Chapel Creek Stream Restoration Project
Orange County, North Carolina

EEP Project #77
SCO ID# 050645701

Mitigation Plan and As-Built Baseline Report - Final

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Chapel Creek Stream Restoration
EEP Project #77
Chapel Hill, North Carolina
Orange County

Mitigation Plan & As-Built Baseline
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Executive Summary

The North Carolina Ecosystem Enhancement Program (EEP) has completed a stream restoration project along approximately 1,350 linear feet of Chapel Creek, located on University of North Carolina property in Chapel Hill, Orange County, North Carolina. The project is located in the Morgan Creek Local Watershed planning area, within the 14-digit HUC 03030002060080. The drainage area for Chapel Creek is approximately 0.42 square miles at the downstream limit of the project where a drainage channel through the A.E. Finley Golf Course flows into Chapel Creek. The land use in the watershed consists of University of North Carolina facilities, single family residential, elementary schools, roadways, and forested land.

The Morgan Creek LWP noted water quality degradation and impaired biological community in the watershed and identified major watershed stressors as: streambank erosion, excess stormwater runoff, and disturbed riparian buffers. The goals of the restoration project are to improve water quality in Chapel Creek and the Cape Fear river basin by:

- Channel restoration of pattern, profile, and dimension for approximately 960 linear feet of Chapel Creek.
- Channel enhancement/stabilization for approximately 330 feet with a Priority Two restoration approach, bankfull bench and stream bank repairs.
- Restore reach to a stable stream channel, capable of transporting flows and sediment load efficiently.
- Improve aquatic habitat by planting trees along the banks in the cleared section to increase shade and adding more sinuosity to create more pool and riffle sections.
- Reduce sediment inputs to the stream from bank erosion by re-vegetating the banks.

There are two distinct types of channels within the project limits of Chapel Creek. The upper reach, existing of the first 957 feet of stream from Highway 15/501 heading southeast, is in a cleared area that was once used as part of the A.E. Finley Golf Course and was regularly mowed and maintained. The lower reach, existing of the last 350 feet of stream, is in a wooded section where trees and other plants provide more bank stabilization and the floodplain has been less disturbed. The design for the upper reach includes approximately 961 linear feet of stream relocation. The design for the lower reach includes benching areas where the stream is entrenched and sloping the banks where possible to give the stream better access to its floodplain for an approximate length of 330 feet. In addition, the project included restoring the riparian buffer to Piedmont Alluvial Forest native plant community.

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1.0 Project Background

1.1 Location and Setting

The restored reach of Chapel Creek is located on University of North Carolina property in Chapel Hill, Orange County, North Carolina (Figure 1). The project begins approximately 40 feet downstream of the existing culvert under Highway 15/501 (Fordham Boulevard). The existing culvert is located approximately 1,200 feet south of the interchange of Highway 15-501 and Highway 54 (Raleigh Road). The study area for Chapel Creek extends downstream from the culvert approximately 1,350 linear feet to approximately 150 feet downstream of an existing bridge crosses. The stream runs through an abandoned fairway of the A.E. Finley Golf Course.

Chapel Creek is located in the Cape Fear River basin (HUC 03030002) and is a tributary to Morgan Creek, which feeds into the Jordan Lake reservoir water supply source. The project site is also in the Morgan Creek Local Watershed planning area (14-digit HUC 03030002060080).

1.2 Project Goals and Objectives

The goals of the restoration project are to improve water quality in Chapel Creek and the Cape Fear river basin by:

- Channel restoration of pattern, profile, and dimension for 961 linear feet of Chapel Creek.
- Channel enhancement/stabilization for 330 feet with a Priority Two restoration approach, bankfull bench.
- The creation of an additional wetland pocket feature where possible to enhance stream and buffer credits.
- Restore the reach to a stable stream channel, capable of transporting flows and sediment load efficiently.
- Improve aquatic habitat by planting trees along the banks in the cleared section to increase shade and adding more sinuosity to create more pool and riffle sections.
- Reduce sediment inputs to the stream from bank erosion by re-vegetating the banks.

1.3 Project Structure, Type, and Approach

Reach 1 of Chapel Creek was restored with a Priority Level I restoration approach for 961 linear feet within the abandoned fairway. The classification of the restored stream is a C4 stream type. The incised stream was reconnected to its floodplain. The stream pattern, profile, and dimension were adjusted to allow the stream to efficiently transport its water and sediment load through a combination of changes to the channel dimension, pattern, and bedform.

The lower reach of Chapel Creek, Reach 2, was enhanced with bankfull benches on one side of the stream to allow flood flows greater than bankfull to expand onto the floodplain. Stream bank locations along the lower reach that were showing signs of erosion were repaired by creating a stable slope, stabilizing the slope with erosion control

matting, and re-vegetating. The length of the Enhancement II reach is 330 feet. The total project area protected by conservation easement is 5.15 acres. A summary of the project components can be found in Tables 1a and 1b.

Three planting zones were developed for the Chapel Creek Stream Restoration project: Zone 1-Wetland Depression, Zone 2-Riparian Buffer, and Zone 3-Streambanks. Zone 1 was planted with species adapted to wetland hydrology. Zone 2 was planted with vegetation typical of a Piedmont Alluvial Forest. Zone 3 was planted with small trees and shrubs typical for a streamside community. A total of 3473 woody stems were planted within the construction limits composed of a total of 23 species. A temporary and perennial seed mix composed of native herbaceous plants was distributed throughout all disturbed surfaces within the conservation easement (Table 9). After the initial planting, 4 vegetation monitoring plots (VP) were established throughout the easement. VP 1 was established along the ephemeral pool margin, VP 2 was established in the floodplain, and VP 3 and 4 were established along the streambanks, with some overlap into the floodplain. Vegetation plots are 100m² in size with Plots 1, 3, and 4 being 5m x 20m and Plot 2 being 10m x 10m in size and shape. The three planting zones and the plant species and quantities are listed in Table 8.

Invasive species such as Chinese privet (*Ligustrum sinense*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), Russian olive (*Elaeagnus angustifolia*), English ivey (*Hedera helix*), and tall fescue (*Lolium arundincaceum*) were treated a glyphosate solution. ----.

1.4 Project History, Contacts, and Attribute Data

The restoration project was completed in July 2008. Two significant rainfall events occurred shortly after construction. A 4.25” inch rainfall event occurred on August 27, 2008 followed by Tropical Storm Hanna, which produced 4.8” in of rain in 8 hours on September 6, 2008; 60% of the precipitation from this even occurred in a 4 hour time period. These events caused some riffles along the stream length to fail. The site was repaired in March 2009. The repaired disturbed area was re-seeded and the containerized plants were installed for the entire project upon completion of the repairs in March 2009. Table 2 summarizes the project activity.

2.0 Success Criteria

2.1 Morphologic Parameters and Channel Stability

2.1.1 Dimension

The dimension parameters of the restored channel should remain stable throughout the monitoring period. Cross sectional overlays should show modest changes from year to year. The channel should not show a trend towards widening or increases in cross-sectional area. Riffle depths should maintain a low bank height ratio (<1.2).

2.1.2 Pattern and Profile

Annual overlays of the longitudinal profile should not indicate significant aggradation of degradation over any substantial continuous lengths of channel. The bedform should develop or be maintained during the monitoring period and be consistent with the reference and design reaches. Variation within bedform parameters is acceptable as long as they are within design distributions. Pattern parameters should show little change over the monitoring period.

2.1.3 Substrate

The substrate should maintain or progress towards the design distribution. Particle size distribution within riffles should coarsen throughout the monitoring period.

2.1.4 Sediment Transport

The success of the parameters described above should be demonstrated by the lack on any significant aggradation or deposition within the channel. Point bar and inner berms should not encroach excessively into the channel. Mid-channel bars should not be present.

2.2 Vegetation

Vegetation monitoring plots set at 100 square meters in size will focus on planted stems only. The success criteria for the preferred species in the restoration areas will be based on annual and cumulative survival and growth over five (5) years. Survival of preferred species must be at a minimum 320 stems/acre at the end of the three years of monitoring and 260 stems/acre after five years. According to initial stem counts within the vegetation monitoring plots 1-4, there are 1277 planted stems/acre (Table7).

2.3 Hydrology

2.3.1 Streams

Two bankfull storm events must be recorded during the standard 5-year monitoring period. For the monitoring to be completed, these events must occur in separate monitoring years.

3.0 Monitoring Plan Guidelines

Monitoring protocol will follow that outlined within the EEP Site Specific Mitigation Plan and detailed in the U.S. Army Corps of Engineers (USACE) Stream Mitigation Guidelines for Monitoring Level I. Monitoring shall occur annually for a minimum of five years and consist of the collection and analysis of stream stability and riparian/stream bank vegetation survivability data to support the evaluation of the project in meeting established restoration objectives. Monitoring shall include measurements of stream dimension, profile, pattern, bed materials, photo documentation, vegetation survivability sampling, and stream bankfull return interval.

3.1 Hydrology

3.1.1 Stream

A crest gage shall be installed on the site to document bankfull events. The gauge shall be checked, documented, and reset during each site visit by the monitoring performer.

3.2 Stream Channel Stability and Geomorphology

This project consisted of a restoration reach and an enhancement reach. Five permanent cross sections were established on the site as detailed below:

- Reach 1 (Restoration): Station 0+00 – 9+94
  - Cross Section 1: Station 3+27 - Riffle
  - Cross Section 2: Station 5+40 - Riffle
  - Cross Section 3: Station 6+28 - Pool
  - Cross Section 4: Station 9+19 - Riffle
- Reach 2 (Enhancement): Station 9+94 – 13+50
  - Cross Section 5: Station 11+23 - Riffle

3.2.1 Dimension

The permanent cross-sections shall be surveyed annually during the monitoring period. These sections should be overlaid to allow for comparison. Dimension parameters shall be calculated from the surveyed cross sections and compared to previous monitoring periods. The dimension data is summarized in Table 5 and detailed by section in Table 6.

3.2.2 Profile and Pattern

The entire length of the restoration site was surveyed for this mitigation plan. The MY-00 profile data for each reach is summarized in Tables 5. For subsequent monitoring years, these reaches shall be surveyed and the profiles overlaid for comparison. Pattern data shall be extracted and compared during the monitoring period.

3.2.3 Visual Assessment

An annual visual assessment shall be conducted during each monitoring year per NCEEP morphometric monitoring guidelines

3.2.4 Bank Stability Assessment

Bank stability assessment (BEHI and NBS) shall be assessed during monitoring year 5.

3.2.5 Vegetation

Four vegetation monitoring plots were established and will focus on planted stems only. The success criteria for the preferred species in the restoration areas will be based on annual and cumulative survival and growth over five (5) years. Survival of preferred species must be at a minimum 320 stems/acre at the end of the three years of monitoring and 260 stems/acre after five years. According to initial stem counts within the vegetation monitoring plots 1-4, there are 1277 planted stems/acre (Table7).

3.2.6 Digital Photos

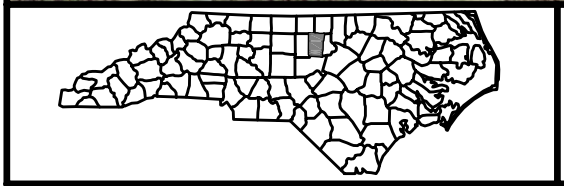
Photo points were established at the start/end of the project and at each cross section. For each subsequent monitoring period, photos shall be taken at the same location and, preferably, within the same two-month window between monitoring periods. The MY-00 photo log can be seen in Appendix D.

4.0 Maintenance and Contingency Plans

If deemed necessary, recommendations for increased monitoring, maintenance, or repair shall be made in the annual monitoring reports. Problem areas shall be located on the monitoring report plan view and tabulated noting the severity and possible causes.

Appendix A

General Tables and Figures



Ecosystem Enhancement PROGRAM

North Carolina – Ecosystem Enhancement Program

Chapel Creek Stream Reference Site
Orange County, North Carolina
SCO ID #050645701

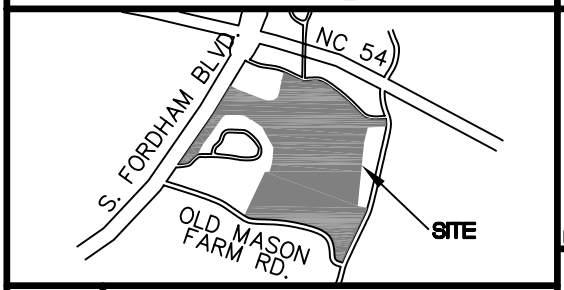


FIGURE 1-A
RESTORATION SITE
CHAPEL CREEK
AERIAL VICINITY MAP

DATE: JULY 25, 2006

N

500 250 0 500

APPROXIMATE SCALE

WARD CONSULTING ENGINEERS, PC

1512 Eglantyne Court
Raleigh, NC 27613

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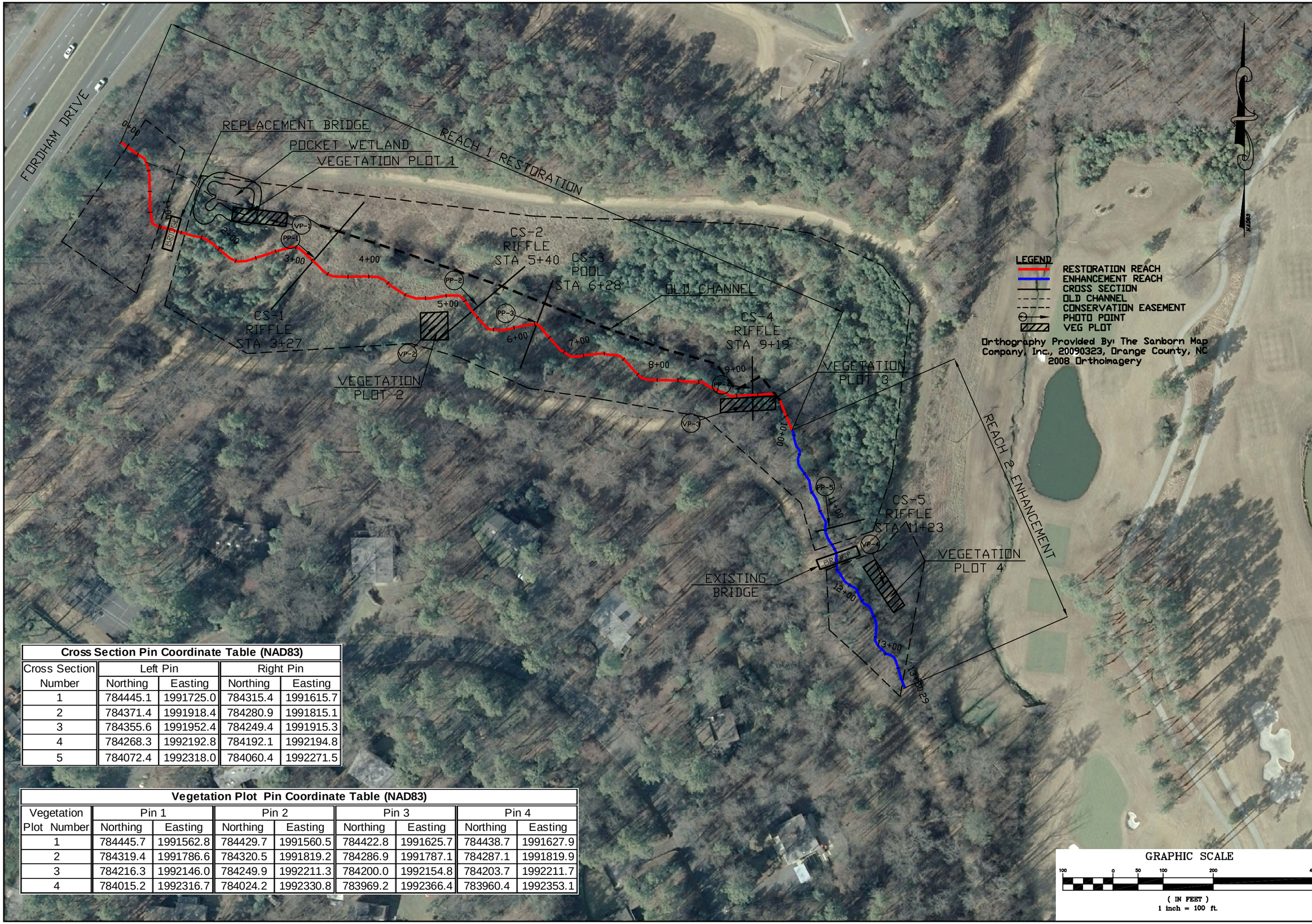
FAX (919) 870-5359



Cross Section Pin Coordinate Table (NAD83)

Cross Section Number	Left Pin		Right Pin	
	Northing	Easting	Northing	Easting
1	784445.1	1991725.0	784315.4	1991615.7
2	784371.4	1991918.4	784280.9	1991815.1
3	784355.6	1991952.4	784249.4	1991915.3
4	784268.3	1992192.8	784192.1	1992194.8
5	784072.4	1992318.0	784060.4	1992271.5

Vegetation Plot Pin Coordinate Table (NAD83)

Vegetation Plot Number	Pin 1		Pin 2		Pin 3		Pin 4	
	Northing	Easting	Northing	Easting	Northing	Easting	Northing	Easting
1	784445.7	1991562.8	784429.7	1991560.5	784422.8	1991625.7	784438.7	1991627.9
2	784319.4	1991786.6	784320.5	1991819.2	784286.9	1991787.1	784287.1	1991819.9
3	784216.3	1992146.0	784249.9	1992211.3	784200.0	1992154.8	784203.7	1992211.7
4	784015.2	1992316.7	784024.2	1992330.8	783969.2	1992366.4	783960.4	1992353.1

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SEAL:

FIGURE 2
CHAPEL CREEK RESTORATION AND ENHANCEMENT
CHAPEL HILL, NORTH CAROLINA

DATE: 12 AUGUST 2009

REVISIONS:

PROJECT NAME: CHAPEL CREEK

DWG NAME: Mitigation Plan

SCALE: 1" = 100'

SHEET NO. 1 OF 1

Table 1a. Project Components Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701							
Project Component or Reach ID	**Pre-Existing Footage**	**Restoration Level**	**Approach**	**Restored Footage**	**Stationing**	**Buffer Acres**	**Comment**
Reach I	957	R	P1	961	0+00 – 9+94	1.2	Includes 900 lf of channel relocation
Reach II	356	EII	P3	330	9+94 – 13+50	-	

Table 1b. Component Summations Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701							
Restoration Level	Stream (lf)	Riparian Wetland (Ac)		Non-Riparian Wetland (Ac)	Upland (Ac)	Buffer (Ac)	BMP
		Riverine	Non-Riverine				
Restoration	961	-	-	-	-		
Enhancement		-	-	-	-		
Enhancement I	-						
Enhancement II	330						
Creation		-	-	-	-		
Preservation	-	-	-	-	-		
HQ Preservation	-	-	-	-	-		
		0	0				
Totals	**1291**	**0**		**0**	**0**	**1.2**	**0**

Table 2. Project Activity and Reporting History Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701		
Activity or Deliverable	**Data Collection Complete**	**Completion or Delivery**
Restoration Plan		Aug-06
Final Design – Construction Plans		Jun-07
Construction		Jul-08
Temporary S&E mix applied to entire project area		Jul-08
Permanent seed mix applied to enitre project area		Jul-08
Repairs to stream due to damages from storm events		Mar-09
Temporary S&E mix applied to area disturbed by repairs		Mar-09
Permanent seed mix applied to area disturbed by repairs		Mar-09
Containerized and B&B plantings for entire reach		Mar-09
Mitigation Plan / As-built (Year 0 Monitoring – baseline)	Mar-09	Aug-09
Year 1 Monitoring		
Year 2 Monitoring		
Year 3 Monitoring		
Year 4 Monitoring		
Year 5 Monitoring		
Year 5+ Monitoring		

Table 3. Project Contacts Table Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701	
Designer Primary project design POC	Ward Consulting Engineers, P.C. 8386 Six Forks Road Suite 101 Raleigh, NC 27615-5088 Becky Ward 919-870-0526
Construction Contractor Construction contractor POC	River Works, Inc. 800 Regency Parkway, Suite 200 Cary, NC 27518 Will Pederson 919-459-9001
Survey Contractor Survey contractor POC	Level Cross Surveying, PLLC (all surveying) 668 Marsh County Lane Randleman, NC 27317 Sherie Willard 336-495-1713
Planting Contractor Planting contractor POC	River Works, Inc. 800 Regency Parkway, Suite 200 Cary, NC 27518 Will Pederson 919-459-9001
Seeding Contractor Contractor point of contact	River Works, Inc. 800 Regency Parkway, Suite 200 Cary, NC 27518 Will Pederson 919-459-9001
Seed Mix Sources	Green Resource 336-855-6363
Nursery Stock Suppliers	Mellow Marsh Farm, Inc. 919-742-1200 Cure Nursery 919-542-6186
Monitoring Performers	Ward Consulting Engineers, P.C. 8386 Six Forks Road Suite 101 Raleigh, NC 27615-5088
Stream Monitoring POC	Robert Langager 919-870-0526
Vegetation Monitoring POC	Chris Sheats - The Catena Group - 919-732-1300
Wetland Monitoring POC	Chris Sheats - The Catena Group - 919-732-1300

Table 4. Project Attribute Table Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701		
Project County	Orange	
Physiographic Region	Piedmont (Triassic Basin)	
Ecoregion	Central Piedmont	
Project River Basin	Cape Fear	
USGS HUC for Project (14 digit)	03030002060080	
NCDWQ Sub-basin for Project	03-06-06	
Within extent of EEP Watershed Plan?	Morgan Creek Little Creek	
WRC Hab Class (Warm, Cool, Cold)	Warm	
% of project easement fenced or demarcated	100%	
Beaver activity observed during design phase?	No	
Restoration Component Attribute Table		
	Reach 1	**Reach 2**
Drainage area	0.42 square miles	
Stream order	2	
Restored length (feet)	961	330
Perennial or Intermittent	Perennial	
Watershed type (Rural, Urban, Developing etc.)	Urban	
Watershed LULC Distribution (e.g.)		
Residential	0.32	
Parking lots, roads, roofs, paved	0.09	
Open space with grass cover > 75%	0.08	
Forested	0.09	
Etc.		
Watershed impervious cover (%)	-	
NCDWQ AU/Index number	16-41-2-8	
NCDWQ classification	WS-IV;NSW	
303d listed?	No	
Upstream of a 303d listed segment?	Yes	
Reasons for 303d listing or stressor	Standard Violation	
Total acreage of easement	5.15 acres	
Total vegetated acreage within the easement	4.99 acres	
Total planted acreage as part of the restoration	3.34 acres	
Rosgen classification of pre-existing	G4	
Rosgen classification of As-built	C4	G4
Valley type	VIII	
Valley slope	0.0136	0.017
Valley side slope range (e.g. 2-3.%)	-	
Valley toe slope range (e.g. 2-3.%)	-	
Cowardin classification	Riverine	
Trout waters designation	No	
Species of concern, endangered etc.? (Y/N)	No	
Dominant soil series and characteristics		
Series	Chewacla	
Depth	-	
Clay%	-	
K	-	
T	-	

Appendix B

Morhpological Summary Data and Plots

Exhibit Table 5a. Baseline Stream Data Summary
Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701

Parameter	Gauge[2]	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			As-built / Baseline					
Dimension and Substrate - Riffle		LL	UL	Eq.	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n	Min	Med	Max	Min	Mean	Med	Max	SD	n
Bankfull Width (ft)	-	-	-	-	9.5	12.7	-	16.3	-	-	16.2	16.7	-	21.1	-	-	-	17.5	-	19.9	20.7	20.5	21.6	0.89	3
Floodprone Width (ft)					18	24.7	-	35	-	-	58	97	-	120	-	-	61	102	126	61	184	224	266	108	3
Bankfull Mean Depth (ft)	-	-	-	-	1.4	1.7	-	1.9	-	-	1.3	1.6	-	1.7	-	-	-	1.59	-	0.87	1.2	1.1	1.5	0.34	3
[1]Bankfull Max Depth (ft)	-				2.8	3.2	-	3.8	-	-	2.2	2.3	-	2.5	-	-	2.3	2.4	2.5	1.8	2.2	2.3	2.4	0.34	3
Bankfull Cross Sectional Area (ft^2)	-	-	-	-	17.5	21.6	-	29.2	-	-	27.2	27.5	-	27.8	-	-	-	27.8	-	18.9	24.1	22.7	30.6	6	3
Width/Depth Ratio	-				5	4.6	-	9.1	-	-	9.6	10.2	-	16	-	-	-	11	-	12.9	18.7	18.5	24.8	0.89	3
Entrenchment Ratio	-				1.5	2.1	-	3.2	-	-	3.5	5.8	-	7.2	-	-	3.5	5.8	7.2	2.8	9	11.3	13	5.5	3
[1]Bank Height Ratio	-				1.7	3.3	-	4.4	-	-	1.5	1.6	-	1.7	-	-	-	1	-	1	1	1	1	0	3
Profile																									
Riffle Length (ft)					3.5	6.8	-	13	-	-	7	21.2	-	42	-	-	7	21.2	42	13.7	23.1	22.91	36.6	6.2	17
Riffle Slope (ft/ft)					0	0.01	-	0.05	-	-	0	0.03	-	0.1	-	-	0	0.03	0.1	0	0.02	0.02	0.05	0.01	17
Pool Length (ft)					6	6.5	-	7	-	-	6.4	13.2	-	19.4	-	-	6.5	13.2	19.4	26.8	34.2	34.3	40.8	4.7	16
Pool Max depth (ft)					2.1	2.7	-	3.5	-	-	2.5	3	-	4.2	-	-	2.5	3	4.2	2.5	3.8	4	4.7	0.7	16
Pool Spacing (ft)					16	42	-	91	-	-	41	56	-	78	-	-	40	55	75	40	56	54	71	9.1	15
Pattern																									
Channel Beltwidth (ft)					15	17.7	-	20	-	-	28.7	22	-	40	-	-	21.2	27.6	38.5	31.9	43.8	40.9	75.9	10.9	14
Radius of Curvature (ft)					14.6	23.4	-	30.1	-	-	10.6	20	-	38.2	-	-	10.2	19.3	36.8	23.7	44.6	42.9	66.7	12.1	13
Rc:Bankfull width (ft/ft)					1.2	1.9	-	2.4	-	-	0.58	1.1	-	2.1	-	-	0.58	1.1	2.1	1.1	2.2	2.1	66.7	0.59	13
Meander Wavelength (ft)					55	58.3	-	65	-	-	113	125	-	140	-	-	109	120	135	90	104	104	121	9.1	13
Meander Width Ratio					1.2	1.43	-	1.62	-	-	1.2	1.6	-	2.2	-	-	1.2	1.6	2.2	1.6	2.2	2.1	2.8	0.55	14
Transport parameters																									
Reach Shear Stress (competency) lb/f^2					-												-			-					
Max part size (mm) mobilized at bankfull					-												-			-					
Stream Power (transport capacity) W/m^2					-												-			-					
Additional Reach Parameters																									
Rosgen Classification	-				G4						C4/E4						C4			C4					
Bankfull Velocity (fps)	-	-	-	-	6.83												5.8			6.92					
Bankfull Discharge (cfs)	-	-	-	-	160																				
Valley length (ft)					870						350														
Channel Thalweg length (ft)					957						400						994			994					
Sinuosity (ft)					1.06						1.14						1.14			1.14					
Water Surface Slope (Channel) (ft/ft)	-				-						-						-			0.0105					
BF slope (ft/ft)	-				0.0128						0.011						0.012			0.0111					
[3]Bankfull Floodplain Area (acres)					-						-						-			-					
[4]Proportion over wide (%)					-						-														
Channel Stability or Habitat Metric					-						-														
Biological or Other					-						-														

Exhibit Table 5b. Baseline Stream Data Summary (Substrate, Bed, Bank, and Hydrologic Containment Parameter Distributions)
Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701

Parameter	Pre-Existing Condition							Reference Reach(es) Data							Design							As-built/Baseline						
[1]Ri% / Ru% / P% / G% / S%	-	-	-	-	-			-	-	-	-	-			-	-	-	-	-	-	-	-	-	-	-	-		
[1]SC% / Sa% / G% / C% / B% / Be%	-	-	-	-	-	-		-	-	-	-	-	-															
[1]d16 / d35 / d50 / d84 / d95 / di^{p} / di^{sp} (mm)	1.6	7.2	11.7	22	30.3	-	-	0.39	1.3	11.4	69.8	164.9	-	-														
[2]Entrenchment Class <1.5 / 1.5-1.99 / 2.0-4.9 / 5.0-9.9 / >10	-	-	-	-	-			-	-	-	-	-										-	-	-	-	-		
[3]Incision Class <1.2 / 1.2-1.49 / 1.5-1.99 / >2.0	-	-	-	-				-	-	-	-											-	-	-	-			
BEHI VL% / L% / M% / H% / VH% / E%	-	-	-	-	-	-		-	-	-	-	-	-															

Shaded cells indicate that these will typically not be filled in.

1 = Riffle, Run, Pool, Glide, Step; Silt/Clay, Sand, Gravel, Cobble, Boulder, Bedrock; dip = max pave, disp = max subpave

2 = Entrenchment Class - Assign/bin the reach footage into the classes indicated and provide the percentage of the total reach footage in each class in the table. This will result from the measured cross-sections as well as visual estimates

3 = Assign/bin the reach footage into the classes indicated and provide the percentage of the total reach footage in each class in the table. This will result from the measured cross-sections as well as the longitudinal profile

Footnotes 2,3 - These classes are loosley built around the Rosgen classification and hazard ranking breaks, but were adjusted slightly to make for easier assignment to somewhat coarser bins based on visual estimates in the field such that measurement of every segment for ER would not be necessary.

The intent here is to provide the reader/consumer of design and monitoring information with a good general sense of the extent of hydrologic containment in the pre-existing and the rehabilitated states as well as comparisons to the reference distributions.

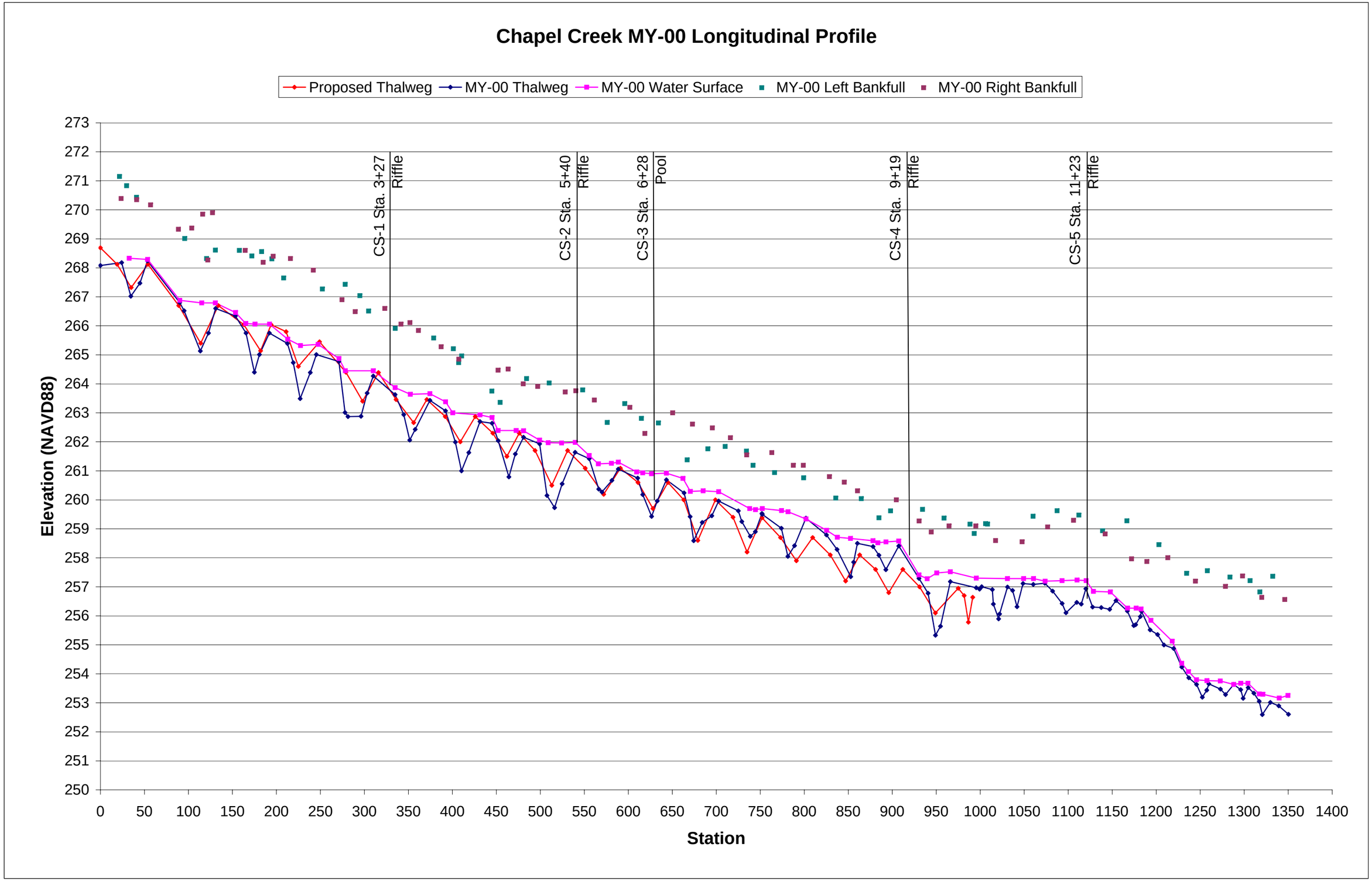
ER and BHR have been addressed in prior submissions as a subsample (cross-sections as part of the design survey), however, these subsamples have often focused entirely on facilitating design without providing a thorough pre-constrution distribution of these parameters, leaving the reader/consumer with a sample that is weighted heavily on the stable sections of the reach. This means that the distributions for these parameters should include data from both the cross-section surveys and the longitudinal profile and in the case of ER, visual estimates. For example, the typical longitudinal profile permits sampling of the BHR at riffles beyond those subject to cross-sections and therefore can be readily integrated and provide a more complete sample distribution for these parameters, thereby providing the distribution/coverage necessary to provide meaningful comparisons.

Exhibit Table 6. Dimensional Morphology Summary (Dimensional Parameters – Cross Sections)

Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701

	Cross Section 1 (Riffle)							Cross Section 2 (Riffle)							Cross Section 3 (Pool)							Cross Section 4 (Riffle)							Cross Section 5 (Riffle)						
Based on fixed baseline bankfull elevation[1]	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Bankfull Width (ft)	19.9							21.5							24.2							21.6							15.4						
Floodprone Width (ft)	224							266							164							61							48						
Bankfull Mean Depth (ft)	1.54							1.11							1.27							0.87							1.88						
Bankfull Max Depth (ft)	2.4							2.34							3.24							1.78							2.87						
Bankfull Cross Sectional Area (ft^2)	30.6							22.7							30.7							18.9							28.9						
Bankfull Width/Depth Ratio	12.9							18.5							19.1							24.7							8.16						
Bankfull Entrenchment Ratio	11.3							13							6.76							2.81							3.13						
Bankfull Bank Height Ratio	1							1							0.96							0.97							1						
Based on current/developing bankfull feature[2]																																			
Bankfull Width (ft)																																			
Floodprone Width (ft)																																			
Bankfull Mean Depth (ft)																																			
Bankfull Max Depth (ft)																																			
Bankfull Cross Sectional Area (ft^2)																																			
Bankfull Width/Depth Ratio																																			
Bankfull Entrenchment Ratio																																			
Bankfull Bank Height Ratio																																			
Cross Sectional Area between end pins (ft^2)																																			
d50 (mm)																																			

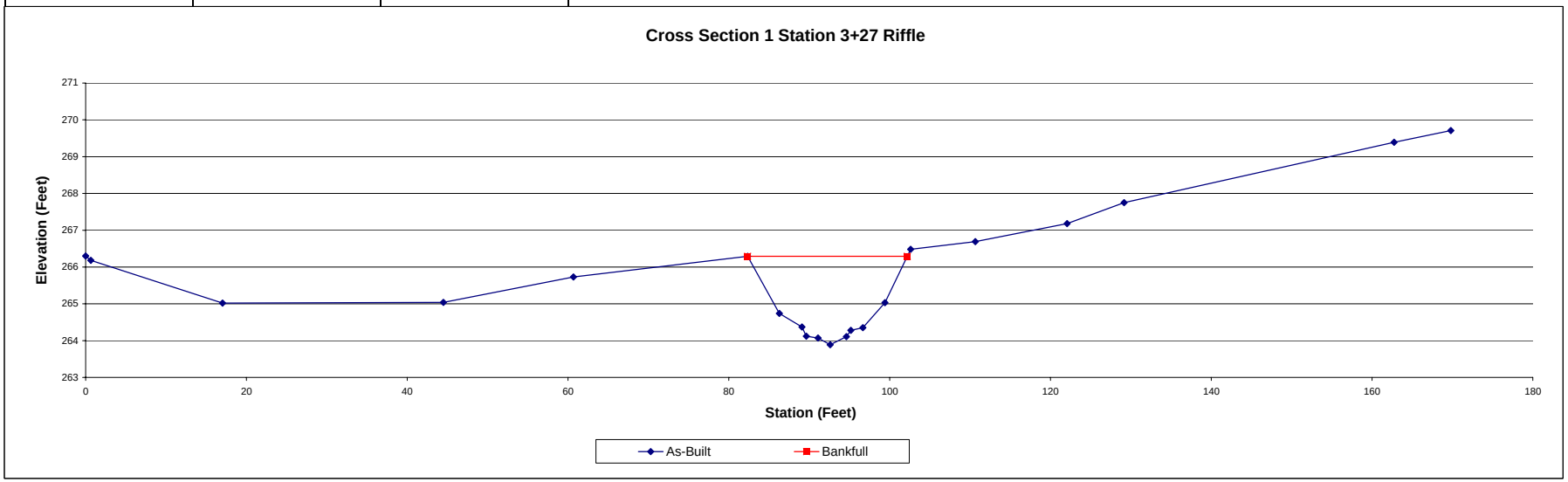
1 = Widths and depths for each resurvey will be based on the baseline bankfull datum regardless of dimensional/depositional development. 2 = Based on the elevation of any dominant depositional feature that develops and is observed at the time of survey. If the baseline datum remains the only significant depositional feature then these two sets of dimensional parameters will be equal, however, if another depositional feature of significance develops above or below the baseline bankfull datum then this should be tracked and quantified in these cells.


Chapel Creek MY-00 Longitudinal Profile
Proposed Thalweg
MY-00 Thalweg
MY-00 Water Surface
MY-00 Left Bankfull
MY-00 Right Bankfull
CS-1 Sta. 3+27 Riffle
CS-2 Sta. 5+40 Riffle
CS-3 Sta. 6+28 Pool
CS-4 Sta. 9+19 Riffle
CS-5 Sta. 11+23 Riffle
Elevation (NAVD88)
Station
273
272
271
270
269
268
267
266
265
264
263
262
261
260
259
258
257
256
255
254
253
252
251
250
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
1000
1050
1100
1150
1200
1250
1300
1350
1400

Project:	Chapel Creek	**Summary (bankfull)**			
Cross Section:	Cross Section 1		MY0	MY1	MY2
Feature	Riffle	A (BKF)	30.6		
Station:	3+27	W (BKF)	19.9		
Date:	3/25/09	Max d	2.4		
Crew:	RL, JW	Mean d	1.5		
		W/D	12.9		

MY0-2009			MY1-2010			MY2-2011		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
0	266.3	CS1LP						
0.64	266.18	CS1						
17.02	265.02	CS1						
44.5	265.04	CS1						
60.68	265.73	CS1						
82.33	266.29	Bankfull						
86.28	264.74	CS1						
89.1	264.37	CS1						
89.64	264.12	CS1TOE						
91.09	264.07	CS1						
92.6	263.89	TW						
94.63	264.11	CS1TOE						
95.18	264.28	CS1						
96.67	264.35	CS1						
99.42	265.03	CS1						
102.61	266.48	Bankfull						
110.65	266.69	CS1						
122.07	267.18	CS1						
129.16	267.75	CS1						
162.74	269.39	CS1						
169.8	269.71	CS1RP						

Photo of XS-1, Sta 3+27 looking in the downstream direction

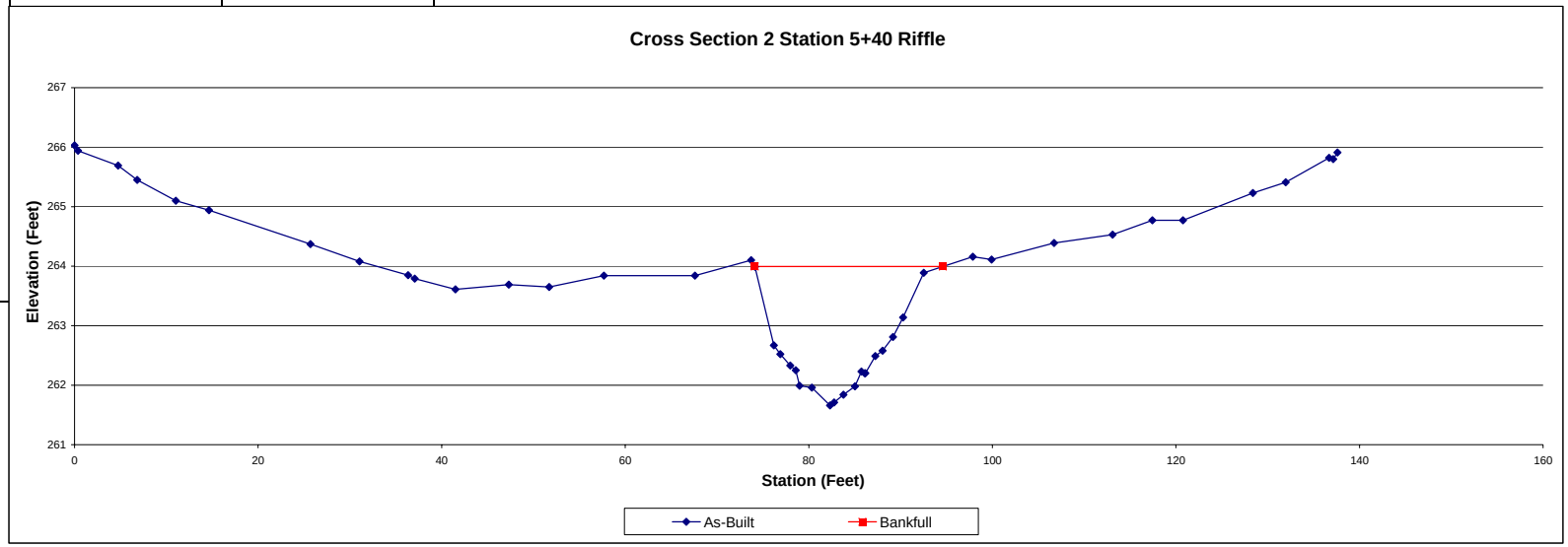


Project:	Chapel Creek
Cross Section:	Cross Section 2
Feature	Riffle
Station:	5+40
Date:	3/25/09
Crew:	RL, JW

Summary (bankfull)			
	MY0	MY1	MY2
A (BKF)	22.7		
W (BKF)	20.5		
Max d	2.3		
Mean d	1.1		
W/D	18.5		

MY0-2009			MY1-2010			MY2-2011		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
0.00	266.03	CS2LP						
0.38	265.94							
4.75	265.69							
6.82	265.45							
11.04	265.10							
14.64	264.94							
25.70	264.37							
31.04	264.08							
36.34	263.85							
37.06	263.79							
41.50	263.61							
47.31	263.69							
51.71	263.65							
57.67	263.84							
67.59	263.84							
73.72	264.10	BKF						
74.13	263.99							
76.20	262.67							
76.90	262.52							
77.98	262.33							
78.59	262.25							
79.00	261.99							
80.33	261.96							
82.32	261.66	TW						
82.76	261.71							
83.77	261.84							
85.02	261.98							
85.73	262.23							
86.10	262.20							
86.17	262.20							
87.25	262.49							
88.04	262.58							
89.18	262.81							
90.27	263.14							
92.52	263.89	BKF						
97.87	264.16							
99.91	264.11							
106.72	264.39							
113.11	264.53							
117.44	264.77							
120.77	264.77							
128.39	265.23							
131.96	265.41							
136.68	265.82							
137.13	265.80							
137.60	265.91	CS2RP						

Photo of XS-2, Sta 5+40 looking in the downstream direction

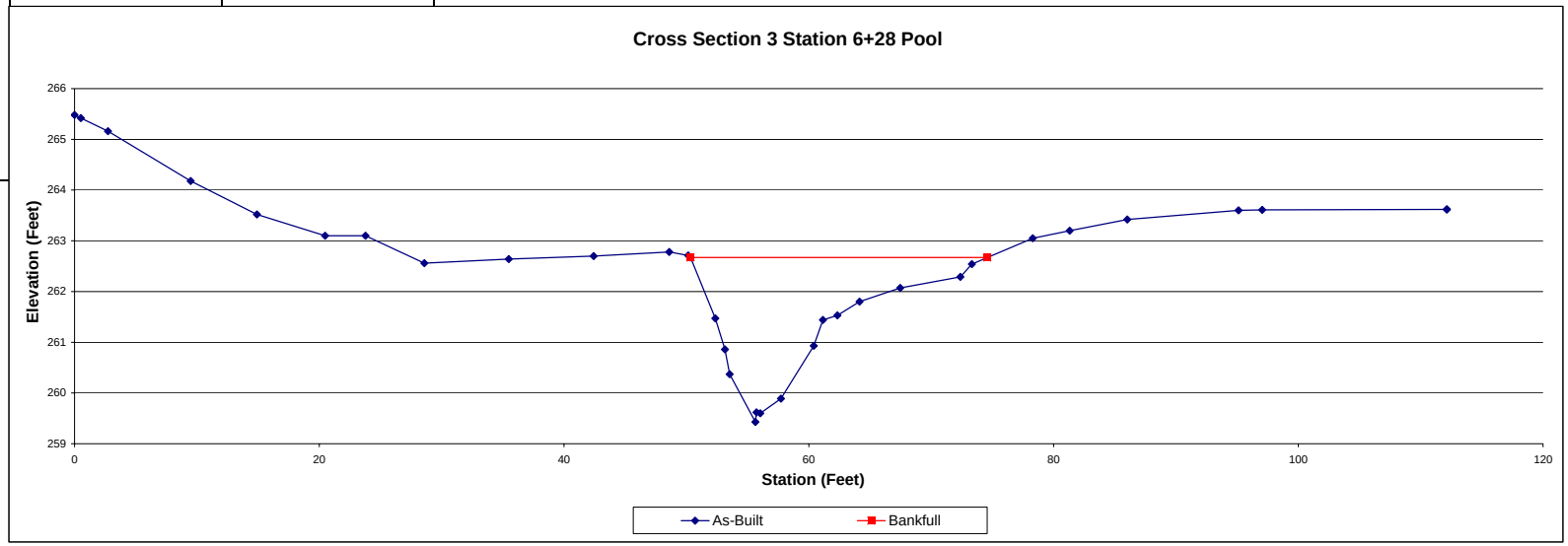


Project:	Chapel Creek
Cross Section:	Cross Section 3
Feature	Pool
Station:	6+28
Date:	3/25/09
Crew:	RL, JW

Summary (bankfull)			
	MY0	MY1	MY2
A (BKF)	30.7		
W (BKF)	24.2		
Max d	3.2		
Mean d	1.3		
W/D	19.1		

MY0-2009			MY1-2010			MY2-2011		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
0	265.48	CS3LP						
0.52	265.42							
2.73	265.16							
9.49	264.18							
14.9	263.52							
20.47	263.1							
23.77	263.1							
28.58	262.56							
35.48	262.64							
42.42	262.7							
48.6	262.78							
50.14	262.71							
50.34	262.67	BKF						
52.36	261.47							
53.15	260.86							
53.53	260.37							
55.64	259.43	TW						
55.72	259.62							
56.04	259.6							
57.72	259.89							
60.4	260.93							
61.16	261.44							
62.34	261.53							
64.14	261.8							
67.47	262.07							
72.39	262.29							
73.32	262.54	BKF						
78.3	263.05							
81.32	263.2							
86.02	263.42							
95.12	263.6							
97.05	263.61							
112.14	263.62	CS3RP						
112.14	263.62							

Photo of XS-3, Sta 6+28 looking in the downstream direction

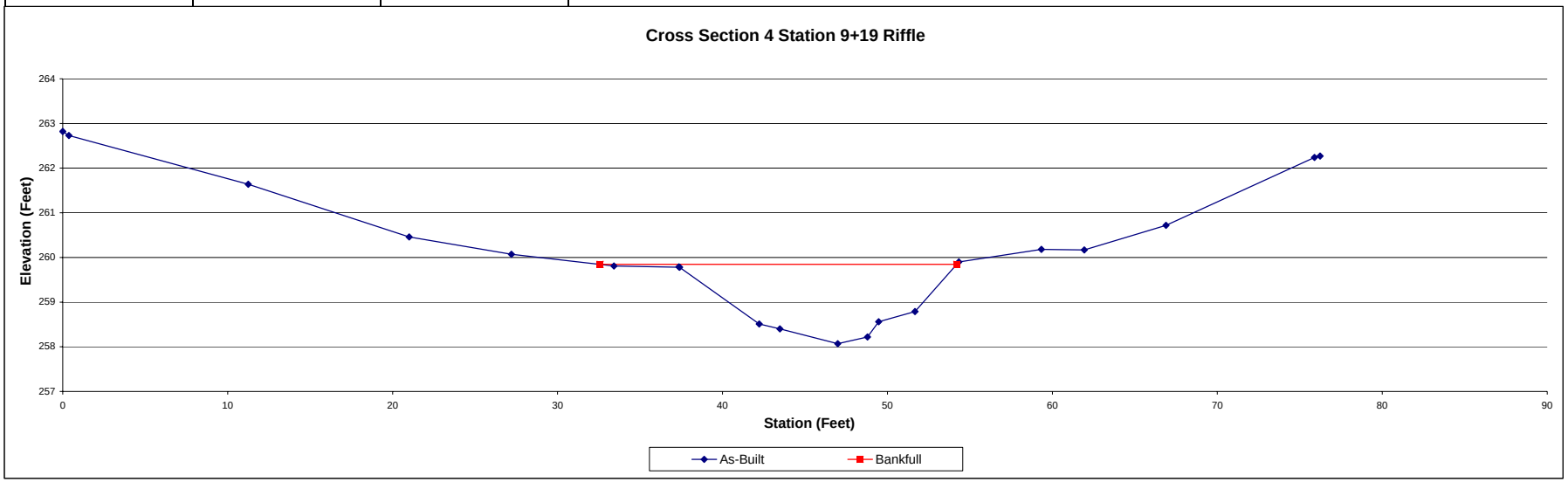


Project:	Chapel Creek
Cross Section:	Cross Section 4
Feature	Riffle
Station:	9+19
Date:	3/25/09
Crew:	RL, JW

Summary (bankfull)			
	MY0	MY1	MY2
A (BKF)	18.9		
W (BKF)	21.6		
Max d	1.8		
Mean d	0.9		
W/D	24.7		

MY0-2009			MY1-2010			MY2-2011		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
0	262.82	CS4LP						
0.37	262.73							
11.25	261.64							
21	260.46							
27.2	260.07							
33.42	259.81							
37.4	259.78							
37.36	259.79	BKF						
42.23	258.51							
43.48	258.4							
46.99	258.07	TW						
48.79	258.22							
49.47	258.56							
51.67	258.79							
54.33	259.9	BKF						
59.33	260.18							
61.93	260.17							
66.89	260.72							
75.89	262.24							
76.23	262.27	CS4RP						

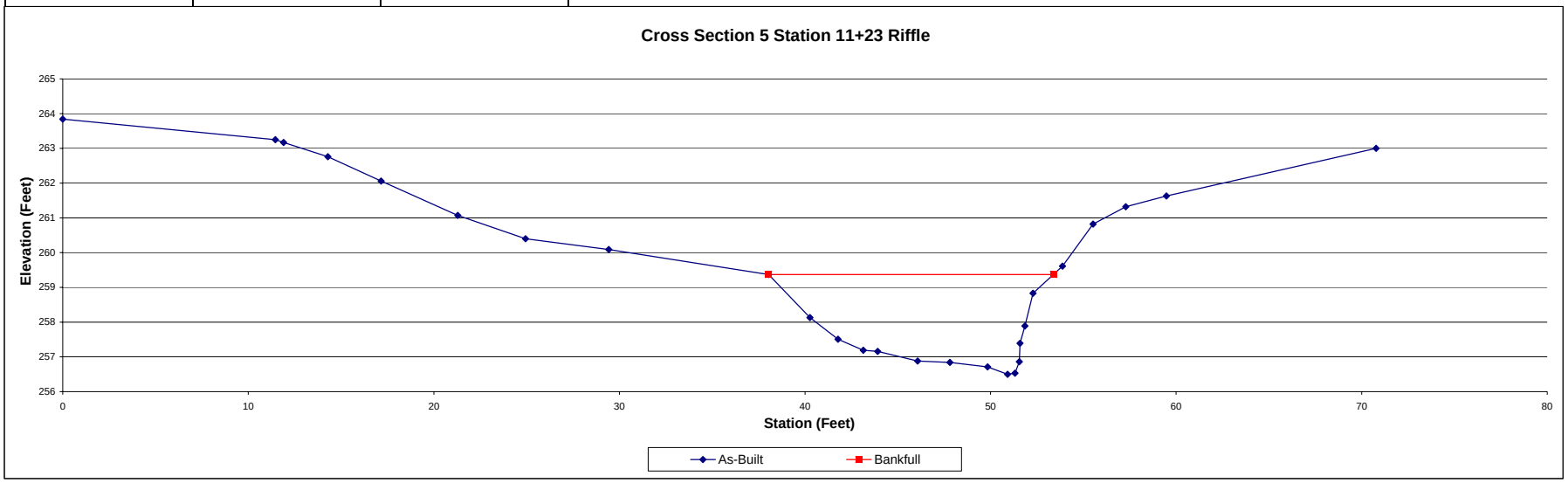
Photo of XS-4, Sta 9+19 looking in the downstream direction



Project:	Chapel Creek	**Summary (bankfull)**			
Cross Section:	Cross Section 5		MY0	MY1	MY2
Feature	Riffle	A (BKF)	28.9		
Station:	11+23	W (BKF)	15.4		
Date:	3/25/09	Max d	2.9		
Crew:	RL, JW	Mean d	1.9		
		W/D	8.2		

MY0-2009			MY1-2010			MY2-2011		
Station	Elevation	Notes	Station	Elevation	Notes	Station	Elevation	Notes
0	263.84							
11.46	263.25	CS5LP						
11.9	263.17							
14.29	262.76							
17.16	262.06							
21.29	261.07							
24.94	260.4							
29.43	260.09							
38.04	259.37	BKF						
40.27	258.13							
41.78	257.51							
43.14	257.19							
43.92	257.16							
46.07	256.88							
47.81	256.84							
49.84	256.71							
50.92	256.5	TW						
51.32	256.53							
51.55	256.86							
51.59	257.39							
51.85	257.89							
52.29	258.83	BKF						
53.88	259.61							
55.53	260.82							
57.29	261.32							
59.48	261.63	CS5RP						
70.78	263							

Photo of XS-5, Sta 11+23 looking in the downstream direction



Appendix C
Vegetation Data

Table 7. Vegetation Plot Attribute Data Project: Chapel Creek, Orange County, North Carolina, SCO# 050645701						
Scientific Name	**Common Name**	Plot*				**Total**
		1	**2**	**3**	**4**	
Magnolia virginiana	Sweetbay Magnolia	3				**3**
Rosa palustris	Swamp Rose	5				**5**
Rhododendron viscosum	Swamp Azalea	4				**4**
Viburnum cassinoides	Northern Wild Raisin	3				**3**
Hibiscus moscheutos	Eastern Rose Mallow	5				**5**
Vaccinium corymbosum	Highbush Blueberry	2				**2**
Diospyros virginiana	American Persimmon	1	3	2		**6**
Lindera benzoin	Spicebush	1	1	8	3	**13**
Quercus nigra	Water Oak		1		4	**5**
Carpinus caroliniana	Ironwood		2		3	**5**
Betula nigra	River Birch		2	4	5	**11**
Fraxinus pennsylvanica	Green Ash		4	2	5	**11**
Platanus occidentalis	Sycamore		3			**3**
Calycanthus floridus	Sweet-shrub		1	1	3	**5**
Hamamelis virgniniana	Witch-hazel		1			**1**
Viburnum dentatum	Mapleleaf Viburnum	1	2			**3**
Viburnum nudum	Possumhaw			17		**17**
Cornus amomum	Silky Dogwood			5		**5**
Xanthorhiza simplicissima	Brook-feather			3		**3**
Cephalanthus occidentalis	Buttonbush			5		**5**
Total		**25**	**20**	**47**	**23**	**115**

* Plot 1,3, &4 are 5x10 meter; Plot 2 is 10x10 meters

Table 8. Plant Species and Quantities for Zones 1, 2, and 3

Zone 1: Wetland Depression (0.14 ac)			
#	***Latin Name***	**Common Name**	**Type**
4	*Cephalanthus occidentalis*	button bush	Small Tree bands
11	*Hibiscus moscheutus*	swamp marshmallow	Plugs
7	*Rosa palustris*	swamp rose	Tublings
11	*Viburnum cassinoides*	southern wild raisin	1 Gallon
7	*Xanthorhiza simplicissima*	yellow root	Small Tree bands
4	*Alnus serrulata*	tag alder	Small Tree bands
4	*Cornus ammomum*	silky dogwood	Seedling
11	*Rhododendron viscosum*	swamp azalea	1 Gallon
7	*Itea virginica*	Virginia willow	bare root
7	*Magnolia virginiana*	sweetbay magnolia	1 gallon
73	***Total***		
Zone 2: Riparian Buffer (3.2 ac)			
#	***Latin Name***	**Common Name**	**Type**
240	*Quercus nigra*	willow oak	Seedling
240	*Platanus occidentalis*	sycamore	Seedling
240	*Fraxinus pennsylvanica*	green ash	Seedling
240	*Carpinus caroliniana*	ironwood	Seedling
160	*Lindera benzoin*	spice bush	Seedling
320	*Viburnum dentatum*	arrowwood	Seedling

160	*Calycanthus floridus*	sweet shrub	Seedling
160	*Viburnum dentatum*	Arrowood	Bare root
160	*Diospyros virginiana*	American persimmon	Bare root
100	*Betula nigra*	River birch	Bare root
216	*Vaccinium corymbosum*	highbush blueberry	Tubling
144	*Hamamelis virginia*	witch hazel	Tubling
2220	***Total***		
Zone 3: Streambanks (2600 lf)			
#	***Latin Name***	**Common Name**	**Type**
216	*Vibernum dentatum*	arrowood	Bare root
144	*Alnus serrulata*	tag alder	Small Tree bands
288	*Cephalanthus occidentalis*	buttonbush	Tubling
144	*Sambucus canadensis*	elderberry	Tubling
144	*Cornus ammomum*	silky dogwood	Tubling
144	*Xanthorhiza simplicissima*	yellowroot	Tubling
50	*Cornus amomum*	silky dogwood	Seedling
50	*Salix sericea*	Silky willow	Seedling
1180	***Total***		

Table 9. Perennial Seed Mix

Scientific Name	**Common Name**	**Percent**
Elymus hystrix	Bottlebrush grass	15
Panicum anceps	Beaked panic grass	15
Agrostis alba	Redtop	10
Bidens frondosa	Devil's beggartick	10
Coreopsis lanceolata	Lanceleaf tickseed	10

Appendix D
Site Photo Log

Site Photo Log

PP-1: Looking downstream at cross section #1, station 3+27.

PP-2: Looking downstream at cross section #2, station 5+40.

PP-3: Looking downstream at cross section #3, station 6+28.

PP-4: Looking downstream at cross section #4, station 9+19.

PP-5: Looking downstream at cross section #5, station 11+23.

VP-1: Vegetation Plot 1.

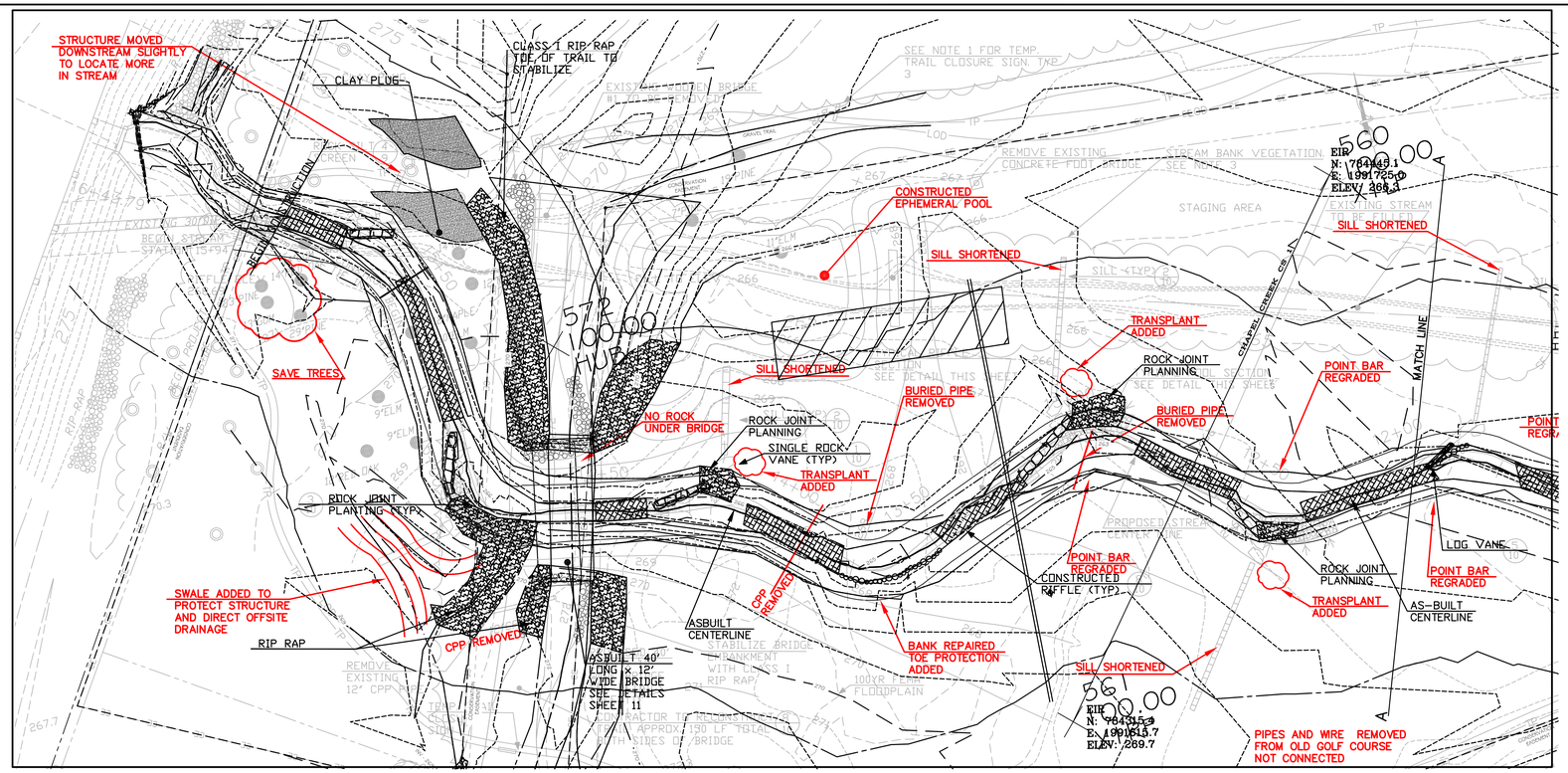
VP-2: Vegetation Plot 2.

VP-3: Vegetation Plot 3.

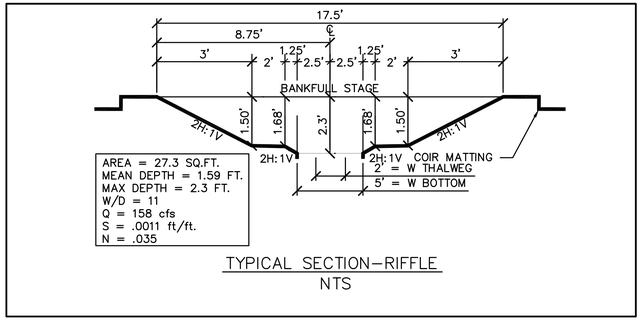
VP-4: Vegetation Plot 4.

Appendix E

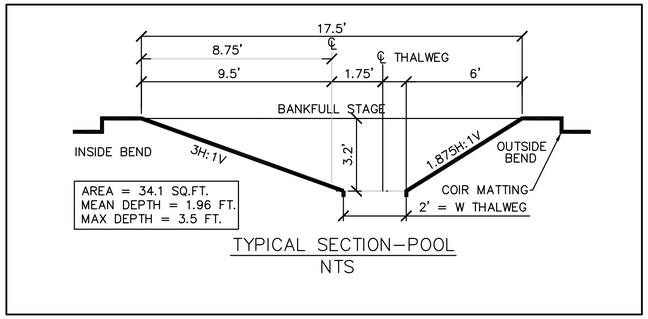
As-Built Plan Sheets



PROPOSED ℄ STREAM PLAN



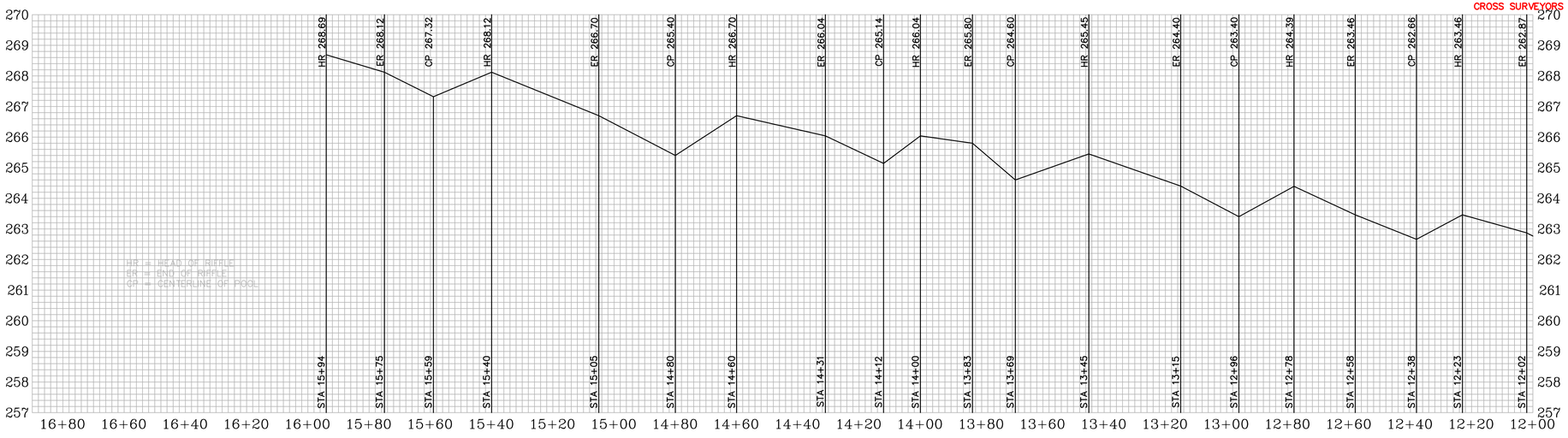
TYPICAL SECTION–RIFFLE
NTS



TYPICAL SECTION–POOL
NTS

RECORD DRAWING INFORMATION
REPAIRS INCLUDED ALL RIFFLES
BY WILDLIFE RESOURCES COMMISION
(WRC) REPAIR DATES (MARCH 9–12, 2009)
REPAIRS INCLUDED RE–GRADING OF POINT BARS–
MARCH 9TH, 2009

NOTE:
1. ASBUILT DATA SHOWN DARK PRINT SCREENED DATA SHOWS CONSTRUCTION PLAN DATA.
2. BASE SURVEY DATA FOR CONSTRUCTION PLANS BY RILEY SURVEYORS ASBUILT SURVEY PROVIDED BY LEVEL CROSS SURVEYORS



PROPOSED ℄ STREAM PROFILE

RECORD DRAWING INFORMATION
ALL RIFFLES REPAIRED–BY WRC
MARCH 9–12, 2009

NOTE: DESIGN PROFILE ONLY SHOWN–SEE EXCEL SPREADSHEET FOR DESIGN AND AS–BUILT PROFILE COMPARISM.

NOTES:
1. BENCHING TO BE CONSTRUCTED FROM N. SIDE OF STREAM
2. CONTRACTOR TO REMAIN OFF GOLF COURSE AT ALL TIMES
3. TYPICAL BENCHING ELEVATIONS ARE SHOWN ON THE CROSS SECTIONS, PLAN SHEETS 5 & 6.

LEGEND
- NAIL
- 5/8" IRON ROD SET
- BENCHMARK
- CENTERLINE
- CONVERSATION EASEMENT
- RIP RAP
- CONSTRUCTED RIFFLE
- EVERGREEN TREE
- DECIDUOUS TREE
- WOODS LINE
- TOP OF BANK LINE
- TOE OF BANK LINE
- ROCK STRUCTURE
- LOG VANE
- ROOT WAD
- TOE PROTECTION
- 1' CONTOUR
- 5' CONTOUR
- WATER LINE
- TREE (NOT SURVEYED BY LCS)

LEGEND
- PROPOSED 1' CONTOUR
- EXISTING 1' CONTOUR
- EXISTING 5' CONTOUR
- TEMPORARY STREAM CROSSING
- BANK REPAIR
- RIP RAP TOE TO BANKFULL
- CONSTRUCTION ACCESS
- EXISTING TREE
- EXISTING TREE TO BE REMOVED
- LIMITS OF EXISTING TRAIL
- LIMITS OF DISTURBANCE
- 100 YR FEMA FLOODPLAIN
- STREAM BANK VEGETATION TO REMAIN DURING INITIAL GRUBBING OPERATIONS
- CONSTRUCTED RIFFLE
- TREE PROTECTION FENCING
- SILT FENCING
- CLAY PLUG
- SILL
- CROSS VANE
- SINGLE ROCK VANE
- ROCK JOINT PLANTING
- ROOT WAD
- LOG VANE

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North Carolina – Ecosystem Enhancement Program

Chapel Creek Stream & Buffer Restoration
Enhancement and Preservation
Orange County, North Carolina

SEAL:

CHAPEL CREEK PLAN COMPARISON OF PROPOSED AND AS–BUILT CONDITIONS STA 16+25 TO 12+00

DATE: 2–23–07

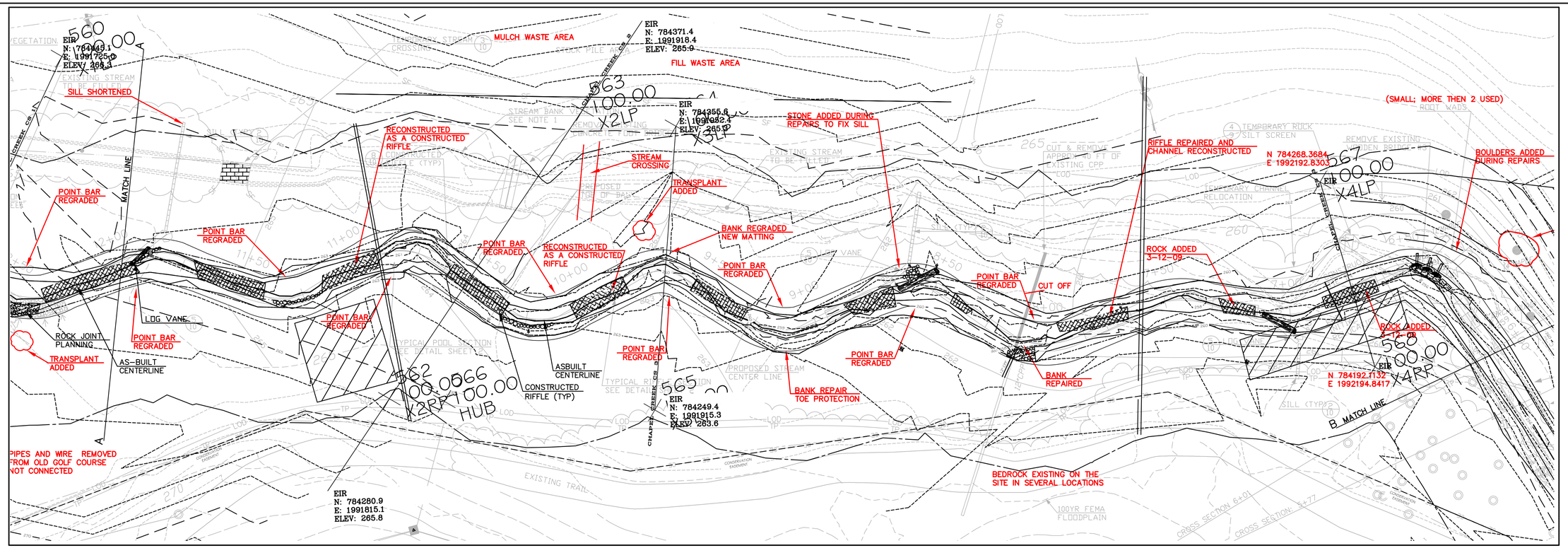
REVISIONS:
EEP Comments 04 June 2007
Construction Set 28 June 2007
Record DWG 29 July 2009

PROJECT NAME: CHAPEL CREEK

DWG NAME: GRADING

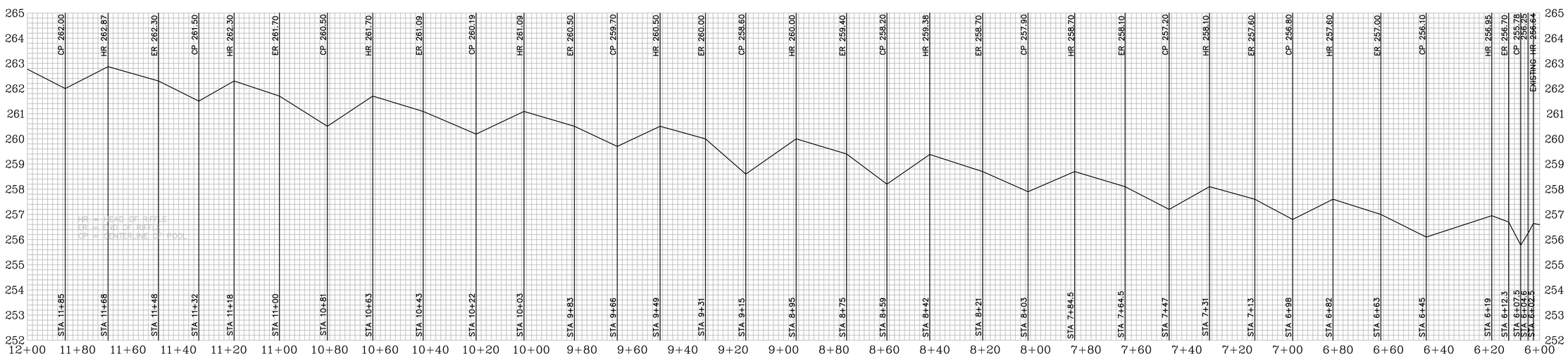
SCALE: 1" = 20'

SHEET NO.



PROPOSED ℄ STREAM PLAN

SCALE IN FEET



PROPOSED ℄ STREAM PROFILE

NOTES:

1. CONTRACTOR TO KEEP VEGETATION BUFFER AT TOP OF STREAM BANK UNTIL NEW STREAM CHANNEL IS STABILIZED. DO NOT REMOVE IN INITIAL GRUBBING OPERATIONS.

LEGEND

- NAIL
- 5/8" IRON ROD SET
- BENCHMARK
- CENTERLINE
- CONVERSATION EASEMENT
- RIP RAP
- CONSTRUCTED RIFFLE
- EVERGREEN TREE
- DECIDUOUS TREE
- WOODS LINE
- TOP OF BANK LINE
- TOE OF BANK LINE
- ROCK STRUCTURE
- LOG VANE
- ROOT WAD
- TOE PROTECTION
- 1' CONTOUR
- 5' CONTOUR
- WATER LINE
- TREE (NOT SURVEYED BY LCS)

RECORD DRAWING INFORMATION
ALL RIFFLES REPAIRED-BY WRC
MARCH 9-12, 2009

NOTE: DESIGN PROFILE ONLY SHOWN-SEE EXCEL SPREADSHEET FOR DESIGN AND AS-BUILT PROFILE COMPARISM.

LEGEND

- PROPOSED 1' CONTOUR
- EXISTING 1' CONTOUR
- EXISTING 5' CONTOUR
- TEMPORARY STREAM CROSSING
- BANK REPAIR
- RIP RAP TOE TO BANKFULL
- CONSTRUCTION ACCESS
- EXISTING TREE
- EXISTING TREE TO BE REMOVED
- LIMITS OF EXISTING TRAIL
- LIMITS OF DISTURBANCE
- 100 YR FEMA FLOODPLAIN
- STREAM BANK VEGETATION TO REMAIN DURING INITIAL GRUBBING OPERATIONS
- CONSTRUCTED RIFFLE
- TREE PROTECTION FENCING
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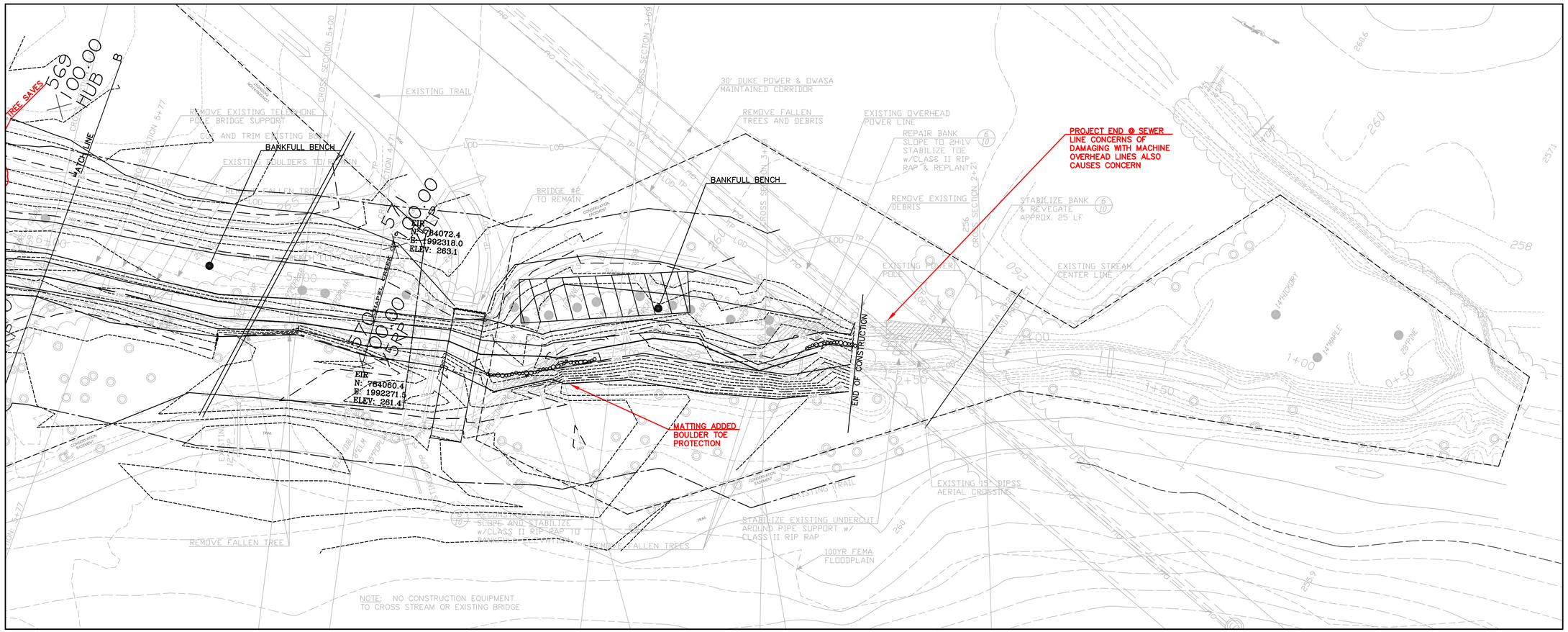
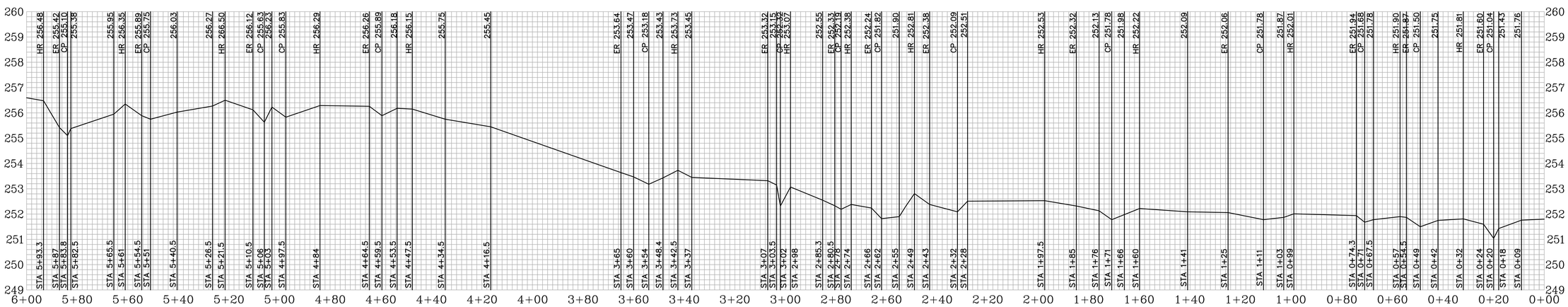


PROPOSED ℄ STREAM PLAN

SCALE IN FEET



EXISTING ℄ STREAM PROFILE

NOTES:
1. BENCHING TO BE CONSTRUCTED FROM N. SIDE OF STREAM
2. CONTRACTOR TO REMAIN OFF GOLF COURSE AT ALL TIMES
3. TYPICAL BENCHING ELEVATIONS ARE SHOWN ON THE CROSS SECTIONS, PLAN SHEETS 5 & 6.

RECORD DRAWING INFORMATION
ALL RIFFLES REPAIRED–BY WRC
MARCH 9–12, 2009

NOTE: DESIGN PROFILE ONLY SHOWN–SEE EXCEL SPREADSHEET FOR DESIGN AND AS–BUILT PROFILE COMPARISM.

LEGEND
- NAIL
- 5/8" IRON ROD SET
- BENCHMARK
- CENTERLINE
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- TOE PROTECTION
- 1' CONTOUR
- 5' CONTOUR
- WATER LINE
- TREE (NOT SURVEYED BY LCS)

RECORD DRAWING INFORMATION
REPAIRS INCLUDED ALL RIFFLES
BY WILDLIFE RESOURCES COMMISION
(WRC) REPAIR DATES (MARCH 9–12, 2009)
REPAIRS INCLUDED RE–GRADING OF POINT BARS–
MARCH 9TH, 2009

NOTE:
1. ASBUILT DATA SHOWN DARK PRINT SCREENED DATA SHOWS CONSTRUCTION PLAN DATA.
2. BASE SURVEY DATA FOR CONSTRUCTION PLANS BY RILEY SURVEYORS
ASBUILT SURVEY PROVIDED BY LEVEL CROSS SURVEYORS

LEGEND
- PROPOSED 1' CONTOUR
- EXISTING 1' CONTOUR
- 265 EXISTING 5' CONTOUR
- TEMPORARY STREAM CROSSING
- BANK REPAIR
- RIP RAP TOE TO BANKFULL
- CONSTRUCTION ACCESS
- EXISTING TREE
- EXISTING TREE TO BE REMOVED
- LIMITS OF EXISTING TRAIL
- LOD LIMITS OF DISTURBANCE
- 100 YR FEMA FLOODPLAIN
- STREAM BANK VEGETATION TO REMAIN DURING INITIAL GRUBBING OPERATIONS
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