Benbow Park
Stream Restoration Monitoring Report
EEP Project # 29
Monitoring Year – 04
2008

Submitted to:

Ecosystem Enhancement PROGRAM

NCDENR-EEP, 1652 Mail Service Center, Raleigh, NC 27699-1652

March 2009

Monitoring Firm

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Design Firm

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EXECUTIVE SUMMARY

In 2004, the North Carolina Ecosystem Enhancement Program (EEP) conducted stream restoration at Benbow Park within the Buffalo Creek Watershed in Greensboro, North Carolina. The 0.7 mi^2 watershed is located within the USGS 14-digit HUC 03030002020050 and the NCDWQ Sub-basin 03-06-02 of the Cape Fear River Basin. The project restored approximately 2,060 linear feet of channel, 780 feet upstream of South Benbow Road and 1,280 feet downstream of South Benbow Road. The design was developed to address vertical instability problems and a lack of bed variability. The restoration plan called for correcting these problems by stabilizing stream banks, installing in-stream structures, adjusting stream planform, and replanting the riparian areas with native vegetation. Project construction occurred in 2004. This report describes the findings of the fourth year monitoring that took place in 2008.

The riparian buffer was planted with seven different species of bare root trees and four different species of live stakes. Three vegetation monitoring plots were established during the as-built survey, two buffer plots and one live stake plot. These plots were monitored during the first year of monitoring. In 2006 the EEP requested that the site be monitored using the new Carolina Vegetation Survey (CVS) vegetation monitoring protocol. Five new plots were established for the second monitoring year, and the previous monitoring plots were discontinued. The five plots were surveyed and the corners marked with metal conduit for future monitoring. The fourth year monitoring counted an average of 550 stems per acre. In late 2008, KCI observed that the city trimmed the understory for much of the project. EEP informed KCI that the city had arranged this with EEP in order to meet the city's maintenance needs. This was to involve trimming of the herbaceous understory and limbing some of the advanced trees to approximately chest height. Since many of the trees on the site have attained a substantial size, the intent of this maintenance was to continue to promote their growth and success while trying to thin out the dense thicket understory to gain access for invasive plant control. As per EEP, this thinning activity is to be a one-time effort to serve as an initial point for invasive plant control by the city, while still permitting the development of a sufficiently dense assemblage of robust native trees. Subsequent invasive control will be at a maintenance level without any widespread pruning. KCI did observe that some larger livestake stems may have been pruned in this effort, which was not part of the arrangement according to EEP, but these stems should resprout rapidly. EEP has reinforced with the city that future efforts are to be limited to string trimming of the herbaceous material and invasive control as needed. The vegetation plots exhibited densities that averaged 550 stems per acre, but it was observed that because they were flagged, they did not appear to have been subjected to the same treatment. KCI will evaluate the site in 2009 to verify whether the plots were treated the same and whether their densities are fully representative. The buffer along Reach 1 also has numerous exotic invasive species, most notably mimosa (*Albizia julibrissin*), ornamental pear (*Pyrus calleryana*), and kudzu (*Pueraria montana*). These plants should be removed from the riparian buffer as soon as possible to control the immediate seed source of these species. The fourth year monitoring found the vegetation component of the project to be on track to meeting the success criteria.

The stream assessment completed during the fourth year monitoring found the stream to be functioning for the majority of the project. Channel dimensions have not changed drastically from the as-built conditions over the course of the stream. The stream has experienced localized erosion, but many of these eroding banks have stabilized. Some channel narrowing and aggradation has continued, specifically between Stations 19+50 to 20+50 and 21+30 to 21+80. Due to the urban nature of this site, trash is scattered throughout the site and has the potential to cause blockages. The majority of the in-stream structures are functioning with minimal problems and the stream is stable.

1.0 PROJECT BACKGROUND

1.1 Project Objectives

- Restore unstable stream channels to natural stable forms by modifying dimension, pattern, and/or profile, based on reference reach parameters.
- Improve floodplain functionality by matching bankfull stage with floodplain elevation.
- Establish native floodplain vegetation through a forested riparian buffer.
- Improve the natural aesthetics of the stream corridor.
- Obtain mitigation credits for unavoidable impacts to streams within the same Hydrologic Unit Code (HUC).

1.2 Project Structure, Restoration Type, and Approach

A previously incised channel through Benbow Park was restored using channel dimension, pattern, and profile modifications and the establishment of a vegetated riparian zone adjacent to the creek. Channel profile is maintained through the use of rock cross vanes and constructed riffles. Channel pattern is maintained through the use of cross vanes, single vanes, root wads, J-hooks, and vegetation along the channel banks.

1.3 Location and Setting

Benbow Park is located within the city limits of Greensboro, North Carolina. The landuse of the 0.7-mi^2 watershed is urban residential with small pockets of industrial/commercial development. The watershed is completely built out with little potential for future development.

1.4 Project History and Background

Table I. Project Restoration Components
Project Number and Name: 29 - Benbow Park

Segment/ Reach ID	Existing Linear Feet	Type	Approach	Linear Feet	Stationing	Comment
Reach 1	780	EI	P2/3	780	10+00 - 17+80	
Reach 2	972	R	P1	1,280	18+50 - 31+30	

DIRECTIONS TO BENBOW PARK SITE:
From I-40, take exit 128 to NC 6 N. Bear right onto E. Lee St. ramp and go 2.2 miles. Turn left onto S. Benbow Road. Follow S. Benbow Road to the restoration site at the intersection with S. Side Boulevard.

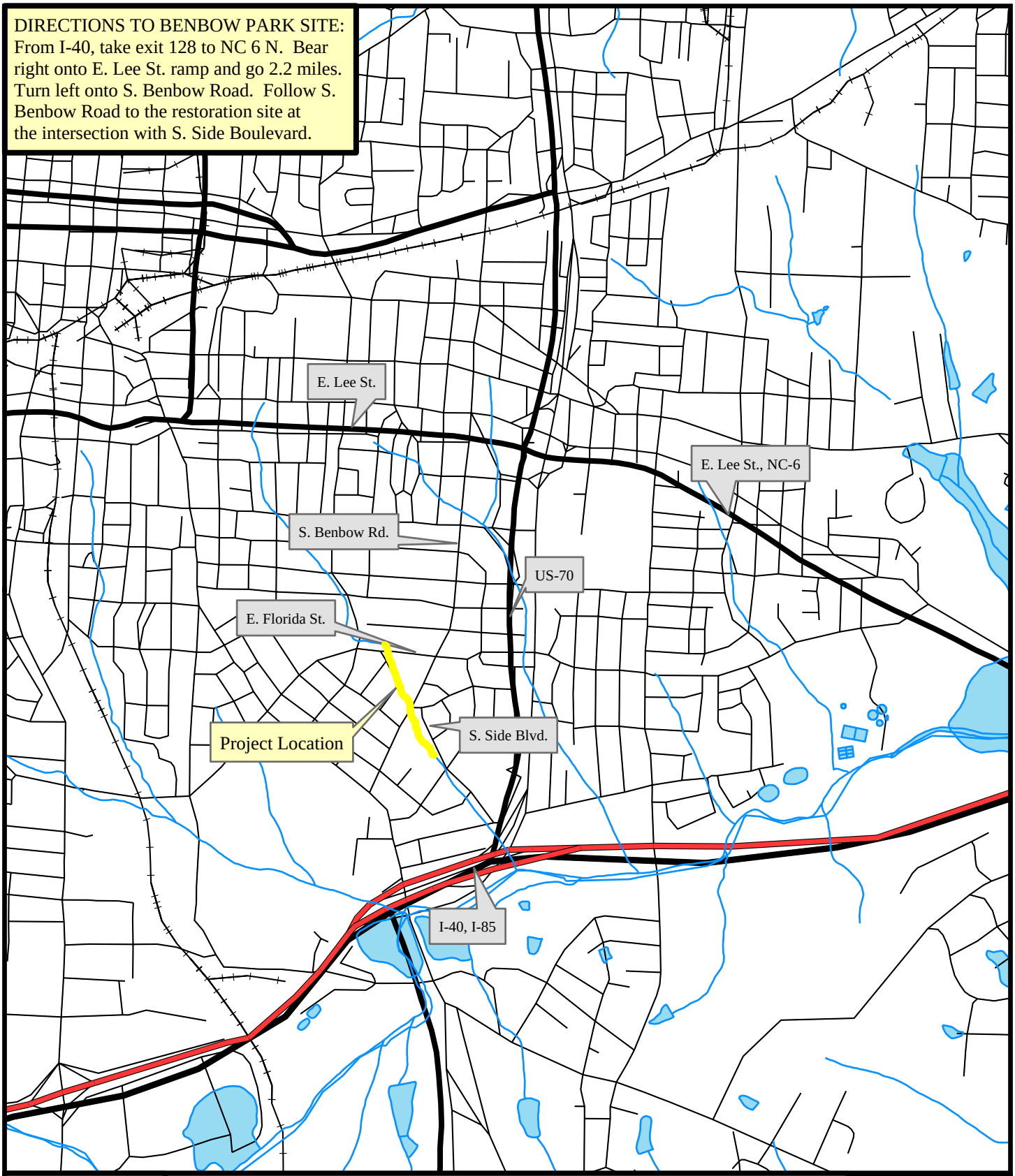


Figure 1. Site Vicinity Map
Benbow Park, Guilford County, EEP Project # 29

0.25 0.125 0 0.25 0.5 Miles

N

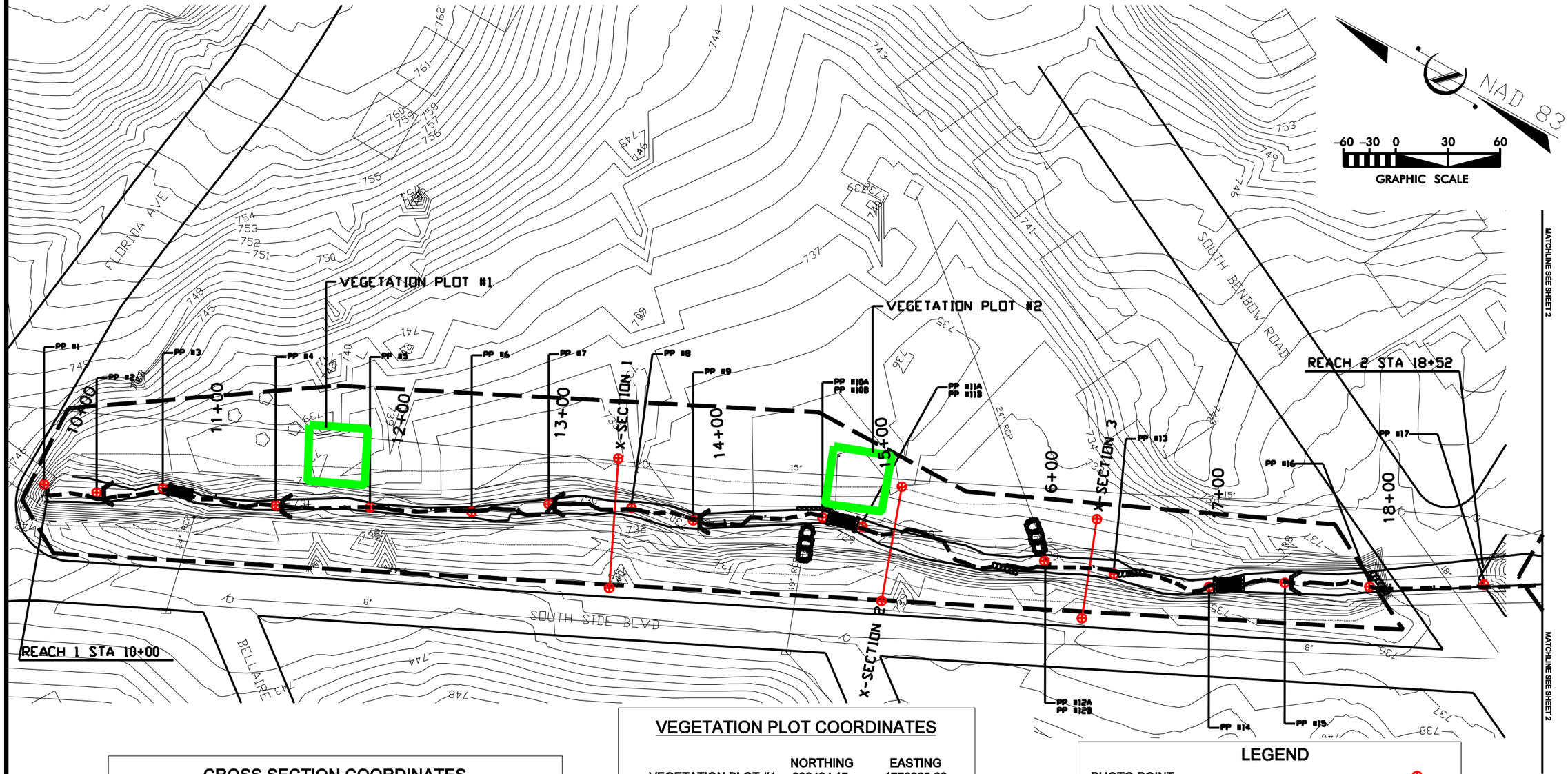
Ecosystem Enhancement Program

KCI ASSOCIATES OF NC

Table II. Project Activity and Reporting History Project Number and Name: 29 - Benbow Park		
Activity or Report	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan		
Final Design - 90%		
Construction	N/A	Aug 04
Stream Repair and Maintenance Seeding	N/A	Apr 05
As-Built Report	2005	Jun 05
Year 1 Monitoring	Nov 05	Jan 06
Adjustments to the Location of the Conservation Easement	N/A	Oct 06
Year 2 Monitoring	Sep 06	Jan 07
Year 3 Monitoring	Sep 07	Jan 08
Year 4 Monitoring	Oct 08	Jan 08

Table III. Project Contact Table Project Number and Name: 29 - Benbow Park	
Design Firm	Buck Engineering 8000 Regency Parkway, Suite 200 Cary, North Carolina 27511 Contact: Mr. Mike Rooney Phone: (919) 463-5488 Fax: (919) 463-5490
Construction Contractor	Shamrock Construction P.O. Box 14987 Greensboro, North Carolina 27415 Contact: Mr. Bill Wright Phone: (336) 375-1989 Fax: (336) 375-1801
Monitoring Performers	
MY-01	Buck Engineering 8000 Regency Parkway, Suite 200 Cary, North Carolina 27511 Contact: Mr. Mike Rooney Phone: (919) 463-5488 Fax: (919) 463-5490
MY-02-04	KCI Associates of NC Landmark Center II, Suite 220 4601 Six Forks Rd. Raleigh, NC 27609 Contact: Mr. Adam Spiller Phone: (919) 783-9214 Fax: (919) 783-9266

Table IV. Project Background Table **Project Number and Name: 29 – Benbow Park**	
Project County	Guilford County
Drainage Area	0.7 mi^2
Drainage Impervious Cover Estimate (%)	61%
Stream Order	Second Order
Physiographic Region	Piedmont
Ecoregion	Southern Outer Piedmont
Rosgen Classification of As-built	B5c (Reach 1)
	E5 (Reach 2)
Dominant Soil Types	Enon - Urban Land Complex (Benbow Stream)
Reference Site ID	N/A
USGS HUC for Project and Reference	03030002020050 (Benbow Stream)
NCDWQ Sub-basin for Project and Reference	03-06-02 (Benbow Stream)
NCDWQ Classification for Project and Reference	N/A (Benbow Stream)
Any portion of the project segment 303d listed?	No - not rated
Any portion of the project segment upstream of a 303d listed segment?	Project stream is approx. 0.4 miles upstream of the listed stream, S. Buffalo Creek.
Reasons for 303d Listing or Stressor	S. Buffalo Creek listed for impaired biological integrity and turbidity violation.
% of Project Easement Fenced	0%
% of Project Easement Demarcated with Bollards	approx. 75% - many bollards have been knocked over



CROSS SECTION COORDINATES

	NORTHING	EASTING	ELEVATION
CROSS SECTION 1 LB	839329.34	1771033.91	736.61
RB	839298.26	1770966.16	740.00
CROSS SECTION 2 LB	839178.72	1771097.96	734.05
RB	839157.49	1771034.75	738.95
CROSS SECTION 3 LB	839071.52	1771135.40	733.47
RB	839051.78	1771081.27	737.82
CROSS SECTION 4 LB	838397.44	1771299.45	728.30
RB	838425.07	1771246.95	729.70
CROSS SECTION 5 LB	838314.09	1771418.26	732.10
RB	838288.35	1771353.07	727.80
CROSS SECTION 6 LB	838180.94	1771418.13	727.84
RB	838133.24	1771409.06	728.95

VEGETATION PLOT COORDINATES

	NORTHING	EASTING
VEGETATION PLOT #1	839494.17	1770965.66
	839463.78	1770979.87
	839449.92	1770950.34
	839479.83	1770937.07
VEGETATION PLOT #2	839224.18	1771099.58
	839192.34	1771110.54
	839182.02	1771079.85
	839212.61	1771068.29
VEGETATION PLOT #3	838517.75	1771228.98
	838457.49	1771256.77
	838452.01	1771240.74
	838513.04	1771214.85
VEGETATION PLOT #4	838320.18	1771302.21
	838296.75	1771363.84
	838282.01	1771356.20
	838305.37	1771294.46
VEGETATION PLOT #5	838188.65	1771391.60
	838180.41	1771458.03
	838172.03	1771389.36
	838164.44	1771454.45

LEGEND

- PHOTO POINT
- THALWEG
- AS-BUILT VEGETATIVE BUFFER BOUNDARY
- CROSS SECTION
- ROOT WAD
- ROCK CROSS VANE
- CONSTRUCTED RIFFLE
- STEP POOL STRUCTURE
- DOUBLE DROP CROSS VANE
- J-HOOK

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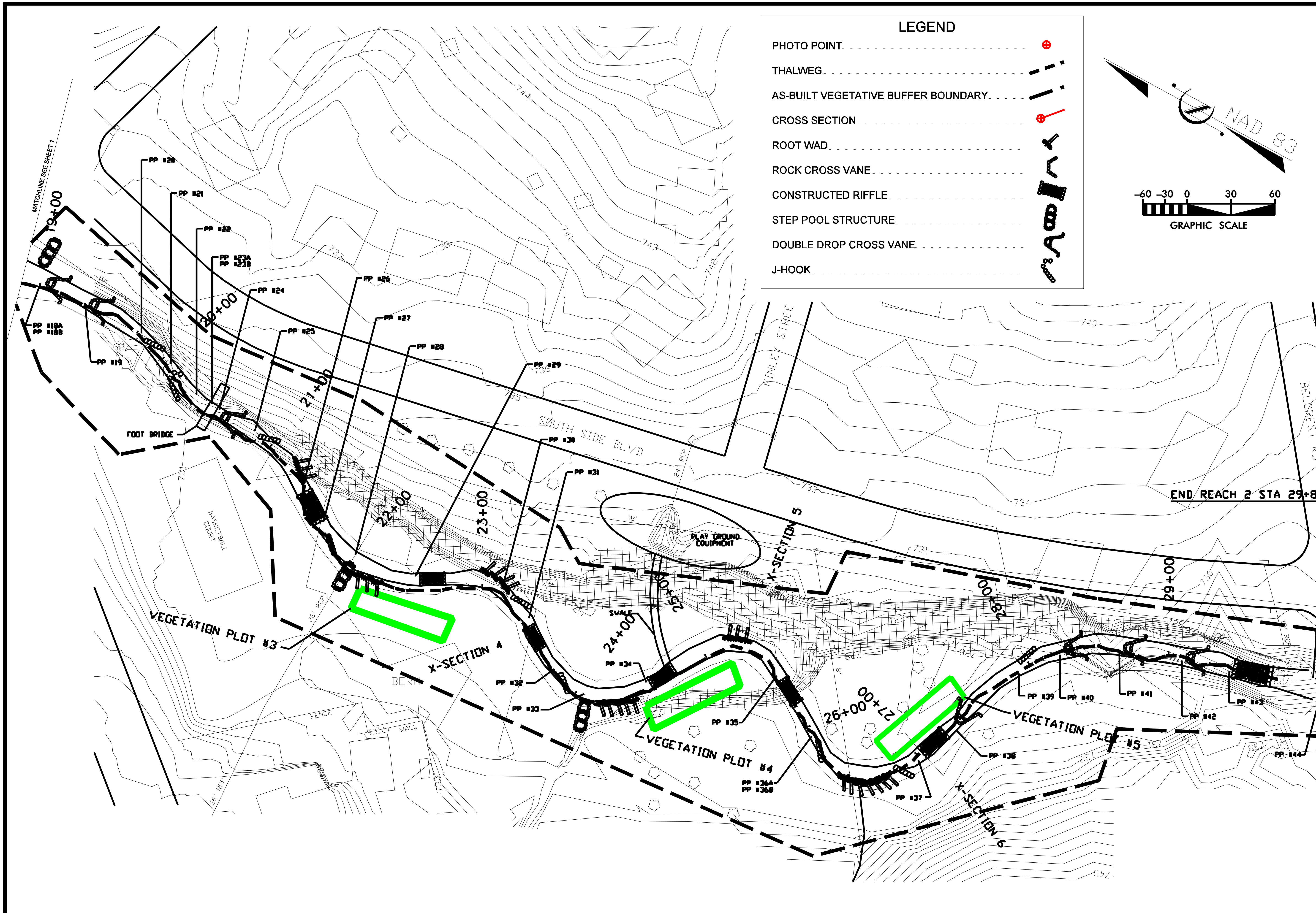
RALEIGH, NORTH CAROLINA 27609

BENBOW PARK
GUILFORD COUNTY, NORTH CAROLINA
EEP PROJECT NUMBER 29 - MY04
STATION 10+00 TO STATION 18+87

DATE NOVEMBER 2008
SHEET SEE SHEET

MONITORING PLAN VIEW

SHEET 1 OF 2


LEGEND
PHOTO POINT
THALWEG
AS-BUILT VEGETATIVE BUFFER BOUNDARY
CROSS SECTION
ROOT WAD
ROCK CROSS VANE
CONSTRUCTED RIFFLE
STEP POOL STRUCTURE
DOUBLE DROP CROSS VANE
J-HOOK
NAD 83
-60 -30 0 30 60
GRAPHIC SCALE
MATCHLINE SEE SHEET 1
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
28+00
29+00
PP #18A
PP #18B
PP #19
PP #20
PP #21
PP #22
PP #23A
PP #23B
PP #24
PP #25
PP #26
PP #27
PP #28
PP #29
PP #30
PP #31
PP #32
PP #33
PP #34
PP #35
PP #36A
PP #36B
PP #37
PP #38
PP #39
PP #40
PP #41
PP #42
PP #43
PP #44
FOOT BRIDGE
BASKETBALL COURT
SOUTH SIDE BLVD
FINLEY STREE
BELCREST RD
PLAY GROUND EQUIPMENT
END REACH 2 STA 29+85
X-SECTION 4
X-SECTION 5
X-SECTION 6
VEGETATION PLOT #3
VEGETATION PLOT #4
VEGETATION PLOT #5
SWALE
BERM
FENCE
WALL
36" RCP
24" RCP

BENBOW PARK
GUILFORD COUNTY, NORTH CAROLINA
EEP PROJECT NUMBER 29 - MY04

STATION 18+87 TO STATION 29+85

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NOVEMBER 2008
SEE SHEET

MONITORING PLAN VIEW

2 2

2.0 PROJECT CONDITIONS AND MONITORING RESULTS

2.1 Vegetation Assessment

The fourth year monitoring counted an average of 550 stems per acre. In late 2008, KCI observed that the city trimmed the understory for much of the project. EEP informed KCI that the city had arranged this with EEP in order to meet the city's maintenance needs. This was to involve trimming of the herbaceous understory and limbing some of the advanced trees to approximately chest height. Since many of the trees on the site have attained a substantial size, the intent of this maintenance was to continue to promote their growth and success while trying to thin out the dense thicket understory to gain access for invasive plant control. As per EEP, this thinning activity is to be a one-time effort to serve as an initial point for invasive plant control by the city, while still permitting the development of a sufficiently dense assemblage of robust native trees. Subsequent invasive control will be at a maintenance level without any widespread pruning. KCI did observe that some larger livestake stems may have been pruned in this effort, which was not part of the arrangement according to EEP, but these stems should resprout rapidly. EEP has reinforced with the city that future efforts are to be limited to string trimming of the herbaceous material and invasive control as needed. The vegetation plots exhibited densities that averaged 550 stems per acre, but it was observed that because they were flagged, they did not appear to have been subjected to the same treatment. KCI will evaluate the site in 2009 to verify whether the plots were treated the same and whether their densities are fully representative. The riparian buffer has also been mechanically mowed around the public infrastructure, such as culverts and bridges, and utility easements. In most of these areas there is not adequate demarcation as to where the easement begins and stops, so it is difficult to tell if the mowing is occurring within the easement boundaries.

The buffer along Reach 1 also has numerous exotic invasive species, most notably, mimosa (*Albizia julibrissin*), ornamental pear (*Pyrus calleryana*), and kudzu (*Pueraria montana*). Japanese honeysuckle (*Lonicera japonica*), porcelainberry (*Ampelopsis brevipedunculata*) white mulberry (*Morus alba*), Japanese hops (*Humulus japonicus)*, multiflora rose (*Rosa multiflora*), and lespedeza (*Lespedeza cuneata)* are also prevelant throughout the riparian buffer. These plants should be removed from the riparian buffer as soon as possible to control the immediate seed source of these species. While it may not be possible to eradicate the invasive species from the riparian buffer, controlling them may give the planted native vegetation a greater chance to compete against the invasive species found at this site. The fourth year monitoring found the vegetation component of the project to be on track to meeting the success criteria. See vegetation data in Appendix A and the Current Conditions Plan View in Appendix C. The taxonomic standard being used for vegetation identifications is "Flora of the Carolinas, Virginia, Georgia, and surrounding areas by Alan S. Weakley.

2.2 Stream Assessment

The stream has experienced localized erosion, but many of these eroding banks have stabilized. Previous areas of erosion along the bank toe are improving due to vegetation stabilization. Some channel narrowing and aggradation has increased, specifically between Stations 19+50 to 20+50 and 21+30 to 21+80. The majority of the in-stream structures are functioning with only minimal problems. The only systematic problem is that many of the rootwads, which were installed above the baseflow, are beginning to rot. Most of them are still serving their function as aquatic and terrestrial habitat, but as they break down specific attention needs to be paid to the banks to make sure that this does not lead to destabilization. The morphological monitoring reveals that the most significant stream adjustment to date occurred between monitoring years 01 and 02. In riffle cross-sections 1, 3, and 4 inner berm features have developed. These depositional features have

caused the bankfull area, and in some cases the bankfull width, to decrease. However, since monitoring year 02, these features have undergone minimal change, which suggests that this is a trend towards stream stability. At this time, there are no areas on the stream that require immediate repair. See additional stream data in Appendix B and the Current Conditions Plan View in Appendix C

2.2.1 Bankfull Event and Stability Assessment

2.2.1.a Verification of Bankfull Events Table

Table V. Verification of Bankfull Events
Project Number and Name: 29 - Benbow Park

Date of Data Collection	Date of Occurence	Method	Photo Number
9/19/2006	9/18/2006	Site visit to evaluate indicators of stage after storm events	N/A
7/23/2008	4/29/2008	Crest Gauge	N/A

2.2.1.b BEHI and Sediment Export Table

Table VI. BEHI and Sediment Export Estimates
Project Number and Name: 29 - Benbow Park

N/A

2.2.2 Stability Assessment Table

Table VII a. Categorical Stream Feature Visual Stability Assessment
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 1 (780 ft.)

Feature	Initial	MY - 01	MY - 02	MY - 03	MY - 04	MY - 05
A. Riffles	100%	N/A	109%	109%	117%	
B. Pools	100%	N/A	120%	120%	123%	
C. Thalweg*	N/A	N/A	N/A	N/A	N/A	
D. Meanders*	N/A	N/A	N/A	N/A	N/A	
E. Bed General	100%	N/A	96%	100%	91%	
F. Bank Condition	100%	N/A	98%	98%	96%	
G. Vanes / J Hooks etc.	100%	N/A	100%	100%	100%	

*Reach 1 is not a meandering channel

Table VII b. Categorical Stream Feature Visual Stability Assessment
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 2 (1,135 ft.)

Feature	Initial	MY - 01	MY - 02	MY - 03	MY - 04	MY - 05
A. Riffles	100%	N/A	80%	80%	86%	
B. Pools	100%	N/A	102%	121%	150%	
C. Thalweg	100%	N/A	67%	67%	67%	
D. Meanders	100%	N/A	53%	53%	61%	
E. Bed General	100%	N/A	96%	98%	93%	
F. Bank Condition	100%	N/A	96%	99%	98%	
G. Vanes / J Hooks etc.	100%	N/A	100%	100%	97%	
H. Wads and Boulders	100%	N/A	92%	84%	84%	

Please note that the riffle and pool features in Table VII may have ratings above 100%. This occurs when there are more of these features identified in the longitudinal profile survey for that monitoring year than were originally counted during the as-built survey.

2.2.3 Quantitative Measures Summary Tables

Table VIII a. Baseline Morphology and Hydraulic Summary
Project Number and Name: 29 – Benbow Park
Segment Reach: Reach 1 (780 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)							14.0	15.0					16.0			16.4	20.3	18.4
Floodprone Width (ft)							34						80			35	38	37
Bankfull Cross Sectional Area (ft^2)							24.0	26.0					25.0			20.3	20.5	20.4
Bankfull Mean Depth (ft)							1.6	1.9					1.6			1.2	1.3	1.3
Bankfull Maximum Depth (ft)							2.9						2.3			2.0	1.7	1.9
Width/Depth Ratio							7.1	9.7					10.0			13.1	15.1	14.1
Entrenchment Ratio							3.0						5.0			2.2	2.2	2.2
Bank Height Ratio							1.7	1.9					1.0			1.0	1.0	1.0
Wetted Perimeter (ft)																		
Hydraulic Radius (ft)																		
Pattern																		
Channel Beltwidth (ft)													48	64				
Radius of Curvature (ft)													32	48				
Meander Wavelength (ft)													128	192				
Meander Width Ratio													3	4				
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)							0.010	0.040					0.007					
Pool Length (ft)																		
Pool Spacing (ft)																		
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)								776						882				
Sinuosity								1.04						1.10				
Water Surface Slope (ft/ft)																		
BF Slope (ft/ft)																		
Rosgen Classification								B5c/E5						E5			B5c	

Table VIII b. Baseline Morphology and Hydraulic Summary
Project Number and Name: 29 – Benbow Park
Segment Reach: Reach 2 (1,135 ft.)

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Med	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Bankfull Width (ft)							18.0	22.0					21.0			18.5	20.0	19.3
Floodprone Width (ft)							87						140			49	59	54
Bankfull Cross Sectional Area (ft^2)							39.0	45.0					45.0			33.2	38.1	35.7
Bankfull Mean Depth (ft)							2.0	2.2					2.1			1.8	1.9	1.9
Bankfull Maximum Depth (ft)							3.5						2.8			2.7	3.0	2.9
Width/Depth Ratio							8.3	11.1					10.0			10.3	10.4	10.4
Entrenchment Ratio							4.2						6.7			2.7	3.0	2.9
Bank Height Ratio							2.0	9.2					1.0			1.0	1.0	1.0
Wetted Perimeter (ft)																		
Hydraulic Radius (ft)																		
Pattern																		
Channel Beltwidth (ft)													63	84				
Radius of Curvature (ft)													42	63				
Meander Wavelength (ft)													168	252				
Meander Width Ratio													3	4				
Profile																		
Riffle Length (ft)																		
Riffle Slope (ft/ft)							0.0100	0.0400					0.0069					
Pool Length (ft)																		
Pool Spacing (ft)																		
Substrate																		
d50 (mm)																		
d84 (mm)																		
Additional Reach Parameters																		
Valley Length (ft)																		
Channel Length (ft)								976						1,178				
Sinuosity								1.8-3.6						1.3				
Water Surface Slope (ft/ft)								0.0056						0.0046				
BF Slope (ft/ft)																		
Rosgen Classification								E5						E5			E5	

Table IXa. Morphology and Hydraulic Monitoring Summary
Project Number and Name: 29 – Benbow Park
Segment Reach: Reach 1 (780 ft.)

Parameter	Cross Section 1 Riffle						Cross Section 2 Pool						Cross Section 3 Riffle					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	15.4	12.9	13.2	12.8			18.7	18.9	19.3	19.8			20.0	16.8	17.1	15.6		
Floodprone Width (ft)	35	34	35	36			49	48	48	49			39	41	39	39		
Bankfull Cross Sectional Area (ft^2)	16.7	13.6	16.6	17.0			47.4	49.8	49.0	48.5			26.9	18.4	17.1	17.5		
Bankfull Mean Depth (ft)	1.1	1.1	1.3	1.3			2.5	2.6	2.5	2.4			1.3	1.1	1.1	1.1		
Bankfull Maximum Depth (ft)	1.8	1.9	2.1	2.1			3.8	3.6	3.6	3.6			2.2	1.9	1.9	1.8		
Width/Depth Ratio	14.1	12.2	10.5	9.6			7.4	7.2	7.6	8.1			14.9	15.3	15.6	13.9		
Entrenchment Ratio	2.1	2.6	2.7	2.8			2.6	2.5	2.5	2.5			2.1	2.4	2.3	2.5		
Bank Height Ratio	1.0	1.0	1.0	1.0			1.0	1.0	1.2	1.2			1.0	1.0	1.0	1.0		
Wetted Perimeter (ft)		13.8	15.0	13.8				21.8	22.1	22.3				15.4	17.8	16.4		
Hydraulic Radius (ft)		1.0	1.1	1.2				2.3	2.2	2.2				1.0	1.1	1.1		
Substrate																		
d50 (mm)		9.8	17.0	5.6				2.4	1.1	1.5				16.6	16.0	18.0		
d84 (mm)		29.0	29.0	39.0				15.0	3.8	6.4				45	56.0	54.0		

Table IXb. Morphology and Hydraulic Monitoring Summary
Project Number and Name: 29 – Benbow Park
Segment Reach: Reach 2 (1,135 ft.)

Parameter	Cross Section 4 Riffle						Cross Section 5 Pool						Cross Section 6 Riffle					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	20.0	20.9	18.5	18.5			18.9	17.2	17.1	17.3			18.5	17.9	18.7	18.3		
Floodprone Width (ft)	59	60	60	60			59	59	60	60			49	48	50	50		
Bankfull Cross Sectional Area (ft^2)	36.1	29.9	30.0	29.0			40.0	36.4	37.8	34.2			35.0	32.2	32.4	32.6		
Bankfull Mean Depth (ft)	1.9	1.4	1.6	1.6			2.1	2.1	2.2	2.0			1.9	1.8	1.7	1.8		
Bankfull Maximum Depth (ft)	2.9	2.8	3.1	2.9			3.9	3.6	3.7	3.7			3.3	2.6	2.6	2.7		
Width/Depth Ratio	10.4	14.6	11.4	11.8			8.9	8.1	7.7	8.8			9.3	10.0	10.7	10.3		
Entrenchment Ratio	3.1	2.8	3.0	3.0			3.3	3.4	3.0	3.0			2.7	2.7	2.5	2.5		
Bank Height Ratio	1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0			1.0	1.0	1.0	1.0		
Wetted Perimeter (ft)		22.3	20.7	20.2				19.6	19.7	20.2				19.9	20.9	20.5		
Hydraulic Radius (ft)		1.3	1.4	1.4				1.9	1.9	1.7				1.6	1.5	1.6		
Substrate																		
d50 (mm)		19.4	22.0	13.0				3.2	1.4	2.4				73.4	15.0	11.0		
d84 (mm)		67.0	41.0	35.0				15.0	6.3	7.2				123.0	140.0	100.0		

Table IXc. Morphology and Hydraulic Monitoring Summary continued
Project Number and Name: 29 - Benbow Park
Segment Reach: Reach 1 (780 ft.)

Parameter	MY - 01 (2005)			MY - 02 (2006)			MY - 03 (2007)			MY - 04 (2008)			MY - 05 (2009)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)				17	37	25	17	37	25	17	37	25			
Radius of Curvature (ft)				-	-	-	-	-	-	-	-	-			
Meander Wavelength (ft)				-	-	-	-	-	-	-	-	-			
Meander Width Ratio				1.1	2.5	1.7	1.1	2.4	1.6	1.2	2.6	1.8			
Profile															
Riffle Length (ft)				9	53	19	13	48	19	9	91	19			
Riffle Slope (ft/ft)				0.001	0.030	0.014	0.000	0.034	0.015	0.001	0.032	0.007			
Pool Length (ft)				12	55	19	8	32	14	5	45	14			
Pool Spacing (ft)				28	117	47	19	160	68	12	131	38			
Additional Reach Parameters															
Valley Length (ft)				772			772			772					
Channel Length (ft)				800			800			800					
Sinuosity				1.01			1.01			1.01					
Water Surface Slope (ft/ft)				0.006			0.005			0.005					
Rosgen Classification	B5c			B4c			B4c			B4c					

Table IXd. Morphology and Hydraulic Monitoring Summary continued
Project Number and Name: 29 - Benbow Park
Segment Reach: Reach 2 (1,135 ft.)

Parameter	MY - 01 (2005)			MY - 02 (2006)			MY - 03 (2007)			MY - 04 (2008)			MY - 05 (2009)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)				36	111	82	36	111	82	36	111	82			
Radius of Curvature (ft)				36	120	47	36	120	47	36	120	47			
Meander Wavelength (ft)				151	228	183	151	228	183	151	228	183			
Meander Width Ratio				1.8	5.6	4.1	1.9	6.0	4.4	2.0	6.0	4.5			
Profile															
Riffle Length (ft)				9	23	13	5	24	20	4	60	20			
Riffle Slope (ft/ft)				0.001	0.033	0.018	0.004	0.033	0.013	0.001	0.020	0.009			
Pool Length (ft)				3	118	25	4	45	11	6	82	16			
Pool Spacing (ft)				10	187	43	10	146	30	13	140	34			
Additional Reach Parameters															
Valley Length (ft)				934			934			934					
Channel Length (ft)				1,150			1,150			1,150					
Sinuosity				1.23			1.23			1.23					
Water Surface Slope (ft/ft)				0.006			0.006			0.005					
Rosgen Classification	E5			E4			E4			E4					

3.0 METHODOLOGY

The CVS-EEP protocol (http://cvs.bio.unc.edu/methods.htm) was used to collect vegetation data from Benbow Park this year, the fourth year of monitoring. This methodology was incorporated during the third year of monitoring. The method used before that time was the EEP 2004 Stem Counting Protocol.

4.0 REFERENCES

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

Weakley, Alan S. 2006. Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas. (http://www.herbarium.unc.edu/FloraArchives/WeakleyFlora_2006-Jan.pdf)

Appendix A
Vegetation Data

A1 –Vegetation Data Tables

Table A1. Vegetation Metadata
Project Number and Name: 29 – Benbow Park

Report Prepared By	Brian Roberts
Date Prepared	9/2/2008 16:14
Database Name	kci-problem-II-fixed.mdb
Database Location	M:\2007\12071067_2007 EEP OPEN END\Veg_database

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

Project Code	Project Name	Description	Length (ft)	Stream-to-Edge Width (ft)	Area (sq m)	Required Plots (calculated)	Sampled Plots
29	Benbow Park	Stream restoration site in Greensboro, NC.	2000	40	14,863	5	5

Table A2. Vegetation Vigor by Species
Project Number and Name: 29 – Benbow Park

	Species	4	3	2	1	0	Missing
	Betula nigra	1	2				
	Cornus amomum	6	4			1	
	Fraxinus pennsylvanica	9	4			1	
	Nyssa sylvatica	1	7				
	Quercus phellos	1					
	Salix nigra	5					
	Salix sericea	5	9				
	Hamamelis virginiana	5	5				
	Platanus occidentalis	4					
TOT:	**9**	**37**	**31**			**2**	

Table A3. Damage by Species
Project Number and Name: 29 – Benbow Park

	Species	All Damage Categories	No Damage	Cut	Deer	Drought
	Betula nigra	3	2	1		
	Cornus amomum	13	11	1	1	
	Fraxinus pennsylvanica	16	15			1
	Hamamelis virginiana	14	13	1		
	Nyssa sylvatica	8	8			
	Platanus occidentalis	4	4			
	Quercus phellos	1	1			
	Salix nigra	5	5			
	Salix sericea	17	17			
TOT:	**9**	**81**	**76**	**3**	**1**	**1**

Table A4. Damage by Plot
Project Number and Name: 29 – Benbow Park

	Plot	All Damage Categories	No Damage	Cut	Deer	Drought
	029-01-0001; year 4	10	10			
	029-01-0002; year 4	12	11			1
	029-01-0003; year 4	10	10			
	029-01-0004; year 4	20	18	1	1	
	029-01-0005; year 4	29	27	2		
TOT:	**5**	**81**	**76**	**3**	1	1

Table A5. Stem Count by Plot and Species
Project Number and Name: 29 – Benbow Park

	Species	Total Stems	# Plots	Avg # Stems	Plot 029-01-0001; year 4	Plot 029-01-0002; year 4	Plot 029-01-0003; year 4	Plot 029-01-0004; year 4	Plot 029-01-0005; year 4
	Betula nigra	3	3	1	1		1		1
	Cornus amomum	12	4	3		2	1	4	5
	Fraxinus pennsylvanica	15	4	4	6	2		6	1
	Hamamelis virginiana	14	4	4	2	4	2		6
	Nyssa sylvatica	8	3	3			2	4	2
	Platanus occidentalis	4	2	2			2		2
	Quercus phellos	1	1	1	1				
	Salix nigra	5	3	2			1	1	3
	Salix sericea	17	4	4		3	1	5	8
TOT:	**9**	**79**	**9**		**10**	**11**	**10**	**20**	**28**

Table A6a. Vegetative Problem Areas
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 1 (850 ft.)

Feature/Issue	Station # / Range	Probable Cause	Photo #
Mowed Buffer	10+00 - 10+30	City of Greensboro maintenance	VP1 and 2
	17+75 - 17+95	City of Greensboro maintenance	
Invasive/Exotic Population	Scattered Throughout	Microstegium: previously established	VP3
	Scattered Throughout	Chinese privet: previously established	
	Scattered Throughout	Japanese honeysuckle: previously established	
	Scattered Throughout	Mimosa: outside seed source	
	Scattered Throughout	Ornamental pear tree: outside seed source	

Table A6b. Vegetative Problem Areas
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 2 (1,135 ft.)

Feature/Issue	Station # / Range	Probable Cause	Photo #
Invasive/Exotic Population	Scattered Throughout	Microstegium: previously established	
	Scattered Throughout	Chinese privet: previously established	
	Scattered Throughout	Japanese honeysuckle: previously establish	
	Scattered Throughout	Mimosa: outside seed source	
	Scattered Throughout	Ornamental pear tree: outside seed source	

A2 – Representative Vegetation Problem Area Photos

VP1 - Mowed vegetative buffer south of Florida Ave. Photo taken near Station 10+00. 10/29/08 - MY 04

VP2 – Underbrush cleared and trees limbed up to approximately 5 feet high in the conservation easement. Photo taken near Station 12+00. 10/29/08 - MY 04

VP3 – Kudzu growing on a mimosa tree, taken near Station 14+30. Also note the cleared riparian area and that the streamside vegetation in the foreground has been significantly pruned. 10/29/08 - MY 04

A3 - Vegetation Monitoring Plot Photos

Plot 1 Photo – Taken looking south from the north corner. 10/29/08 - MY 04

Plot 2 Photo – Taken looking south from the north corner. 10/29/08 - MY 04

Plot 3 Photo – Taken looking north from the south corner. 10/29/08 - MY 04

Plot 4 Photo – Taken looking northwest from the southeast corner. 10/29/08 - MY 04

Plot 5 Photo – Taken looking east from the west corner. 10/29/08 - MY 04

Appendix B
Geomorphologic Data

B1 – Representative Stream Problem Area Photos

SP1 - Bank erosion. Photo taken near Station 25+50. 11/5/08 - MY 4

SP2 - Step pool structure failed, de-stabilizing stormwater outlet. Photo taken near Station 19+00. 11/5/08 - MY 04

SP3 - Bank erosion has occurred behind rootwads. Photo taken near Station 26+75. 11/5/08 - MY 04

SP4 – Aggradation has occurred, creating a mid-channel bar. Photo taken near Station 12+75. 10/29/08 - MY 04

SP5 - Stream aggradation on right side of A-Vane. Photo taken near Station 20+00. 10/29/08 - MY 04

B2 - Stream Photo Station Photos

PP#1 – MY04 – 11/5/08

PP#2 – MY04 – 11/5/08

PP#3 – MY04 – 11/5/08

PP#4 – MY04 – 11/5/08

PP#5 – MY04 – 11/5/08

PP#6 – MY04 – 11/5/08

PP#7 – MY04 – 11/5/08

PP#8 – MY04 – 11/5/08

PP#9 – MY04 – 11/5/08

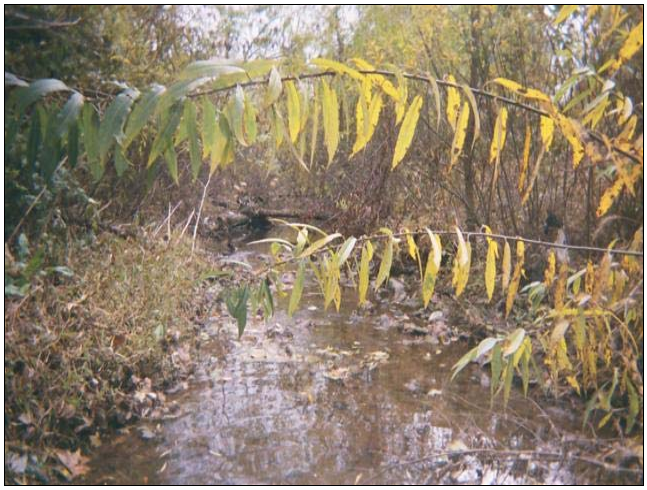
PP#10A – MY04 – 11/5/08

PP#10B – MY04 – 11/5/08

PP#11A – MY04 – 11/5/08

PP#11B – MY04 – 11/5/08

PP#12A – MY04 – 11/5/08



PP#12B – MY04 – 11/5/08

PP#13 – MY04 – 11/5/08

PP#14 – MY04 – 11/5/08

PP#15 – MY04 – 11/5/08

PP#16 – MY04 – 11/5/08

PP#17 – MY04 – 11/5/08

PP#18A – MY04 – 11/5/08

PP#18B – MY04 – 11/5/08

PP#19 – MY04 – 11/5/08

PP#20 – MY04 – 11/7/08

PP#21 – MY04 – 11/7/08

PP#22 – MY04 – 11/5/08

PP#23A – MY04 – 11/5/08

PP#23B – MY04 – 11/5/08

PP#24 – MY04 – 11/5/08

PP#25 – MY04 – 11/5/08

PP#26 – MY04 – 11/5/08

PP#27 – MY04 – 11/5/08

PP#28 – MY04 – 11/5/08

PP#29 – MY04 – 11/5/08

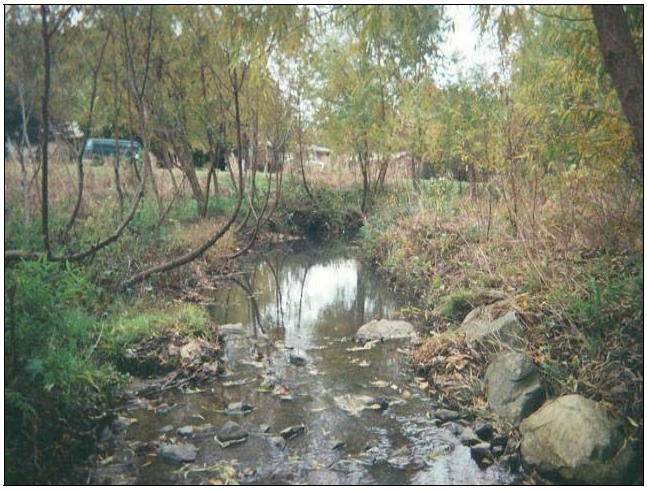
PP#30 – MY04 – 11/5/08

PP#31A – MY04 – 11/5/08

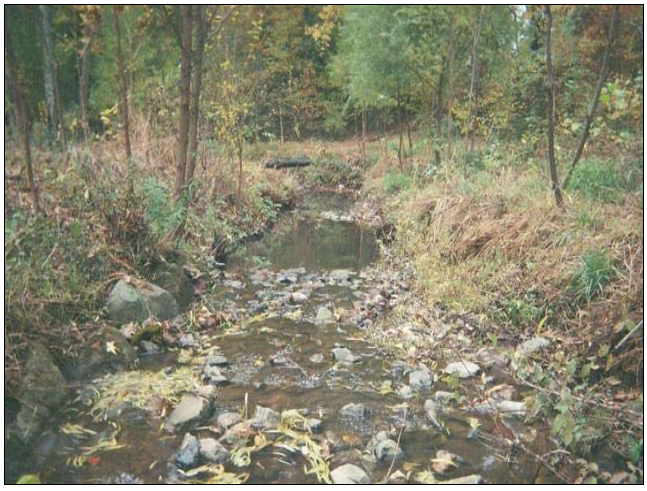
PP#31B – MY04 – 11/5/08

PP#32 – MY04 – 11/5/08

PP#33 – MY04 – 11/5/08



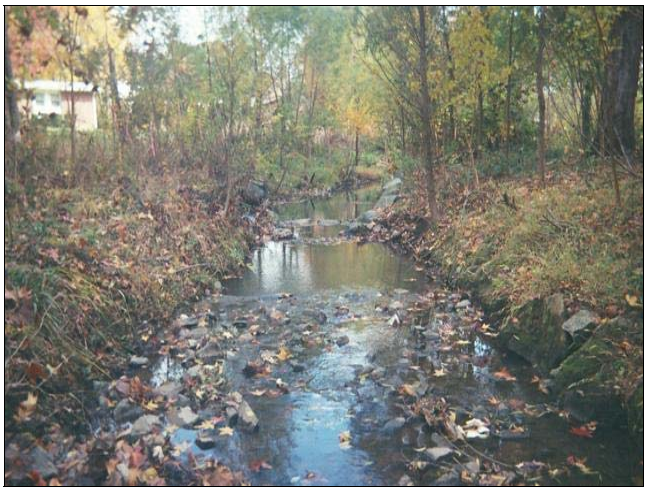
PP#34 – MY04 – 11/5/08



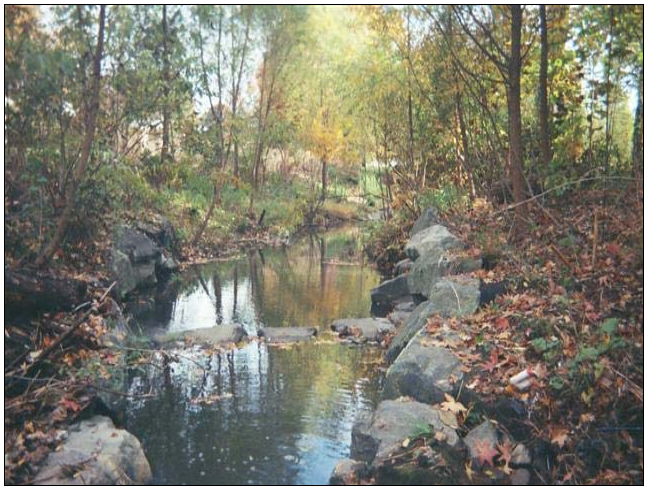
PP#35 – MY04 – 11/5/08

PP#36A – MY04 – 11/5/08

PP#36B – MY04 – 11/5/08

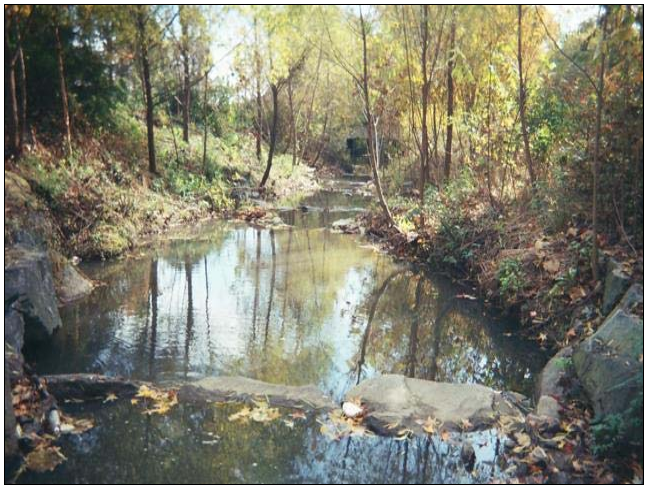


PP#37 – MY04 – 11/5/08

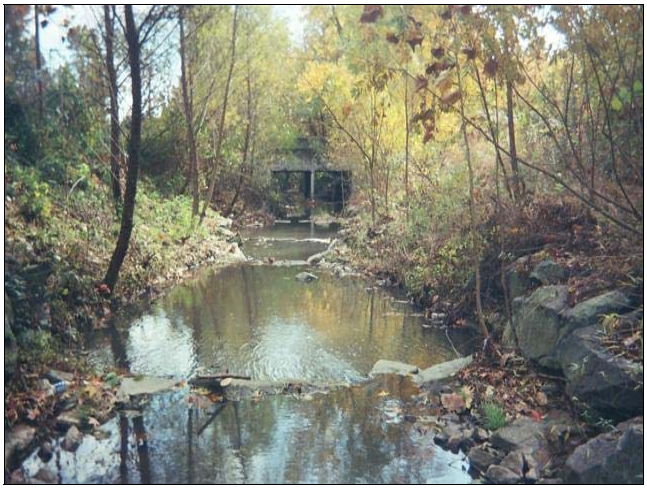


PP#38 – MY04 – 11/5/08

PP#39 – MY04 – 11/5/08

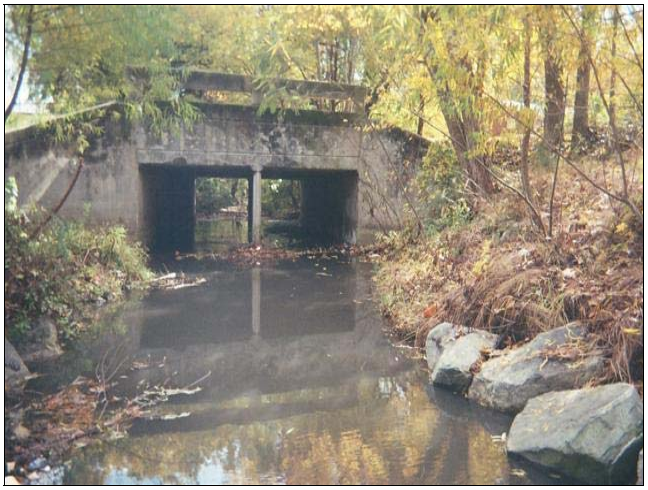


PP#40 – MY04 – 11/5/08



PP#41 – MY04 – 11/5/08

PP#42 – MY04 – 11/5/08



PP#43 – MY04 – 11/5/08

PP#44 – MY04 – 11/7/08

B3 - Qualitative Visual Stability Assessment

Table B2a. Qualitative Visual Stability Assessment
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 1 (780 ft.)

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?	11	7	N/A	157%	
	2. Armor stable (e.g. no displacement)?	7	7	N/A	100%	
	3. Facet grade appears stable?	6	7	N/A	86%	
	4. Minimal evidence of embedding/fining?	7	7	N/A	100%	
	5. Length appropriate?	10	7	N/A	143%	**117%****
B. Pools	1. Present? (e.g. no severe aggradation)	13	10	N/A	130%	
	2. Sufficiently deep (Dmax pool:Mean Bkf > 1.6?)	13	10	N/A	130%	
	3. Length appropriate?	11	10	N/A	110%	**123%****
C. Thalweg #	1. Upstream of meander bend centering?			N/A		
	2. Downstream of meander centering?			N/A		
D. Meanders #	1. Outer bend in state of limited/controlled erosion?			N/A		
	2. Of those eroding, # w/ concomitant point bar			N/A		
	3. Apparent Rc within spec?			N/A		
	4. Sufficient floodplain access and relief?			N/A		
E. Bed General	1.General channel bed aggradation areas (bar formation)	N/A	N/A	1/5	99%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?	N/A	N/A	0/0	100%	**99%**
F. Bank	1.Actively eroding, wasting, or slumping bank	N/A	N/A	3/55	96%	**96%**
G. Vanes	1. Free of back or arm scour?	6	6	N/A	100%	
	2. Height appropriate?	6	6	N/A	100%	
	3. Angle and geometry appear appropriate?	6	6	N/A	100%	
	4. Free of piping or other structural failures?	6	6	N/A	100%	**100%**

*Total number of features per as-built estimated from as-built profile and planview sheets.

** The total number of features for monitoring year 4 is greater than the number of features in the as-built profile.

Reach 1 is not a meandering channel.

Table B2b. Qualitative Visual Stability Assessment
Project Number and Name: 29 – Benbow Park
Segment/Reach: Reach 2 (1,135 ft.)

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?	8	7	N/A	114%	
	2. Armor stable (e.g. no displacement)?	7	7	N/A	100%	
	3. Facet grade appears stable?	4	7	N/A	57%	
	4. Minimal evidence of embedding/fining?	4	7	N/A	57%	
	5. Length appropriate?	7	7	N/A	100%	**86%**
B. Pools**	1. Present? (e.g. no severe aggradation)	22	14	N/A	157%	
	2. Sufficiently deep (Dmax pool:Mean Bkf > 1.6?)	22	14	N/A	157%	
	3. Length appropriate?	19	14	N/A	136%	**150%**
C. Thalweg	1. Upstream of meander bend centering?	4	6	N/A	67%	
	2. Downstream of meander centering?	4	6	N/A	67%	**67%**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	5	7	N/A	71%	
	2. Of those eroding, # w/ concomitant point bar formation?	1	2	N/A	50%	
	3. Apparent Rc within spec?[#]	N/A	7	N/A	N/A	
	4. Sufficient floodplain access and relief?	6	7	N/A	86%	**61%**
E. Bed General	1.General channel bed aggradation areas (bar formation)	N/A	N/A	4/125	86%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting?	N/A	N/A	0/0	100%	**93%**
F. Bank	1.Actively eroding, wasting, or slumping bank	N/A	N/A	2/30	98%	**98%**
G. Vanes	1. Free of back or arm scour?	14	16	N/A	88%	
	2. Height appropriate?	16	16	N/A	100%	
	3. Angle and geometry appear appropriate?	16	16	N/A	100%	
	4. Free of piping or other structural failures?	16	16	N/A	100%	**97%**
H. Wads / Boulders	1. Free of scour?	4	6	N/A	67%	
	2. Footing stable?	6	6	N/A	100%	**84%**

*Total number of features per as-built estimated from as-built profile and planview sheets.

** The total number of features for monitoring year 4 is greater than the number of features in the as-built profile.

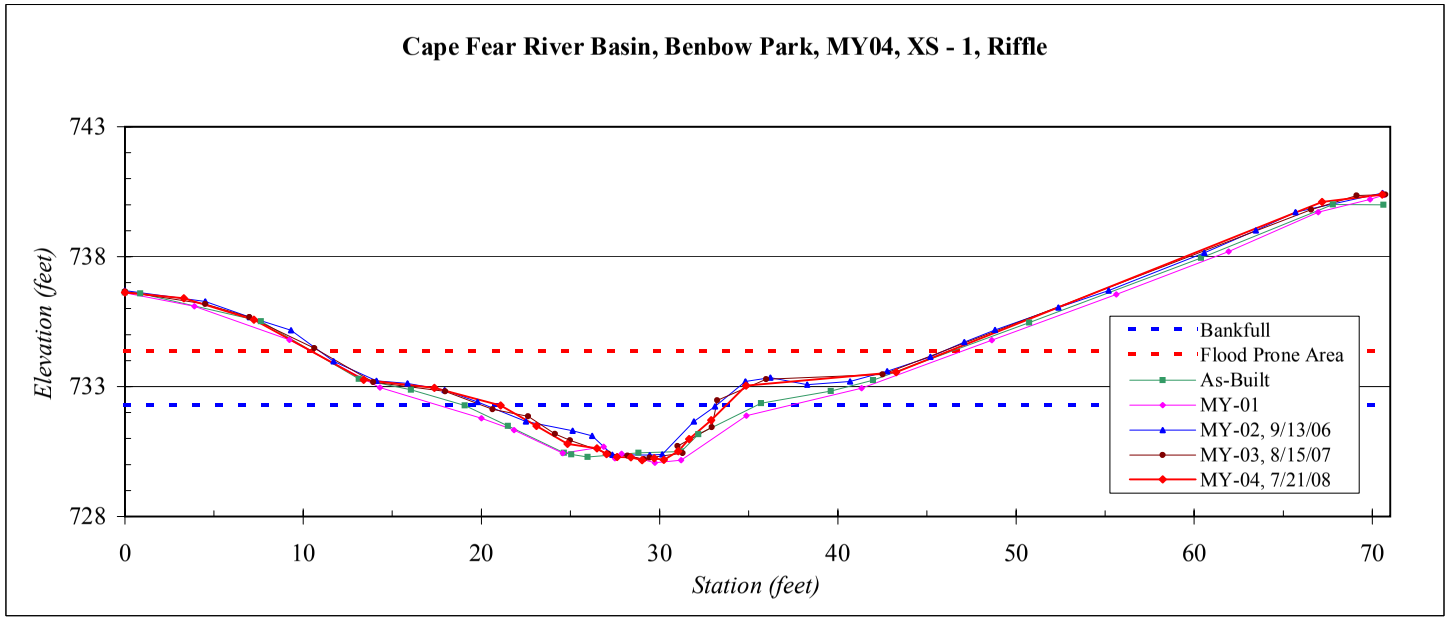
No design data is available to compare to current values.

B4 - Cross-Section Plots

River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 1, Riffle
Drainage Area (sq mi):	0.7
Date:	7/21/2008
Field Crew:	B. Roberts, K. Vaughan

Station	Elevation
0.0	736.62
3.3	736.40
7.2	735.57
13.4	733.26
17.4	732.95
21.1	732.27
23.1	731.48
24.8	730.80
26.5	730.63
27.0	730.40
27.6	730.29
28.4	730.28
29.0	730.17
29.7	730.25
30.2	730.19
31.0	730.52
31.6	730.98
32.9	731.71
34.8	733.04
43.3	733.56
67.2	740.11
70.5	740.39

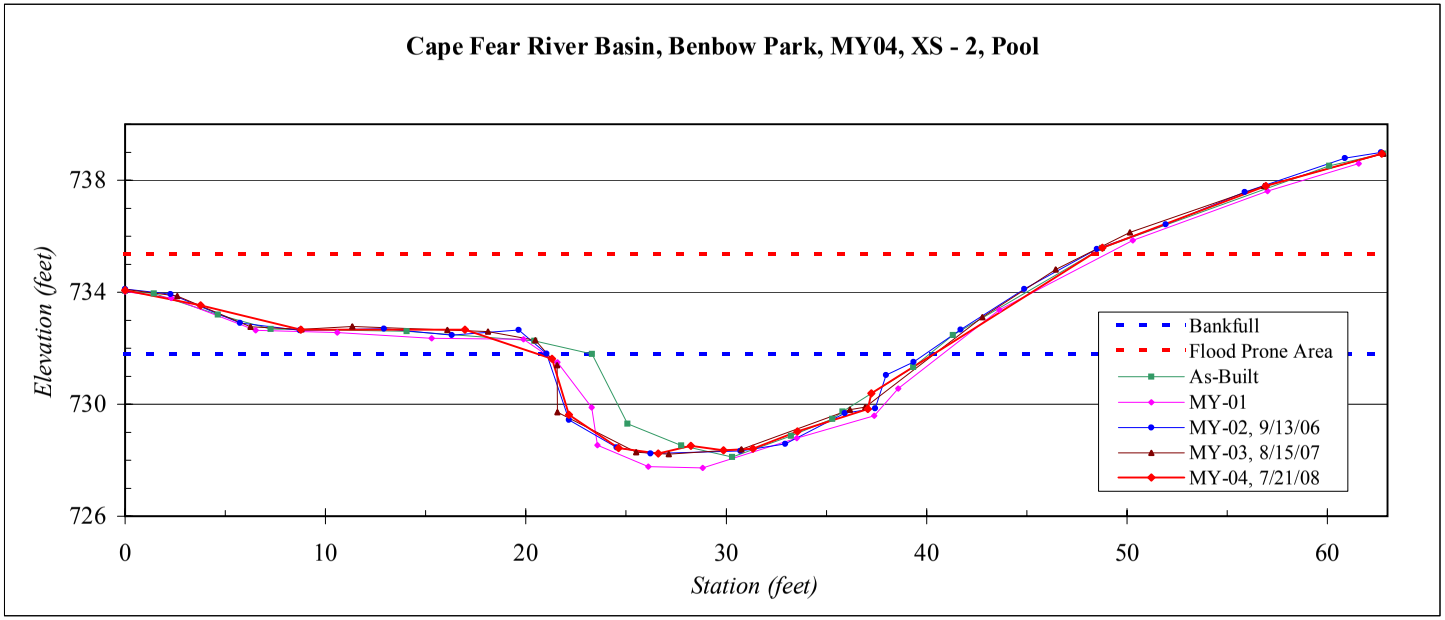
SUMMARY DATA	
Bankfull Elevation:	732.3
Bankfull Cross Sectional Area:	17.0
Bankfull Width:	12.8
Flood Prone Area Elevation:	734.4
Flood Prone Width:	36.2
Max Depth at Bankfull:	2.1
Mean Depth at Bankfull:	1.3
W / D Ratio:	9.6
Entrenchment Ratio:	2.8
Bank Height Ratio:	1.0



River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 2, Pool
Drainage Area (sq mi):	0.7
Date:	7/21/2008
Field Crew:	B. Roberts, K. Vaughan

Station	Elevation
0.0	734.06
3.8	733.53
8.8	732.66
17.0	732.67
21.3	731.62
22.2	729.63
24.6	728.43
26.6	728.24
28.2	728.51
29.9	728.36
31.3	728.41
33.6	729.03
37.1	729.83
37.2	730.39
48.8	735.59
56.9	737.79
62.7	738.95

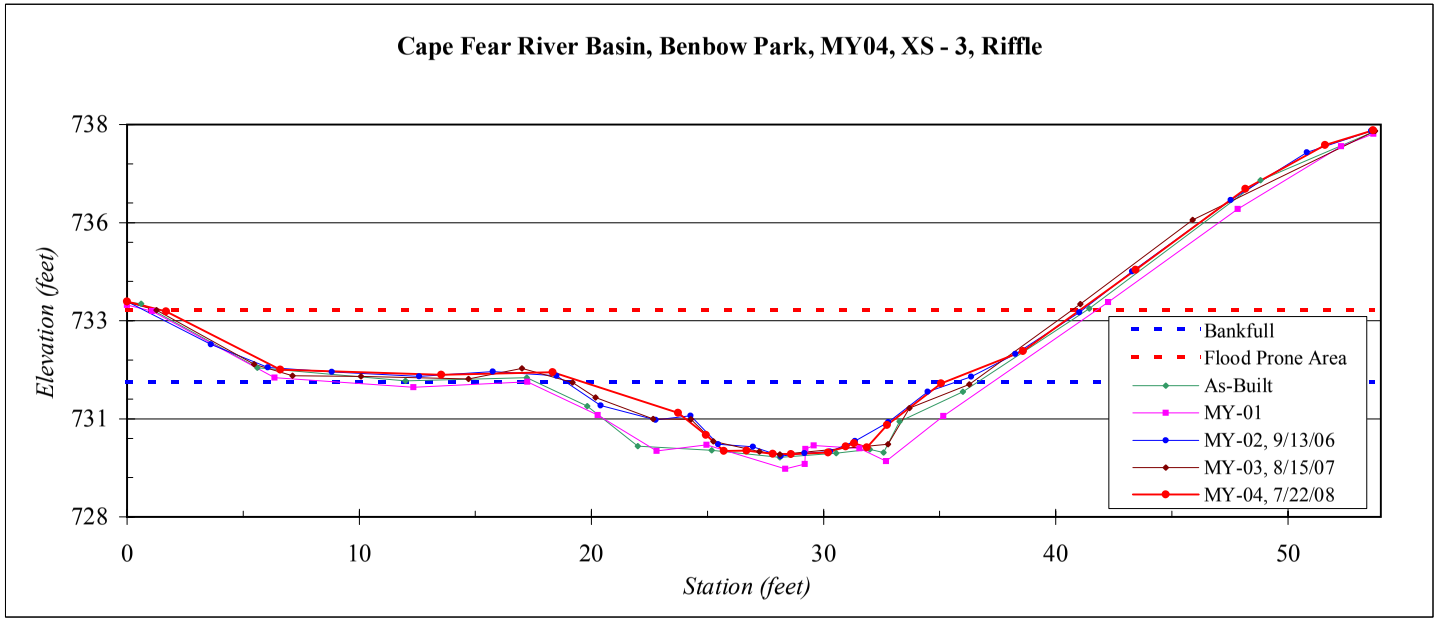
SUMMARY DATA	
Bankfull Elevation:	731.8
Bankfull Cross Sectional Area:	48.5
Bankfull Width:	19.8
Flood Prone Area Elevation:	735.4
Flood Prone Width:	>50
Max Depth at Bankfull:	3.6
Mean Depth at Bankfull:	2.4
W / D Ratio:	8.1
Entrenchment Ratio:	>2.5
Bank Height Ratio:	1.2



River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 3, Riffle
Drainage Area (sq mi):	0.7
Date:	7/22/2008
Field Crew:	B. Roberts, K. Vaughan

Station	Elevation
0.0	733.49
1.7	733.24
6.6	731.75
13.5	731.62
18.3	731.69
23.7	730.65
24.9	730.09
25.7	729.68
26.7	729.69
27.8	729.61
28.6	729.60
30.2	729.64
31.0	729.80
31.3	729.88
31.9	729.77
32.7	730.34
35.1	731.40
38.6	732.22
43.4	734.30
48.2	736.36
51.6	737.48
53.7	737.85

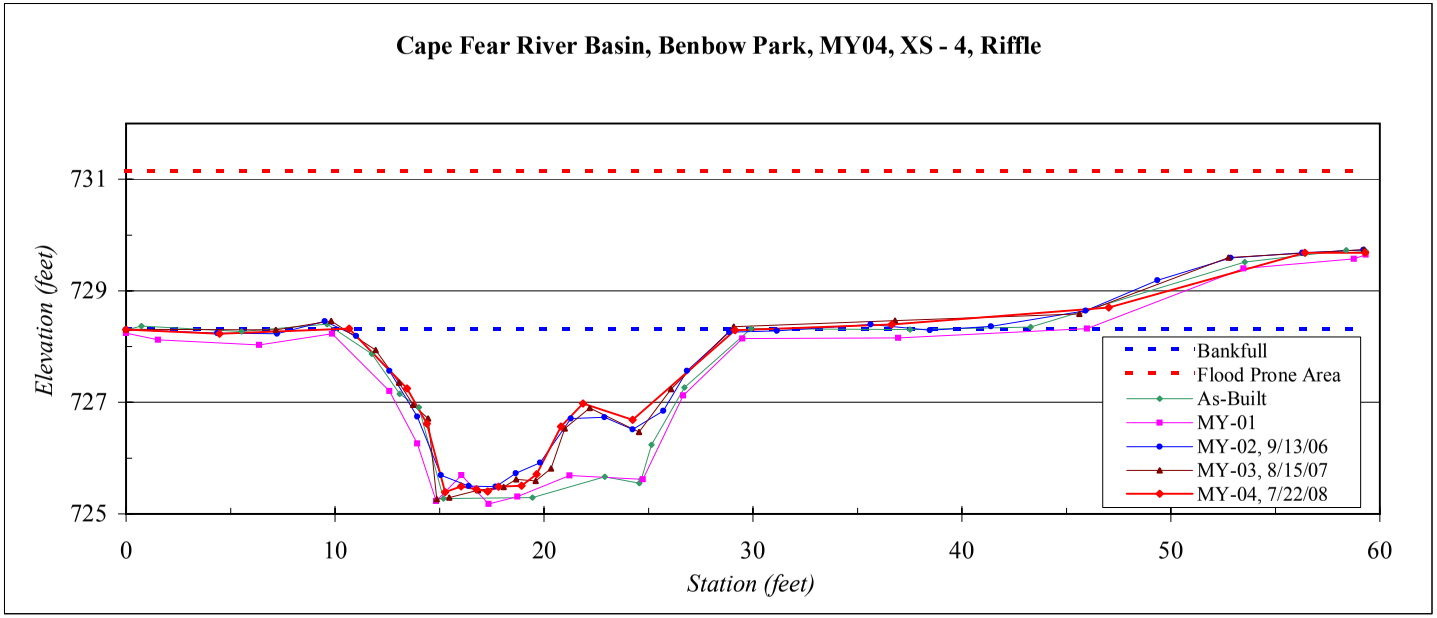
SUMMARY DATA	
Bankfull Elevation:	731.4
Bankfull Cross Sectional Area:	17.5
Bankfull Width:	15.6
Flood Prone Area Elevation:	733.3
Flood Prone Width:	39
Max Depth at Bankfull:	1.8
Mean Depth at Bankfull:	1.1
W / D Ratio:	13.9
Entrenchment Ratio:	2.5
Bank Height Ratio:	1.0



River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 4, Riffle
Drainage Area (sq mi):	0.7
Date:	7/22/2008
Field Crew:	B. Roberts, K. Vaughan

Station	Elevation
0.0	728.31
4.5	728.23
10.7	728.32
13.4	727.25
14.4	726.62
15.3	725.39
16.0	725.49
16.8	725.44
17.3	725.40
17.8	725.49
18.9	725.51
19.6	725.71
20.8	726.57
21.9	726.98
24.2	726.69
29.1	728.30
36.6	728.40
47.0	728.70
56.4	729.68
59.3	729.68

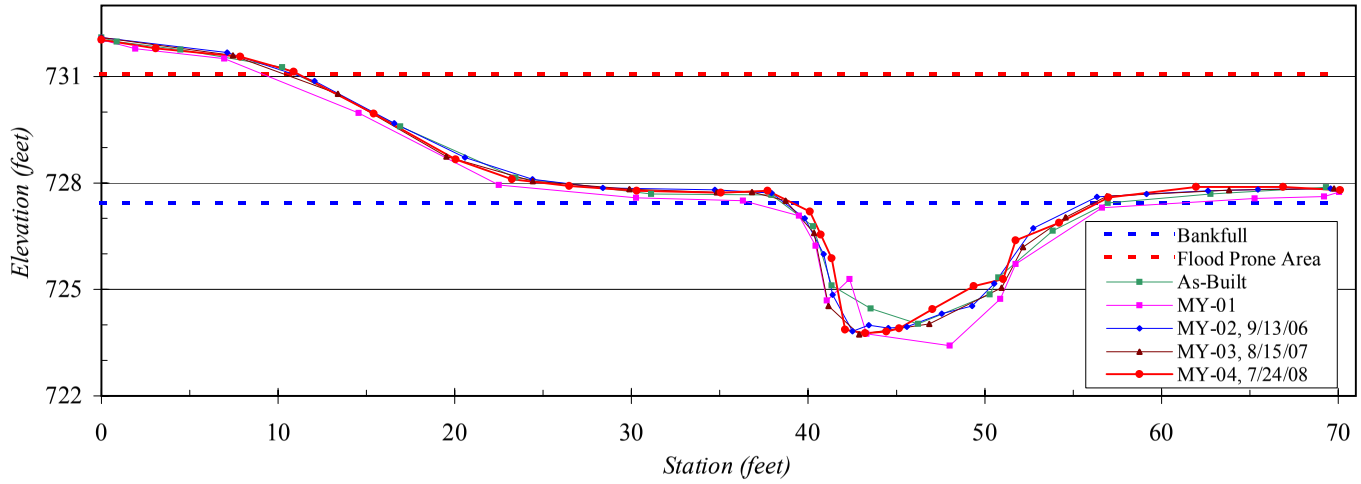
SUMMARY DATA	
Bankfull Elevation:	728.3
Bankfull Cross Sectional Area:	29.0
Bankfull Width:	18.5
Flood Prone Area Elevation:	731.2
Flood Prone Width:	>60
Max Depth at Bankfull:	2.9
Mean Depth at Bankfull:	1.6
W / D Ratio:	11.8
Entrenchment Ratio:	>3
Bank Height Ratio:	1.0



River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 5, Pool
Drainage Area (sq mi):	0.7
Date:	7/24/2008
Field Crew:	B. Roberts, K. Vaughan

Station	Elevation
0.0	732.04
3.1	731.79
7.9	731.56
10.9	731.14
15.4	729.96
20.0	728.66
23.2	728.10
26.5	727.92
30.3	727.78
35.1	727.73
37.7	727.78
40.1	727.20
40.7	726.54
41.3	725.88
42.1	723.86
43.2	723.76
44.4	723.81
45.1	723.90
47.0	724.44
49.4	725.09
51.0	725.29
51.8	726.38
54.2	726.88
57.0	727.59
62.0	727.89
66.9	727.89
70.1	727.80

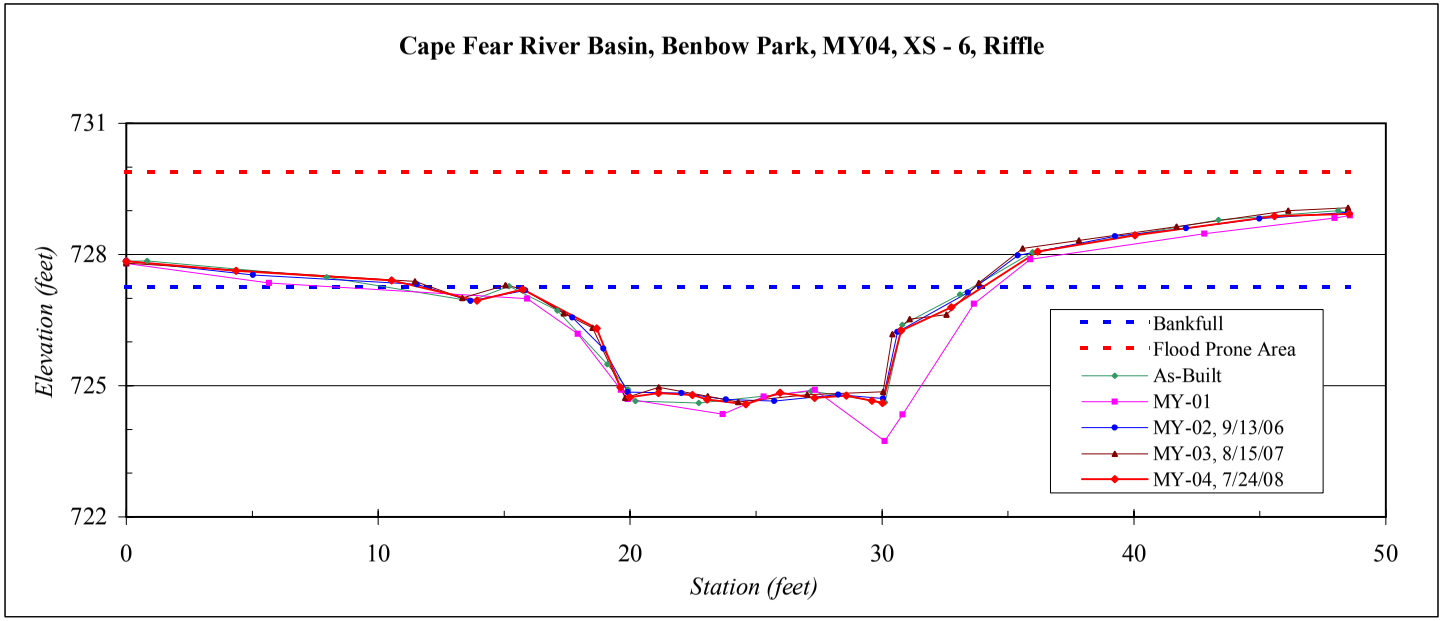
SUMMARY DATA	
Bankfull Elevation:	727.4
Bankfull Cross Sectional Area:	34.2
Bankfull Width:	17.3
Flood Prone Area Elevation:	731.1
Flood Prone Width:	>60
Max Depth at Bankfull:	3.7
Mean Depth at Bankfull:	2.0
W / D Ratio:	8.8
Entrenchment Ratio:	>3
Bank Height Ratio:	1.0



River Basin:	Cape Fear
Watershed:	Benbow Park, MY04
XS ID	XS - 6, Riffle
Drainage Area (sq mi):	0.7
Date:	7/24/2008
Field Crew:	B. Roberts, K. Vaughan

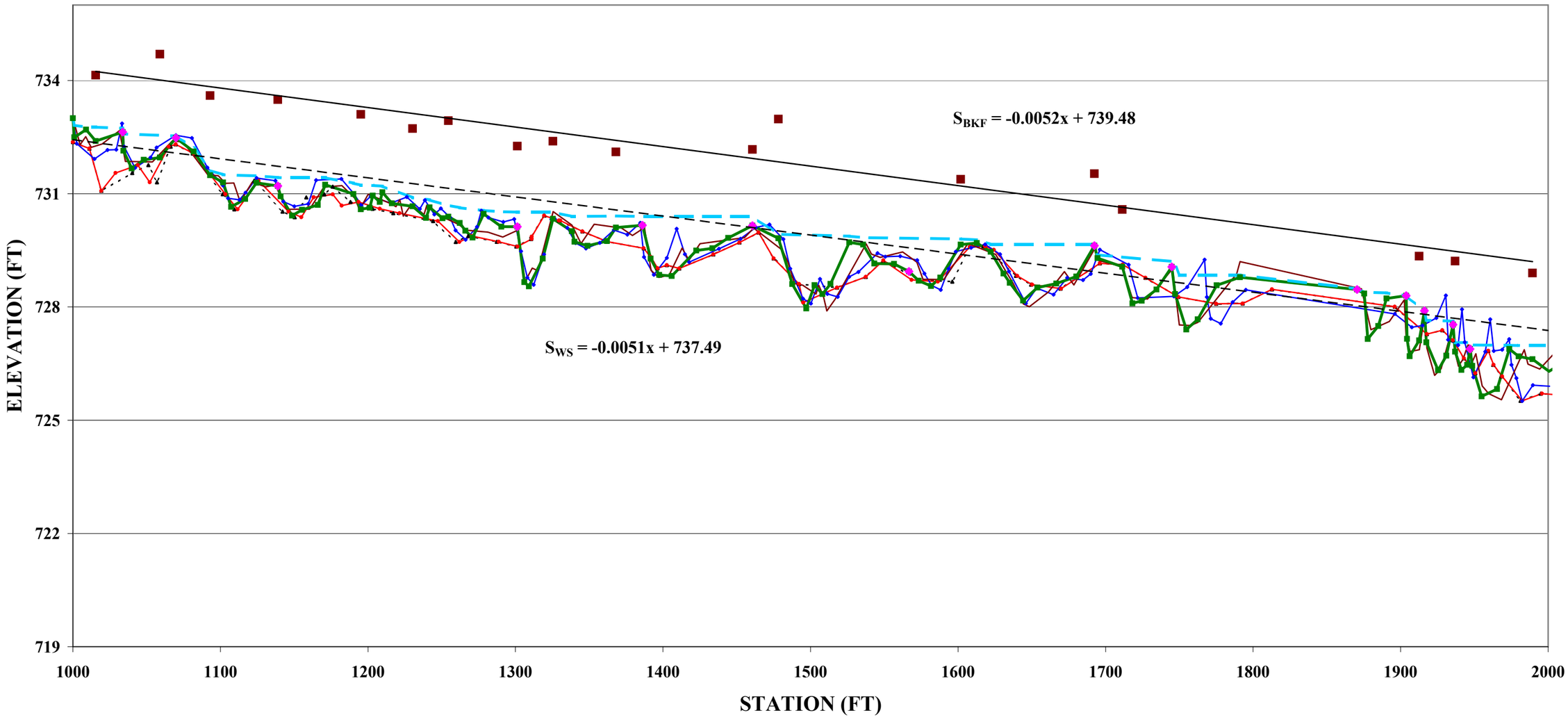
Station	Elevation
0.0	727.84
4.4	727.63
10.5	727.41
13.9	726.94
15.7	727.21
18.7	726.31
19.6	724.97
20.0	724.74
21.1	724.83
22.5	724.79
23.1	724.69
24.6	724.57
26.0	724.84
27.3	724.72
28.6	724.77
29.6	724.66
30.0	724.60
30.8	726.26
32.8	726.79
36.2	728.07
40.0	728.44
45.6	728.88
48.5	728.93

SUMMARY DATA	
Bankfull Elevation:	727.3
Bankfull Cross Sectional Area:	32.6
Bankfull Width:	18.3
Flood Prone Area Elevation:	729.9
Flood Prone Width:	>50
Max Depth at Bankfull:	2.7
Mean Depth at Bankfull:	1.8
W / D Ratio:	10.3
Entrenchment Ratio:	>2.5
Bank Height Ratio:	1.0

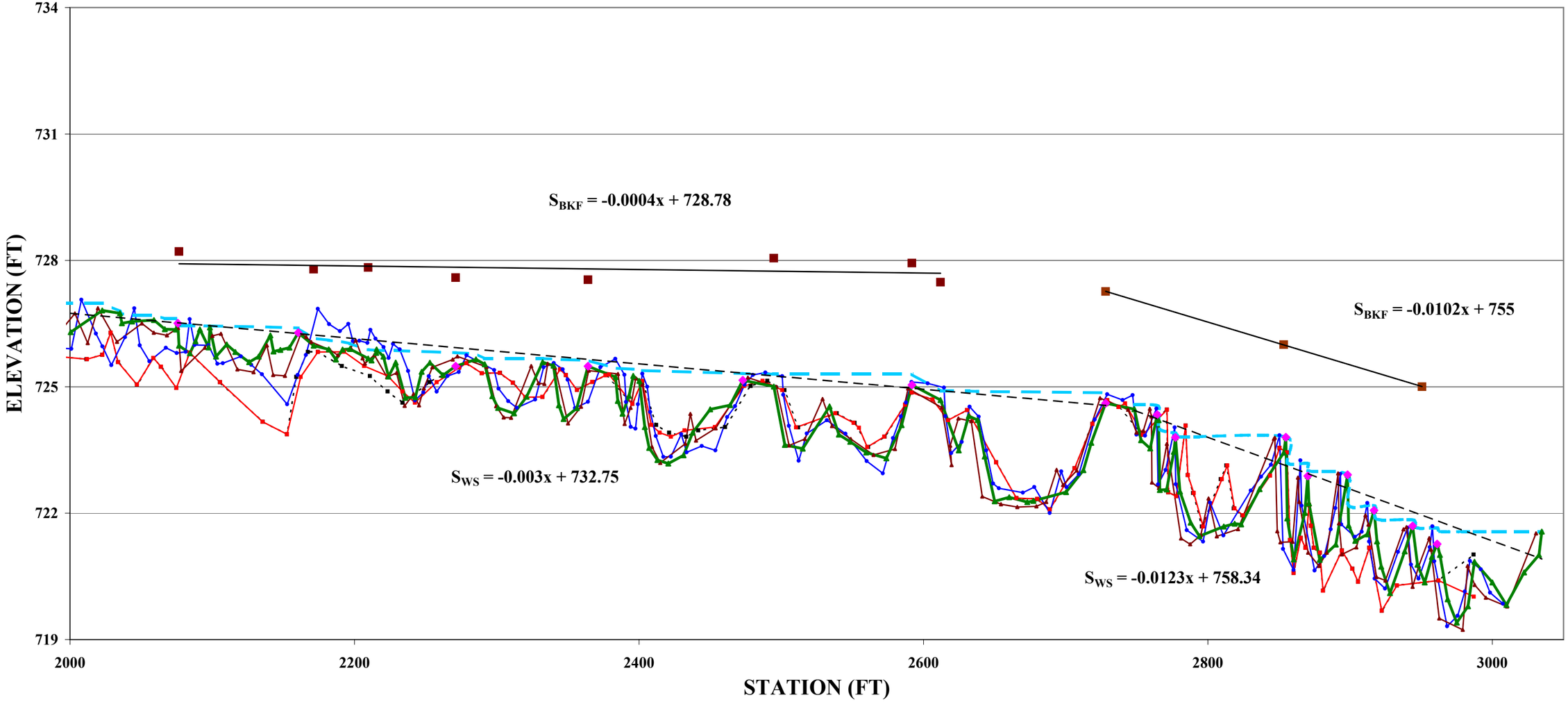


B5 - Longitudinal Plots

Longitudinal Profile
Benbow Park
EEP Project Number 29 - MY04
Stations 10+00 - 20+00



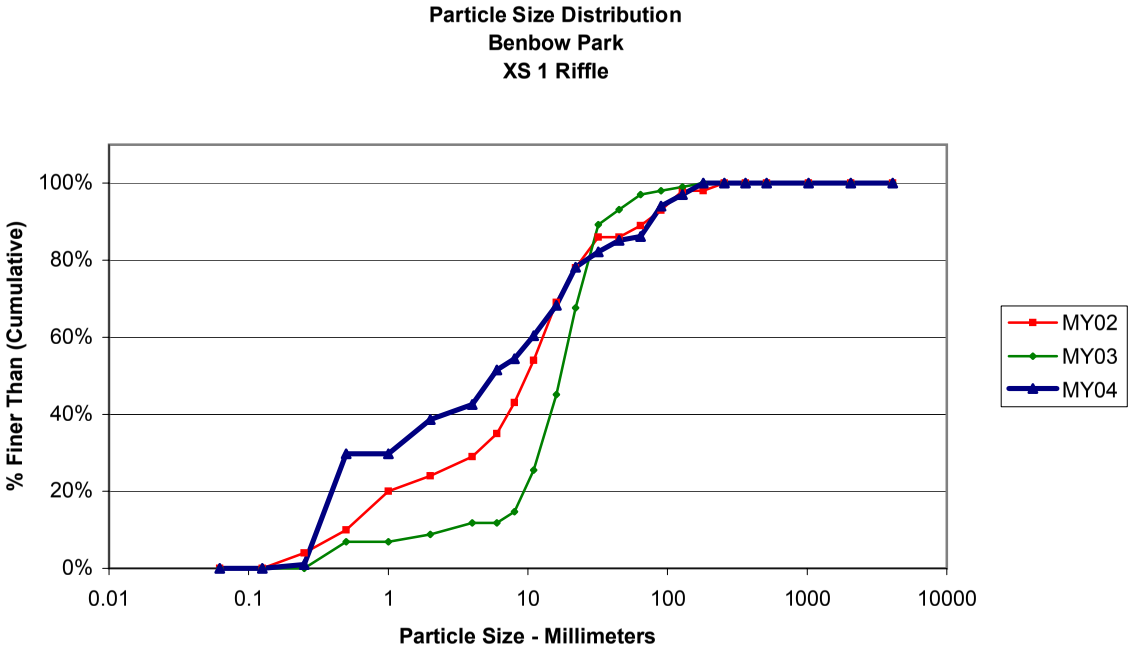
Longitudinal Profile
Benbow Park
EEP Project Number 29 - MY04
Stations 20+00 - 30+50



B6 - Pebble Count Plots

Cross Section 1 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	1
Medium	.25 - .50	N	29
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	9
Very Fine	2 - 4		4
Fine	4 - 5.7	G	9
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	6
Medium	11.3 - 16	V	8
Coarse	16 - 22.6	E	10
Coarse	22.6 - 32	L	4
Very Coarse	32 - 45	S	3
Very Coarse	45 - 64		1
Small	64 - 90	C	8
Small	90 - 128	O	3
Large	128 - 180	B	3
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	101

Note:



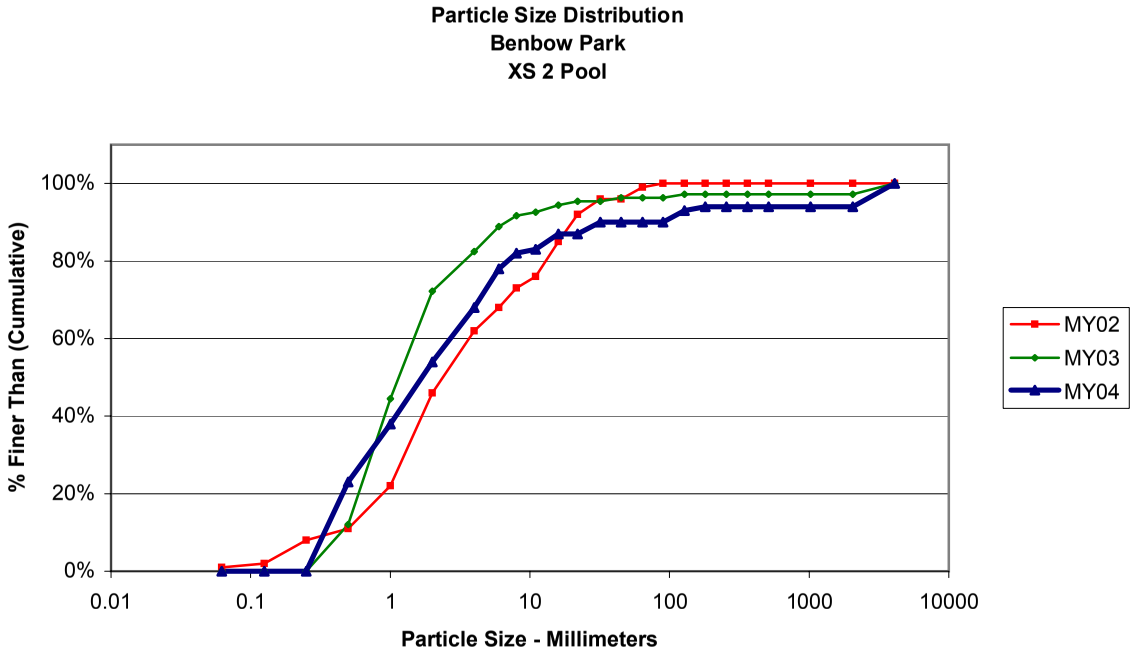
Size (mm)	
D16	0.36
D35	1.5
D50	5.6
D65	14
D84	39
D95	100

Size Distribution	
mean	3.7
dispersion	11.3
skewness	-0.12

Type	
silt/clay	0%
sand	39%
gravel	48%
cobble	14%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross Section 2 Pool - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	23
Coarse	.50 - 1	D	15
Very Coarse	1 - 2	S	16
Very Fine	2 - 4		14
Fine	4 - 5.7	G	10
Fine	5.7 - 8	R	4
Medium	8 - 11.3	A	1
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	3
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	3
Large	128 - 180	B	1
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	6
		Total	100

Note:



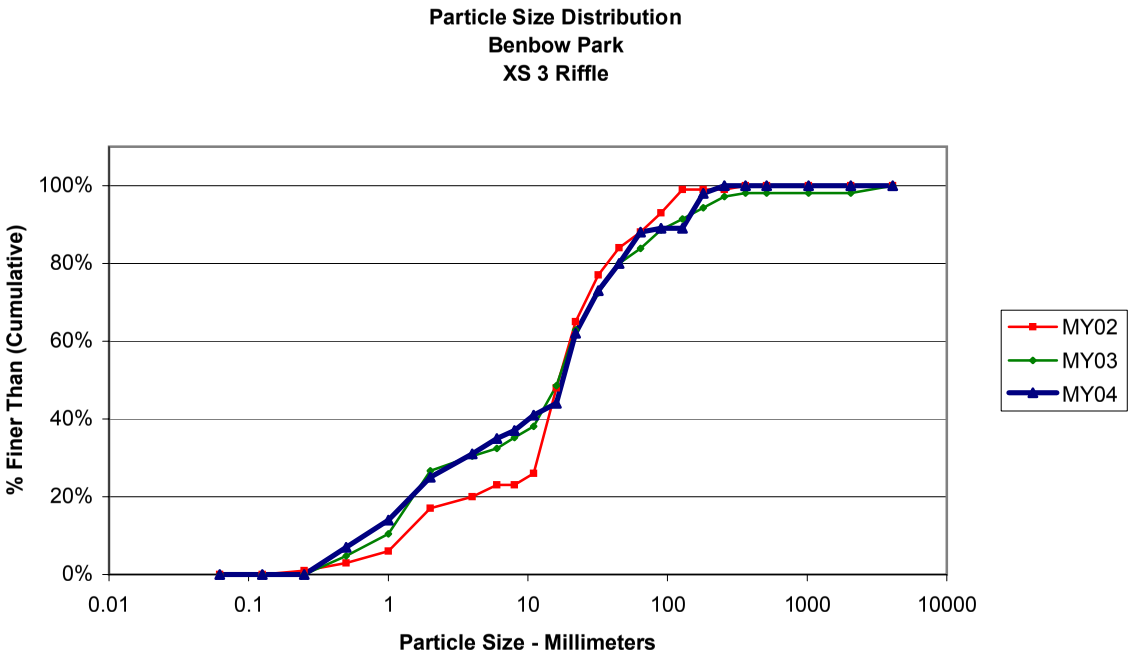
Size (mm)	
D16	0.39
D35	0.79
D50	1.5
D65	2.8
D84	6.4
D95	29

Size Distribution	
mean	1.6
dispersion	4.1
skewness	0.02

Type	
silt/clay	0%
sand	54%
gravel	36%
cobble	4%
boulder	0%
bedrock	6%
hardpan	0%
wood/det	0%
artificial	0%

Cross Section 3 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	7
Coarse	.50 - 1	D	7
Very Coarse	1 - 2	S	11
Very Fine	2 - 4		6
Fine	4 - 5.7	G	4
Fine	5.7 - 8	R	2
Medium	8 - 11.3	A	4
Medium	11.3 - 16	V	3
Coarse	16 - 22.6	E	18
Coarse	22.6 - 32	L	11
Very Coarse	32 - 45	S	7
Very Coarse	45 - 64		8
Small	64 - 90	C	1
Small	90 - 128	O	
Large	128 - 180	B	9
Large	180 - 256	L	2
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



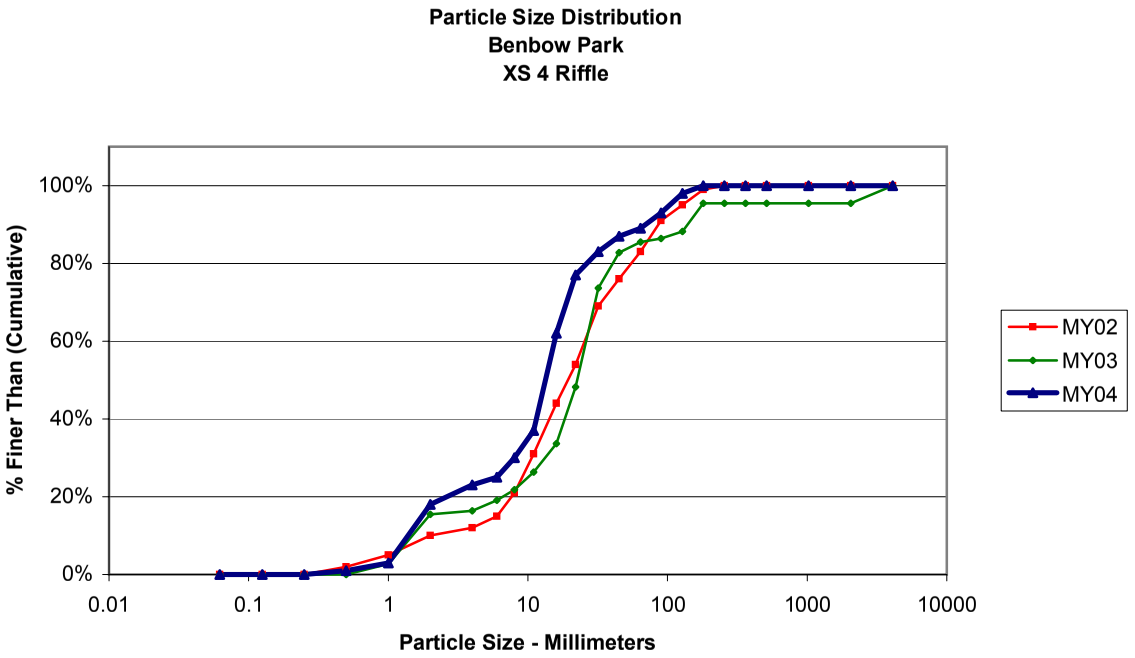
Size (mm)	
D16	1.1
D35	6
D50	18
D65	24
D84	54
D95	160

Size Distribution	
mean	7.7
dispersion	9.7
skewness	-0.28

Type	
silt/clay	0%
sand	25%
gravel	63%
cobble	12%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross Section 4 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	
Medium	.25 - .50	N	1
Coarse	.50 - 1	D	2
Very Coarse	1 - 2	S	15
Very Fine	2 - 4		5
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	5
Medium	8 - 11.3	A	7
Medium	11.3 - 16	V	25
Coarse	16 - 22.6	E	15
Coarse	22.6 - 32	L	6
Very Coarse	32 - 45	S	4
Very Coarse	45 - 64		2
Small	64 - 90	C	4
Small	90 - 128	O	5
Large	128 - 180	B	2
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:



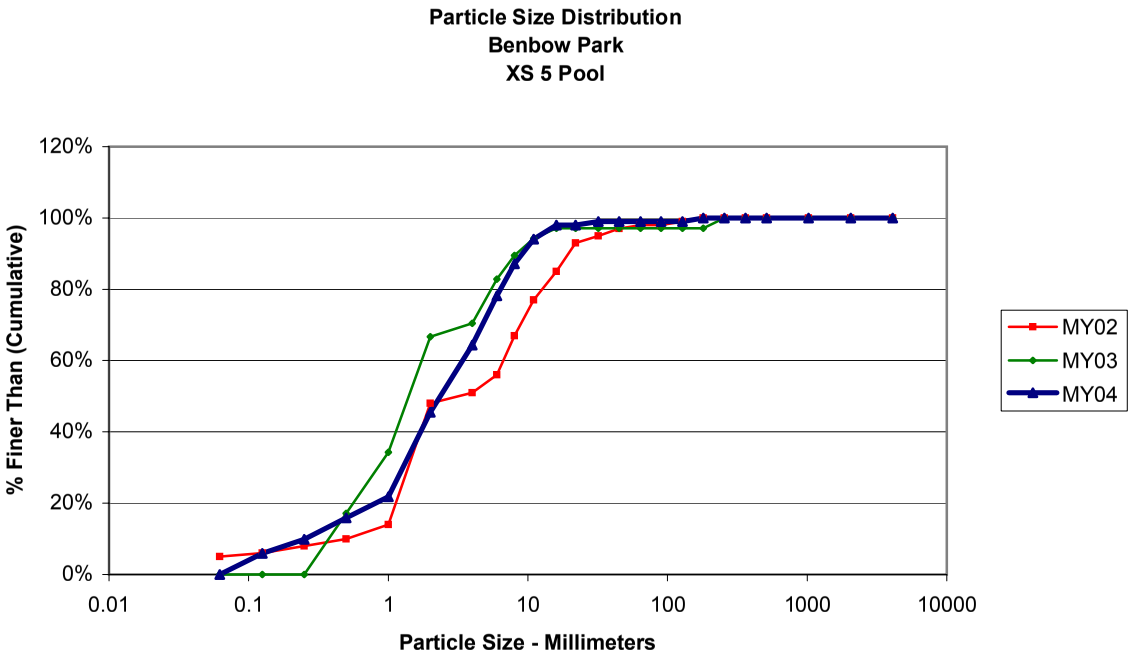
Size (mm)	
D16	1.8
D35	10
D50	13
D65	17
D84	35
D95	100

Size Distribution	
mean	7.9
dispersion	5.0
skewness	-0.19

Type	
silt/clay	0%
sand	18%
gravel	71%
cobble	11%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross Section 5 Pool - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	6
Fine	.125 - .25	A	4
Medium	.25 - .50	N	6
Coarse	.50 - 1	D	6
Very Coarse	1 - 2	S	24
Very Fine	2 - 4		19
Fine	4 - 5.7	G	14
Fine	5.7 - 8	R	9
Medium	8 - 11.3	A	7
Medium	11.3 - 16	V	4
Coarse	16 - 22.6	E	
Coarse	22.6 - 32	L	1
Very Coarse	32 - 45	S	
Very Coarse	45 - 64		
Small	64 - 90	C	
Small	90 - 128	O	
Large	128 - 180	B	1
Large	180 - 256	L	
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	101

Note:



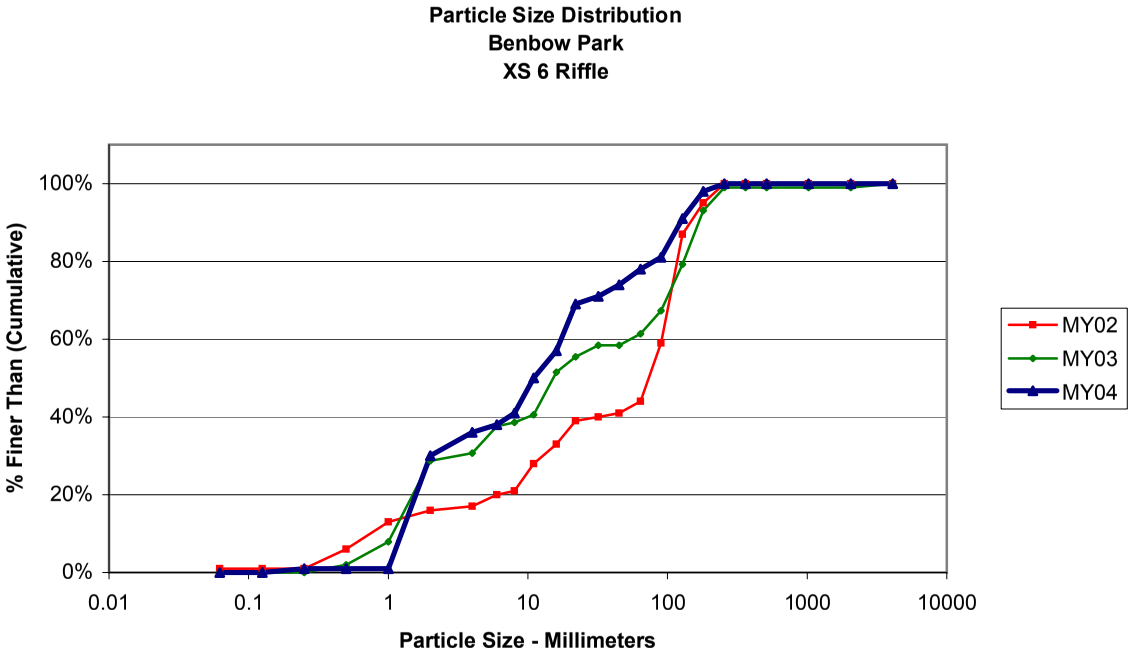
Size (mm)	
D16	0.51
D35	1.5
D50	2.4
D65	4.1
D84	7.2
D95	12

Size Distribution	
mean	1.9
dispersion	3.9
skewness	-0.09

Type	
silt/clay	0%
sand	46%
gravel	53%
cobble	1%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Cross Section 6 Riffle - MY04			
Particle	Millimeter		Count
Silt/Clay	< 0.062	S/C	
Very Fine	.062 - .125	S	
Fine	.125 - .25	A	1
Medium	.25 - .50	N	
Coarse	.50 - 1	D	
Very Coarse	1 - 2	S	29
Very Fine	2 - 4		6
Fine	4 - 5.7	G	2
Fine	5.7 - 8	R	3
Medium	8 - 11.3	A	9
Medium	11.3 - 16	V	7
Coarse	16 - 22.6	E	12
Coarse	22.6 - 32	L	2
Very Coarse	32 - 45	S	3
Very Coarse	45 - 64		4
Small	64 - 90	C	3
Small	90 - 128	O	10
Large	128 - 180	B	7
Large	180 - 256	L	2
Small	256 - 362	B	
Small	362 - 512	L	
Medium	512 - 1024	D	
Lrg- Very Lrg	1024 - 2048	R	
Bedrock	>2048	BDRK	
		Total	100

Note:

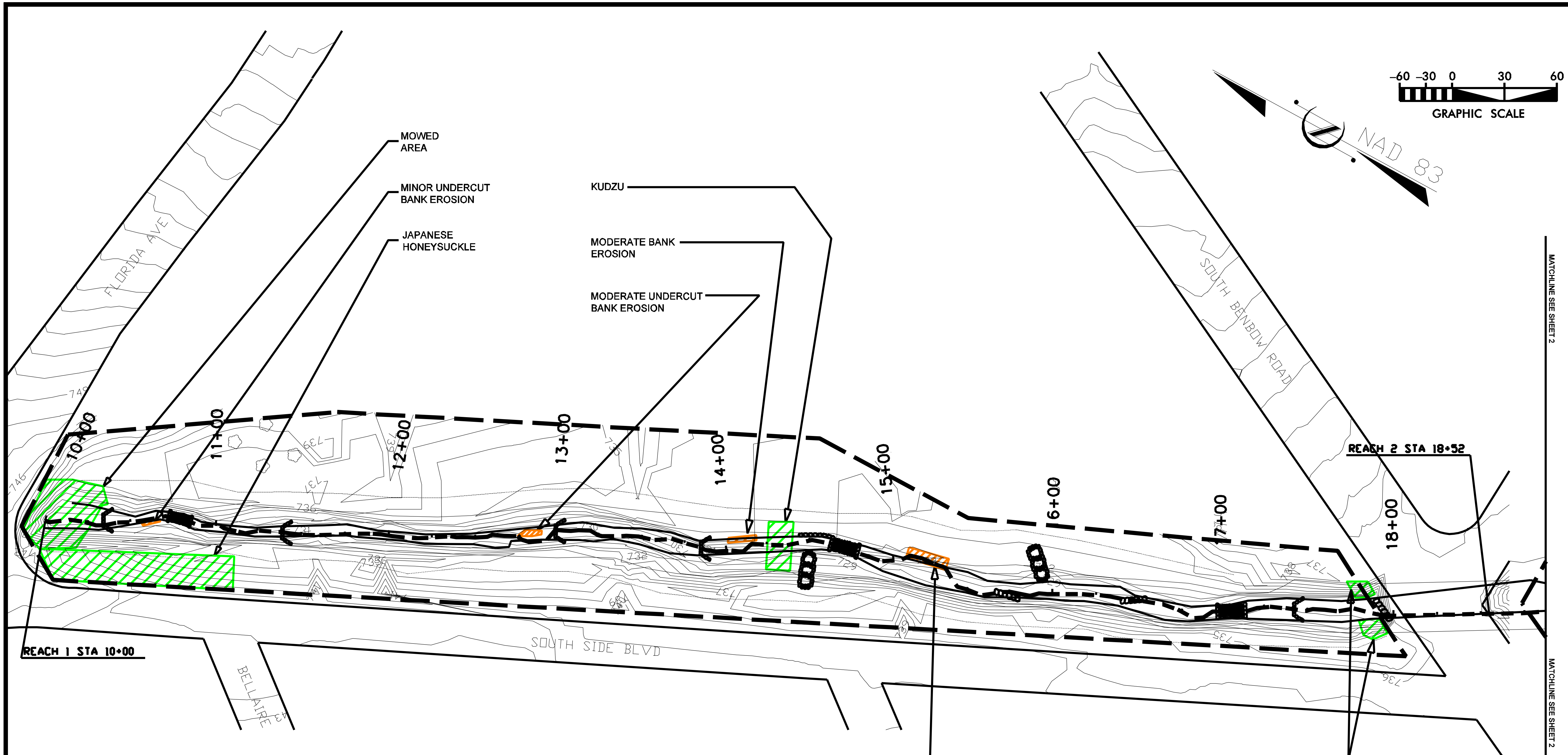


Size (mm)	
D16	1.4
D35	3.6
D50	11
D65	20
D84	100
D95	160

Size Distribution	
mean	11.8
dispersion	8.5
skewness	0.02

Type	
silt/clay	0%
sand	30%
gravel	48%
cobble	22%
boulder	0%
bedrock	0%
hardpan	0%
wood/det	0%
artificial	0%

Appendix C
Current Conditions Plan View



LEGEND

THALWEG	
AS-BUILT VEGETATIVE BUFFER BOUNDARY	
ROOT WAD	
ROCK CROSS VANE	
CONSTRUCTED RIFFLE	
STEP POOL STRUCTURE	
DOUBLE DROP CROSS VANE	
J-HOOK	

GENERAL NOTE:

THE UNDERBRUSH HAS BEEN CLEARED THROUGHOUT THE EASEMENT FROM APPROXIMATELY STATION 10+00 TO 14+50 AND STATION 18+50 TO 29+85, EXCLUDING SOME TREES LARGER THAN APPROXIMATELY 1.5" IN DIAMETER. THE TREES THAT HAVE BEEN LEFT HAVE BEEN LIMBED UP TO APPROXIMATELY 5'.

Ecosystem Enhancement PROGRAM

KCI ASSOCIATES OF NC
ENGINEERS • PLANNERS • SCIENTISTS
4601 SIX FORKS ROAD
RALEIGH, NORTH CAROLINA 27609

BENBOW PARK
GUILFORD COUNTY, NORTH CAROLINA
EEP PROJECT NUMBER 29 - MY04
STATION 10+00 TO STATION 18+87

NOVEMBER 2008
SEE SHEET

CURRENT CONDITIONS PLAN VIEW

1 OF 2

GENERAL NOTE:

THE UNDERBRUSH HAS BEEN CLEARED THROUGHOUT THE EASEMENT FROM APPROXIMATELY STATION 10+00 TO 14+50 AND STATION 18+50 TO 29+85, EXCLUDING SOME TREES LARGER THAN APPROXIMATELY 1.5" IN DIAMETER. THE TREES THAT HAVE BEEN LEFT HAVE BEEN LIMBED UP TO APPROXIMATELY 5'.

LEGEND

- THALWEG
- AS-BUILT VEGETATIVE BUFFER BOUNDARY
- ROOT WAD
- ROCK CROSS VANE
- CONSTRUCTED RIFFLE
- STEP POOL STRUCTURE
- DOUBLE DROP CROSS VANE
- J-HOOK

NAD 83

–60 –30 0 30 60

GRAPHIC SCALE

MATCHLINE SEE SHEET 1

FAILED STEP POOL

MOWED AREA

MODERATE BANK EROSION

MODERATE BED AGGRADATION

MOWED AREA

MODERATE BED AGGRADATION

MOWED AREA

MODERATE BED AGGRADATION

VANE ARM STRESSED DUE TO EROSION FROM FLOODPLAIN WATER RETURNING TO CHANNEL

STRESSED ROOT WADS DUE TO EROSION

MOWED AREA

STRESSED ROOT WADS DUE TO UNDERCUT BANK EROSION

MODERATE BANK EROSION

MOWED AREA

STRESSED ROCK VANE DUE TO BACK ARM SCOUR

MINOR EROSION ALONG LEFT VANE ARM

CONSTRUCTED RIFFLE, UNDER BACKWATER FROM BOX CULVERT.

FINLEY STREE

SOUTH SIDE BLVD

BELCREST RD

20+00 21+00 22+00 23+00 24+00 25+00 26+00 27+00 28+00 29+00

735 734 733 732 731 730 729 728 727 726 725 724 723 722 721

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BENBOW PARK
GUILFORD COUNTY, NORTH CAROLINA
EEP PROJECT NUMBER 29 - MY04

STATION 18+87 TO STATION 29+85

DATE NOVEMBER 2008
SHEET SEE SHEET

CURRENT CONDITIONS PLAN VIEW

SHEET 2 OF 2