Monitoring Summary
Cross Creak Stream Mitigation Site/Project No. 105
(Cross Creek)

Parameter	ET-Cross Section 1						ET-Cross Section 2			ET-Cross Section 3								
	Cross Section 1 Stantec - MY2 1+66.3 Riffle			Cross Section 2 Stantec - MY2 1+80.3 Pool			Cross Section 3 Stantec - MY2 10+04.3 Riffle			Cross Section 4 Stantec - MY2 10+71.0 Pool								
Dimension	MY0	MY1	MY2*	MY0	MY1	MY2*	MY0	MY1	MY2*	MY0	MY1	MY2*						
BF Width (ft)	34.2	33.6	21.6			33.4	38.6	19.37	33.47	49.6	37.8	35.82						
Floodprone Width (ft) (approx)	>100	91.8	>100			n/a	>100	78.37	128		101.4	n/a						
BF Cross Sectional Area (ft^2)	67.8	62.7	39.92			92.18	70.8	34.6	71.91	113.6	78.6	111.5						
BF Mean Depth (ft)	2.0	1.87	1.4			2.76	1.8	1.78	2.15	2.3	2.08	3.11						
BF Max Depth (ft)	3.2	3.26	2.58			5.29	3.4	2.25	3.86	4.3	4.59	5.93						
Width/Depth Ratio	17.3	17.95	15.4			12.1	21.0	10.9	15.6	21.7	18.2	11.5						
Entrenchment Ratio	>2.9	2.73	>4.6			n/a	>1.8	4.04	3.82		2.68	n/a						
Wetted Perimeter (ft)		34.6				n/a		20.9			42.4	n/a						
Hydraulic radius (ft)		1.81				n/a		1.65			1.85	n/a						
Substrate																		
d50 (mm)	<.062	0.25	0			n/a	1.0-2.0	0.37	0.32	.5-1.0	0.04	n/a						
d84 (mm)	.25-.5	0.61	6.8			n/a	6.0-22.	0.83	3.90	1.0-2.0	18.84	n/a						

Parameter	MY-01 (2006)			MY-02 (2007)#			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)			MY+ (2011)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	32	90	61	52	97	72												
Radius of Curvature (ft)	71	134	91.5	78	126	96												
Meander Wavelength (ft)	210	380	295	275	366	339												
Meander Width Ratio	1.37	2.47	2.04	1.88	35.00	2.70												
Profile																		
Riffle Length (ft)	8	78	30	47.1	79.6	65.1												
Riffle Slope (ft)	0.0009	0.0067	0.0035	0.0550	0.0910	0.1100												
Pool Length (ft)	9	106	46	47.3	79.6	65.0												
Pool Spacing (ft)	27	203	73	36	147	86												
Additional Reach Parameters																		
Valley Length (ft)	1215.3			1215.3														
Channel Length (ft)	1442			1442														
Sinousity	1.19			1.19														
Water Surface Slope (ft/ft)	0.00194			0.0024														
BF Slope (ft/ft)	0.0021			0.0031														
Rosgen Classification	C			C														
Habitat Index	n/a			n/a														
Macrobenthos	n/a			n/a														

* EarthTech (ET) MY1 Cross Section 1 is near Stantec MY2 Cross Section 1, Stantec Cross Section 2 is new ET MY1 Cross Section 2 is near Stantec MY2 Cross Section 3, and ET MY1 Cross Section 3 is near Stantec MY2 Cross Section 4

Even though the Cross Sections are not in identical spots, ranges for the reach may be compared.

Exhibit Table IXB. Morphology and Hydraulic Monitoring Summary
Cross Creak Stream Mitigation Site/Project No. 105
(Little Cross Creek)

Parameter	ET-Cross Section 4			ET-Cross Section 5														
	Cross Section 6 Stantec - MY2 1+94 Riffle			Cross Section 5 Stantec - MY2 2+91 Pool														
Dimension	MY0	MY1	MY2*	MY0	MY1	MY2*	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2	MY0	MY1	MY2
BF Width (ft)	36.4	67	35.78	23.3	17.5	24.1												
Floodprone Width (ft) (approx)		100.5	108	90.0	89.4	n/a												
BF Cross Sectional Area (ft^2)	50.1	69	58.99	35.5	23.4	35.91												
BF Mean Depth (ft)	1.4	1.03	1.65	1.5	1.36	1.49												
BF Max Depth (ft)	3.0	3.16	3.8	2.3	2.61	3.0												
Width/Depth Ratio	26.5	65.1	21.7	15.3	12.9	16.2												
Entrenchment Ratio		1.5	3.02	3.9	5.01	n/a												
Wetted Perimeter (ft)		69.2	n/a		22.5	n/a												
Hydraulic radius (ft)		1.0	n/a		1.06	n/a												
Substrate																		
d50 (mm)	)62-.12	0.42	0	.5-1.0	0.35	n/a												
d84 (mm)	2.0-4.0	10.97	11	2.0-4.0	0.97	n/a												

Parameter	MY-01 (2006)			MY-02 (2007)#			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)			MY+ (2011)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	32	90	61	59	92	71												
Radius of Curvature (ft)	71	134	91.5	67	90	79												
Meander Wavelength (ft)	210	380	295	272	329	300												
Meander Width Ratio	1.37	2.47	2.04	1.52	2.36	1.90												
Profile																		
Riffle Length (ft)	10	64	23															
Riffle Slope (ft)	0.0011	0.0145	0.0056	0.0540	0.1090	0.0890												
Pool Length (ft)	12	67	42.8	29	66	45												
Pool Spacing (ft)	10	46	30	23	85	55												
Additional Reach Parameters																		
Valley Length (ft)	661			661														
Channel Length (ft)	714			714														
Sinousity	1.08			1														
Water Surface Slope (ft/ft)	0.002879			0.0026														
BF Slope (ft/ft)	0.0099			0.0026														
Rosgen Classification	C			C														
Habitat Index	n/a			n/a														
Macrobenthos	n/a			n/a														

* EarthTech (ET) MY1 Cross Section 4 is near Stantec MY2 Cross Section 6
and ET MY1 Cross Section 5 is near Stantec MY2 Cross Section 5

Even though the Cross Sections are not in identical spots, ranges for the reach may be compared.

3.0 References

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APPENDIX A – VEGETATION RAW DATA & PHOTOS

Appendix A. Vegetation Raw Data

A.1 VEGETATION DATA TABLES

EXHIBIT TABLE A1. VEGETATION METADATA

Report Prepared By	Amber Coleman
Date Prepared	11/19/2007 19:32
database name	CrossCreek_CVS_EEP_EntryTool_v220.mdb
database location	U:\171300168
computer name	COLEMANA
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT	
Metadata	This worksheet, which is a summary of the project and the project data.
Proj, planted	Each project is listed with its PLANTED stems, for each year. This excludes live stakes and lists stems per acre.
Proj, total stems	Each project is listed with its TOTAL stems, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems. Listed in stems per acre.
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.
ALL Stems by Plot and spp	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	105
project Name	Cross Creek
Description	Stream Restoration in Fayetteville
River Basin	Cape Fear
length(ft)	
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	
Sampled Plots	8

EXHIBIT TABLE A2. VEGETATION VIGOR BY SPECIES

	Species	4	3	2	1	0	Missing
	Alnus serrulata	12	4				
	Aronia arbutifolia		4				
	Callicarpa americana	5	4	1			
	Carpinus caroliniana var. caroliniana		2	2	2		
	Cercis canadensis var. canadensis		2				
	Clethra alnifolia		1	1	1		
	Fothergilla gardenii	1	1				
	Fraxinus pennsylvanica	3	1	1	1		
	Ilex decidua var. decidua	6	1	2			
	Ilex glabra	2		1			
	Nyssa sylvatica	3	3	1	1		
	Populus heterophylla	3	1				
	Quercus lyrata		4				
	Quercus phellos	2	2		1		
	Sambucus canadensis		1				
	Taxodium distichum	11	3	1			
	Ulmus americana var. americana	2	3	1			
	Viburnum nudum	2	3				
	Morella cerifera	6	2	1			
	Quercus shumardii var. shumardii		2				
	Quercus	4	1	2	1		
	Unknown			1		5	
TOT:	**22**	**62**	**45**	**15**	**7**	**5**	

EXHIBIT TABLE A3. VEGETATION DAMAGE BY SPECIES

	Species	All Damage Categories	(no damage)	Drought	Other/Unknown Animal	Unknown	Vine Strangulation
	Alnus serrulata	16	13				3
	Aronia arbutifolia	4	4				
	Callicarpa americana	10	9		1		
	Carpinus caroliniana var. caroliniana	6	1	3			2
	Cercis canadensis var. canadensis	2	1				1
	Clethra alnifolia	3	1	2			
	Fothergilla gardenii	2	1		1		
	Fraxinus pennsylvanica	6	4	2			
	Ilex decidua var. decidua	9	7	2			
	Ilex glabra	3	2	1			
	Morella cerifera	9	6				3
	Nyssa sylvatica	8	5	1			2
	Populus heterophylla	4	4				
	Quercus	8	5	2		1	
	Quercus lyrata	4	2				2
	Quercus phellos	5	3	1			1
	Quercus shumardii var. shumardii	2	1				1
	Sambucus canadensis	1					1
	Taxodium distichum	15	15				
	Ulmus americana var. americana	6	5		1		
	Unknown	6		1		5	
	Viburnum nudum	5	4				1
TOT:	**22**	**134**	**93**	**15**	**3**	**6**	**17**

EXHIBIT TABLE A4. VEGETATION DAMAGE BY PLOT

	plot	All Damage Categories	(no damage)	Drought	Other/Unknown Animal	Unknown	Vine Strangulation
	0105-01-0101-year:2	17	17				
	0105-01-0102-year:2	31	31				
	0105-01-0103-year:2	14	11		2	1	
	0105-01-0104-year:2	12	7	5			
	0105-01-0105-year:2	24	11	9		4	
	0105-01-0106-year:2	11	10	1			
	0105-01-0107-year:2	11	2			1	8
	0105-01-0108-year:2	14	4		1		9
TOT:	**8**	**134**	**93**	**15**	**3**	**6**	**17**

EXHIBIT TABLE A5-A. STEM COUNT BY PLOT AND SPECIES

	Species	Total Planted Stems	# plots	avg# stems	plot 0105-01-0101-year:2	plot 0105-01-0102-year:2	plot 0105-01-0103-year:2	plot 0105-01-0104-year:2	plot 0105-01-0105-year:2	plot 0105-01-0106-year:2	plot 0105-01-0107-year:2	plot 0105-01-0108-year:2
Shrubs	*Alnus serrulata*	16	5	3.2	1	7	3			1		4
	Aronia arbutifolia	4	2	2					3			1
	Callicarpa americana	10	4	2.5	2	4	3		1			
	Clethra alnifolia	3	2	1.5					2		1	
	Fothergilla gardenii	2	2	1	1							1
	Ilex decidua var. decidua	9	4	2.25	2	3	2	2				
	Ilex glabra	3	3	1	1	1			1			
	Morella cerifera	9	5	1.8	1	2			2		2	2
	Sambucus canadensis	1	1	1							1	
	Viburnum nudum	5	4	1.25	1	1			2		1	
Trees	*Carpinus caroliniana var. caroliniana*	6	4	1.5				2	2		1	1
	Cercis canadensis var. canadensis	2	2	1		1					1	
	Fraxinus pennsylvanica	6	4	1.5	2			1	1	2		
	Nyssa sylvatica	8	4	2		3	1		2			2
	Populus heterophylla	4	2	2		2				2		
	Quercus	8	3	2.67			1	5	2			
	Quercus lyrata	4	4	1					1	1	1	1
	Quercus phellos	5	4	1.25	1	1		2				1
	Quercus shumardii var. shumardii	2	2	1							1	1
	Taxodium distichum	15	4	3.75	3	5	2			5		
	Ulmus americana var. americana	6	4	1.5	2	1	2				1	
	Unknown	1	1	1					1			
TOT:	**22**	**129**	**22**		**17**	**31**	**14**	**12**	**20**	**11**	**10**	**14**
	Total Planted Stems/Acre				688	1255	567	486	809	445	405	567
	Trees/Acre				324	526	243	405	364	405	202	243

Exhibit Table A6. Vegetation Problem Areas Cross Creek Stream Restoration - EEP Project No. 105					
MAJOR PROBLEM AREAS					
Feature/Issue	**Stream Reach**	**Station # / Range**	**Probable Cause**	**ID**	**Photo #**
Kudzu	Little Cross Creek	Right bank - top of bank to edge of easement	Pre-existing or neighboring populations invaded	VP1	1
	Cross Creek	Throughout - but primarily near middle to end of reach			2
MINOR PROBLEM AREAS					
Feature/Issue	**Stream Reach**	**Station # / Range**	**Probable Cause**	**ID**	**Photo #**
Chinese Privet	Little Cross Creek	Upper end of project	Pre-existing or neighboring populations invaded	VP2	NA
	Cross Creek	~16+00			
Mimosa	Both	Throughout	Pre-existing or neighboring populations invaded	NA	NA
Johnson Grass	Cross Creek	Lower end of project	Seed source either already present or likely washed in from stream	NA	NA

A.2 VEGETATION PROBLEM AREA PHOTOS

Photo 1: Kudzu invasion near Veg Plot 107 (10/1/07)

Photo 2: Kudzu on either side of the channel near Veg Plot 102 (10/2/07)

A.3 VEGETATION MONITORING PLOT PHOTOS

Photo Station 7 – Veg plot 107 looking west (10/1/07)

Photo Station 8 – Veg plot 107 looking southwest (10/1/07)

Photo Station 9 – Veg plot 108 looking northwest (10/2/07)

Photo Station 10 – Veg plot 108 looking west (10/2/07)

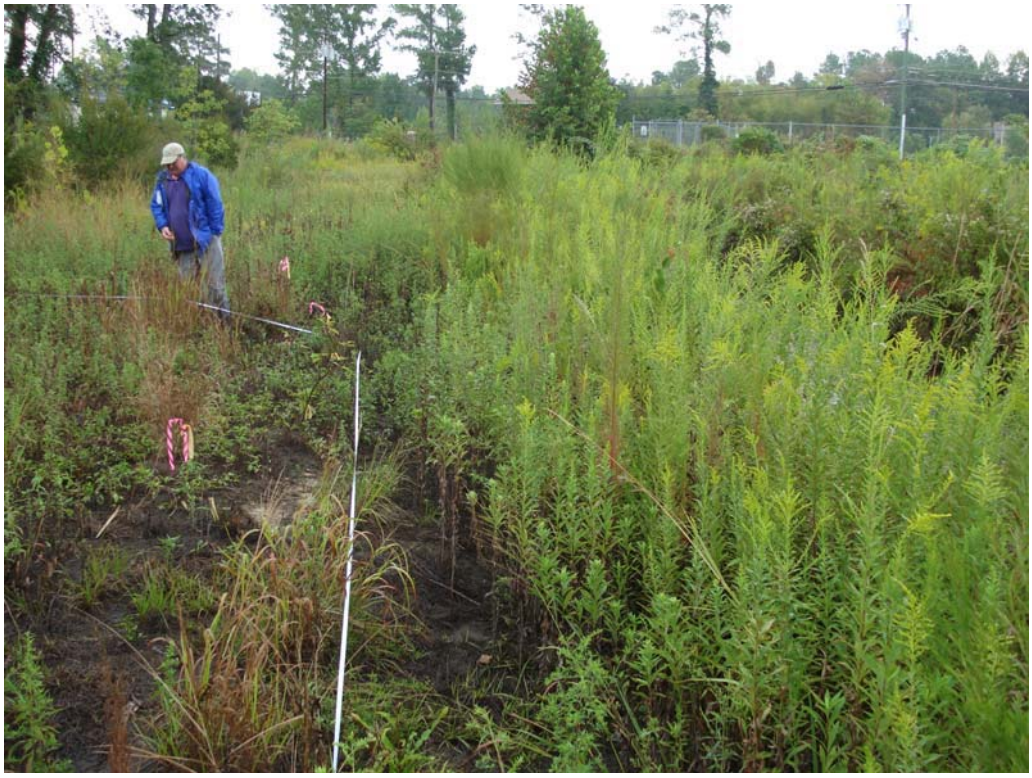


Photo Station 11 – Veg plot 105 looking northeast (9/20/07)

Photo Station 12 – Veg plot 105 looking north (9/20/07)

Photo Station 13- Veg plot 104 looking north (10/1/07)

Photo Station 14 – Veg plot 104 looking northwest (10/1/07)

Photo Station 15 – Veg plot 103 looking northwest (10/1/07)

Photo Station 16 – Veg plot 103 looking west (10/1/07)

Photo Station 17 – Veg plot 102 looking northwest (10/1/07)

Photo Station 18 – Veg plot 102 looking west (10/1/07)

Photo Station 19 – Veg plot 101 looking north (10/1/07)

Photo Station 20 – Veg plot 101 looking northwest (10/1/07)

Photo Station 21 – Veg plot 106 looking west (10/1/07)

Photo Station 22 – Veg plot 106 looking southwest (10/1/07)

APPENDIX B – GEOMORPHOLOGIC RAW DATA

Appendix B. Geomorphologic Raw Data

B.1 CURRENT CONDITION PLAN VIEW (STREAM)

Please see the Integrated Current Condition Plan View in Appendix D for stream problem areas.

B.2 STREAM PROBLEM AREA TABLE

Exhibit Table B1. Stream Problem Areas Cross Creek Stream Restoration - EEP Project No. 105					
MAJOR PROBLEM AREAS					
Feature/Issue	**Stream Reach**	**Station # / Range**	**Probable Cause**	**ID**	**Photo #**
Stormwater Channel Failure	Cross Creek	~22+00	Channel is too small to handle flow	SP 9	1-3
Wetland Pond Failure	Cross Creek	~23+00	Failure of adjacent stormwater channel	SP 10	4-5
MINOR PROBLEM AREAS					
Feature/Issue	**Stream Reach**	**Station # / Range**	**Probable Cause**	**ID**	**Photo #**
Structure Failure	Little Cross Creek	10+50 - 11+80	improper design or installation	SP 2-4	6
	Cross Creek	19+25	improper design or installation	SP 16	
Rootwad Failure	Little Cross Creek	14+75	erosion around rootwad	SP 7	7
	Cross Creek	15+50	erosion around vane structure due to poor fill material at the former channel intersect	SP 11	
	Cross Creek	21+05	erosion around rootwad	SP 19	
Toe Scour	Little Cross Creek	10+20	scour from culvert outlet	SP 1	8
	Cross Creek	18+00; 21+00	confluence; scour upstream from j-hook	SP 13, 18	
Bank Erosion	Little Cross Creek	13+50; 16+75		SP 5-6, 8	9
	Cross Creek	16+10; 18+00 - 18+75; 20+30		SP 12, 14 15, 17	

B.3 REPRESENTATIVE STREAM PROBLEM AREA PHOTOS

Photo 1. (SP 9) Stormwater outlet pipe entering into the design plunge basin (7/4/07)

Photo 2. (SP 9) Bank erosion and migration of the design trapezoidal plunge basin (7/4/07)

Photo 3. (SP 9) Outlet failure of the stormwater channel into the main reach (7/4/07)

Photo 4. (SP 10) Outlet failure of the wetland pond into the main reach (7/4/07)

Photo 5. (SP 10) Bank erosion, migration, and failure of the wetland pond (7/4/07)

Photo 6. (SP 2-4, 16) Example of poorly built structure leading to structural failure and causing erosion on the banks (7/4/07)

Photo 7. (SPA 7, 11, 19) Example of root wad failure - scouring around a root wad structure (7/4/07)

Photo 8. (SPA 1, 13, 18) Example of toe scouring around meandering bends (7/4/07)

Photo 9. (SPA 5, 6, 8, 12, 14, 15, 17) Example of bank erosion (7/4/07)

B.4 STREAM PHOTO STATION PHOTOS

Photo Station 1. Cross-section #5 looking downstream (7/4/07)

Photo Station 2. Cross-section #6 looking upstream (7/4/07)

Photo Station 3. Cross-section #1 looking downstream (6/28/07)

Photo Station 4. Cross-section #2 looking downstream (6/28/07)

Photo Station 5. Cross-section #3 looking downstream (6/28/07)

Photo Station 6. Cross-section #4 looking downstream (6/28/07)

B.5 QUALITATIVE VISUAL STABILITY ASSESSMENT

Exhibit Table B.2.1. Visual Morphological Stability Assessment Cross Creek Stream Restoration - EEP Project No. 105 (Cross Creek)						
Feature Category	**Metric (per As-built and reference baselines)**	**(# Stable) Number Performing as Intended**	**Total Number per As-built**	**Total Number/Feet in Unstable State**	**% Perform in Stable Condition**	**Feature Perform. Mean or Total**
A. Riffles	1. Present?	6	8		75%	
	2. Armor stable (eg no displacement?)	N/A	N/A			
	3. Facet grade appears stable?	7	8		88%	
	4. Minimal evidence of embedding/fining?	N/A	N/A			
	5. Length appropiate?	7	8		88%	83%
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	7	8		88%	
	2. Sufficiently deep (Max Pool D:Mean Bkf > 1.6?)	6	8		75%	
	3. Length appropriate?	6	8		75%	79%
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	8	8		100%	
	2. Downstream of meander (glide/inflection) centering?	7	8		88%	94%
D. Meanders	1. Outer bend in state of limited/controlled erosion?	6	8		75%	
	2. Of those eroding, # w/concomitant point bar formation?	1	2		50%	
	3. Apparent Rc within spec?	8	8		100%	
	4. Sufficient floodplain access and relief?	8	8		100%	81%
E. Bed General	1. General channel bed aggradation areas (bar formation)		1400	50	96%	
	2. Channel bed degradation - areas of increasing down-cutting or head-cutting?		1400	150	89%	86%
F. Bank	1. Actively eroding, wasting, or slumping bank?		1400	250	82%	82%
G. Vanes	1. Free of back or arm scour?	7	11		64%	
	2. Height appropriate?	8	11		73%	
	3. Angle and geometry appear appropriate?	7	11		64%	
	4. Free of piping or other structural failures?	9	11		82%	70%
H. Wads/Boulders	1. Free of scour?	1	4		25%	
	2. Footing stable?	N/A	N/A			25%

Exhibit Table B.2.2. Visual Morphological Stability Assessment Cross Creek Stream Restoration - EEP Project No. 105 (Little Cross Creek)						
Feature Category	**Metric (per As-built and reference baselines)**	**(# Stable) Number Performing as Intended**	**Total Number per As-built**	**Total Number/Feet in Unstable State**	**% Perform in Stable Condition**	**Feature Perform. Mean or Total**
A. Riffles	1. Present?	4	4		100%	
	2. Armor stable (eg no displacement?)	N/A	N/A			
	3. Facet grade appears stable?	4	4		100%	
	4. Minimal evidence of embedding/fining?	N/A	N/A			
	5. Length appropiate?	3	4		75%	92%
B. Pools	1. Present? (e.g. not subject to severe aggrad. or migrat.?)	4	4		100%	
	2. Sufficiently deep (Max Pool D:Mean Bkf > 1.6?)	4	4		100%	
	3. Length appropriate?	3	4		75%	92%
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	4	4		100%	
	2. Downstream of meander (glide/inflection) centering?	4	4		100%	100%
D. Meanders	1. Outer bend in state of limited/controlled erosion?	4	4		100%	
	2. Of those eroding, # w/concomitant point bar formation?	N/A	N/A			
	3. Apparent Rc within spec?	4	4		100%	
	4. Sufficient floodplain access and relief?	4	4		100%	100%
E. Bed General	1. General channel bed aggradation areas (bar formation)		650	40	94%	
	2. Channel bed degradation - areas of increasing down-cutting or head-cutting?		650	0	100%	94%
F. Bank	1. Actively eroding, wasting, or slumping bank?		4400	1200	73%	73%
G. Vanes	1. Free of back or arm scour?	4	6		67%	
	2. Height appropriate?	4	6		67%	
	3. Angle and geometry appear appropriate?	4	6		67%	
	4. Free of piping or other structural failures?	5	6		83%	71%
H. Wads/Boulders	1. Free of scour?	2	3		67%	
	2. Footing stable?	N/A	N/A			67%

B.6 CROSS SECTION PLOTS

See following pages for the Cross Section Plots.

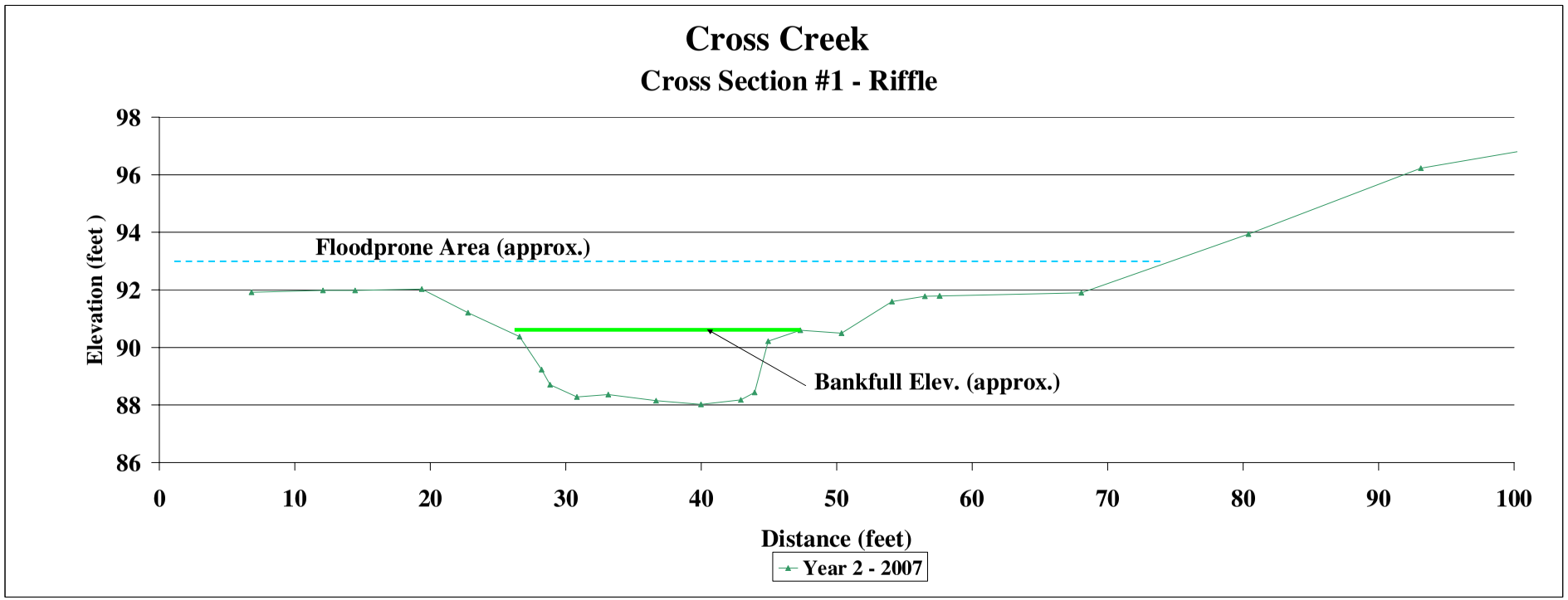
Project Name:	Cross Creek	**Feature:**	Pool	**Date:**	Year 02-7/4/2007
Cross Section:	Cross Section 1			**Crew:**	Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									6.81	91.92							
									12.07	91.98	Left Pin						
									14.46	91.98							
									19.37	92.03							
									22.78	91.21	LBK						
									26.58	90.38							
									28.22	89.23							
									28.85	88.7							
									30.82	88.28							
									33.14	88.36							
									36.67	88.15							
									39.99	88.02							
									42.93	88.18							
									43.95	88.44							
									44.95	90.22							
									47.31	90.6	RBK						
									50.36	90.5							
									54.08	91.59							
									56.51	91.78							
									57.59	91.79							
									57.6	91.79	Right Pin						
									68.06	91.9							
									80.39	93.94							
									93.12	96.23							
									104.81	97.17							

Photo of Cross-Section 1 - Reach 1 - Looking Downstream @ STA 12+54

	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				39.92	n/a	n/a
Width				21.76	n/a	n/a
Mean Depth				1.84	n/a	n/a
Max Depth				2.58	n/a	n/a
W/D				11.86	n/a	n/a

*Note: The pins for the original cross-sections could not be located, making comparisons with Years 0 and 1 data invalid.

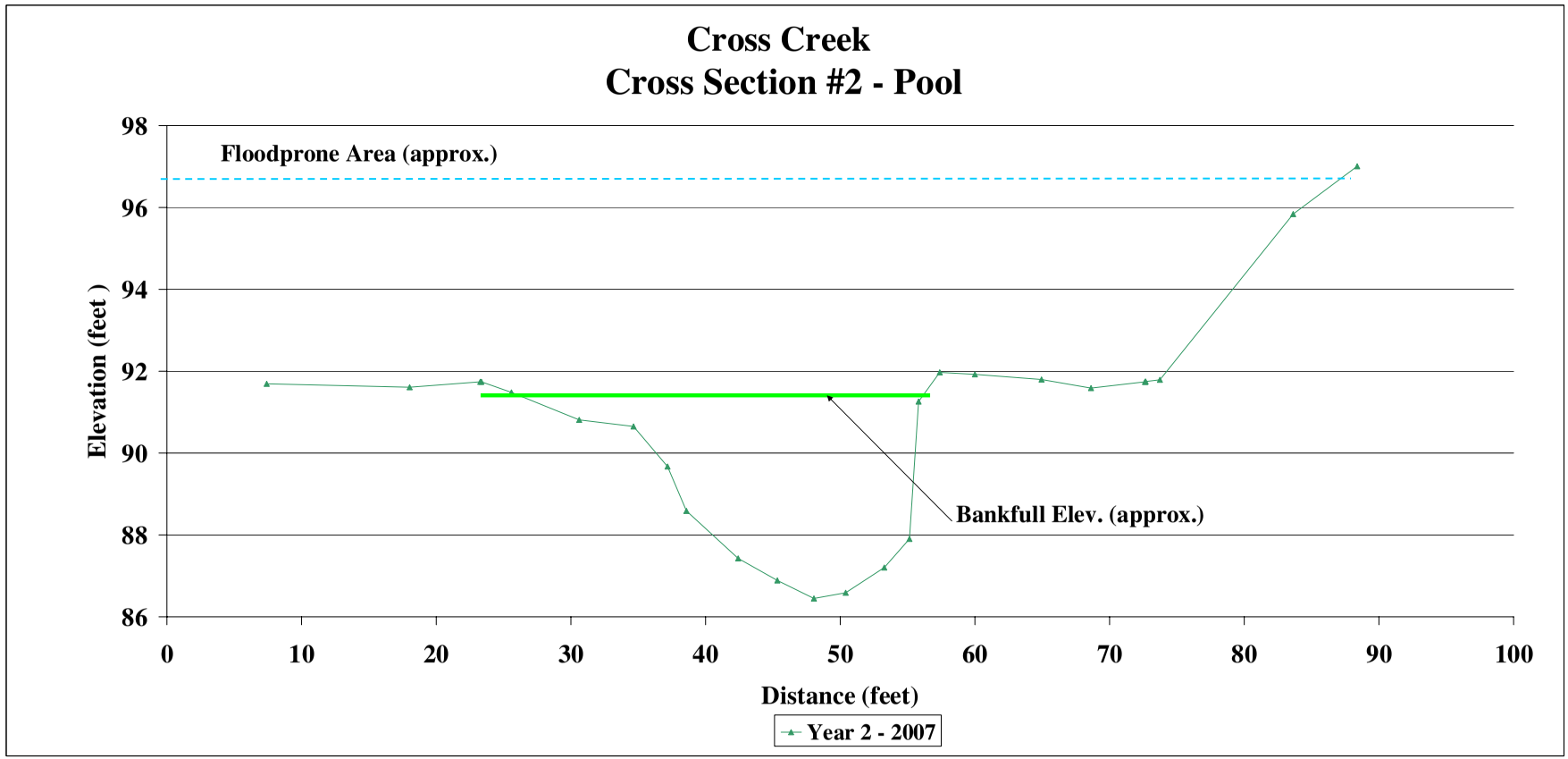


Project Name: Cross Creek **Feature:** Pool **Date:** Year 02-7/4/2007
Cross Section: Cross Section 2 **Crew:** Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									7.4	91.69							
									18.02	91.61							
									23.27	91.74	Left Pin						
									23.36	91.74	LBK						
									25.59	91.48							
									30.61	90.81							
									34.66	90.65							
									37.18	89.67							
									38.57	88.59							
									42.41	87.43							
									45.33	86.89							
									48.04	86.45							
									50.41	86.59							
									53.27	87.2							
									55.14	87.9							
									55.81	91.26							
									57.39	91.97	RBK						
									60.01	91.92							
									64.95	91.8							
									68.63	91.59							
									72.63	91.74							
									72.66	91.74							
									72.68	91.75	Right Pin						
									73.73	91.79							
									83.64	95.84							
									88.38	97.01							

Photo of Cross-Section 2 - Reach 1 - Looking Downstream @ STA 13+60

	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				92.18	n/a	n/a
Width				33.44	n/a	n/a
Mean Depth				2.76	n/a	n/a
Max Depth				5.29	n/a	n/a
W/D				12.13	n/a	n/a

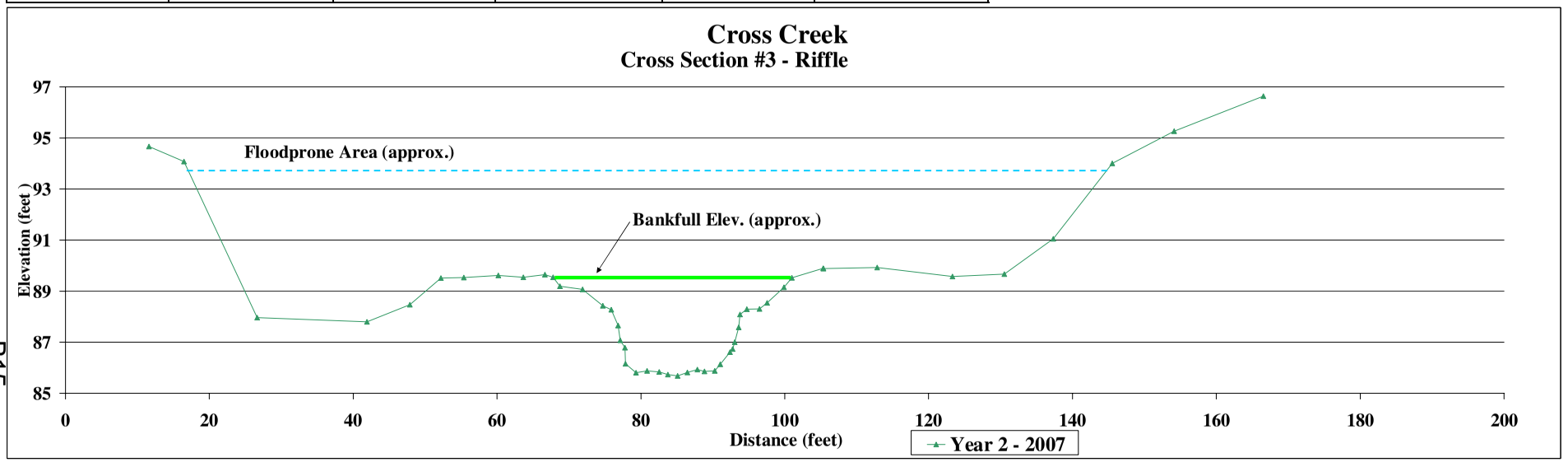


Project Name:	Cross Creek	**Feature:**	Riffle	**Date:**	Year 02-7/4/2007
Cross Section:	Cross Section 3			**Crew:**	Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									11.59	94.67							
									16.48	94.08							
									26.63	87.96							
									41.9	87.80							
									47.89	88.47							
									52.21	89.51							
									55.38	89.53							
									60.19	89.62							
									63.66	89.54							
									66.65	89.65	Left Pin						
									67.78	89.54	LBK						
									68.75	89.19							
									71.89	89.07							
									74.7	88.43							
									75.89	88.27							
									76.84	87.65							
									77.13	87.08							
									77.79	86.79							
									77.85	86.16							
									79.33	85.81							
									80.84	85.88							
									82.54	85.84							
									83.74	85.73							
									85.11	85.68							
									86.44	85.82							
									87.83	85.93							
									88.83	85.86							
									90.26	85.88							
									91.02	86.14							
									92.37	86.61							
									92.74	86.73							
									93.06	87.00							
									93.59	87.58							
									93.76	88.09							
									94.74	88.29							
									96.49	88.30							
									97.56	88.54							
									99.9	89.15							
									100.98	89.52							
									105.34	89.90	RBK						
									105.39	89.88	Right Pin						
									112.85	89.93							
									123.32	89.58							
									130.51	89.67							
									137.32	91.05							
									145.54	94.01							
									154.14	95.26							
									166.56	96.64							

Photo of Cross-Section 3 - Reach 1- Looking Downstream @ STA 20+58

	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				71.91	n/a	n/a
Width				33.47	n/a	n/a
Mean Depth				2.15	n/a	n/a
Max Depth				3.86	n/a	n/a
W/D				15.58	n/a	n/a

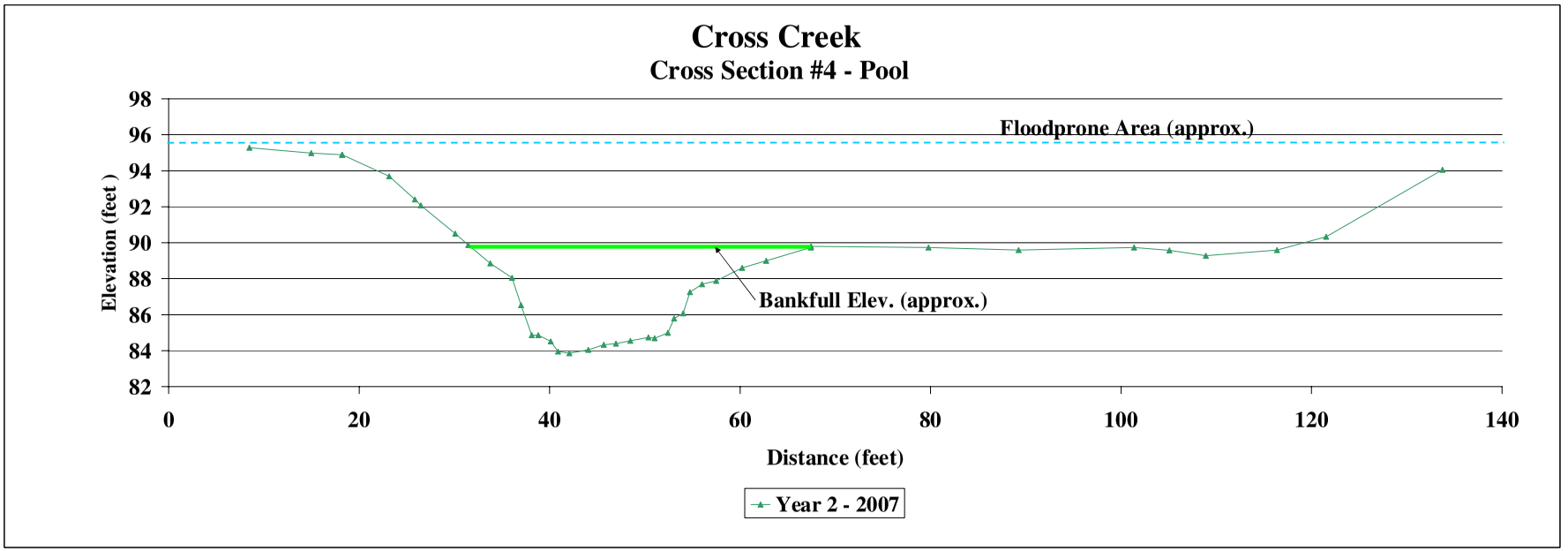


Project Name:	Cross Creek	**Feature:**	Pool	**Date:**	Year 02-7/4/2007
Cross Section:	Cross Section 4			**Crew:**	Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									8.48	95.28							
									14.96	94.99							
									18.21	94.89							
									18.22	94.89							
									23.15	93.70							
									25.85	92.41							
									26.48	92.08	Left Pin						
									30.09	90.50							
									31.45	89.88	LBK						
									33.77	88.85							
									36.04	88.05							
									37.01	86.53							
									38.12	84.86							
									38.81	84.86							
									40.1	84.51							
									40.89	83.95							
									42.07	83.86							
									44.07	84.04							
									45.7	84.32							
									46.97	84.39							
									48.48	84.54							
									50.36	84.73							
									51.02	84.69							
									52.42	84.98							
									53.07	85.78							
									54.02	86.07							
									54.73	87.25							
									56	87.69							
									57.48	87.88							
									60.21	88.60							
									62.73	88.99							
									67.41	89.73	RBK						
									67.45	89.79	Right Pin						
									79.77	89.73							
									89.23	89.59							
									101.37	89.74							
									105.08	89.57							
									108.9	89.28							
									116.37	89.59							
									121.53	90.33							
									133.74	94.06							

Photo of Cross-Section 4 - Reach 1 - Looking Downstream @ STA 23+05

	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				111.50	n/a	n/a
Width				35.82	n/a	n/a
Mean Depth				3.11	n/a	n/a
Max Depth				5.93	n/a	n/a
W/D				11.51	n/a	n/a

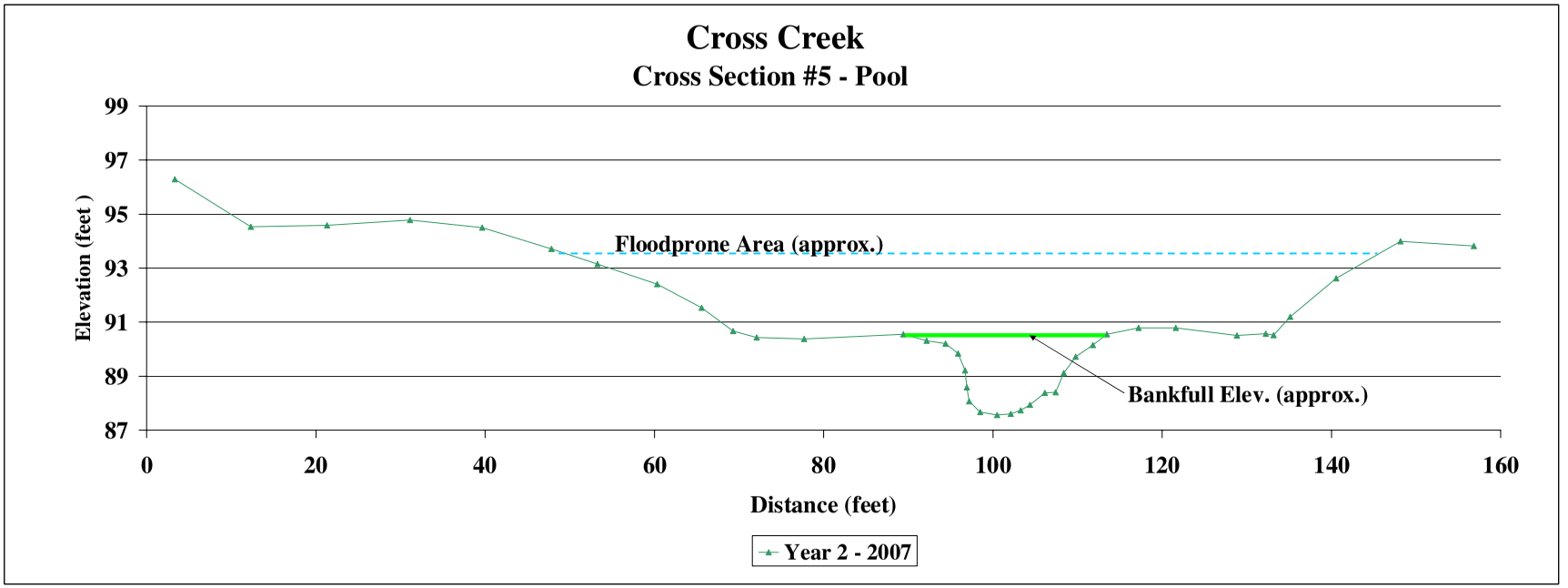


Project Name:	Cross Creek	**Feature:**	Pool	**Date:**	Year 02-7/4/2007
Cross Section:	Cross Section 5			**Crew:**	Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									3.32	96.29							
									12.32	94.53							
									21.31	94.59							
									31.13	94.78							
									39.66	94.5							
									47.84	93.71							
									53.27	93.15							
									60.33	92.41							
									65.6	91.53							
									69.32	90.67							
									72.1	90.43	Left Pin						
									77.69	90.38							
									89.43	90.55	LBK						
									92.16	90.31							
									94.42	90.21							
									95.9	89.84							
									96.71	89.21							
									96.92	88.59							
									97.21	88.07							
									98.5	87.67							
									100.51	87.56							
									102.1	87.6							
									103.28	87.73							
									104.4	87.94							
									106.14	88.38							
									107.4	88.4							
									108.39	89.11							
									109.77	89.72							
									111.8	90.15							
									113.45	90.55	RBK						
									117.21	90.79							
									121.63	90.79							
									128.85	90.51							
									132.26	90.57	Right Pin						
									133.19	90.52							
									135.14	91.2							
									140.57	92.62							
									148.17	93.99							
									156.83	93.82							

Photo of Cross-Section 5 - Reach 2 - Looking Downstream @ STA 3+11

	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				35.91	n/a	n/a
Width				24.10	n/a	n/a
Mean Depth				1.49	n/a	n/a
Max Depth				2.99	n/a	n/a
W/D				16.18	n/a	n/a



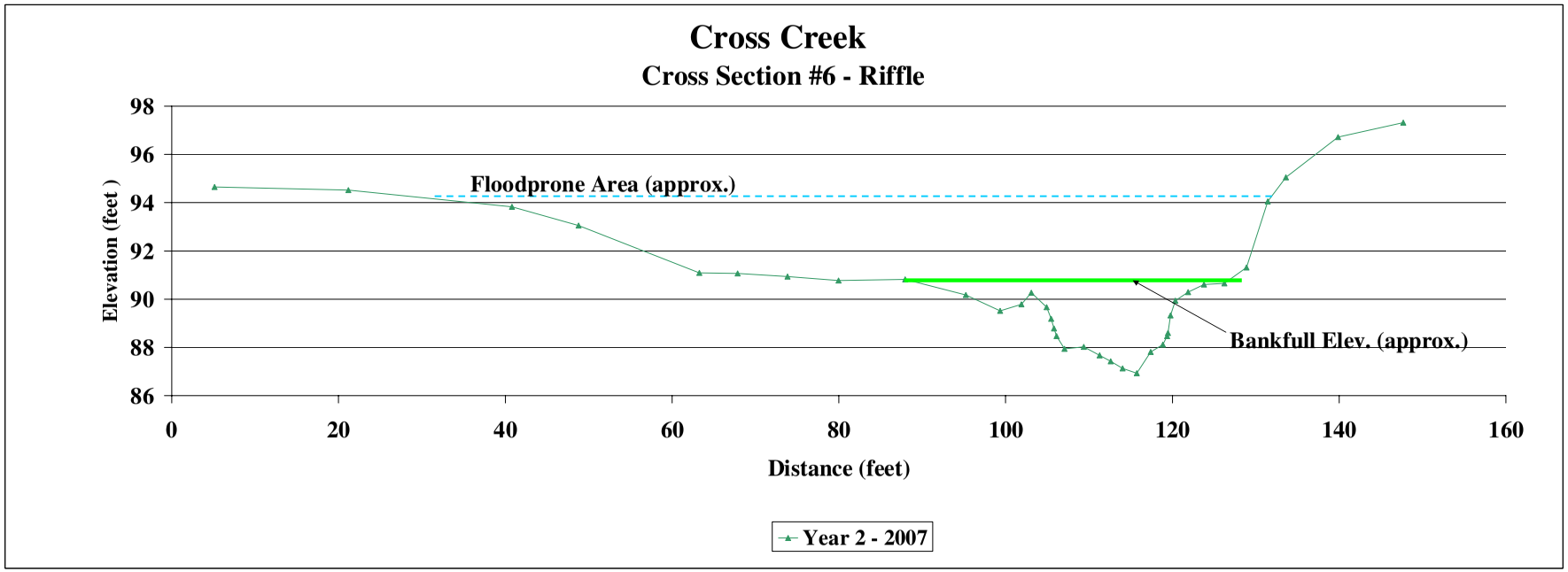
Project Name:	Cross Creek	**Feature:**	Riffle	**Date:**	Year 02-7/4/2007
Cross Section:	Cross Section 6			**Crew:**	Bidelspach, Jean, Geenen

Year 5 - 2010 2010 Survey			Year 4 - 2009 2009 Survey			Year 3 - 2008 2008 Survey			Year 2 - 2007 2007 Survey			Year 1 - 2006 2006 Survey			AS-BUILT 2005 AS-BUILT Survey		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
									5.13	94.65							
									21.18	94.52							
									40.81	93.83							
									48.79	93.05							
									63.28	91.09							
									67.86	91.06							
									73.84	90.94	Left Pin						
									79.97	90.77							
									87.96	90.82	LBK						
									95.23	90.17							
									99.35	89.51							
									101.9	89.79							
									103.08	90.27							
									104.91	89.67							
									105.45	89.18							
									105.8	88.78							
									106.12	88.47							
									107.08	87.94							
									109.38	88.02							
									111.28	87.67							
									112.6	87.42							
									114.04	87.13							
									115.73	86.93							
									117.39	87.81							
									118.87	88.12							
									119.37	88.47							
									119.49	88.6							
									119.78	89.33							
									120.37	89.94							
									121.88	90.29							
									123.79	90.61							
									126.23	90.66	Right Pin						
									128.9	91.31	RBK						
									131.44	94.05							
									133.61	95.05							
									139.88	96.72							
									147.69	97.32							

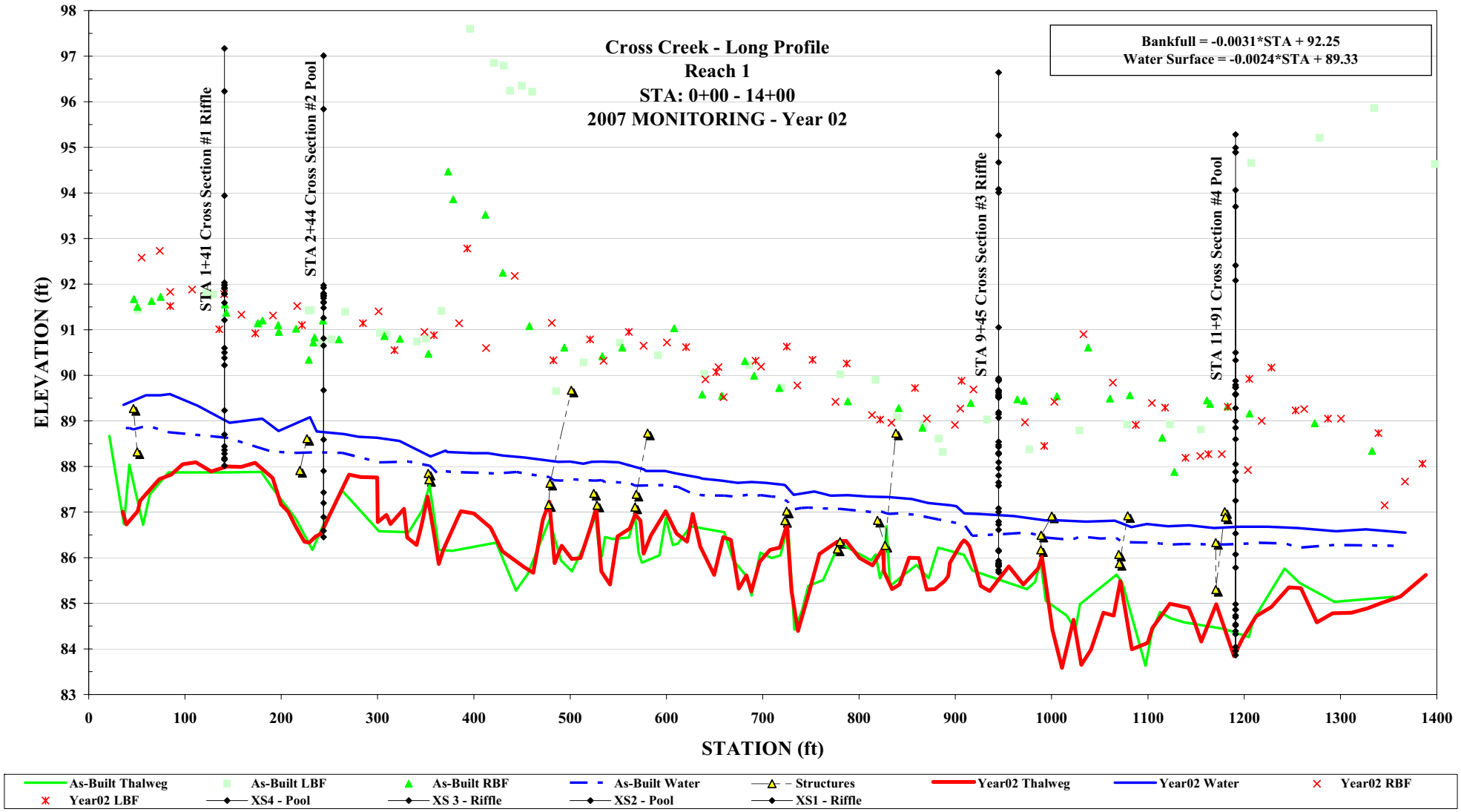
Photo of Cross-Section 6 - Reach 2 - Looking Downstream @ STA 3+81

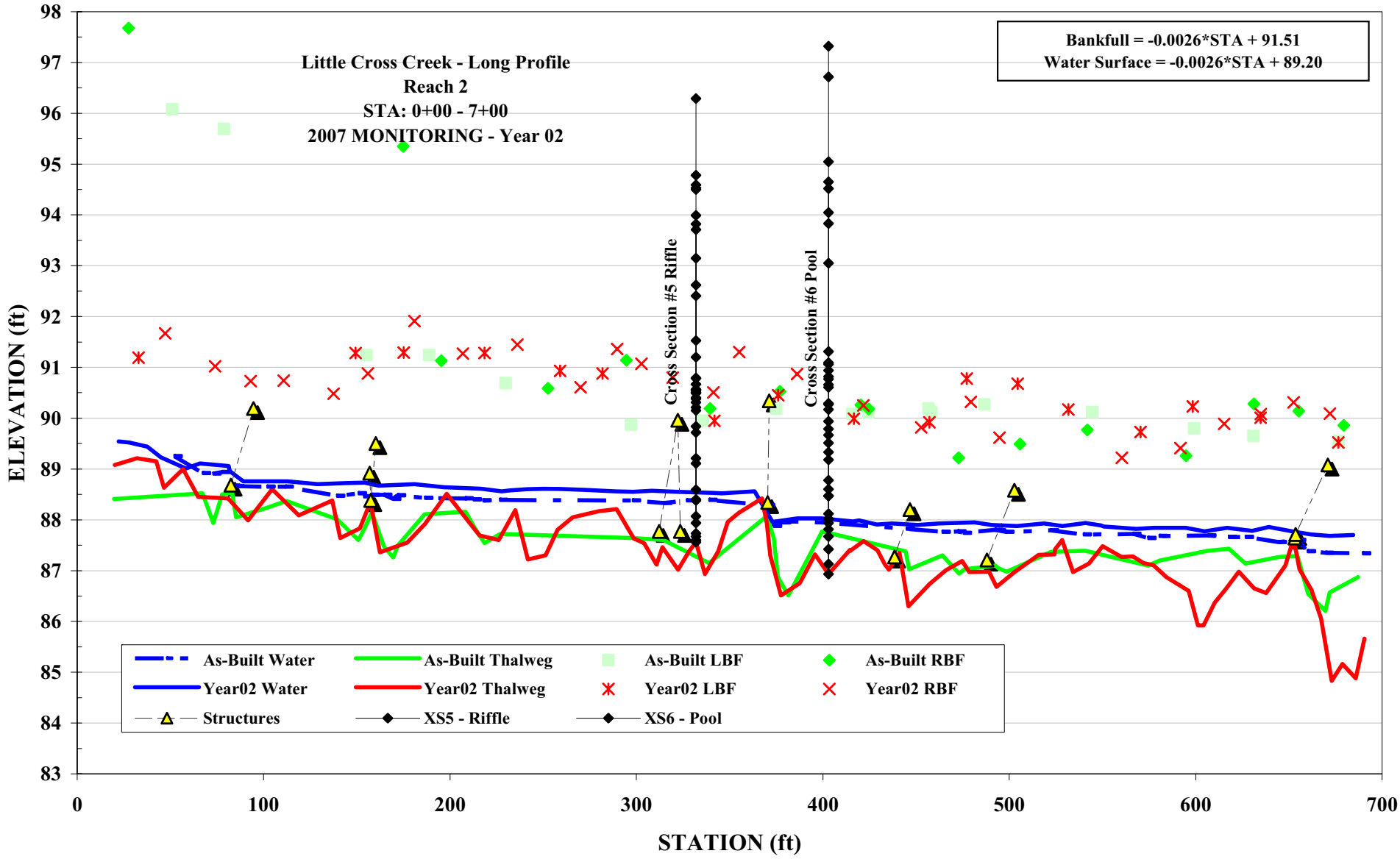
	Year 5 - 2010	Year 4 - 2009	Year 3 - 2008	Year 2 - 2007	Year 1 - 2006	AS-BUILT 2005
Area				59.50	n/a	n/a
Width				38.92	n/a	n/a
Mean Depth				1.53	n/a	n/a
Max Depth				3.88	n/a	n/a
W/D				25.46	n/a	n/a

*Note: The pins for the original cross-sections could not be located, making comparisons with Years 0 and 1 data invalid.



B.7 LONGITUDINAL PLOTS



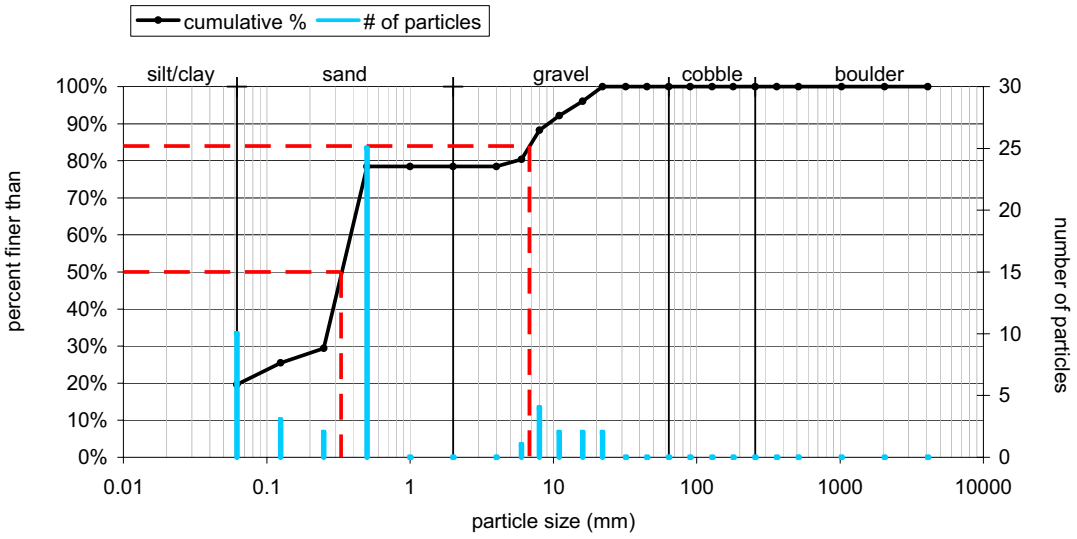

Little Cross Creek - Long Profile
Reach 2
STA: 0+00 - 7+00
2007 MONITORING - Year 02
Bankfull = -0.0026*STA + 91.51
Water Surface = -0.0026*STA + 89.20
Cross Section #5 Riffle
Cross Section #6 Pool
ELEVATION (ft)
STATION (ft)
98
97
96
95
94
93
92
91
90
89
88
87
86
85
84
83
0
100
200
300
400
500
600
700
As-Built Water
As-Built Thalweg
As-Built LBF
As-Built RBF
Year02 Water
Year02 Thalweg
Year02 LBF
Year02 RBF
Structures
XS5 - Riffle
XS6 - Pool

B.8 PEBBLE COUNT DISTRIBUTION

Cross Creek Cross Section 1 Pebble Count

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**10**
very fine sand	0.062 - 0.125	**3**
fine sand	0.125 - 0.25	**2**
medium sand	0.25 - 0.5	**25**
coarse sand	0.5 - 1	**0**
very coarse sand	1 - 2	**0**
very fine gravel	2 - 4	**0**
fine gravel	4 - 6	**1**
fine gravel	6 - 8	**4**
medium gravel	8 - 11	**2**
medium gravel	11 - 16	**2**
coarse gravel	16 - 22	**2**
coarse gravel	22 - 32	**0**
very coarse gravel	32 - 45	**0**
very coarse gravel	45 - 64	**0**
small cobble	64 - 90	**0**
medium cobble	90 - 128	**0**
large cobble	128 - 180	**0**
very large cobble	180 - 256	**0**
small boulder	256 - 362	**0**
small boulder	362 - 512	**0**
medium boulder	512 - 1024	**0**
large boulder	1024 - 2048	**0**
very large boulder	2048 - 4096	**0**
	total particle count:	51
bedrock	----------	
clay hardpan	----------	
detritus/wood	----------	
artificial	----------	
	total count:	51

Note: XS1 - Cross Creek



Size (mm)	
D16	0.062
D35	0.27
D50	0.33
D65	0.41
D84	6.8
D95	14

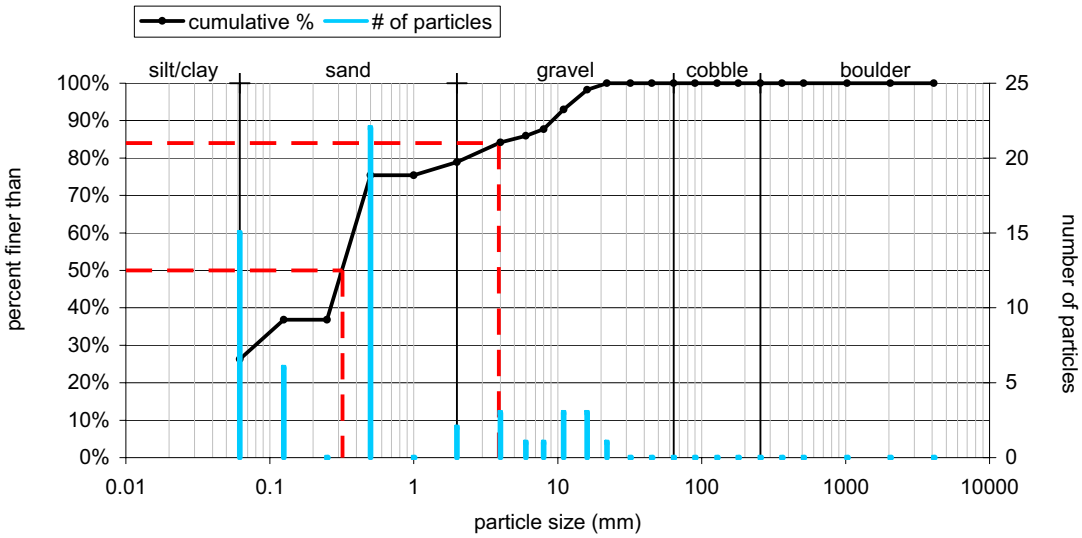
Size Distribution	
mean	0.6
dispersion	13.0
skewness	0.21

Type	
silt/clay	20%
sand	59%
gravel	22%
cobble	0%
boulder	0%

Cross Creek Cross Section 3 Pebble Count

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**15**
very fine sand	0.062 - 0.125	**6**
fine sand	0.125 - 0.25	**0**
medium sand	0.25 - 0.5	**22**
coarse sand	0.5 - 1	**0**
very coarse sand	1 - 2	**2**
very fine gravel	2 - 4	**3**
fine gravel	4 - 6	**1**
fine gravel	6 - 8	**1**
medium gravel	8 - 11	**3**
medium gravel	11 - 16	**3**
coarse gravel	16 - 22	**1**
coarse gravel	22 - 32	**0**
very coarse gravel	32 - 45	**0**
very coarse gravel	45 - 64	**0**
small cobble	64 - 90	**0**
medium cobble	90 - 128	**0**
large cobble	128 - 180	**0**
very large cobble	180 - 256	**0**
small boulder	256 - 362	**0**
small boulder	362 - 512	**0**
medium boulder	512 - 1024	**0**
large boulder	1024 - 2048	**0**
very large boulder	2048 - 4096	**0**
	total particle count:	57
bedrock	----------	
clay hardpan	----------	
detritus/wood	----------	
artificial	----------	
	total count:	57

Note: XS3 - Cross Creek



Size (mm)	
D16	0.062
D35	0.11
D50	0.32
D65	0.41
D84	3.9
D95	13

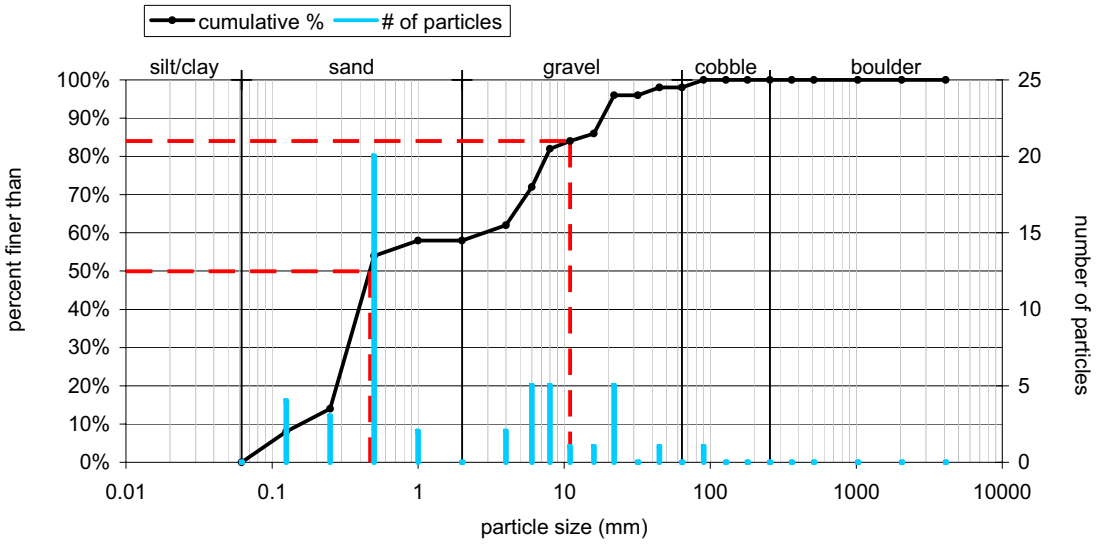
Size Distribution	
mean	0.5
dispersion	8.7
skewness	0.14

Type	
silt/clay	26%
sand	53%
gravel	21%
cobble	0%
boulder	0%

Cross Creek Cross Section 6 Pebble Count

Material	Size Range (mm)	Count
silt/clay	0 - 0.062	**0**
very fine sand	0.062 - 0.125	**4**
fine sand	0.125 - 0.25	**3**
medium sand	0.25 - 0.5	**20**
coarse sand	0.5 - 1	**2**
very coarse sand	1 - 2	**0**
very fine gravel	2 - 4	**2**
fine gravel	4 - 6	**5**
fine gravel	6 - 8	**5**
medium gravel	8 - 11	**1**
medium gravel	11 - 16	**1**
coarse gravel	16 - 22	**5**
coarse gravel	22 - 32	**0**
very coarse gravel	32 - 45	**1**
very coarse gravel	45 - 64	**0**
small cobble	64 - 90	**1**
medium cobble	90 - 128	**0**
large cobble	128 - 180	**0**
very large cobble	180 - 256	**0**
small boulder	256 - 362	**0**
small boulder	362 - 512	**0**
medium boulder	512 - 1024	**0**
large boulder	1024 - 2048	**0**
very large boulder	2048 - 4096	**0**
	total particle count:	50
bedrock	----------	
clay hardpan	----------	
detritus/wood	----------	
artificial	----------	
	total count:	50

Note: XS6 - Cross Creek



Size (mm)	
D16	0.26
D35	0.36
D50	0.47
D65	4.5
D84	11
D95	21

Size Distribution	
mean	1.7
dispersion	12.6
skewness	0.44

Type	
silt/clay	0%
sand	58%
gravel	40%
cobble	2%
boulder	0%

APPENDIX C – WETLAND RAW DATA

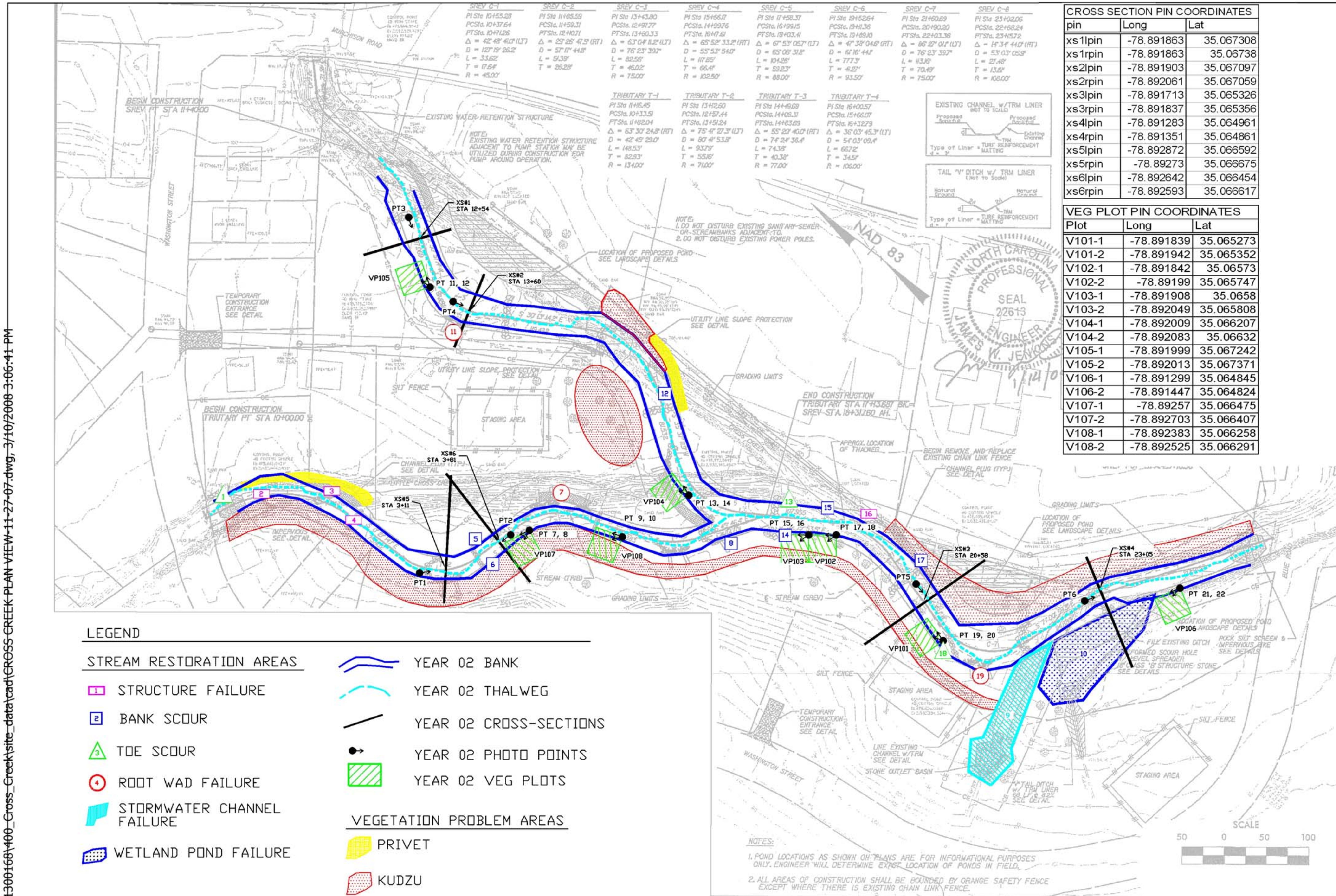
Appendix C. Wetland Raw Data (N/A)

Wetlands were not restored at the Cross Creek Stream Restoration Site.

APPENDIX D – CURRENT CONDITION PLAN VIEW

Appendix D. Current Condition Plan View

See following page for Current Condition Plan View Map.



CROSS SECTION PIN COORDINATES		
pin	Long	Lat
xs1lpin	-78.891863	35.067308
xs1rpin	-78.891863	35.06738
xs2lpin	-78.891903	35.067097
xs2rpin	-78.892061	35.067059
xs3lpin	-78.891713	35.065326
xs3rpin	-78.891837	35.065356
xs4lpin	-78.891283	35.064961
xs4rpin	-78.891351	35.064861
xs5lpin	-78.892872	35.066592
xs5rpin	-78.89273	35.066675
xs6lpin	-78.892642	35.066454
xs6rpin	-78.892593	35.066617

VEG PLOT PIN COORDINATES		
Plot	Long	Lat
V101-1	-78.891839	35.065273
V101-2	-78.891942	35.065352
V102-1	-78.891842	35.06573
V102-2	-78.89199	35.065747
V103-1	-78.891908	35.0658
V103-2	-78.892049	35.065808
V104-1	-78.892009	35.066207
V104-2	-78.892083	35.06632
V105-1	-78.891999	35.067242
V105-2	-78.892013	35.067371
V106-1	-78.891299	35.064845
V106-2	-78.891447	35.064824
V107-1	-78.89257	35.066475
V107-2	-78.892703	35.066407
V108-1	-78.892383	35.066258
V108-2	-78.892525	35.066291

CROSS CREEK STREAM RESTORATION (105)
APPENDIX D
CURRENT CONDITIONS PLAN VIEW

CROSS CREEK

SOURCE – EARTH TECH
STREAM RESTORATION CONSTRUCTION PLANS
C-3, 12/24/03, UPDATED 1/4/04

DATE 08/03/07
PROJECT NO.
FILENAME CROSSCREEK.dwg
SHEET NO.
DRAWING NO.

\171300168\400_Cross_Creek\site_data\cad\CROSS CREEK PLAN VIEW 11-27-07.dwg, 3/10/2008 3:06:41 PM