Cato Farms Stream Restoration Project

Mitigation Plan and As-Built Report

Prepared for

Ecosystem Enhancement PROGRAM

Prepared by

CH2MHILL

November 2005

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Section 1 Introduction

The stream restoration site is at Cato Farm, located in northern Mecklenburg County, North Carolina, just east of the Town of Huntersville. The existing stream is an unnamed tributary (UT) draining an area of 0.41 square miles into Clark's Creek in the Yadkin-Pee Dee River Basin (Figure 1).

Several activities in the vicinity of the stream caused degradation to the stream and its riparian zone. First, the land has been cleared to provide open pasture for the cattle. Secondly, the cows were not prevented from entering the stream. Also, the stream channel appeared to have been moved and straightened from its original course. Finally, at least three ditches had been graded to the stream for the purpose of drying out a marshy area adjacent to the stream. These activities created a straight, actively eroding, and incising stream channel adjacent to a drying area of hydric soil which was once likely a wetland.

Speaking in terms of geomorphology, the profile of the existing channel through Cato Farm was unstable. Channel incision was evident in localized spots in the upper end of the channel and increased in severity in the lower channel reach. In addition, there was very little diversity in the existing channel bedform, *i.e.*, pools, riffles, glides, and runs were nearly indistinguishable from each other.

This stream restoration site was chosen with the goals of improving aquatic and terrestrial habitat, creating channel stability, and improving water quality. Establishing a riparian buffer zone and excluding cattle along this stream length will also help achieve these goals.

Section 2 Summary

2.1 Project Description

Construction of the Cato Farm Stream Restoration Project restored approximately 1790 linear feet of degraded stream to approximately 2500 linear feet of stream in two sections – a Rosgen Priority 1 Restoration Section (Rosgen E stream type) in the upper two-thirds of the project reach, reconnecting the stream to its relic floodplain, and a Transition Section to connect the Restoration Section back to the existing stream (Rosgen B stream type). In addition, the Rosgen E stream type portion of the stream restoration project now meanders through a former wetland area of pasture that had been previously drained, re-hydrating the soils of the wetland.

The restoration of the stream channel at Cato Farm included the following elements:

- Stream Restoration - adjustment of the upper two-thirds of the stream reach into a Rosgen E stream type
- Stream Transition - adjustment of the lower one-third of the stream reach into a Rosgen B stream type
- Planting and preservation of the riparian zone
- Providing for cattle crossing at one location along the restored stream reach

To design this stream restoration project, natural channel design methodologies were used. Dave Rosgen's natural channel design principles were used in conjunction with his channel classification scheme, a reference reach analysis, and North Carolina regional curve data. These steps follow those typically used in North Carolina.

The project site is located within an active dairy farm. Before construction, the upper portion of the stream length was within a grazing field for the cattle. The lower two-thirds of the stream length was wooded, but lacked vegetation in the understory stratum. Cattle exclusion fences were constructed as part of this project.

The UT and its watershed were studied to understand the relationship between the stream and its drainage basin and to determine bankfull discharge and causes of channel degradation. Reference reaches were chosen that have the same valley type, land type, and stream type as the design reach. Morphological characterization information was compiled for each of the two chosen reference reaches. Then, a series of iterative calculations were performed, using data from the reference reach, to determine the appropriate stable cross-sectional, profile, and plan form dimensions of the design reach. When all channel dimensions had been calculated and checked, the proposed plan view and longitudinal profile with the appropriate bankfull width, cross-sections, pool width and spacing, meander wavelength, radius, belt width, etc. were laid out.

Two reference reaches were necessary for use in designing the Cato Farm Stream Restoration – a low gradient, meandering stream type and a relatively high gradient stream type. A high gradient stream reach was found on Coffey Creek within the Catawba River Basin in southern Mecklenburg County. The Coffey Creek reference reach is a Rosgen B4c stream type. It is moderately entrenched, with a series of steps and irregularly spaced scour pools. The stream bed is gravel dominated with large cobble and medium boulders controlling the grade. The second reference reach was found on an UT to Little Sugar Creek within the Catawba River Basin in southern Mecklenburg County. This low gradient, meandering stream reach is a Rosgen E5 stream type. It is a low width-to-depth ratio, glide-pool stream that is not entrenched. The stream bed is sand dominated. The most reliable bankfull indicator on this particular stream was a change in slope on the stream bank.

Existing Vegetation

The upper portion of the existing channel was an open field. The field was comprised mostly of grasses and the channel itself was bordered by a narrow band of woody vegetation – including cedar (*Juniperus* spp.), Mock orange (*Philedelphus* sp.), Chinese privet (*Ligustrum sinense*), Sycamore (*Platinus occidentalis*), and Tag alder (*Alnus*

serrulata). The middle and lower third of the existing channel reach was in a wooded area with a largely absent understory. The adjacent forest is comprised of hardwoods, including Sycamore, various oak species (*Quercus* spp.), and Tulip poplar (*Liriodendron tulipifera*).

Construction

Construction began in March of 2003. During the construction period, rainfall at the site was exceeded normal levels. As a result, construction and planting were delayed. The construction phase of the project was completed in July of 2003. Planting of woody vegetation occurred in February and March of 2004. Repairs to two erosion spots were made in July 2005.

This document describes the as-built dimensions of the project and a monitoring plan layout to ensure that the project site can be evaluated to:

- Ensure that stabilization structures are functioning properly.
- Monitor channel response in dimension, pattern and profile, channel stability (aggradation/degradation), particle size distribution of channel materials, and sediment transport and stream bank erosion rates.
- Determine biological response (food chains, standing crop, species diversity, etc.).
- Determine the extent to which the restoration objectives have been met.

2.2 Easement Boundary

An area approximately 75 feet wide, with varying width in places, is preserved via a conservation easement for this project. A fence was installed along the easement boundary. The restored channel meanders within the easement; the top of the stream bank at the outside of a meander bend is no closer than 28 feet from the easement boundary. Within the easement, a vegetated buffer was planted. A sewer line was constructed adjacent to the stream in the summer of 2004. Construction disturbed an area within the fenced zone near the confluence with Clarke Creek. However, due to construction errors, the alignment of the line was corrected and is now outside the fenced protected area.

The most upland section of the buffer is a filter strip-type buffer (Zone 3) consisting of native grass plantings. This section of buffer will be 8 feet wide, measured between the fence and the stream. The landowner will be allowed to maintain this native grass strip free of woody vegetation to protect the fence from damage by trees which might cause a breach allowing the cattle access to the stream restoration, potentially damaging it. The section of buffer adjacent to the channel was planted in trees, shrubs, and grasses (Zone 1 and 2).

2.3 Design and Construction Contact Information

Design Firm: CH2M HILL
4824 Parkway Plaza Blvd, Ste 200
Charlotte, NC 28217
704.329.0072
Contact: Jill Davenport

Construction Firm: Hunter Landscape
11800 Statesville Rd
Huntersville, NC 28078
704.947.0010
Contact: West Hunter, III

Ecosystem Enhancement Program Project Manager:
Project Manager: Jim Stanfill, updated to Ed Hajnos

2.4 Methodologies

2.4.1 Dimension

Dimension is monitored by establishing permanent cross sections along the restoration reach, both in riffles and pools. Using conventional survey equipment, edge of channel, thalweg, bankfull depth, top of bank, and major slope changes have been identified at each cross section.

2.4.2 Pattern

Sinuosity, meander width ratio, and radius of curvature are measured to monitor the pattern of the new channel. Sinuosity is measured during the longitudinal profile by measuring the length of the new channel and the valley length. Meander width ratio is calculated by measuring the belt widths and dividing by the bankfull width (W blt/W bkf). Radius of curvature is measured for a series of meanders and a range is typically presented.

2.4.3 Profile

Profile is the longitudinal profile (or slope) of the stream channel and is used to classify stream type. This slope varies between riffles and pools. The sequence of riffles and pools should remain constant over time. Profile should be monitored by measuring the overall average slope, the slopes of each of the pools and riffles, and the pool to pool spacing. Maximum pool depth should be recorded for each of the pools to monitor changes over time. It is expected that some pools may get deeper over time but this is not considered to be an indicator of channel instability.

2.4.4 Materials

Pebble counts are used to monitor particle size in the pools and riffles. Pebble counts are to be conducted at each of the permanent cross sections. Two pools and four riffles will be monitored, which is based on the percentage of pools and riffles. Methodology should follow the Wolman pebble count protocol.

2.4.5 Photographs

Photograph stations are used to monitor visual aspects within the project area, including vegetation growth over time and changes channel stability. Photograph stations were established to include each in-stream structure and all permanent monitoring stations.

2.4.6 Vegetation

The planted riparian buffer zone will be monitored to measure woody plant species' survival. From the center point, vegetation is monitored within a 16.7-foot radius. All tree stems, including volunteers, will be identified to species and tallied.

Section 3 Success Criteria

The following sections provide detailed descriptions of the as-built stream restoration project. Dimension, pattern, and profile are described and surveyed data are provided for future monitoring purposes.

3.1. Dimension

Dimension, or the cross-sectional view of a stream channel, is monitored at six locations. Permanent cross sections have been established and are shown in Figure 2 and locations are presented in Table 1.

TABLE 1
Cross Section Locations
Cato Farms Stream Restoration

Cross Section	Coordinates (N)	Coordinates (W)	Coordinates (N)	Coordinates (W)
	Right Bank		Left Bank	
XS 1	35' 24. 488	80' 49. 239	35' 24. 492	80' 49. 232
XS 2	35' 24. 510	80' 49. 246	35' 24. 516	80' 49. 244
XS 3	35' 24. 549	80' 49. 290	35' 24. 553	80' 49. 283
XS 4	35' 24. 572	80' 49. 297	35' 24. 575	80' 49. 292
XS 5	35' 24. 589	80' 49. 302	35' 24. 587	80' 49. 300
XS 6	35' 24. 629	80' 49. 313	35' 24. 633	80' 49. 313

First-year monitoring cross sections are presented in Figures 3a through 3h. Calculations based on these data include:

- Width-to-depth ratio
- Entrenchment ratio
- Bankfull Area

These data are presented in Table 2. Due to the small size of the channel, the low bank height ratio was not calculated for this system.

TABLE 2

Channel Dimension Parameters
Cato Farms Stream Restoration

Cross Section	Bankfull Width (ft)	Entrenchment Ratio	Width/Depth Ratio	Bankfull Area (ft^2)	Channel Type
1	6.58	4.1	8.32	5.2	E
2*	14.51	1.67	68.2	3.09	B
3	7.2	4.85	7.32	7.08	E
4	8.91	2.9	18.95	4.2	E
5	7.15	2.94	7.73	6.6	E
6	7.78	4.79	10.28	5.89	E

*Located in middle of Cross Section 2, which is filling with sediment

During the monitoring period, these cross sections will be resurveyed. To be deemed successful, the dimension of the stream channel at these locations should not change radically over time. Some lateral movement may be expected as the stream channel adjusts and stabilizes itself, but these changes should be minimal.

It should be noted that Cross Section 2 was established across the center of a cross vane, which is experiencing aggregation of materials. The cross section location was specifically selected to monitor the change in this area.

3.2 Pattern

Pattern, or the plan view of the stream sinuosity, will be monitored to ensure no changes occur over the monitoring period. The pattern is indicative of the valley type and stream type. Changes in pattern over time can be compared to baseline conditions in Figure 2. Measurements of pattern include:

- Sinuosity
- Meander width ratio

- Radius of curvature (on newly constructed meanders during first year of monitoring)

These data are presented in Table 3.

TABLE 3
Pattern Measurements
Cato Farms Stream Restoration

	Measurements
Sinuosity	1.39
Meander Width Ratio	6.0
Radius of Curvature	13.0 to 28.0 feet

3.3 Profile

The longitudinal profile is presented in Figure 4. Elevations are based on the permanent marker set in the pole near the upstream culvert. The overall channel slope is 0.007. Note the differences in slope within the Rosgen E channel section and the Rosgen B channel section. The slope of the top E channel section is 0.006 while the slope of the transitional B channel is 0.015. The range of riffle slopes is -0.00361 (where some aggredation is present) to 0.133, with a median slope of 0.0176. The range of pool slopes is -0.076 to 0.020 with a median of 0.0018. This is consistent with the expectation that riffles would have steeper slopes than pools. Transitional runs and glides are also present in the channel. It is expected that pools exhibit very little change in water surface elevation while higher energy riffles show a steeper water surface profile. Overall, these slopes are consistent with Rosgen E and B channel type parameters.

3.4 Materials

Pebble counts are to be conducted at each of the permanent cross sections. Two pools and four riffles will be monitored, which is based on the percentage of pools and riffles. One of these riffles has formed within Cross Section 2 (see photographs in Appendix A.). Over time, the baseline diameters of bed material (d50 and d85) should increase in coarseness in riffles and increase in fineness in pools. Table 4 presents pebble count data at each of the monitored cross-sections.

TABLE 4
Pebble Count Data Summary
Cato Farms Stream Restoration

Cross Section	d50 (mm)	Class	d84 (mm)	Class	Type
XS 1	< 2	Silt	< 2	Fine sand	Riffle
XS 2	1	Coarse sand	5	Fine gravel	Riffle*
XS 3	< 2	Silt/Clay	< 2	Medium sand	Riffle
XS 4	< 2	Medium sand	1	Coarse sand	Pool
XS 5	< 2	Medium sand	1	Coarse sand	Riffle
XS 6	< 2	Medium sand	1	Coarse sand	Pool

*Data collected where a cross vane is filling with sediment and forming a riffle

3.5 Photographs

Permanent photograph stations are shown in Figure 2. At each cross-section, a photograph station was established to monitor any visual changes such as erosion and vegetation establishment. Photograph stations were also established to observe possible changes at structure locations and to observe vegetative growth at each of the vegetation plots. The angles at which photographs were taken are presented in Table 5. The photographs themselves are presented in Appendix A.

TABLE 5

Photograph Stations
Cato Farms Stream Restoration

Photo Station	Description	Direction	Coordinates (N)	Coordinates (W)
1.A	Looking downstream at cross vane 1,2 and confluence	SE	35' 24. 461	80' 49. 214
1.B	Looking upstream at cross vane 3	N	35' 24. 461	80' 49. 214
2.A	Looking downstream at cross vane 3 and 4	SE	35' 24. 471	80' 49. 211
2.B	Looking upstream at cross vane 5	W	35' 24. 471	80' 49. 211
3.A	Looking downstream at cross vane 6	E	35' 24. 486	80' 49. 237
3.B	Looking upstream at cross vane 7 and 8	N	35' 24. 486	80' 49. 237
4.A	Looking downstream at cross vane 7	SE	35' 24. 492	80' 49. 234
4.B	Looking upstream at cross vane 8	N	35' 24. 492	80' 49. 234
4.C	Looking at cross-section 1	NE	35' 24. 492	80' 49. 234
5.A	Looking downstream at cross vane 9	S	35' 24. 507	80' 49. 234
5.B	Looking upstream at cross vane 10	NW	35' 24. 507	80' 49. 234
5.C	Looking at cross-section 2	NE	35' 24. 507	80' 49. 234
5.D	Looking at vegetation plot 1	SW	35' 24. 507	80' 49. 234
6.A	Looking downstream at right bank	S	35' 24. 531	80' 49. 231
6.B	Looking upstream at right bank	NW	35' 24. 531	80' 49. 231
7.A	Looking at cross-section 3	SW	35' 24. 559	80' 49. 288
8.A	Looking upstream at left bank	N	35' 24. 572	80' 49. 287
8.B	Looking downstream at left bank	SE	35' 24. 572	80' 49. 287
9.A	Looking at cross-section 4	NE	35' 24. 573	80' 49. 295
10.A	Looking upstream at cattle crossing	NW	35' 24. 572	80' 49. 297
11.A	Looking downstream at cattle crossing	SE	35' 24. 580	80' 49. 308
11.B	Looking at cross-section 5	N	35' 24. 580	80' 49. 308
12.A	Looking at cross-section 5	Vertical	35' 24. 587	80' 49. 300
13.A	Looking at hole in right bank	S	35' 24. 605	80' 49. 306
13.B	Looking downstream at left bank	SE	35' 24. 605	80' 49. 306
14.A	Looking at erosion hole	S	35' 24. 608	80' 49. 315
14.B	Looking downstream at left bank	E	35' 24. 608	80' 49. 315
15.A	Looking at cross-section 6	NW	35' 24. 631	80' 49. 308

TABLE 5

Photograph Stations
Cato Farms Stream Restoration

Photo Station	Description	Direction	Coordinates (N)	Coordinates (W)
1.A	Looking downstream at cross vane 1,2 and confluence	SE	35' 24. 461	80' 49. 214
1.B	Looking upstream at cross vane 3	N	35' 24. 461	80' 49. 214
2.A	Looking downstream at cross vane 3 and 4	SE	35' 24. 471	80' 49. 211
15.B	Looking at vegetation plot 2	SW	35' 24. 631	80' 49. 308
16.A	Looking downstream toward sycamore	SW	35' 24. 662	80' 49. 317
16.B	Looking upstream toward hillside	W	35' 24. 662	80' 49. 317
16.C	Looking upstream at culvert	NW	35' 24. 662	80' 49. 317
16.D	Looking at ponded area	NE	35' 24. 662	80' 49. 317
17.A	Looking downstream of culvert face	SW	35' 24. 714	80' 49. 329
17.B	Looking upstream at culvert face	NW	35' 24. 714	80' 49. 329
18.A	Looking at vegetation plot 3	SW	35' 24. 703	80' 49. 317

3.6 Vegetation

The planted riparian buffer zone will be monitored to measure woody plant species' survival. This is accomplished by the establishment of three vegetative plots (Figure 2; Table 6). Plots 1 and 2 border the stream channel. Plot 3 is located in an upland area within the conservation easement.

From the center point, vegetation is monitored within a 16.7-foot radius. All tree stems, including volunteers, will be identified to species and tallied. Data from the as-built survey are included in Table 6. To be successful, survival must be 320 stems per acre after five years and maintain a similar woody species composition as the reference site.

Vegetation was planted in February and March 2004. Herbaceous vegetation is successfully covering the site. No evidence of browsing by deer has been observed. The cattle exclusion fences are also successfully keeping deer out of the area. Many volunteer Red maples have been observed throughout the site, as evidenced in the vegetation plots (Table 6). Other volunteers are also growing, including Sycamores and Dogwoods. These species were expected to come in due to the neighboring forested area.

TABLE 6
Vegetation Plots
Cato Farms Stream Restoration

Common Name	Scientific Name	Quantity	
		Planted	Volunteer
Vegetation Plot 1 (Location =N 35 24.508, W 80 49.241)			
Black Willow	*Salix nigra*	8	-
Sweetspire	*Itea virginica*	5	-
Purple oiser dogwood	*Salix purpurea*	2	-
Red maple	*Acer rubrum*	-	50
Sycamore	*Plantanus occidentalis*	-	4
Silky dogwood	*Cornus amomum*	8	3
Eastern red cedar	*Juniperus virginiana*	1	-
Vegetation Plot 2 (Location =N 35 24.628, W 80 49.313)			
Silky dogwood	*Cornus amomum*	12	2
Purple oiser dogwood	*Salix purpurea*	2	-
Red maple	*Acer rubrum*	-	8
Swamp white oak	*Quercus bicolor*	1	-
Highbush blueberry	*Vaccinium corymbosum*	1	-
American holly	*Ilex opaca*	1	-
		-	-
Vegetation Plot 3 (Location =N 35 24.702, W 80 49.319)			
Sycamore	*Plantanus occidentalis*	4	3
Sweetspire	*Itea virginica*	7	5
Red maple	*Acer rubrum*	-	1
Eastern red cedar	*Juniperus virginiana*	-	1

Note: GPS locations were recorded at the center stake of each plot.

Section 4 Monitoring

4.1 Monitoring Period

Monitoring will be for a period of 5 years from the date of project completion. In this case, monitoring will be conducted from March 2005 to March 2010. Monitoring reports will be compiled and sent at the end of the first, third, and fifth years to the U.S. Army Corps of Engineers (USACE) and to the North Carolina Department of Environment and Natural Resources (NCDENR) Division of Water Quality (DWQ).

Monitoring Firm: NC State University
Contact: Dan Clinton

Section 5 Mitigation

The Cato Farms Stream Restoration Site was constructed to meet restoration criteria and achieve mitigation credits needed by the NC EEP. The upper portion project length is a Priority 1 Rosgen E channel restoration and should be eligible for a 1:1 mitigation credit ratio. The lower 500 the project length is a transitional Rosgen B channel to tie the restored section to the elevation of Clarke Creek. The transition begins at Station 30+00 (Figure 2b), with 2,000 linear feet of Priority 1 restoration and the remainder of the project length as the transitional zone. Monitoring of the channel for the achievement of success criteria will be key factor in the final determination of stream mitigation credit. Mitigation credits will be applied against the deficit of credits needed in the watershed.

Section 6 Maintenance and Contingency Plans

If during the monitoring period it is discovered that the project site is failing to meet any one or more of the above success criteria, a contingency plan would be implemented to address any problems.

In July 2005, a section of erosion was repaired by installing coir fiber logs, backfilling erosion areas, and re-establishing vegetation. Photographs from this effort are included in Appendix B. Also, a tree had fallen across the channel in the fall of 2004 during a

large storm event. Over six inches of rain fell from remnants of Hurricanes Ivan and Frances. This tree was causing a diversion of flow and further erosion. The tree was removed from the channel, re-establishing normal flow.

Section 7 References

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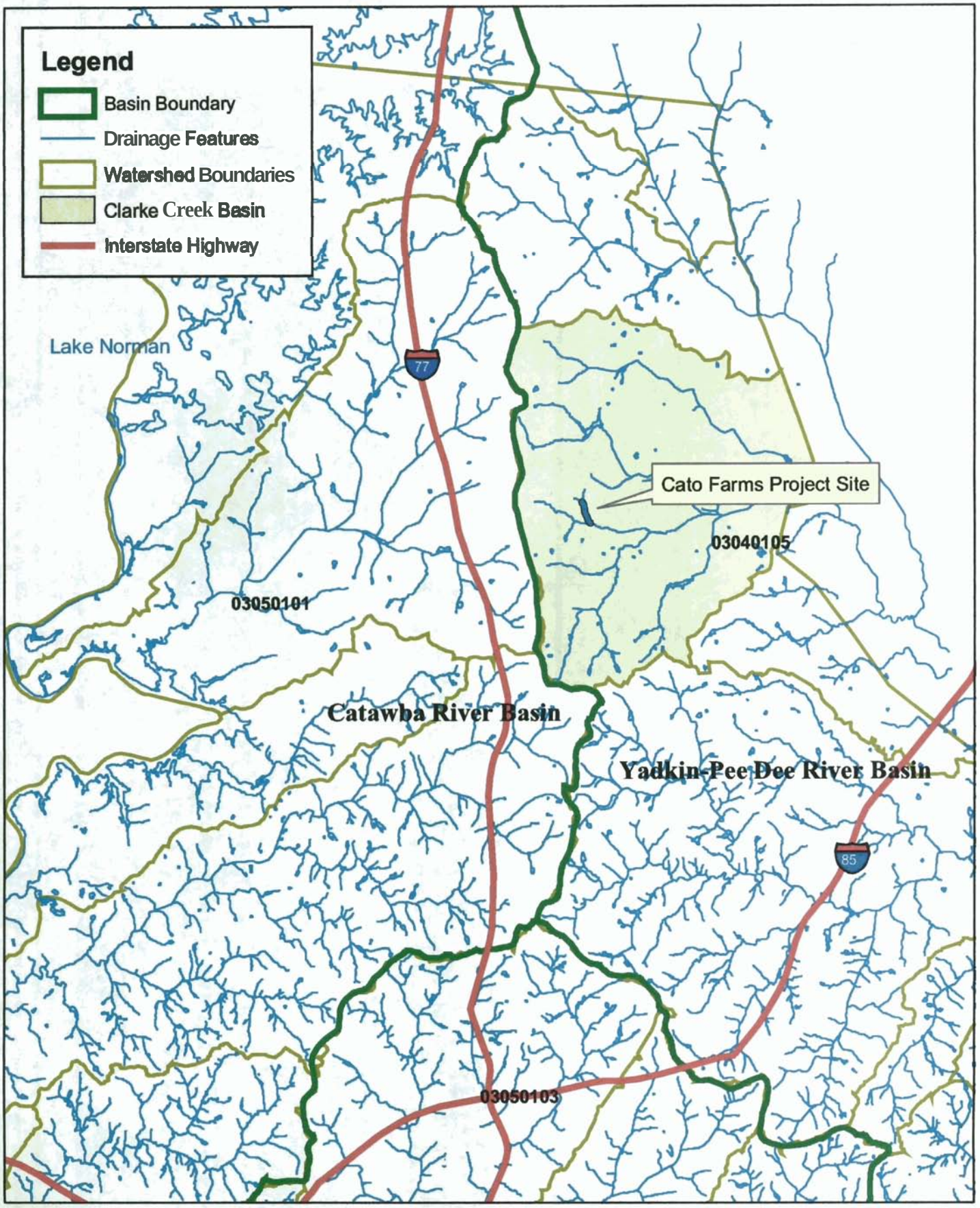

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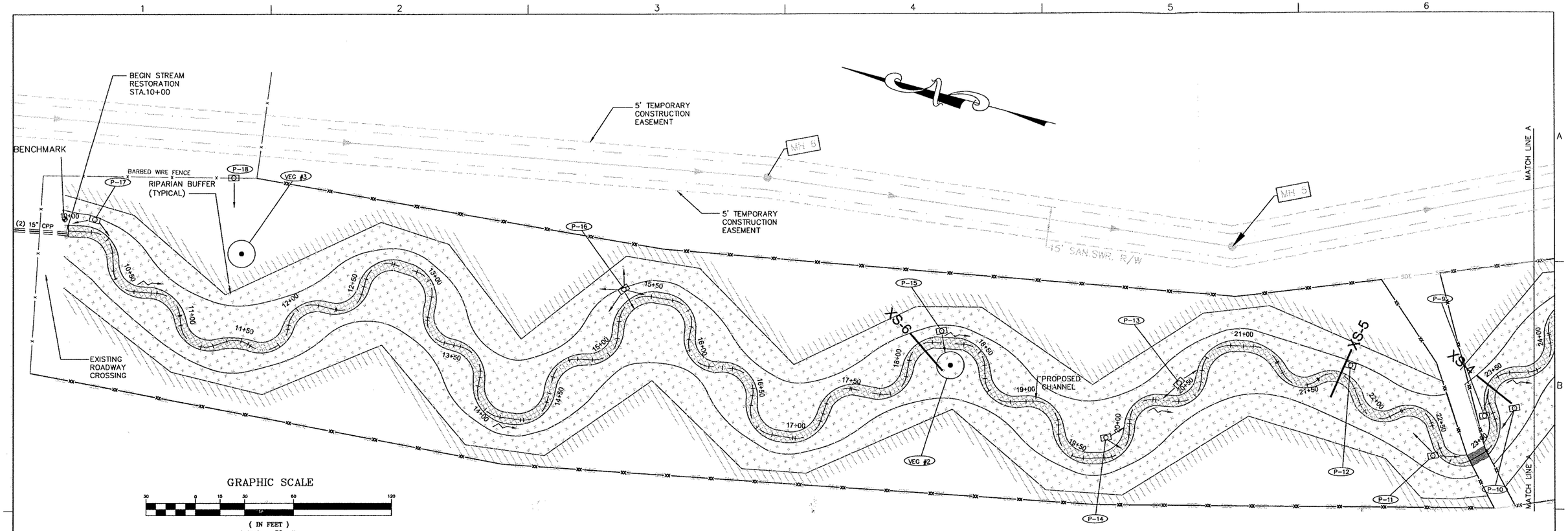
Figure 1
Cato Farms Stream Restoration
Watershed Location



GRAPHIC SCALE

30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

LEGEND

PLANTING ZONES

- ZONE 1
- ZONE 2
- ZONE 2A
- ZONE 3
- ZONE 4

- P-18 — PHOTOGRAPH STATIONS
- VEG #1 — VEGETATION PLOTS
- V11 — CROSS VANES
- XS-2 — CROSS SECTIONS
- BENCHMARK
- FENCE
- SDE — STORM DRAINAGE EASEMENT

NOTES:

1. THE PURPOSE OF THIS FIGURE IS TO DEPICT MONITORING STATION LOCATIONS. THESE LOCATIONS ARE OVERLAYED ON A BASE MAP FOR REFERENCE PURPOSES (THE BASE MAP IS NOT AN AS-BUILT DRAWING).
2. THE FOLLOWING FEATURES DO NOT DEPICT CURRENT CONDITIONS: SEWER LINE LOCATION, FENCE ALIGNMENT
3. STREAM ALIGNMENT WAS BUILT AS SHOWN.
4. ORIGINAL BASE SURVEY BY:

THE SURVEY COMPANY, INC.
4105-B STUART ANDREW BLVD
CHARLOTTE, NC 28217
(704) 561-9970 (704) 561-9972 FAX
EMAIL: surveyco@bellsouth.net

DSGN	GMH						VERIFY SCALE
DR	JHR						BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.
CHK							
APVD		NO.	DATE	REVISION	BY	APVD	

CH2MHILL
CH2M HILL, INC.
4824 PARKWAY PLAZA BOULEVARD
SUITE 200
CHARLOTTE, N.C. 28217-1968
(704) 329-0072

CATO FARMS
STREAM RESTORATION PROJECT
MONITORING STATION LOCATIONS

SHEET	FIGURE 2a
DWG	
DATE	5/27/05
PROJ	171915

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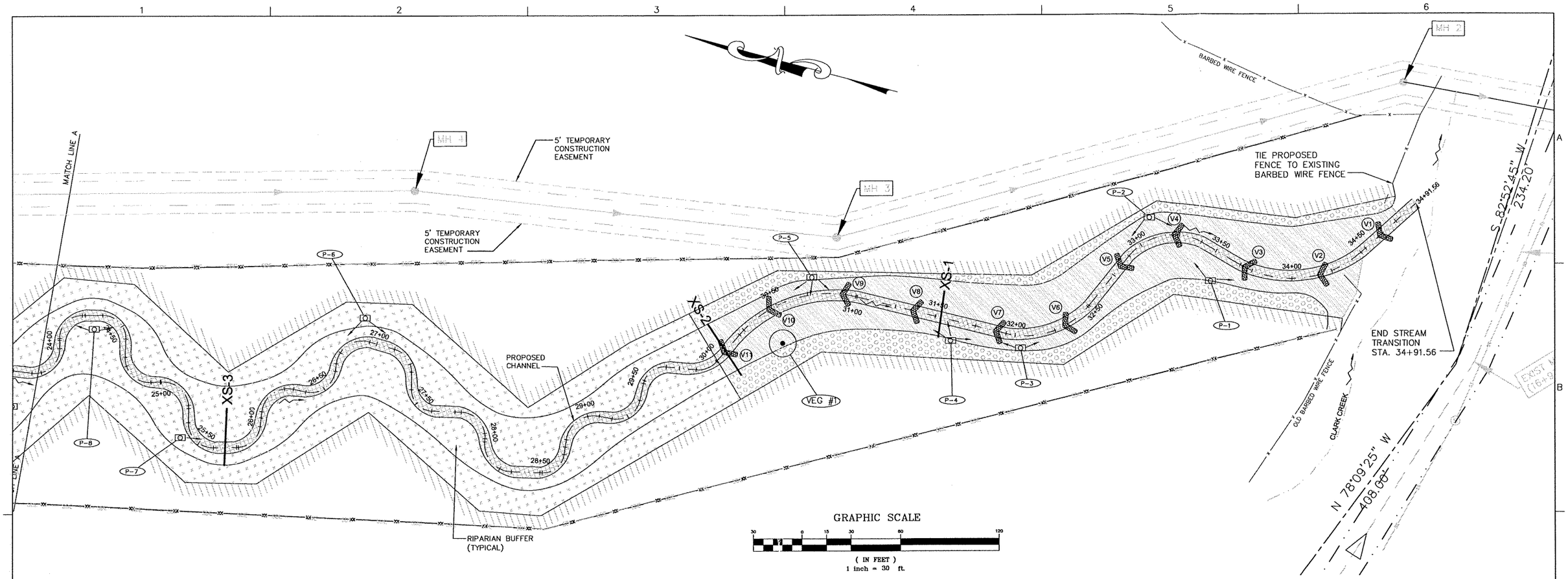

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30 0 15 30 60 120

(IN FEET)
1 inch = 30 ft.

LEGEND

PLANTING ZONES

- ZONE 1
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EMAIL: surveyco@bellsouth.net

DSGN	GMH
DR	JHR
CHK	
APVD	

NO.	DATE	REVISION	BY	APVD

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

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CH2M HILL, INC.
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SUITE 200
CHARLOTTE, N.C. 28217-1968
(704) 329-0072

CATO FARMS
STREAM RESTORATION PROJECT
MONITORING STATION LOCATIONS

SHEET	FIGURE 2b
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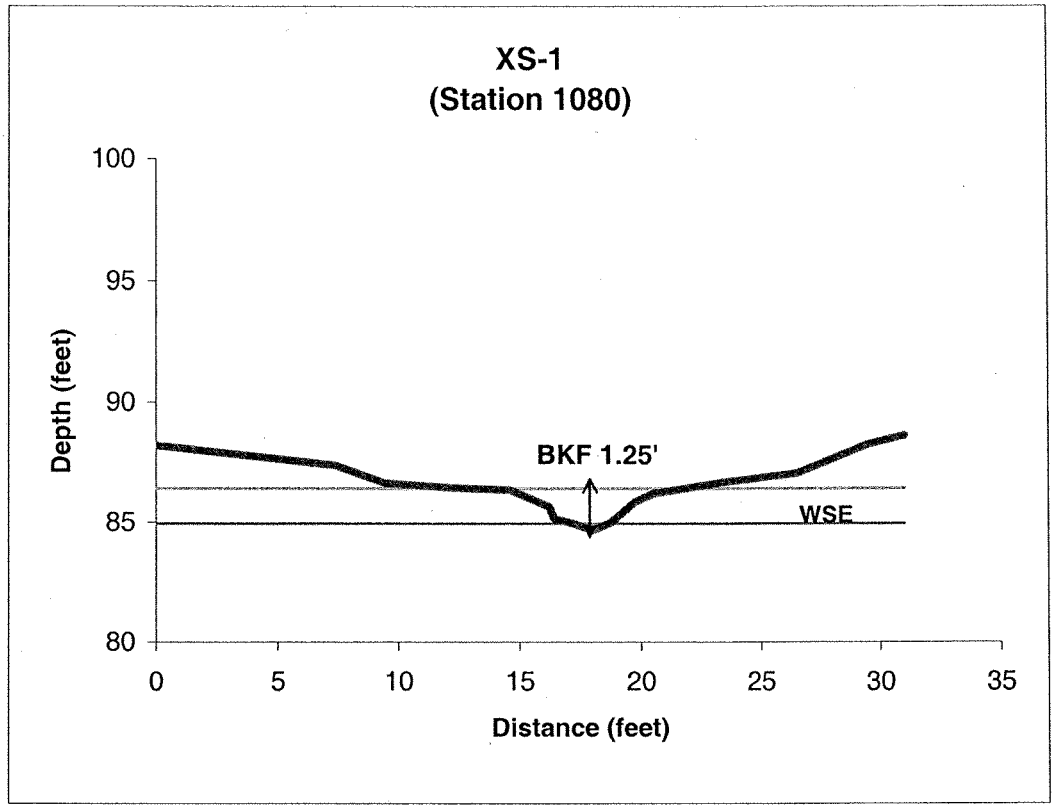


Figure 3a

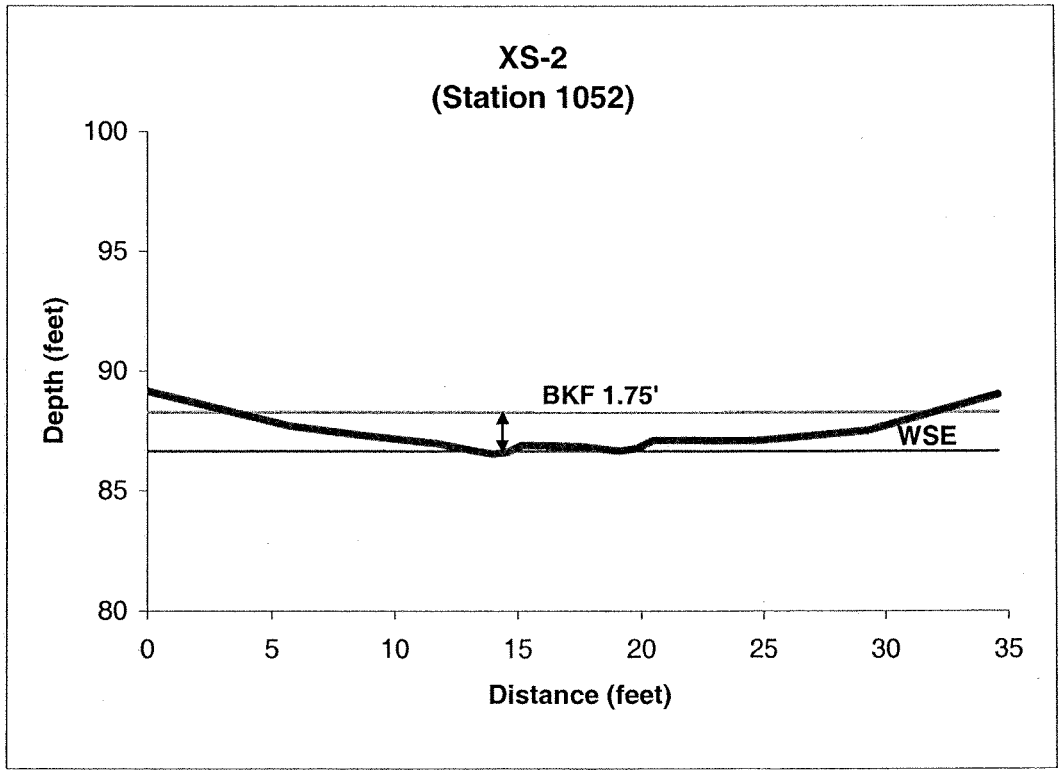
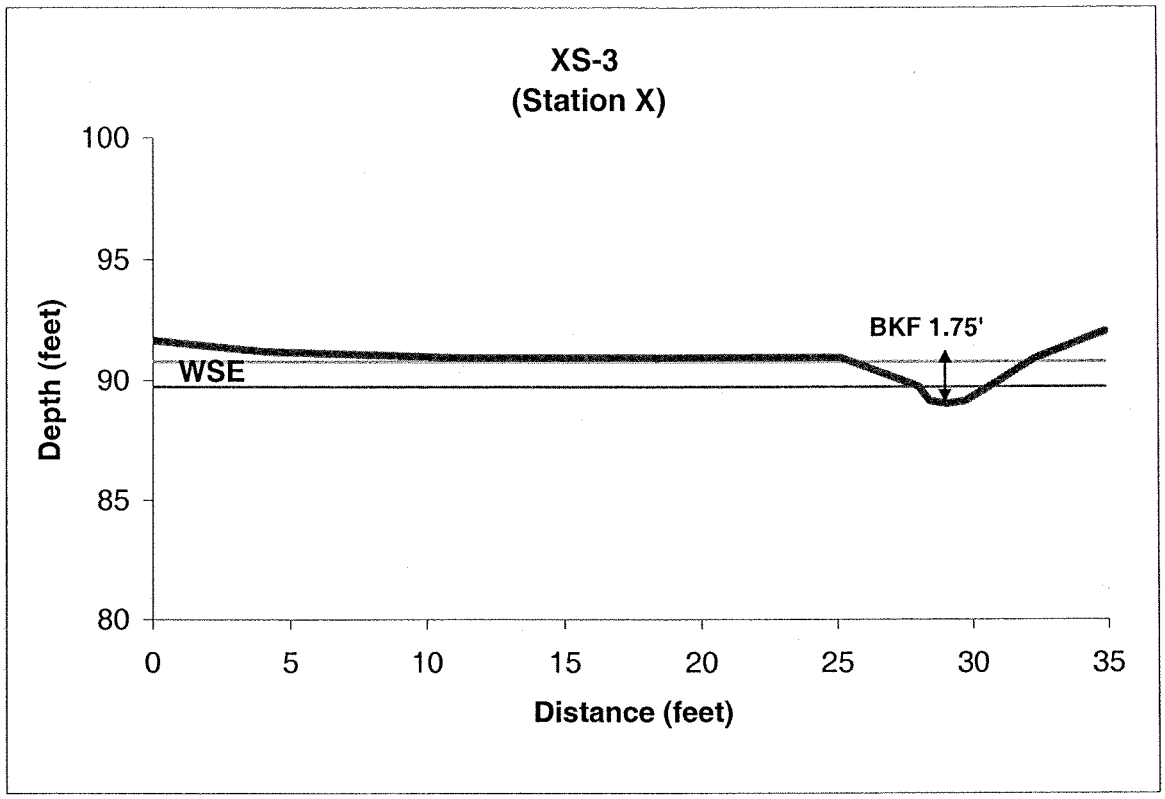


Figure 3b.



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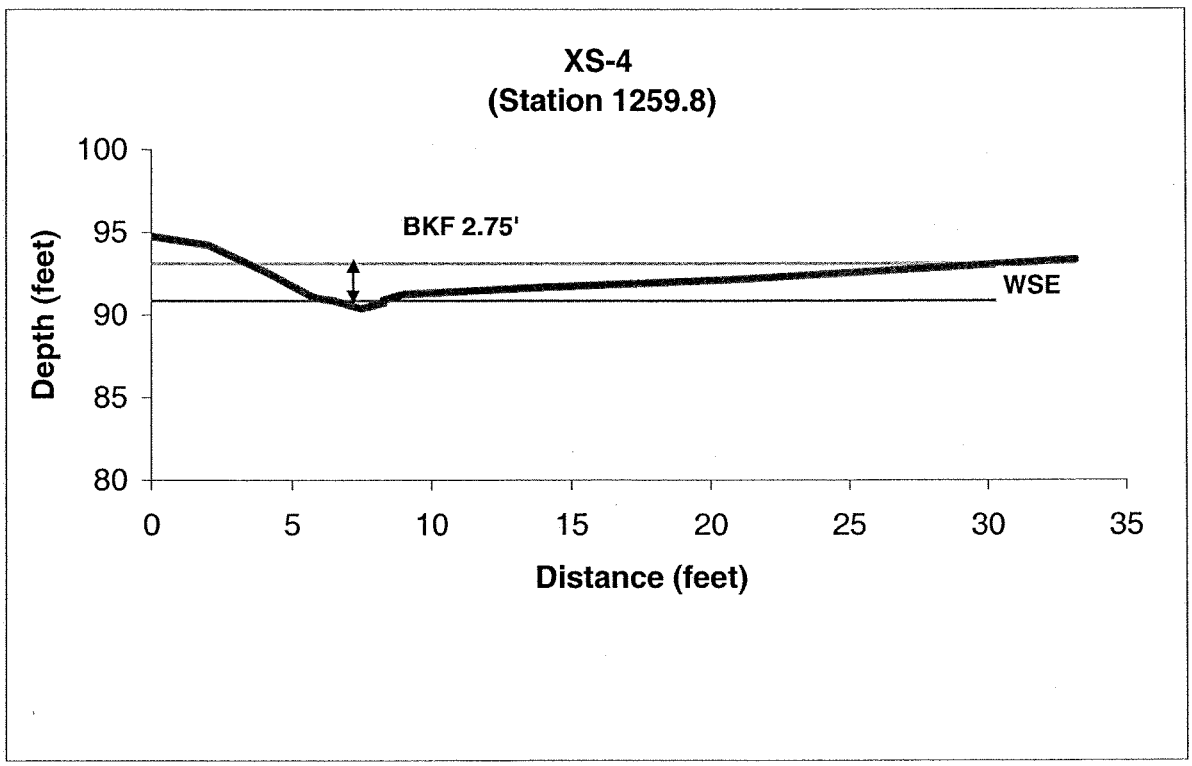


Figure3d.

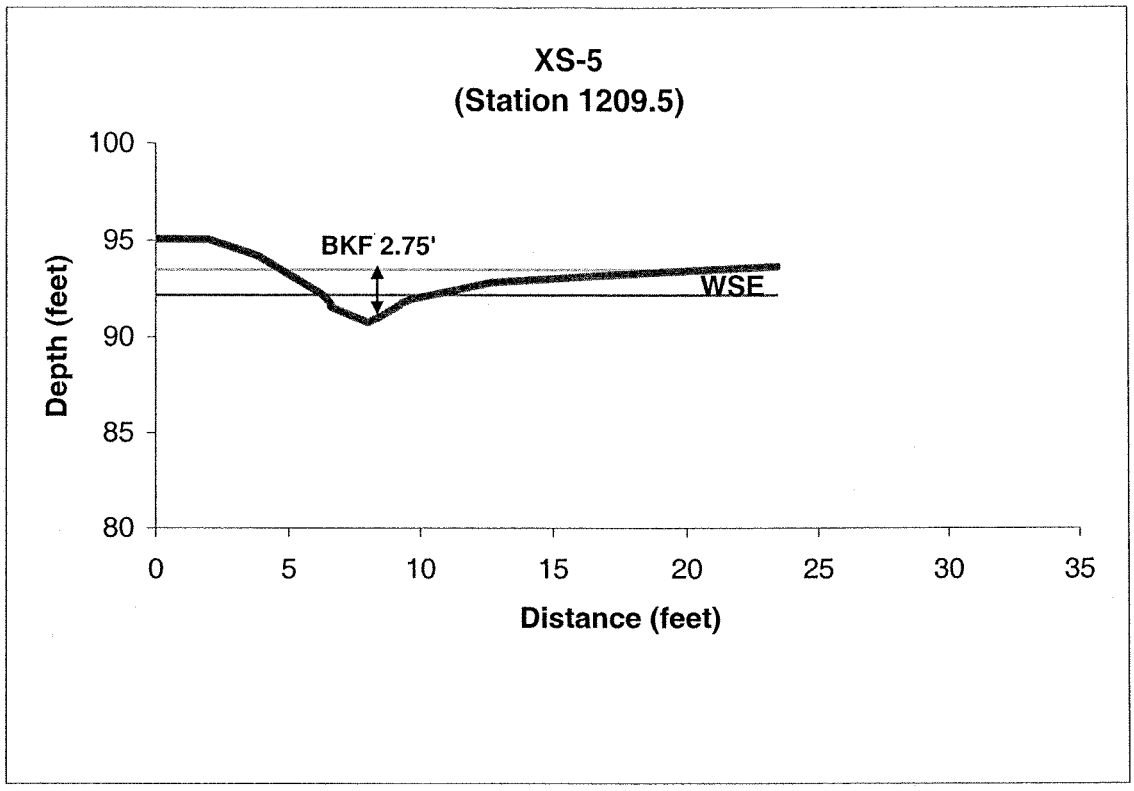


Figure 3e.

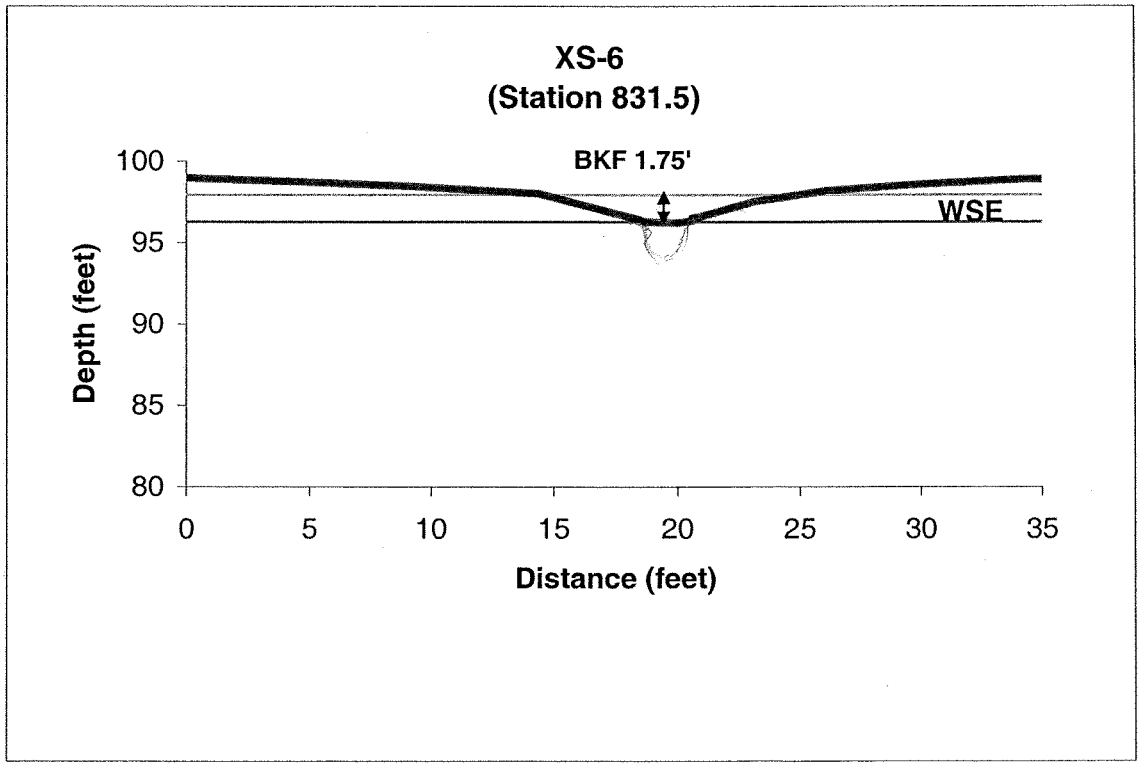
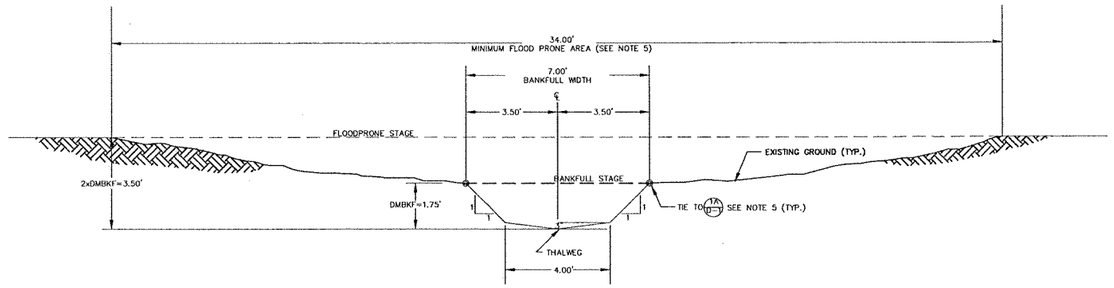
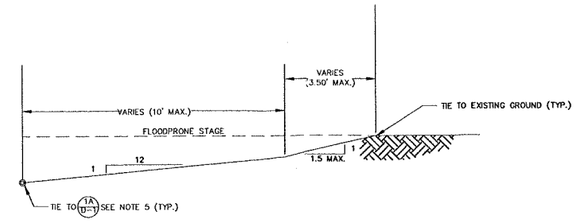


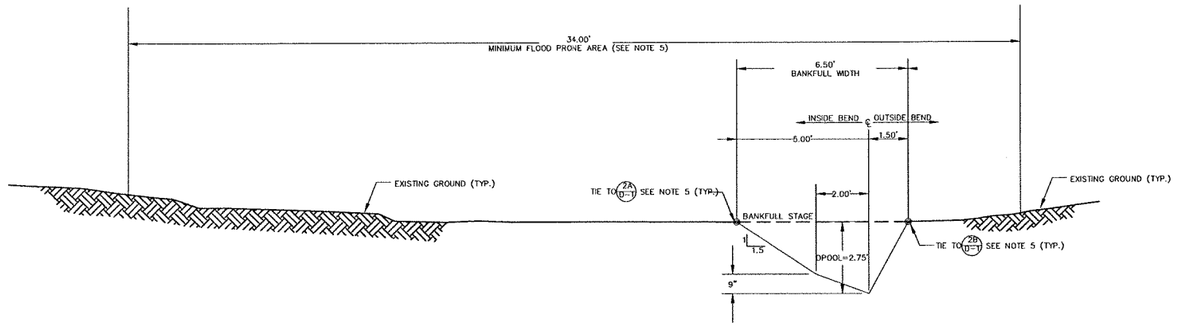
Figure 3f.



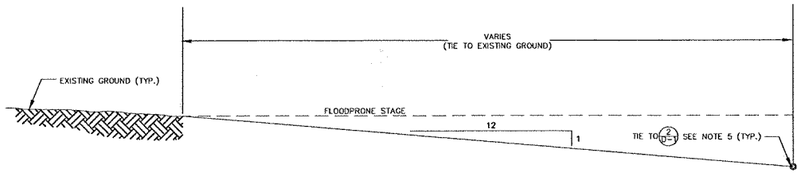
1 D-1 STREAM RESTORATION TYPICAL RIFFLE CROSS-SECTION
NTS



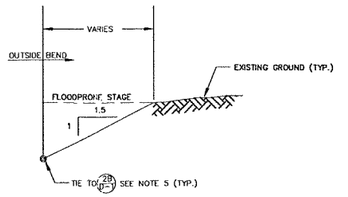
1A D-1 FLOODPRONE AREA PARTIAL RIFFLE CROSS-SECTION
NTS



2 D-1 STREAM RESTORATION TYPICAL POOL (BEND) CROSS-SECTION
NTS



2A D-1 FLOODPRONE AREA PARTIAL POOL CROSS-SECTION (INSIDE BEND)
NTS



2B D-1 FLOODPRONE AREA PARTIAL POOL CROSS-SECTION (OUTSIDE BEND)
NTS

CROSS SECTION NOTES:

1. ALL TYPICAL SECTIONS ARE VIEWED FACING DOWNSTREAM.

2. REVERSE TYPICAL SECTION (2 D-1) AS NEEDED DEPENDING ON THE DIRECTION OF THE BEND IN THE STREAM – 2:1 SLOPE SHALL BE USED ON THE OUTSIDE STREAMBANK IN A BEND (MEANDER) AND 12:1 SLOPE SHALL BE USED ON THE INSIDE STREAMBANK IN A BEND (MEANDER).

3. TYPICAL SECTION VERTICAL CONTROL SHALL BE ABOUT THE THALWEG POINT PER THE PROFILE SHOWN ON SHEET PR-1 AND PR-2.

4. SEE STREAM SCHEMATIC, (1 D-1) FOR LOCATIONS OF POOLS/RIFFLES IN THE PLAN VIEW. TYPICAL SECTIONS (1 D-1) AND (2 D-1) SHALL BE APPLIED IN ACCORDANCE WITH THE STREAM SCHEMATIC.

5. IF LOCALIZED VARIATIONS IN TOPOGRAPHY RESULT IN A FLOODPRONE WIDTH OF LESS THAN THE MINIMUM, THEN A FLOODPRONE AREA SHALL BE GRADED PER PARTIAL SECTION (1A D-1), (2A D-1), OR (2B D-1).

DSGN SPB, SDC DR TDC CHK APVD	NO.	DATE	REVISION	BY	APVD	VERIFY SCALE BAR IS ONE INCH ON ORIGINAL DRAWING. 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	THE SURVEY COMPANY, INC. 4105-B STUART ANDREW BLVD CHARLOTTE, NC 28217 (704) 561-9970 (704) 561-9972 FAX EMAIL: surveyco@bellsouth.net	CH2M HILL, INC. 4824 PARKWAY PLAZA BOULEVARD SUITE 200 CHARLOTTE, N.C. 28217-1968 (704) 329-0072

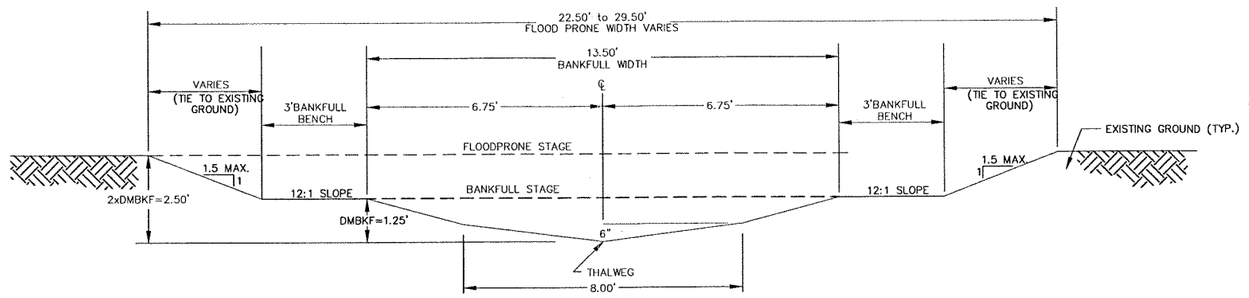
P:\Land Projects\CHM02 Cato Farm\dwg\CHM02_rev5.dwg

CATO FARMS
STREAM RESTORATION PROJECT
DETAILS

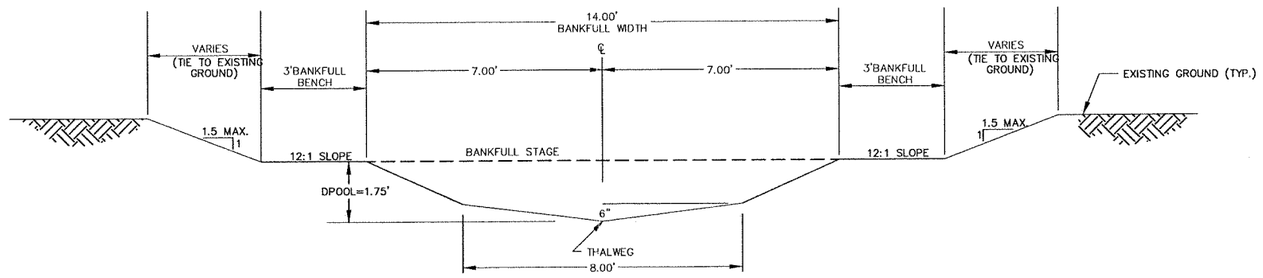
SHEET	D-1
DWG	CHM02
DATE	10/9/02
PROJ	171915

10/9/02 07/23/02

FILENAME: P:\Land Projects\CHM02 Cato Farm\dwg\CHM02_rev5.dwg



1 / D-2 STREAM TRANSITION TYPICAL VANE (RIFFLE) CROSS-SECTION
NTS



2 / D-2 STREAM TRANSITION TYPICAL POOL CROSS-SECTION
NTS

CROSS SECTION NOTES:

1. ALL TYPICAL SECTIONS ARE VIEWED FACING DOWNSTREAM.

2. REFER TO PLAN SHEET P-2 FOR LOCATION OF VANES.

3. TYPICAL SECTION VERTICAL CONTROL SHALL BE ABOUT THE THALWEG POINT PER THE PROFILE SHOWN ON SHEET PR-1 AND PR-2.

DSGN	SPB, SDC
DR	TDC
CHK	
APVD	

NO.	DATE	REVISION	BY	APVD
2	9/12/02	NOTE 4	SPB	
1	9/12/02	ADDED 3' WIDE BANKFULL BENCH	SPB	

VERIFY SCALE
BAR IS ONE INCH ON ORIGINAL DRAWING.
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

THE SURVEY COMPANY, INC.
4105-B STUART ANDREW BLVD
CHARLOTTE, NC 28217
(704) 561-9970 (704) 561-9972 FAX
EMAIL: surveyco@bellsouth.net

CH2M HILL, INC.
4824 PARKWAY PLAZA BOULEVARD
SUITE 200
CHARLOTTE, N.C. 28217-1968
(704) 329-0072

P:\Land Projects\CHM02 Cato Farm\dwg\CHM02_rev5.JPG

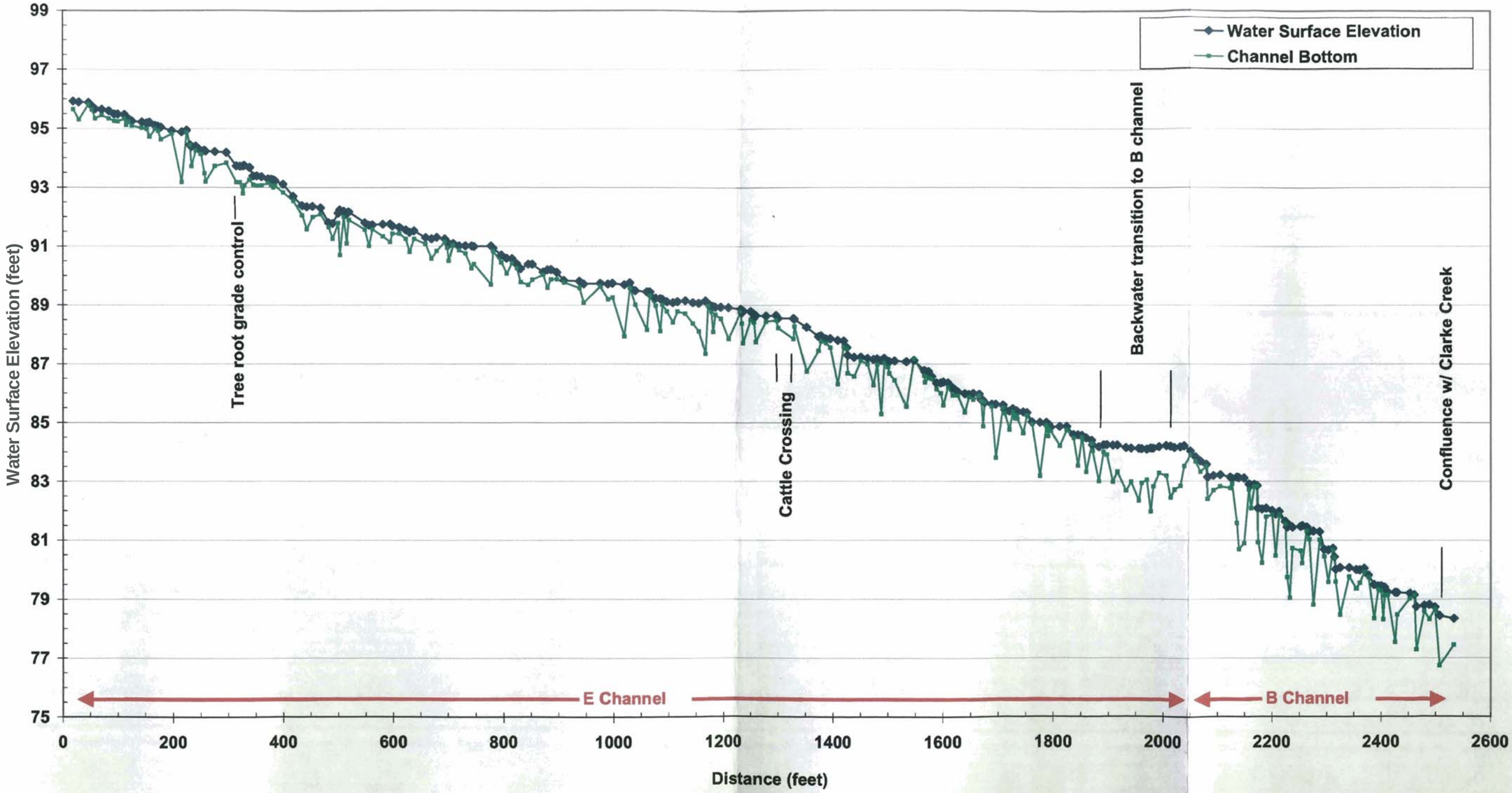
CATO FARMS
STREAM RESTORATION PROJECT
DETAILS

SHEET	D-2
DWG	CHM02
DATE	10/9/02
PROJ	171915

FILENAME: P:\Land Projects\CHM02 Cato Farm\dwg\CHM02_rev5.dwg

PLOT DATE: 10/9/02

Figure 4
Cato Farms Stream Restoration Longitudinal Profile



Appendix A
Monitoring Station Photograph Log

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 1.A: Looking downstream at cross vanes 1 and 2 and confluence with Clarke Creek

Photo Station 1.B: Looking upstream at cross vane 3

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 2.A: Looking downstream at cross vanes 3 and 4.

Photo Station 2.B: Looking upstream at cross vane 5.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 3.A: Looking downstream at cross vane 6.

Photo Station 3.B: Looking upstream at cross vanes 7 and 8.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 4.A: Looking downstream at cross vane 7.

Photo Station 4.B: Looking upstream at cross vane 8.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 4C: Looking at cross-section 1.

Photo Station 5.A: Looking downstream at cross vane 9.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 5.B: Looking upstream at cross vane 10.

Photo Station 5C: Looking at cross-section 2.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 5.D: Looking at Vegetation Plot 1.

Photo Station 6.A: Looking downstream at right bank.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 6.B: Looking upstream at right bank.

Photo Station 7.A: Looking at cross-section 3.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 8.A: Looking upstream left bank.

Photo Station 8.B: Looking downstream at left bank.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 9.A: Looking at cross-section 4.

Photo **Station 10.A: Looking upstream at cattle crossing.**

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 11.A: Looking downstream at cattle crossing.

Photo Station 11.B: Looking at cross-section 5.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 12.A: Looking at cross-section 5.

Photo Station 13.A: Looking at hole in right bank.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 13.B: Looking downstream at left bank.

Photo Station 14.A: Looking at erosion hole.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 14.B: Looking downstream at left bank.

Photo Station 15.A: Looking at cross-section 6.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 15.B: Looking at Vegetation Plot 2.

Photo Station 16.A: Looking downstream toward Sycamore tree.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 16.B: Looking upstream toward hillside.

Photo Station 16.C: Looking upstream at culvert/start of project limits.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 16.D: Looking at standing water (often present in spring season) and sewer line right-of-way.

Photo Station 17.A: Looking downstream of culvert outlet.

Cato Farms Stream Restoration Project
Photograph Log

Photo Station 17.B: Looking upstream at culvert face.

Photo Station 18.A: Looking at Vegetation Plot 3.

Appendix B
Photograph Log – Repair Section

Cato Farms Stream Restoration Project
Photograph Log - Repair Section

Photo 1: Looking at erosion hole fix upstream of Station 20+00

Photo 2: Looking at erosion fix between Stations 20+00 and 20+50

Cato Farms Stream Restoration Project
Photograph Log - Repair Section

Photo 3: Looking at erosion fix between Stations 20+20 and 20+50

Photo 4: Looking at erosion fix on outer bend downstream of Station 20+00

Cato Farms Stream Restoration Project
Photograph Log - Repair Section

Photo 4: Tree removed from channel near Station 14+00