HORSE CREEK STREAM RESTORATION
MONITORING REPORT
EEP Project No. 71082
Monitoring Year – 01
2006

Design Firm:

Dewberry

2301 Rexwoods Drive, Suite 200
Raleigh, North Carolina 27606

Submitted To:

Ecosystem Enhancement Program

1652 Mail Service Center,
Raleigh, North Carolina 27699-1652

Monitoring Firm:

S&ME

9751 Southern Pine Boulevard
Charlotte, North Carolina 28273

September 2006

TABLE OF CONTENTS

EXECUTIVE SUMMARY 1
Project Summary 1
1 PROJECT BACKGROUND 3
1.1 Location and Setting 3
1.2 Structure and Objectives 3
1.3 Project History and Background 4
1.4 Monitoring Plan View 9
2 PROJECT CONDITION AND MONITORING RESULTS 14
2.1 Vegetative Assessment 14
2.1.1 Soil Data 14
2.1.2 Vegetative Problem Areas 15
2.1.3 Vegetative Problem Areas Plan View 16
2.1.4 Stem Counts 16
2.1.5 Vegetative Plot Photographs 20
2.2 Stream Assessment 20
2.2.1 Stream Problem Areas Plan View 21
2.2.2 Stream Problem Areas Table Summary 21
2.2.3 Numbered Issues Photograph Section 23
2.2.4 Fixed Photograph Station Photographs 23
2.2.5 Stability Assessment Table 23
2.2.6 Quantitative Measures Summary Tables 24
2.3 Wetland Assessment 31
3 METHODOLOGOY 31
3.1 Stream and Buffer Assessment 31
3.2 Stream Morphology Assessment 31
3.3 Vegetative Plot Assessment 32
3.4 Photograph Point Establishment 33
4 REPORT AND DATA SUBMISSION FORMAT 33

FIGURES AND PLAN VIEW SHEETS

Figure 1: Horse Creek Vicinity Map 5
Monitoring Areas - Sheet 1 9
Monitoring Areas - Sheet 2 10
Monitoring Areas - Sheet 3 11
Monitoring Areas - Sheet 4 12
Monitoring Areas - Sheet 5 13

TABLES

Table 1: Project Structure Table 6
Table 2: Project Objectives Table 6
Table 3: Project Activity and Reporting History 6
Table 4: Project Contact Table 7
Table 5: Project Background Table 8
Table 6: Preliminary Soil Data 14
Table 7: Vegetative Problem Areas 15

Table 8: Stem Counts for Each Species Arranged by Plot 18
Table 9: Verification of Bankfull Events 21
Table 10: Stream Problem Areas 22
Table 11-A: Categorical Stream Feature Visual Stability Assessment – Horse Creek 23
Table 11-B: Categorical Stream Feature Visual Stability Assessment – UT 24
Table 12-A: Baseline Morphology and Hydraulic Summary - Horse Creek 25
Table 12-B: Baseline Morphology and Hydraulic Summary - UT 26
Table 13-A: Morphology and Hydraulic Monitoring Summary - Horse Creek 27
Table 13-B: Morphology and Hydraulic Monitoring Summary - UT 29

APPENDICES

Appendix A Vegetation Raw Data

A.1 Vegetation Survey Data Tables
A.2 Photos of Vegetation Problem Areas
A.3 Plan View of Vegetation Problem Areas
A.4 Photos of Vegetation Monitoring Plots

Appendix B Geomorphologic Raw Data

B.1 Plan View of Stream Problem Areas
B.2 Photos of Representative Stream Problem Area
B.3 Photos of Stream Photo Stations
B.4 Qualitative Visual Stability Assessment
B.5 Cross-section Plots and Raw Data Tables
B.6 Longitudinal Plots and Raw Data Tables
B.7 Pebble Count Plots and Raw Data Tables

EXECUTIVE SUMMARY

Project Summary

The North Carolina Ecosystem Enhancement Program (EEP), formerly the North Carolina Wetland Restoration Program (WRP), identified Horse Creek, located on the Wake Forest Country Club (WFCC) property, as a stream restoration site. The project includes 2,285 linear feet (lf) of Horse Creek and 550 lf of an Unnamed Tributary to Horse Creek (UT). The majority of the pre-construction streambank lacked naturally occurring vegetation which resulted in increased bank erosion and reduced buffer filtration rates. Restoration of Horse Creek reconnected the stream to its original floodplain in a new alignment, and increased the stream's length and sinuosity. The UT was entrenched and lacked sinuosity. The design for the UT raised the channel elevation and reconnected the stream to its original floodplain along a new alignment.

This report serves as the Year 1 reporting requirement for the project and consists of five sections:

- Executive Summary;
- Project Background Information;
- Project Condition and Monitoring Results (Vegetation and Stream Assessments);
- Methodology; and
- Report and Data Submission Format.

Figures, tables, and representative photographs have been included as appropriate. Supplemental and supporting information is included in the appendices.

Vegetation Results - Stem counts and visual assessments were made of the streambanks and surrounding floodplain. This analysis was used to determine if the planted vegetation has survived. The complete stream assessment methodology is discussed in Section 3.

With the exception of two locations, streambank vegetation appeared healthy and extensive. However, riparian habitat continues to suffer as a result of aggressive mowing and buffer encroachment during golf course maintenance. The vegetative assessment yielded 14 problem features along Horse Creek and its UT. Two of these features were identified as bare bank, and the remaining 12 as bare floodplain. Large portions of the riparian buffer have been denuded of the native woody and herbaceous species originally planted there, and replaced only by maintained lawn grass. Of the 18 vegetative plots originally laid out and monitored along Horse Creek and its UT, six were identified with a 75 percent survival rate based on the number of "living" individuals identified in the initial post-construction assessment report. Twelve of the 18 had less than the required 75 percent survival rate. Six of the 18 had zero percent survival. The lack of floodplain vegetation within the riparian buffer constitutes the most acute problem area associated with both reaches.

Stream Results - The stream assessment yielded 15 problem areas along Horse Creek. No problem areas were identified in connection with the UT. The problem areas are identified on the Stream Problem Area Plan View (Appendix B.1) and are color-coded to reflect the degree of concern associated with each area.

Isolated areas of aggradation (primarily upstream) and degradation (primarily downstream) were observed within Horse Creek, but the majority of the reach appears stable. Although alterations from the As-Built dimension and profile of the constructed stream do not appear to have resulted in extensive

reduction of stream function, several areas of the Horse Creek reach will likely require remedial measures or increased scrutiny during future monitoring. Aside from vegetation, no problem areas were identified in connection with the UT.

Overall, the Horse Creek Stream Restoration project appears generally stable. However, to maintain future stream stability, remedial measures may be required for several areas within Horse Creek. Extensive remedial measures are required to address landowner-induced problem areas identified within the riparian buffer.

1 PROJECT BACKGROUND

1.1 Location and Setting

The Horse Creek Stream Restoration project is located within the Wake Forest Golf and Country Club (WFCC) property in the Town of Wake Forest, Wake County, North Carolina (Figure 1 - Page 5). The watershed is located entirely within the Piedmont Physiographic Region. At its former confluence with the Neuse River, the watershed has a drainage area of approximately 22 square miles. The Horse Creek watershed is roughly bounded by Falls Lake to the south, U.S. Highway 1 (Capital Boulevard) to the east, N.C. Highway 96 to the north, and State Roads (SR) 1922, 1923, and 1139 along its western boundary. The northern watershed limits along NC Highway 96 form the boundary between the Tar-Pamlico River basin to the north and the Neuse River basin to the south. The drainage area at the upstream limit of the site is approximately 7.9 square miles, and at the downstream end of the project site, is approximately 9.8 square miles.
Directions to Site: From Raleigh, follow Capital Boulevard/US-1 North to Wake Forest. Wake Forest Country Club is on the left at 13239 Capital Boulevard. The project is located entirely within the Wake Forest Country Club golf course property in Wake Forest, North Carolina. Access is no longer available through the Wake Forest Country Club drive and parking lot, as part of the unpaved access road has been sold. Access is vailable along a Town of Wake Forest sanitary sewer and power easement from a point on Jenkins Road approximately 2,500 feet west of the intersection of Jenkins Road and Capital Boulevard / US 1 North.

1.2 Structure and Objectives

Prior to restoration, Horse Creek was a Rosgen Type C5/E5 stream that was identified as a stream restoration site by the North Carolina Ecosystem Enhancement Program (EEP), formerly the North Carolina Wetland Restoration Program (WRP). Although C and E stream types are usually stable, Horse Creek was actively eroding. Degradation of the stream and lack of naturally occurring vegetation on the streambanks resulted in bank erosion, reduced buffer filtration rates, sediment deposition, undercutting of streambank trees and a loss of in-stream features and habitat. Additionally, recent upstream development had begun to place increased stress on this site.

The overall mitigation strategy for Horse Creek called for an increase in stream length, additional riffle-pool features, reshaping of the bankfull cross-sectional area and restoration of the riparian buffer along the project reach. The stream restoration was designed to improve bank stability, reduce erosion rates, improve aquatic habitat, and replace or augment the vegetated riparian buffer.

In general, the restoration supported, wholly or in part, the following EEP goals:

- Protection and improvement of water quality by restoring wetland, stream and riparian area functions and values lost through historic, current, and future impacts.
- Achievement of a net increase in functions and values in North Carolina's major river basins.

Specifically, the stream restoration aimed to have the following benefits:

- Reduce downstream sedimentation by stabilizing eroding streambanks within the WFCC property;
- Replace degraded stream reaches with a stabilized streams that support natural stream processes;
- Reduce property loss within the WFCC property;

- Improve aquatic habitat, including pools for fish, woody debris for habitat, and reduce water temperature from shading by riparian trees; and
- Improve aesthetics of the restored stream reach.

Specifically, the restoration of the riparian buffer aimed to have the following benefits:

- Reduce nitrogen to Falls Lake and the Neuse River by establishing new riparian buffer to filter nutrients along the denuded reach within the WFCC;
- Provide additional source water protection for Falls Lake, Raleigh's water supply; and
- Establish a riparian corridor for wildlife between existing wooded areas.

1.3 Project History and Background

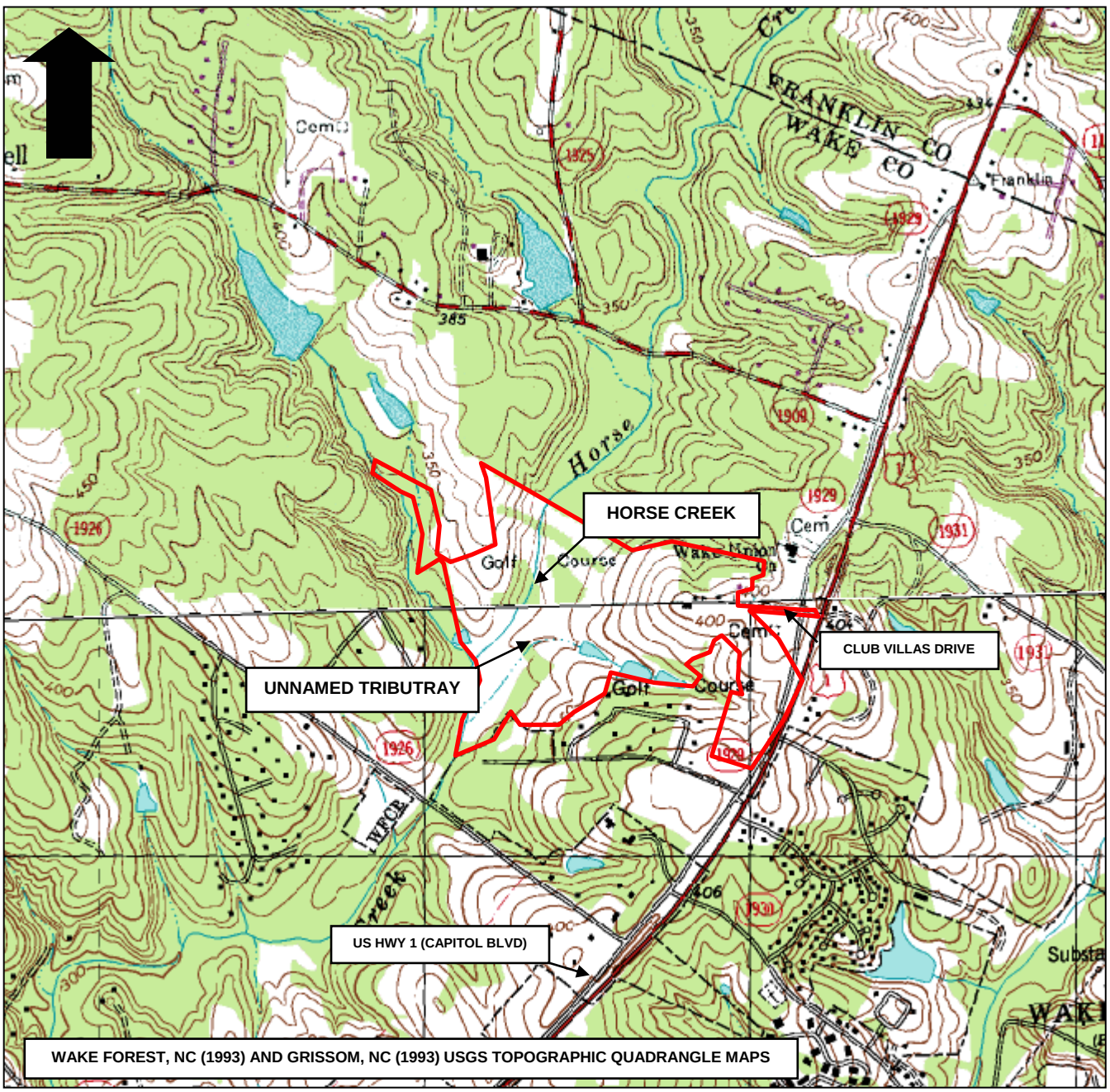
The EEP identified Horse Creek, located within the WFCC property, as a stream restoration site in connection with Targeted Local Watershed 65020. Horse Creek is a tributary of the Neuse River and discharges into Falls Lake.

Before restoration of the stream took place, removal of vegetation along the creek had resulted in increased opportunity for bank erosion and reduced filtration rates. The channel was in the process of transitioning from its natural state to one in which active streambank erosion occurred. Scour pools had developed immediately downstream of flow constrictions caused by the golf cart bridges and a large metal culvert. A wooded area along the eastern side of the downstream portion of Horse Creek contained a large number of invasive, exotic plant species.

Prior to its restoration, Horse Creek was a C5/E5 stream that was moving towards instability from various on-site and off-site factors. The design cross-sections for Horse Creek were developed to create a Rosgen C5 stream. The bank angles were lowered based on guidelines for sandy loam soils, and the new design called for increased sinuosity. Length was added in an effort to return natural meander to the reach. This effort was limited by several on-site physical constraints, including three existing bridges and one culvert whose locations were to remain unchanged, and specific areas within fairways that are identified as landing zones for golfers.

The pre-existing channel for the UT was entrenched and lacked sinuosity. Restoration of the UT raised the channel elevation and reconnected the stream to its floodplain along a new alignment. The UT was transformed from a G5c to an E5 stream type, and was made more sinuous than its previous state. Although the riparian area around the UT contained several mature overstory trees, the understory was virtually nonexistent. The riparian areas along Horse Creek and the UT were planted upon completion of construction.

Figure 1: Horse Creek Vicinity Map



The Horse Creek Stream Restoration Project encompassed two restored stream reaches and restoration of the riparian buffer along as much of the stream reaches as possible. Details of restoration are summarized in the following tables. Table 1 identifies each reach; Table 2 lists the objectives; Table 3 conveys the dates associated with each restoration activity; Table 4 identifies the parties responsible for each portion of the restoration efforts; and Table 5 provides background information about the project site.

Table 1: Project Structure Table

Horse Creek Stream Restoration EEP Project No. 71082	
Segment/Reach ID	**Linear Feet**
Horse Creek	2825
UT to Horse Creek	550

Table 2: Project Objectives Table

Horse Creek Stream Restoration EEP Project No. 71082		
Segment/Reach ID	**Objectives**	**Linear Footage**
Horse Creek	Stream and riparian buffer restoration	2825
UT to Horse Creek	Stream and riparian buffer restoration	550

Table 3: Project Activity and Reporting History

Horse Creek Stream Restoration EEP Project No. 71082			
Activity or Report	**Calendar Year of Planned Completion**	**Current Planned Calendar Year of Completion**	**Actual Completion Date**
Restoration Plan	2002	Complete	November 22, 2002
Mitigation Plan	2003	Complete	March 27, 2003
Construction	2003	Complete	April 1, 2005
Temporary S&E mix applied to entire project area	2003	Complete	April 1, 2005
As-Built Report	2003	Complete	April 1, 2005
Permanent seed mix applied to reach	2003	Complete	April 1, 2005
Containerized and B&B plantings for reach	2003	Complete	April 1, 2005
Initial Year 1 monitoring	2004	2006	August 1, 2006
Year 2 Monitoring	2005	2007	NA
Year 3 Monitoring	2006	2008	NA
Year 4 Monitoring	2007	2009	NA
Year 5 Monitoring	2008	2010	NA

Table 4: Project Contact Table

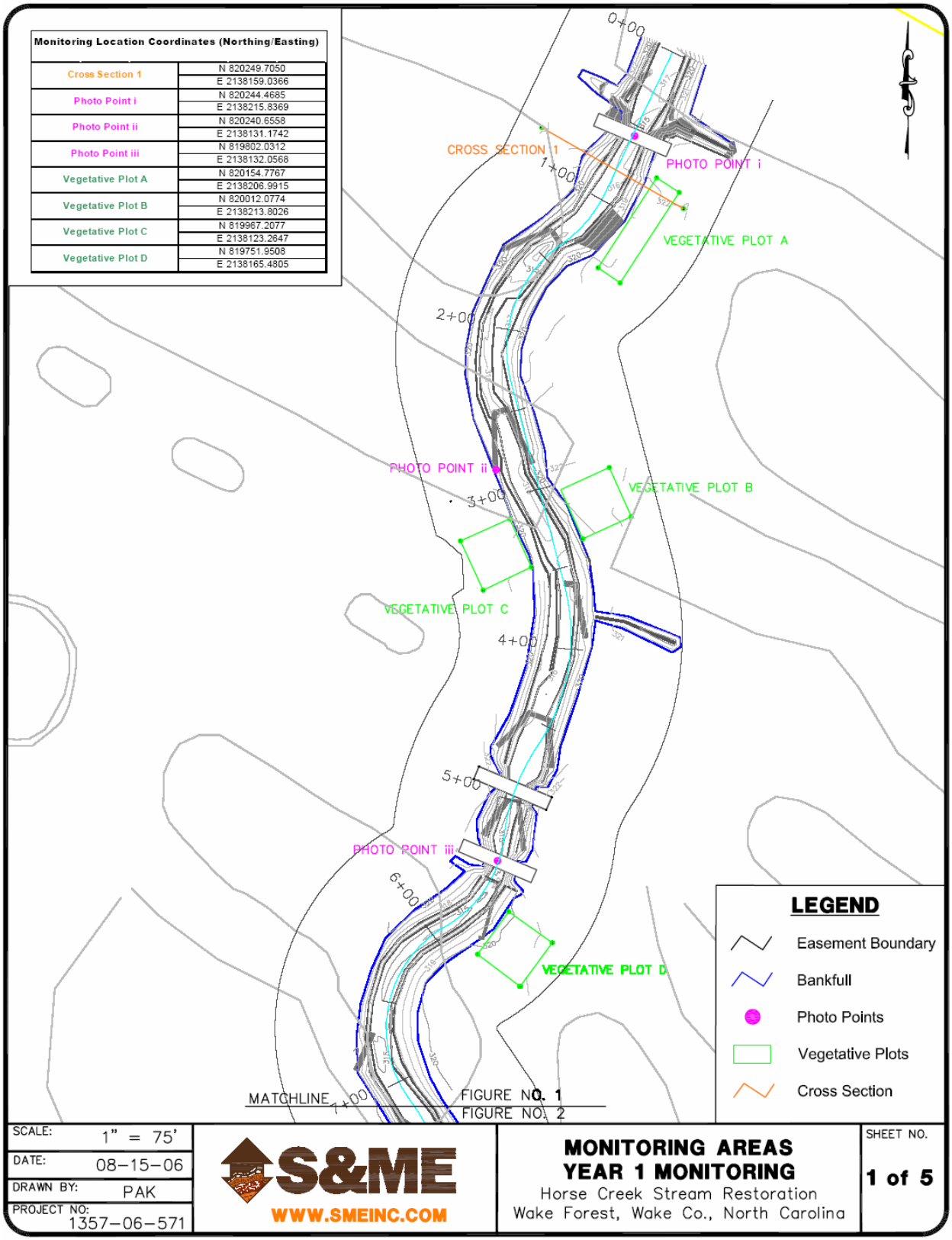
Horse Creek Stream Restoration EEP Project No. 71082	
Designer: Dewberry and Davis, Inc. POC: Kenneth Ashe, PE	2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607-3366 POC phone number: 919.881.9939
Construction Contractor Contaminant Control, Inc. POC: Allen Eudy	Firm Information/Address: 438-C Robeson Street Fayetteville, NC 28301 Project Manager POC phone number: 910.484.7000
Planting Contractor: HARP POC: Dr. Jim Matthews	9305-D Monroe Road Charlotte, NC 28270 POC phone number: 704.687.4061
Seeding Contractor Seneca Landscapes POC Andrew VanVlack	705 Comphrey Court Wake Forest NC 27587 POC phone number: 919.570.6163
Seed Mix Sources: Mellow Marsh Farm	1312 Woody Store Road, Siler City, NC 27344 POC phone number: 919.742.1200
Nursery Stock Suppliers: Mellow Marsh Farm	1312 Woody Store Road, Siler City, NC 27344 POC phone number: 919.742.1200
Monitoring Performers Dewberry and Davis, Inc. & S&ME POC: Kenneth Ashe, PE, Joey Lawler (S&ME)	Firm Information/Address: 2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607-3366 POC phone number: 919.881.9939
Stream Monitoring POC: Kenneth Ashe, PE	POC phone number: 919.881.9939
Vegetation POC: Kenneth Ashe, PE	POC phone number: 919.881.9939
Monitoring POC: Kenneth Ashe, PE POC	POC phone number: 919.881.9939
Wetland Monitoring POC: NA	POC phone number: NA

Table 5: Project Background Table

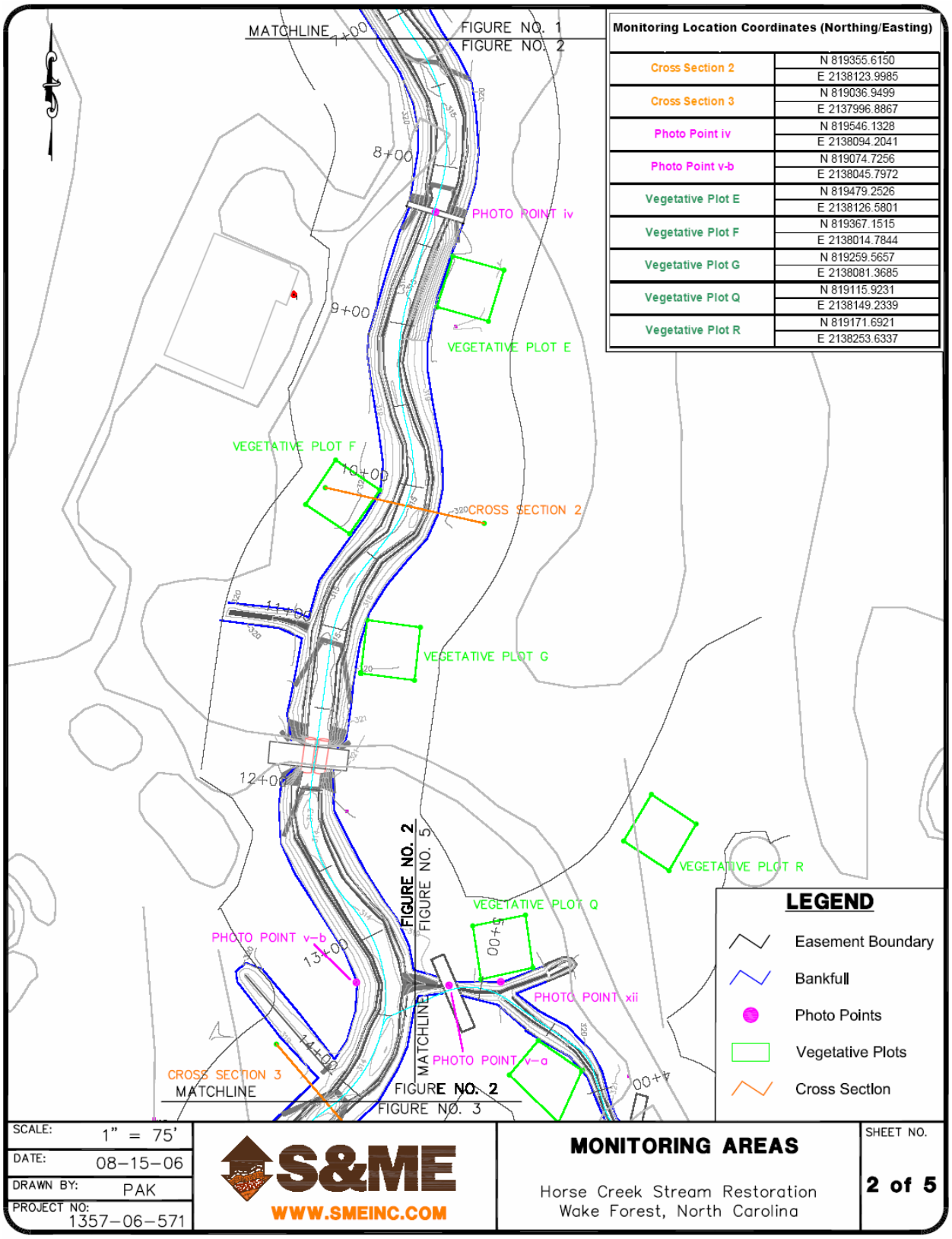
Horse Creek Stream Restoration EEP Project No. 71082		
	Horse Creek	**UT To Horse Creek**
Project County	Wake County	Wake County
Drainage Area	7.9 square miles	0.13 square mile
Drainage impervious cover estimate (%)	7.80	< 5.0
Stream Order	Third Order	First Order
Physiographic Region	Piedmont	Piedmont
Ecoregion	45f	45f
Rosgen Classification of As-built	C5	E5
Cowardin Classification	NA	NA
Dominant soil types	Chewacla	Mantachie, Wehadkee, Chewacla
Reference site ID	Little Beaverdam Creek	UT to Lower Barton Creek
USGS HUC for Project and Reference	03020201065020	03020201065020
NCDWQ Sub-basin for Project and Reference	Neuse River Subbasin 03-04-01	Neuse River Subbasin 03-04-01
NCDWQ classification for Project and Reference	WS-IV NSW	WS-IV NSW
Any portion of any project segment 303d listed?	No	No
Any portion of any project segment upstream of a 303d listed segment?	No	No
Reasons for 303d listing or stressor	NA	NA
Percent of project easement fenced	0	0

1.4 Monitoring Plan View

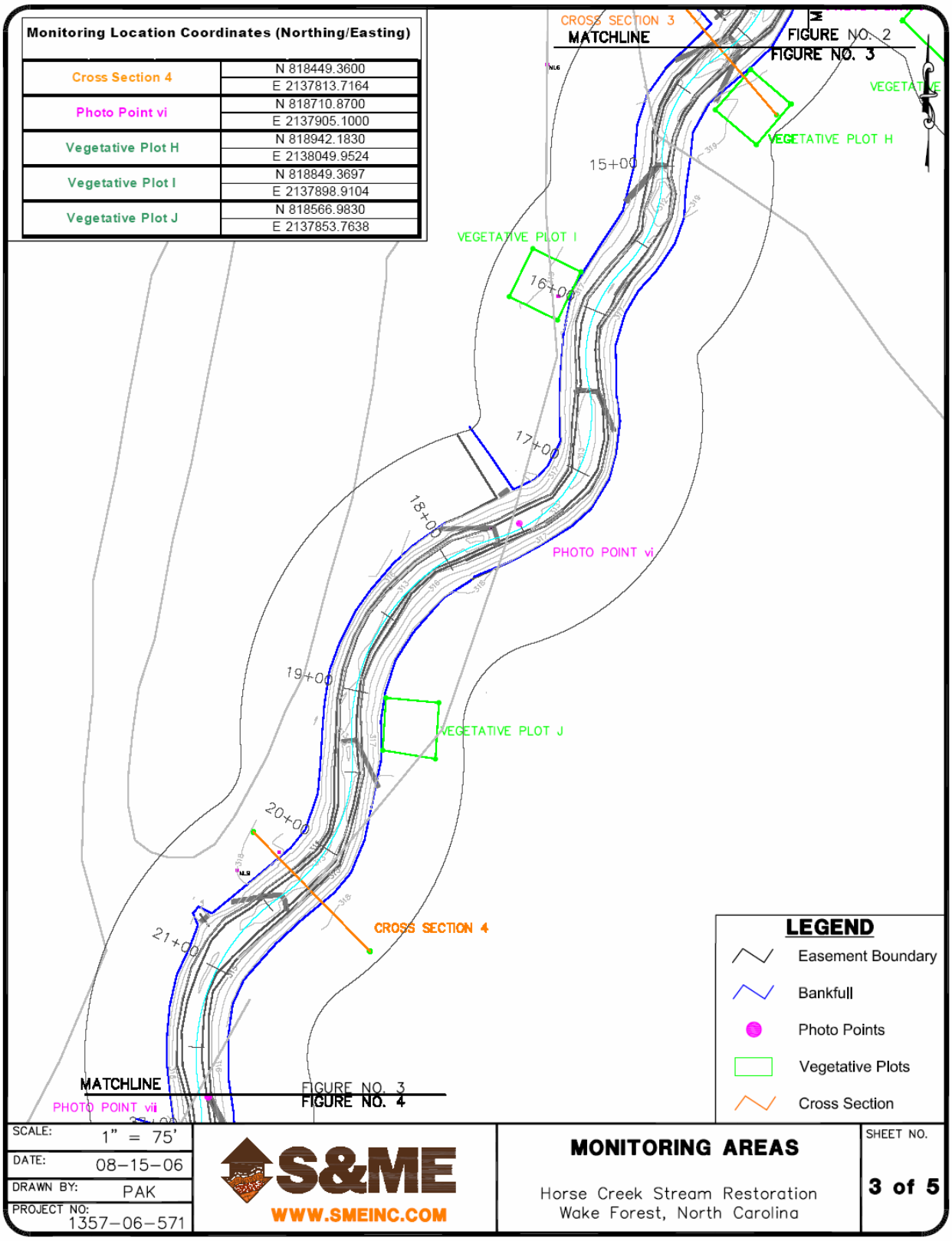
Monitoring Areas - Sheet 1



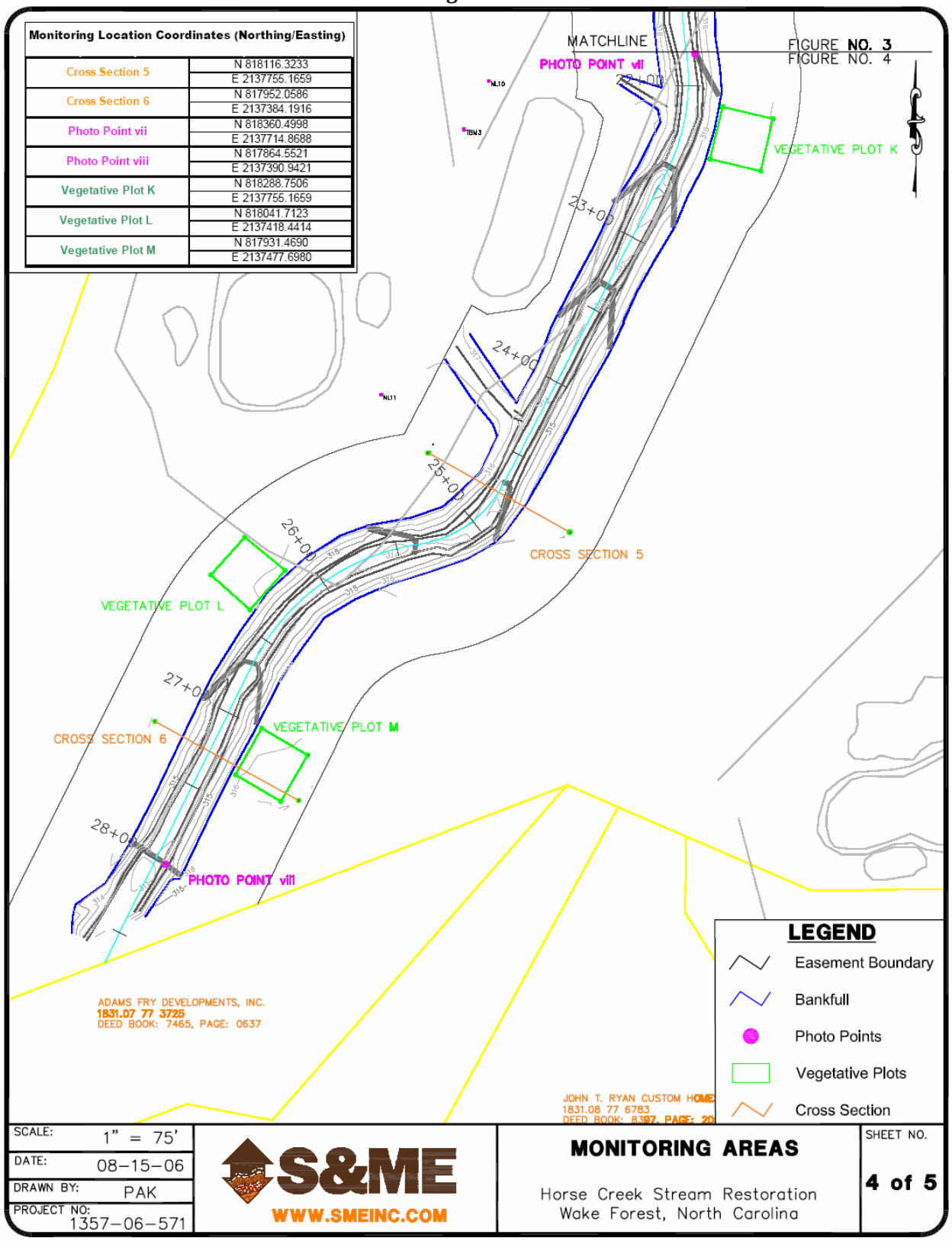
Monitoring Areas - Sheet 2



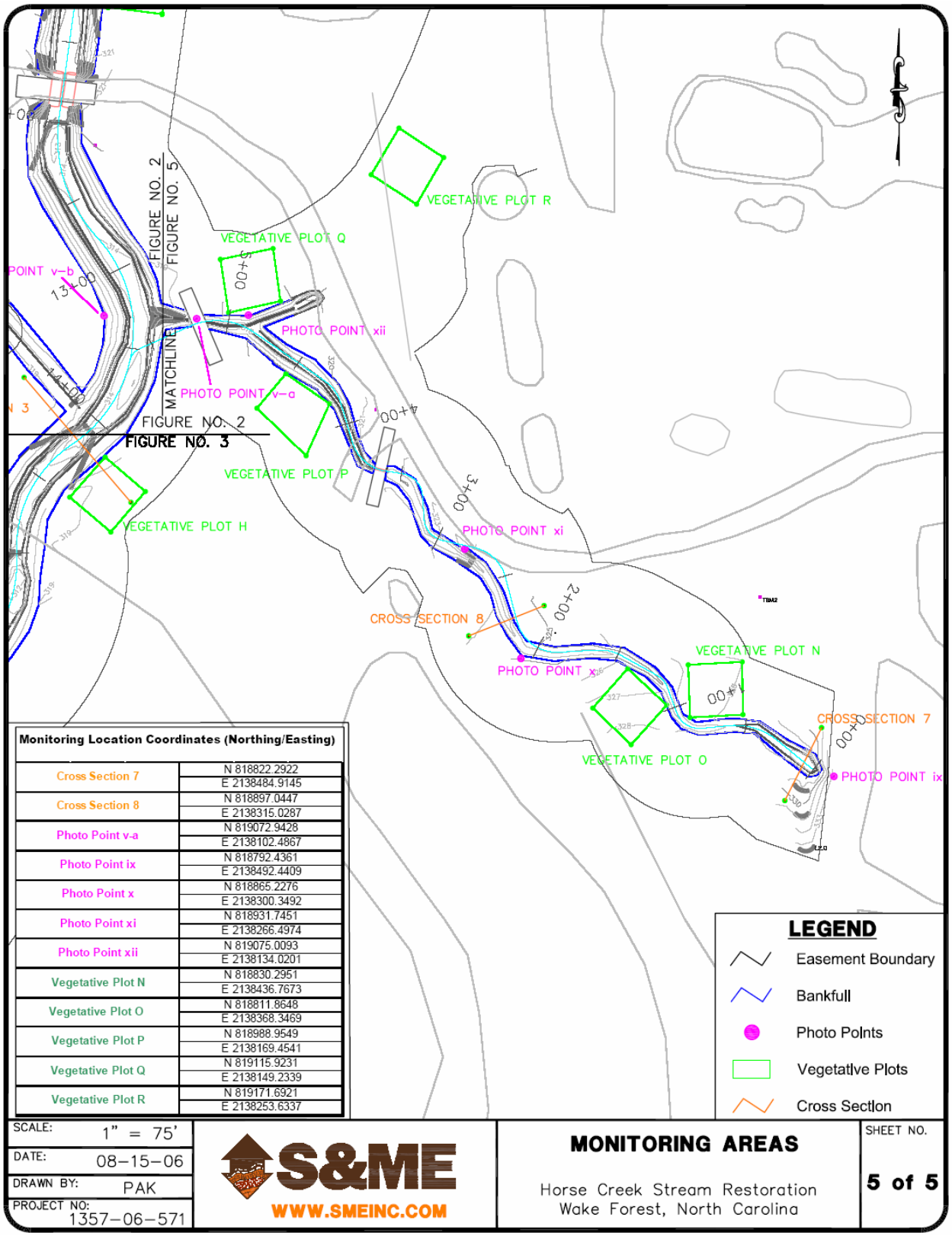
Monitoring Areas - Sheet 3



Monitoring Areas - Sheet 4



Monitoring Areas - Sheet 5



Monitoring Location Coordinates (Northing/Easting)	
Cross Section 7	N 818822.2922
	E 2138484.9145
Cross Section 8	N 818897.0447
	E 2138315.0287
Photo Point v-a	N 819072.9428
	E 2138102.4867
Photo Point ix	N 818792.4361
	E 2138492.4409
Photo Point x	N 818865.2276
	E 2138300.3492
Photo Point xi	N 818931.7451
	E 2138266.4974
Photo Point xii	N 819075.0093
	E 2138134.0201
Vegetative Plot N	N 818830.2951
	E 2138436.7673
Vegetative Plot O	N 818811.8648
	E 2138368.3469
Vegetative Plot P	N 818988.9549
	E 2138169.4541
Vegetative Plot Q	N 819115.9231
	E 2138149.2339
Vegetative Plot R	N 819171.6921
	E 2138253.6337

SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

MONITORING AREAS

Horse Creek Stream Restoration
Wake Forest, North Carolina

SHEET NO.
5 of 5

2 PROJECT CONDITION AND MONITORING RESULTS

The requirements and specific methodology used for the stream morphology, vegetative plot, and problem area monitoring are discussed in Section 3 along with information about the establishment of photograph points.

Stem Counts and Visual Assessments were made of the streambanks and surrounding floodplain. This analysis was used to determine if the planted vegetation has survived. The complete stream assessment methodology is discussed in Section 3.

Stem Counts

Of the 18 vegetative plots originally laid out and monitored along Horse Creek and its UT, six were identified with a 75 percent survival rate based on the number of "living" individuals identified in the initial post-construction assessment report. Twelve of the 18 had less than the required 75 percent survival rate. Six of the 18 had zero percent survival. It should be noted that the initial plant totals identified in Table 8 are not based on the number of individuals originally planted in connection with construction of the project, but those identified during the post-construction assessment, after which many of those originally planted had already been destroyed through landowner maintenance and animal grazing.

Problem Areas

The vegetative problem areas were classified into four categories: 1) bare bank; 2) bare bench; 3) bare floodplain; and 4) invasive/exotic populations. With the exception of two small bare bank areas, the vegetative problem areas consisted entirely of bare floodplain. Areas were included as bare floodplain if the planted vegetation was present but had been significantly disturbed such as having been mowed, or if the area contained vegetation, but none of the vegetation had been planted.

2.1 Vegetative Assessment

2.1.1 Soil Data

Horse Creek runs through Chewacla soils. The soils of this mapping unit are on the flood plains of streams. Infiltration is good and surface runoff is slow. Table 6 lists specific soils data for Chewacla soils.

Table 6: Preliminary Soil Data

Horse Creek Stream Restoration EEP Project No. 71082					
Series	Max Depth (in)	% Clay on Surface	K	T	OM %
Chewacla, Cm	65	10-27	0.28	5	1-4

The UT to Horse Creek flows through Mantachie, Wehadkee, and Chewacla soils. Other than Chewacla, the information needed to complete the Preliminary Soil Data Table was unavailable, so short descriptions of the remaining soil type follows.

Mantachie (Me) soils have good infiltration and slow to medium surface runoff. Flooding is frequent but of short duration. These soils are generally located in depressions and draws in the uplands and have 0 to 4 percent slopes.

Wehadkee (Wn) silt loam is a poorly drained soil with 0 to 2 percent slopes on the flood plains of streams. Infiltration is good and surface runoff is slow to ponded. This soil is wet and subject to overflow and ponding.

2.1.2 Vegetative Problem Areas

A majority of the project banks appeared well-vegetated. The most extensive vegetative problem areas consist of bare floodplain. Problem areas identified within the project boundaries are listed in Table 7 along with appropriate location information and a brief statement regarding the probable cause. Photographs are provided and arranged sequentially in Appendix A.2.

Problem areas where bare banks were observed are limited to Areas "c" and "i." Area "a" continues to undergo landowner maintenance by golf course personnel, and has expanded from its original size identified in the Year 0 report to include additional areas downstream. Further, bankfull event(s) have resulted in a large amount of sediment accumulation along the floodplain in this area. As a result of similar landowner maintenance and regular mowing, Areas "b" and "c" have expanded downstream to encompass additional floodplain.

Area "i" may still be experiencing possible soil deficiencies within the floodplain. This area is adjacent to a sewer and power line easement. A large amount of sediment accumulation was also observed at this location. A portion of this area near Station 22+50 has shown improvement and was no longer considered part of the problem area.

Bare floodplain was observed within the remaining problem areas. Areas "d," "e," "g," "k" and "l" have expanded from their original Year 0 dimensions as mowing and landowner maintenance practices continue to encroach within the buffer.

Table 7: Vegetative Problem Areas

Horse Creek Stream Restoration EEP Project No. 71082					
Feature/Issue	**Area**	**Station No. /Range**	**Bank**	**Probable Cause**	**Photograph No.**
Bare Bank	c	4+00 - 4+50	Left	Sediment accumulation from flood event(s).	VPA 1
	i	22+00 - 22+50	Left	Sediment accumulation from flood event(s).	VPA 2
Bare Bench	--	None Observed	--	--	--
Bare Floodplain	a	0+80 - 3+50	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 3
	b	0+80 - 4+80	Right	Land owner maintenance.	VPA 4

	c	4+00 – 4+50	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 5
	d	6+00 - 10+00	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 6
	e	5+50 - 7+50	Right	Land owner maintenance.	VPA 7
	f	12+50 - 16+50	Right	Land owner maintenance.	VPA 8
	g	13+50 - 15+30	Left	Land owner maintenance.	VPA 9
	h	17+00 - 20+50	Right	Land owner maintenance.	VPA 10
	i	21+80 - 22+50	Left	Possible soil deficiency; adjacent to power and sewer line right-of-way.	VPA 11
	j	25+50 - 27+00	Left	Sewer line right-of-way vegetation spreading.	VPA 12
	k	Throughout UT	Right	Land owner maintenance.	VPA 13
	l	Throughout UT	Left	Land owner maintenance.	VPA 14
Invasive/Exotic Populations				During Year 1 monitoring activities, invasive/exotic populations did not appear to constitute problem areas.	NA

2.1.3 Vegetative Problem Areas Plan View

Vegetation Problem Areas Plan View Sheets 1 - 5 are located in Appendix A.3.

2.1.4 Stem Counts

Stem counts were conducted within the randomly placed 10m x 10m plots. Because the original design required a narrower riparian buffer along the fairways, one of the plots located in the fairway near Hole No. 1 has dimensions of five-meter (m) x 20m to adequately represent the riparian buffer at that location. This variation was discussed and approved by EEP prior to monitoring. The chosen plot locations were scattered throughout the project area to obtain a representative sample of the entire area of disturbance. The corners of each plot were originally marked with 18-inch x 1/2-inch sections of rebar driven into the ground. Because of the location of this project, the metal conduit was driven flush into the ground in order to avoid damage to golf course maintenance equipment. Each rebar stake was then marked with a plastic cap and each plot was identified by letter in the sequence in which they were sampled.

The stem count procedure only applied to planted woody vegetation. For shrub species with multiple stems, the base was considered one stem. Trees with two or more main stems branching from the base, or near the ground, were considered one stem. Planted stems were only declared dead when foliage was completely absent, or if breaking a stem failed to reveal living tissue. If the foliage had been removed by grazing animals, the plant's status was based on its potential to recover and produce new growth.

Within the planted buffer, species survival was determined within 50 feet of the top of the streambanks in 10m by 10m vegetative plots. Species density and survival were documented, as well as introduction of species not installed during the buffer planting.

The temporary marking method for the vegetative plot marking was minimal. Because the area is a golf course, no flagging was used; rather, caps were placed on the ends of the metal conduits. Ideally, the markers were to be unnoticeable to the public but easily recognized by staff with the use of a monitoring plan view sheet. Maintenance of the gold course and encroachment into the buffer rendered most of the existing caps indiscernible.

Eighteen vegetative plots were originally laid out and monitored along Horse Creek and its UT. Of the 18, six were identified with a 75 percent survival rate based on the number of individuals identified in the initial post-construction assessment report. Twelve of the 18 had less than the required 75 percent survival rate. Six of the 18 had zero percent survival. In areas that have not been subject to encroachment by landowner maintenance (primarily downstream), seedlings from natural recruitment appear high. More specific data is located in Table 8.

PLEASE NOTE that while survivability is listed as 79%, the overall density of woody species fall below 320 stems per acre. The survivability is measured agains the number of woody stems present at the post-construction assessment, and does not account for the loss of woody stems due to property maintenance during and following planting and nutural grazing of the local beavers and deer. The EEP is aware of the issues with woody survival during and following construction. The denity of woody stems in the 16 non-fairway monitoring plots is approximately 215 woody stems per acre.

Table 8: Stem Counts for Each Species Arranged by Plot

Horse Creek EEP Project No. 71082																						
Species		**Plots**																		**Initial Totals**	**Year 1 Totals**	**Survival %**
Scientific Name	**Common Name**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**			
Tree																						
Betula nigra	River birch											1								1	1	100
Cornus florida	Flowering dogwood												2							2	2	100
Diospyros virginiana	Persimmon										1	1								2	2	100
Fraxinus pennsylvanica	Green ash						2	2			2			1	2					8	9	100
Juniperus virginiana	Eastern red cedar																			0	0	0
Magnolia virginiana	Sweetbay						1	2						1						4	4	100
Nyssa sylvatica	Black gum									1										10	1	10
Platanus occidentalis	Sycamore					1	2					4		6						5	13	100
Quercus alba	White oak										1									1	1	100
Salix nigra	Black willow					1						2								2	3	100
Shrubs																						
Aronia arbutifolia	Red chokeberry		1			1														2	2	100
Cephalanthus occidentalis	Buttonbush						1	1				2	2	1						4	7	100
Euonymus americanus	Strawberry bush			2																2	2	100

Ilex decidua	Deciduous holly																			0	0	--
Ilex glabra	Inkberry																			1	0	0
Itea virginica	Virginia willow										1									6	1	17
Lindera benzoin	Spicebush											1		2						27	3	11
Salix sericea	Silky willow							2						3						5	5	100
Sambucus Canadensis	Common elderberry			1			2													1	3	100
Dead/Unidentifiable																						
Dead																				26	0	0
Unidentifiable (too small)				10																3	10	100
Total																						
Total number living		0	1	13	0	3	8	7	0	1	5	11	4	14	2	0	0	0	0	86	68	79%

2.1.5 Vegetative Plot Photographs

Two representative digital photographs of each sample plot were taken on the same day vegetative sampling was conducted. These photographs are provided in Appendix A.4 and identified by plot number and the date taken.

2.2 Stream Assessment

Dimension, pattern, profile and pebble-count measurements of the restored channel were completed and the stream geomorphology classified using the results of the survey data and the Rosgen (1996) system. This analysis was used to assess channel stability and particle-size distribution of channel materials to determine if stabilization and grade-control structures are functioning properly. The complete stream assessment methodology is discussed in Section 3.

Dimension

Generally, minor variation from post-construction monitoring was observed in most of the surveyed cross-sections. Based on Year 1 monitoring, average bankfull width is 37.5 feet, max riffle depth is 4.8 feet, average width to depth ratio is 14.3, and the average riffle bankfull area is 101 feet. With respect to the UT, average bankfull width is 12 feet, max riffle depth is 1.6 feet, average width to depth ratio is 12.5, and the riffle bankfull area is 8.6 feet. Complete dimension measurements and calculations can be found in the tables that follow within this section.

Pattern

Based on review of the Horse Creek and UT meander pattern, neither reach displayed notable variation from that identified by the post-construction assessment. The post-construction assessment indicated that meander wavelengths and beltwidths were close to the design, while radii of curvature showed slightly more variation. Since there was no evidence of lateral channel migration, additional plan form surveying was not conducted in connection with the Year 1 monitoring. Pattern measurements and calculations are found in the tables that follow within this section.

Profile

The Horse Creek reach profile differs from that of the as-built condition to varying degrees. Some of the variation can likely be attributed to the level of detail associated with the respective surveys. Much of the apparent channel adjustment has not resulted in problem areas beyond those identified during the post-construction assessment. Where changes were evident (i.e. - bar formation), new problem areas were identified and documented in this report. The UT profile was closer to that of the post-construction profile, although minor deepening of the channel thalweg was noted. Profile measurements and calculations for both reaches can be found in the tables that follow within this section.

Verification of Bankfull Events

Bankfull events occurring during the five-year monitoring period are to be documented. In order for the monitoring to be considered complete, a minimum of two events must be documented within the five-year monitoring period. Gauge resources were unavailable within the project reach at the time of the Year 1 monitoring event. On June 14, 2006, nearly eight inches of rain fell in the Wake County area as Tropical

Storm Alberto moved through the region. Large amounts of recent sediment generated during the event were observed on the floodplain of Horse Creek. The sediment (primarily sand) was observed at depths exceeding six inches in areas. Anecdotal evidence supplied by the accounts of golf course personnel supports extensive flooding of Horse Creek and the UT. The flood event severely damaged a wooden and concrete vehicular crossing near the origin of the reach. Golf course personnel further indicated that additional bankfull events of a smaller scale had occurred previously, but these events have not been documented.

Data related to bankfull verification is summarized in Table 9.

Table 9: Verification of Bankfull Events

Horse Creek EEP Project No. 71082			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photograph # (if available)**
07.31.06	06.14.06	Large amount of fresh sediment observed on floodplain. Event observed by golf course personnel.	NA

Bank Erodibility Hazard Index (BEHI) and sediment export estimates apply only to Monitoring Years Three and Five, and accordingly, were not performed this year.

Problem Areas

The areas in this section are labeled on the plan view, and further identified by color code to reflect degree of concern. Those problem areas with a color code of yellow show signs of change that may lead to instability in the future, but are currently stable. These areas should continue to be monitored, and may or may not become unstable in the future. Problem areas with a red color code are those that have already shown instability, are likely to need continual monitoring and/or maintenance in the future.

2.2.1 Stream Problem Areas Plan View

A plan view of stream problem areas is located in Appendix B.1.

2.2.2 Stream Problem Areas Table Summary

Table 10 provides categorical features issues by station, the suspected cause, and denotes the number of a representative photograph of the condition.

Table 10: Stream Problem Areas

Project Number 71082 (Horse Creek) Segment/Reach: Horse Creek			
Feature Issue	**Station No.**	**Suspected Cause**	**Photograph No.**
Aggradation/bar formation			
Problem Area I	1+80	Increased bedload resulting from upstream construction as land use changes from agricultural to residential.	SPA-1
Problem Area III	4+90	Washed-out material under bridge resulting in channel widening and less entrainment of bed material directly upstream.	
Problem Area IV	11+75	Road crossing design and debris resulting in channel widening and less entrainment of bed material directly upstream.	
Problem Area VIII	21+20	Bank sloughing and subsequent establishment of vegetation of mid-channel bars.	
Problem Area XV	27+40	Bank sloughing and resultant re-direction of flow vectors.	
Bank scour			
Problem Area XI	25+10	Bank slumping before establishment of vegetation; matting washed away.	SPA-2
Problem Area XIII	26+00	Bank slumping before establishment of vegetation; matting washed away.	
Problem Area XIV	27+10	Bank slumping before establishment of vegetation.	
Engineered structures-back or arm scour			
Problem Area II	2+85	Bank failure around right arm of structure and exposed footer rocks.	SPA-3
Problem Area VI	14+20	Construction deviated from Design - structure arms too high.	
Problem Area IX	22+00	Downstream vegetated mid-channel bar (Problem Area VIII) is causing restricted flow and backwater areas upstream.	
Problem Area X	23+50	Construction deviated from Design - structure too high.	
Problem Area XII	25+60	Construction deviated from Design - structure too high.	

Channel over widening			
Problem Area III	4+90	See aggradation/bar formation	SPA-4
Problem Area V	13+80	Suspected bank failure before vegetation established; angle discharge from UT.	
Problem Area VII	15+30	Suspected bank failure before vegetation established.	
Problem Area X	23+50	See engineered structures - back or arm scour.	

2.2.3 Numbered Issues Photograph Section

An example photograph of each issue category is provided in Appendix B.2 for the feature issues listed in Table 10. The intent is not to collect photographs of every occurrence within an issue category, but to provide a photograph that is representative of the feature issue category.

2.2.4 Fixed Photograph Station Photographs

Stream photographs from the established photograph stations were collected at the same time as the vegetation photographs. These photographs are located in Appendix B.3.

2.2.5 Stability Assessment Table

A semi-quantitative summary of results from the visual inspection conducted over each reach is presented in Tables 11-A and 11-B. The summary is designed to assess each structural feature category by deriving a simple performance percentage.

Table 11-A: Categorical Stream Feature Visual Stability Assessment – Horse Creek

Horse Creek – Project No. 71082 Segment/Reach: Horse Creek						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	65%	64%				
B. Pools	50%	54%				
C. Thalweg	80%	74%				
D. Meanders	80%	70%				
E. Bed General	95%	93%				
F. Vanes/J Hooks etc.	60%	60%				
G. Wads and Boulders	NA	NA				

* Evaluation based on As-Built features rather than Design

Table 11-B: Categorical Stream Feature Visual Stability Assessment – UT

Horse Creek – Project No. 71082 Segment/Reach: UT						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	90%	90%				
B. Pools	80%	83%				
C. Thalweg	100%	100%				
D. Meanders	100%	100%				
E. Bed General	100%	100%				
F. Vanes/J Hooks etc.	NA	NA				
G. Wads and Boulders	NA	NA				

* Evaluation based on As-Built features rather than Design

2.2.6 Quantitative Measures Summary Tables

These tables provide the quantitative summary data from the cross-sectional surveys, longitudinal surveys and pebble counts. The associated raw data and plots are located in Appendix B.

Table 12-A: Baseline Morphology and Hydraulic Summary - Horse Creek

Project Number 71082 Segment/Reach: Horse Creek (2899 feet)																		
Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	NA	NA	NA	31.2			20.1	38.8	32.6	16.8	28.2	27.6	36	36	36	36.7	38.6	37.4
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	407	700	599.3	200	200	200	>600			>600		
BF Cross Sectional Area (ft^2)	NA	NA	NA	98.3			61.9	98.5	82.5	56.2	59	57.4	106.5	106.5	106.5	110.1	126.5	118.9
BF Mean Depth (ft)	NA	NA	NA	3.1			1.9	3.7	2.5	2.0	2.1	2.1	3.0	3.0	3.0	2.9	3.4	3.2
BF Max Depth (ft)	NA	NA	NA	NA	NA	NA	3.9	6.1	4.1	2.8	3.2	3.0	4.5	4.5	4.5	5.1	5.7	5.4
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	6.4	20.5	11.3	12.8	14.2	13.3	12.2	12.2	12.2	10.8	13.5	11.8
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	13	21.9	18.4	9.2	9.6	9.4	11.3	11.3	11.3	15+	15+	15+
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	32.7	60.5	40.6	36.2	89.5	56.0	37.6	38.6	38.1	34.3	41.0	37.7
Hydraulic radius (ft)	NA	NA	NA	NA	NA	NA	1.21	2.44	2.03	0.52	1.35	0.93	2.83	2.93	2.88	2.60	3.50	3.00
Pattern	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	19	102	44	35	36	36	68	126	97	47	97	69
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	4	137	30	13	53	25	70	144	107	32	132	76
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA	24	261	94	100	112	106	108	216	162	131	369	212
Meander Width ratio	NA	NA	NA	NA	NA	NA	0.8	8.0	2.9	3.6	4.1	3.8	3.0	6.0	4.5	3.5	9.9	5.7
Profile	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Riffle length (ft)	NA	NA	NA	NA	NA	NA	7	57	25	11	42	27	5	50	29	5	59	22
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	0	0	---	0.011	0.014	0.013	0.002	0.032	0.008	0.003	0.087	0.027
Pool length (ft)	NA	NA	NA	NA	NA	NA	9.0	54.0	26.6	26.0	48.0	33.0	20.0	74.4	51.7	25.6	131.2	69.6
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	18.0	97.5	50.2	37.0	102.0	69.5	44.0	144.0	94.0	37.5	324.6	129.3
Substrate	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
d50 (mm)	NA	NA	NA	NA	NA	NA	0.2			4.9			0.2			0.13		
d84 (mm)	NA	NA	NA	NA	NA	NA	2.3			16.5			2.3			0.5		
Additional Reach Parameter	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Valley Length (ft)	NA	NA	NA	NA	NA	NA	2645			203			2645			2645		
Channel Length (ft)	NA	NA	NA	NA	NA	NA	2890			220			2885			2899		

Sinuosity	NA	NA	NA	NA	NA	NA	1.09			1.09			1.09			1.10			
Water Surface Slope (ft/ft)	NA	NA	NA	NA	NA	NA	0.0016			0.0027			---	---	---	---	---	---	
BF slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---	
Rosgen Classification	NA	NA	NA	NA	NA	NA	C5/E5			C4			C5/E5			C5/E5			
Number of Bankfull Events	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---	
Extent of BF floodplain (acres)	NA	NA	NA	NA	NA	NA	37.12			1.86			37.12			37.12			
BEHI	NA	NA	NA	NA	NA	NA	21	43	36	---	---	---	NA	NA	NA	9	21	14	
Habitat Index	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	NA	NA	NA	---	---	---	
Macrobenthos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	

Table 12-B: Baseline Morphology and Hydraulic Summary - UT

Project Number 71082 **Segment/Reach: UT to Horse Creek (550 feet)**																		
Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
Dimension	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
BF Width (ft)	NA	NA	NA	5.1			3.8	5.8	4.6	3.6	5.7	4.7			7.5			6.5
Floodprone Width (ft)	NA	NA	NA	NA	NA	NA	6.4	6.4	5.5	10.5	10.5	10.5	>200			>200		
BF Cross Sectional Area (ft^2)	NA	NA	NA	5.6			2.4	3.7	2.5	3.3	3.6	3.3			5.4			5.3
BF Mean Depth (ft)	NA	NA	NA	0.8			0.6	0.6	0.5	0.7	0.8	0.7			0.77			0.81
BF Max Depth (ft)	NA	NA	NA	NA	NA	NA	0.4	2.2	0.5	0.4	2.2	0.6			1.3			1.3
Width/Depth Ratio	NA	NA	NA	NA	NA	NA	---	---	8.4	4.4	6.6	5.5			9.7			8.0
Entrenchment Ratio	NA	NA	NA	NA	NA	NA	---	---	1.2	2.2	2.2	2.2			>20			>20
Wetted Perimeter (ft)	NA	NA	NA	NA	NA	NA	---	---	---	14.2	28.3	21.2			8.6			10.4
Hydraulic radius (ft)	NA	NA	NA	NA	NA	NA	---	---	---	0.12	0.25	0.19			0.87			0.51
Pattern	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Channel Beltwidth (ft)	NA	NA	NA	NA	NA	NA	9.4	18.4	14.1	62.0	62.0	62.0	21.0	35.0	28.0	7.6	28.2	15.9
Radius of Curvature (ft)	NA	NA	NA	NA	NA	NA	8.8	38.9	18.7	3.5	23.6	13.5	14.0	35.0	22.5	15.8	61.0	31.2
Meander Wavelength (ft)	NA	NA	NA	NA	NA	NA	38.2	88.4	57.2	18.0	32.0	25.0	28.0	53.0	40.5	54.1	107.2	81.4
Meander Width ratio	NA	NA	NA	NA	NA	NA	8.3	19.2	12.4	3.8	6.8	5.3	3.7	4.7	5.4	5.8	11.5	8.6
Profile	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean

Riffle length (ft)	NA	NA	NA	NA	NA	NA	---	---	---	8	20	15	4.0	20.0	10.2	92.0	215.2	151.4
Riffle slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	0.033	0.060	0.045	0.100	0.325	0.119	0.024	0.043	0.031
Pool length (ft)	NA	NA	NA	NA	NA	NA	---	---	---	5	9	8	11.8	39.1	24.3	21.3	39.3	30.9
Pool spacing (ft)	NA	NA	NA	NA	NA	NA	---	---	---	17.4	35.1	23.1	5.3	9.8	7.5	150.9	273.4	212.2
Substrate	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
d50 (mm)	NA	NA	NA	NA	NA	NA		3.7			4.9			3.7			0.125	
d84 (mm)	NA	NA	NA	NA	NA	NA		20.4			74			20.4			0.5	
Additional Reach Parameter	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Valley Length (ft)	NA	NA	NA	NA	NA	NA		591			68			479*			479*	
Channel Length (ft)	NA	NA	NA	NA	NA	NA		612			101			550			548	
Sinuosity	NA	NA	NA	NA	NA	NA		1.04			1.49			1.15			1.15	
Water Surface Slope (ft/ft)	NA	NA	NA	NA	NA	NA		0.017			0.0263		---	---	---	---	---	---
BF slope (ft/ft)	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Rosgen Classification	NA	NA	NA	NA	NA	NA		G4c			E4			E4			E4	
Number of Bankfull Events	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Extent of BF floodplain (acres)	NA	NA	NA	NA	NA	NA		2.71			2.71			2.71			2.71	
BEHI	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	7.5	13.5	10.5
Habitat Index	NA	NA	NA	NA	NA	NA	---	---	---	---	---	---	---	---	---	---	---	---
Macrobenthos	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

*Valley Length shortened in As-built due to change in location of confluence with Horse Creek

Table 13-A: Morphology and Hydraulic Monitoring Summary - Horse Creek

Project Number 71082 **Segment/Reach: Horse Creek (2825 feet)**																																		
Parameter	**Cross Section 1 Riffle**						**Cross Section 2 Pool**						**Cross Section 3 Pool**						**Cross Section 4 Riffle**						**Cross Section 5 Pool**						**Cross Section 6 Riffle**					
	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Dimension																																		
BF Width (ft)	37	40					39	39					31	33.2					39	38.9					34	39					37	35				
Floodprone Width (ft)	>600	600					>600	600					>600	600					>600	600					600	600					>600	600				
BF Cross Sectional Area	120	131					126	101					99	98					110	95.7					95	97					126	78				

(ft^2)																																
BF Mean Depth (ft)	3.3	3.3					3.2	2.6					3.2	2.9					2.9	2.5					2.8	2.5					3.4	2.2				
BF Max Depth (ft)	5.7	6.08					5.7	3.7					7	7					5.1	3.8					5.3	5.7					5.5	4.5				
Width/Depth Ratio	11	12.2					12	15					9.9	11.2					14	16					12	16					11	16				
Entrenchment Ratio	>2.7	2.4					---	2.2					---	2.6					>2.6	2.19					---	1.9					>2.7	2.4				
Wetted Perimeter (ft)	34	42					41	42					36	36					40	40					36	42					39	37				
Hydraulic radius (ft)	3.5	3.13					3.1	2.4					2.8	2.6					2.7	2.4					2.6	2.3					3.2	2.12				
Substrate																																				
d50 (mm)	0.13	1.18					0.15	0.43					0.16	1.33					0.10	1.06					0.12	0.63					0.12	0.43				
d84 (mm)	0.75	32.0					0.50	1.41					0.35	37.0					0.50	6.60					0.37	1.81					4.00	3.03				

Additional Reach Parameters	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Pattern																		
Channel Beltwidth (ft)	47	97	69	47	97	69												
Radius of Curvature (ft)	32	132	76	32	132	76												
Meander Wavelength (ft)	131	369	212	131	369	212												
Meander Width ratio	3.5	9.9	5.7	3.5	9.9	5.7												
Profile																		
Riffle length (ft)	5	59	22	15.7	56.5	33.7												
Riffle slope (ft)	0.003	0.087	0.027	0.0015	0.0069	0.0139												
Pool length (ft)	26	131	70	18.5	74.3	46.1												
Pool spacing (ft)	38	325	129	45.11	204	45.1												
Additional Reach Parameters																		
Valley Length (ft)	2645			2645														
Channel Length (ft)	2899			2899														
Sinuosity	1.09			1.09														
Water Surface Slope (ft/ft)	---	---	---	.0019														
BF slope (ft/ft)	---	---	---	.0019														
Rosgen Classification	C5/E5			C5/E5														
Number of Bankfull Events	---	---	---	1														
Extent of BF floodplain (area)	37.12			37.12														
BEHI	9	21	14	NA														
Habitat Index	---	---	---															
Macrobenthos	---	---	---															

Table 13-B: Morphology and Hydraulic Monitoring Summary - UT

Project Number 71082 Segment/Reach: UT to Horse Creek (550 feet)												
Parameter	**Cross Section 7 Pool**						**Cross Section 8 Riffle**					
	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
Dimension												
BF Width (ft)	15	14.7					6.5	9.48				
Floodprone Width (ft)	>200	>200					>200	>200				
BF Cross Sectional Area (ft^2)	21	14.8					5.3	8.66				
BF Mean Depth (ft)	1.4	1					0.8	0.91				
BF Max Depth (ft)	2.6	2.01					1.3	1.68				
Width/Depth Ratio	11	14.7					8.0	10.4				
Entrenchment Ratio	---	13.6					>20	21				
Wetted Perimeter (ft)	28	15.3					10.4	10.4				
Hydraulic radius (ft)	0.7	0.96					1.3	0.83				
Substrate												
d50 (mm)	0.19	0.11					0.12	0.14				
d84 (mm)	1.00	0.88					0.18	0.93				

Additional Reach Parameters	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05 (2010)		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Pattern																		
Channel Beltwidth (ft)	7.6	28.2	15.9	7.6	28.2	15.9												
Radius of Curvature (ft)	15.8	61	31.2	15.8	61	31.2												
Meander Wavelength (ft)	54.1	107.2	81.4	54.1	107.2	81.4												
Meander Width ratio	5.8	12	8.6	5.8	12	8.6												
Profile																		
Riffle length (ft)	92.0	216.2	151.4	63.58	133.85	84.54												
Riffle slope (ft)	0.024	0.043	0.031	0.027	0.044	0.033												

Pool length (ft)	21.31	39.28	30.86	11.18	36.33	22.7												
Pool spacing (ft)	150.9	273.41	212.16	147.42	161.63	187.25												
Additional Reach Parameters																		
Valley Length (ft)	499			499														
Channel Length (ft)	540			540														
Sinuosity	1.08			1.08														
Water Surface Slope (ft/ft)	---	---	---															
BF slope (ft/ft)	---	---	---															
Rosgen Classification	E4			E4														
Number of Bankfull Events	---	---	---	1														
Extent of BF floodplain (area)	2.71			2.71														
BEHI	7.5	13.5	10.5	NA														
Habitat Index	NA	NA	NA															
Macrobenthos	NA	NA	NA															

2.3 Wetland Assessment

Wetlands are not a part of this project.

3 METHODOLOGOY

3.1 Stream and Buffer Assessment

In general, this monitoring data provides the U.S. Army Corps of Engineers (USACE) and the North Carolina Division of Water Quality (NCDWQ) with evidence that the goals of the project were met. Specifically, the purpose of the Horse Creek Stream Restoration Monitoring Plan is to:

- Check channel stability by measuring dimension, pattern, and profile; particle-size distribution of channel materials; sediment transport; and streambank erosion rates.
- Determine if stabilization and grade-control structures are functioning properly.
- Determine if the specific objectives of the restoration have been met.

To accomplish these objectives, the monitoring efforts are organized into three types of assessments: stream morphology, vegetative plots and photograph points. With the exception of a vegetative plot modification (stem counts in fairway plots discussed in Section 2.1), the monitoring methods employed were established using the standard regulatory guidance and procedures documents listed below.

- USACE (2003) Stream Mitigation Guidelines (USACE, U.S. Environmental Protection Agency, N.C. Wildlife Resources Commission, NCDWQ).
- Rosgen, D. L. (1996) Applied River Morphology. Wildland Hydrology Books, Pagosa Springs, CO.
- Harrelson, et al. (1994) *Stream Channel Reference Sites*. U.S. Department of Agriculture Forest Service Manual.

Current agency stream-mitigation monitoring requirements include morphology, photo-documentation, and vegetation. These parameters are required to be monitored at least once a year for five years after construction. The required monitoring will be performed each year for the five-year monitoring period, and no less than two bankfull flow events documented through the monitoring period. If less than two bankfull events occur during the first five years, monitoring will continue until the second bankfull event is documented. The bankfull events must occur during separate monitoring years. In the event that the required bankfull events do not occur during the five year monitoring period, the USACE and NCDWQ, in consultation with the resource agencies, may determine that further monitoring is not required. A monitoring report will be prepared annually.

3.2 Stream Morphology Assessment

Methods Applied

Two types of stream surveys, cross-sectional and longitudinal, were completed for both project construction and project monitoring, following the methodology contained in the USDA Forest Service Manual, *Stream Channel Reference Sites* (Harrelson, et al. 1994). Dimension, pattern, and profile measurements of the restored channels were measured.

The stream geomorphology was classified using the results of survey data and the Rosgen (1996) system. The survey was stationed from upstream to downstream starting at 0+00. Six permanent cross-section (three riffles and three pools) were taken on Horse Creek and two (one riffle and one pool) were surveyed on the UT. Eighteen-inch pieces of rebar were initially driven level with the ground and capped to denote the location of the permanent cross-sections. Cross-sections were surveyed left to right facing downstream.

Pebble counts were completed at each cross-section and longitudinally. No fewer than 100 pebbles were measured at each cross-section. More than 100 pebbles were measured for the longitudinal count and pebbles were collected in the same proportion as the ratio of riffle length to pool length throughout the reach.

Success Criteria

Minimal changes in the cross sections, profile, and substrate composition are anticipated. Physical parameters of particular concern include:

- width-to-depth ratio;
- entrenchment ratio;
- bank height ratio;
- radius-of-curvature ratio;
- feature slopes; and
- substrate composition.

Indicators that are closely evaluated include:

- Channel aggradation or degradation;
- Bank erosion;
- Lack of riparian vegetation establishment;
- Developing instream bars (should be absent); and
- Significant change from the as-built dimension and the as-built longitudinal profile.

Additionally, the riffle/pool spacing should remain fairly constant and pools should not be filling in (aggradation) or riffles starting to change to pools (degradation). Accordingly, pebble counts should show a change in the size of bed material toward a desired composition.

3.3 Vegetative Plot Assessment

Methods Applied

Survival of vegetation was evaluated using survival plots and direct counts along the entire corridor of the restored streams. Stem-counts and photographs were recorded at pre-established 10m x 10m plot areas that comprise five percent of the total riparian buffer. Vegetation was sampled during the growing season.

Two photographs were taken at each plot. The plots were initially marked with rebar in the same manner as the permanent cross-sections. The counts included only woody vegetation and shrubs. Results and probable causes for mortality are located in Section 2.

Success Criteria

The criteria for vegetative success is 80 percent species survival.

3.4 Photograph Point Establishment

Methods Applied

Photograph documentation is required twice a year: summer and winter. Photograph documentation is required at cross-sections, vegetative plots, and problem areas.

Photographs were taken upstream, downstream, and from each bank at each cross-section. At each vegetative plot, one photograph was taken from the center of the side of the plot closest to the streambank. An additional photograph was taken from the center of the side of the plot farthest from the streambank. The photograph points taken at problem areas were not as structured, and the number at each area varied according to the complexity of the area. In addition to the photograph points required for the cross-sections, vegetative plots, and problem areas, photograph points were taken at intermittent locations in order to provide a broader visual survey of the stream.

Success Criteria

The photograph points are used to supplement stream and riparian data and aid in analysis of the success of each. The photographs also aid in showing succession in the plant community over time.

4 REPORT AND DATA SUBMISSION FORMAT

The data included in this report is in the following form:

- Hardcopies of the report
- A master folder with the name 71082_Horse_Creek to house e-files
- A subfolder named “Report” including the following:
    - A consolidated PDF document through the end of Section 1- Background
    - A consolidated PDF document of the entire report including plan views
- A second subfolder named “Support Files” with three subfolders a named:
    - Vegetation
    - Stream
    - Monitoring Plan View
- Both the Vegetation and Stream subfolders contain three subfolders named:
    - Photograph Folder

    - Plan Folder
    - Data Spreadsheet

- The vegetation spreadsheet workbook includes a spreadsheet for each of the following:

    - Summary tables for plots
    - E-versions of raw data sheets

- The stream data spreadsheet workbook includes a spreadsheet for each of the following:

    - Summary table XIV
    - Raw Data Tables

APPENDIX A

VEGETATION RAW DATA

Appendix A.1

Vegetation Survey Data Tables

APPENDIX A.1. STEM COUNTS FOREACH SPECIES ARRANGED BY PLOT

Horse Creek EEP Project No. 71082																						
Species		**Plots**																		**Initial Totals**	**Year 1 Totals**	**Survival %**
Scientific Name	**Common Name**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**H**	**I**	**J**	**K**	**L**	**M**	**N**	**O**	**P**	**Q**	**R**			
Tree																						
Betula nigra	River birch											1								1	1	100
Cornus florida	Flowering dogwood												2							2	2	100
Diospyros virginiana	Persimmon										1	1								2	2	100
Fraxinus pennsylvanica	Green ash						2	2			2			1	2					8	9	100
Juniperus virginiana	Eastern red cedar																			0	0	0
Magnolia virginiana	Sweetbay						1	2						1						4	4	100
Nyssa sylvatica	Black gum									1										10	1	10
Platanus occidentalis	Sycamore					1	2					4		6						5	13	100
Quercus alba	White oak										1									1	1	100
Salix nigra	Black willow					1						2								2	3	100
Shrubs																						
Aronia arbutifolia	Red chokeberry		1			1														2	2	100
Cephalanthus occidentalis	Buttonbush						1	1				2	2	1						4	7	100
Euonymus americanus	Strawberry bush			2																2	2	100

APPENDIX A.1 - VEGETATIVE PROBLEM AREAS

Horse Creek Stream Restoration EEP Project No. 71082					
Feature/Issue	**Area**	**Station No. /Range**	**Bank**	**Probable Cause**	**Photograph No.**
Bare Bank	c	4+00 - 4+50	Left	Sediment accumulation from flood event(s).	VPA 1
	i	22+00 - 22+50	Left	Sediment accumulation from flood event(s).	VPA 2
Bare Bench	--	None Observed	--	--	--
Bare Floodplain	a	0+80 - 3+50	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 3
	b	0+80 - 4+80	Right	Land owner maintenance.	VPA 4
	c	4+00 – 4+50	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 5
	d	6+00 - 10+00	Left	Land owner maintenance, sediment accumulation from flood event(s).	VPA 6
	e	5+50 - 7+50	Right	Land owner maintenance.	VPA 7
	f	12+50 - 16+50	Right	Land owner maintenance.	VPA 8
	g	13+50 - 15+30	Left	Land owner maintenance.	VPA 9
	h	17+00 - 20+50	Right	Land owner maintenance.	VPA 10
	i	21+80 - 22+50	Left	Possible soil deficiency; adjacent to power and sewer line right-of-way.	VPA 11
	j	25+50 - 27+00	Left	Sewer line right-of-way vegetation spreading.	VPA 12
	k	Throughout UT	Right	Land owner maintenance.	VPA 13
	l	Throughout UT	Left	Land owner maintenance.	VPA 14
Invasive/Exotic Populations				During Year 1 monitoring activities, invasive/exotic populations did not appear to constitute problem	NA

Ilex decidua	Deciduous holly																			0	0	--
Ilex glabra	Inkberry																			1	0	0
Itea virginica	Virginia willow										1									6	1	17
Lindera benzoin	Spicebush											1		2						27	3	11
Salix sericea	Silky willow							2						3						5	5	100
Sambucus Canadensis	Common elderberry			1			2													1	3	100
Dead/Unidentifiable																						
Dead																				26	0	0
Unidentifiable (too small)				10																3	10	100
Total																						
Total number living		0	1	13	0	3	8	7	0	1	5	11	4	14	2	0	0	0	0	86	68	79%

Appendix A.2

Photos of Vegetation Problem Areas

VPA 1: Vegetative Problem Area "c" 4+00 – 4+50

VPA 2: Vegetative Problem Area "i" 22+00 – 22+50

VPA 3: Vegetative Problem Area "a" 0+80 – 3+50

VPA 4: Vegetative Problem Area "b" 0+80 – 4+80

VPA 5: Vegetative Problem Area "c" 4+00 – 4+50

VPA 6: Vegetative Problem Area "d" 6+00 – 10+00

VPA 7: Vegetative Problem Area "e" 5+50 – 7+50

VPA 8: Vegetative Problem Area "f" 12+50 – 16+50

VPA 9: Vegetative Problem Area "g" 13+50 – 15+30

VPA 10: Vegetative Problem Area "h" 17+00 – 20+50

VPA 11: Vegetative Problem Area "i" 21+80 – 22+50

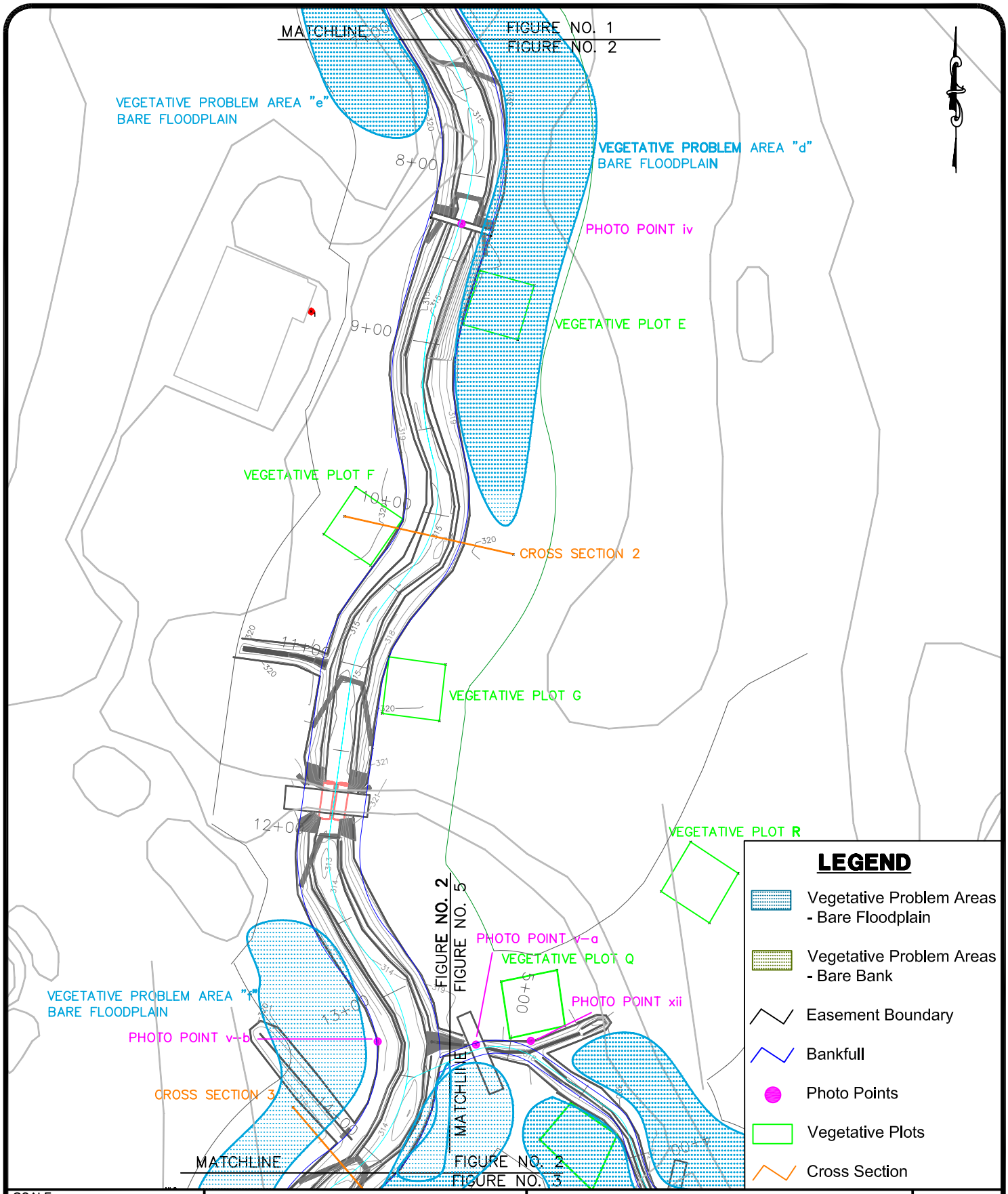
VPA 12: Vegetative Problem Area "j" 25+50 – 27+00

VPA 13: Vegetative Problem Area "k" throughout UT

VPA 14: Vegetative Problem Area "l" throughout UT

Appendix A.3

Plan View of Vegetation Problem Areas



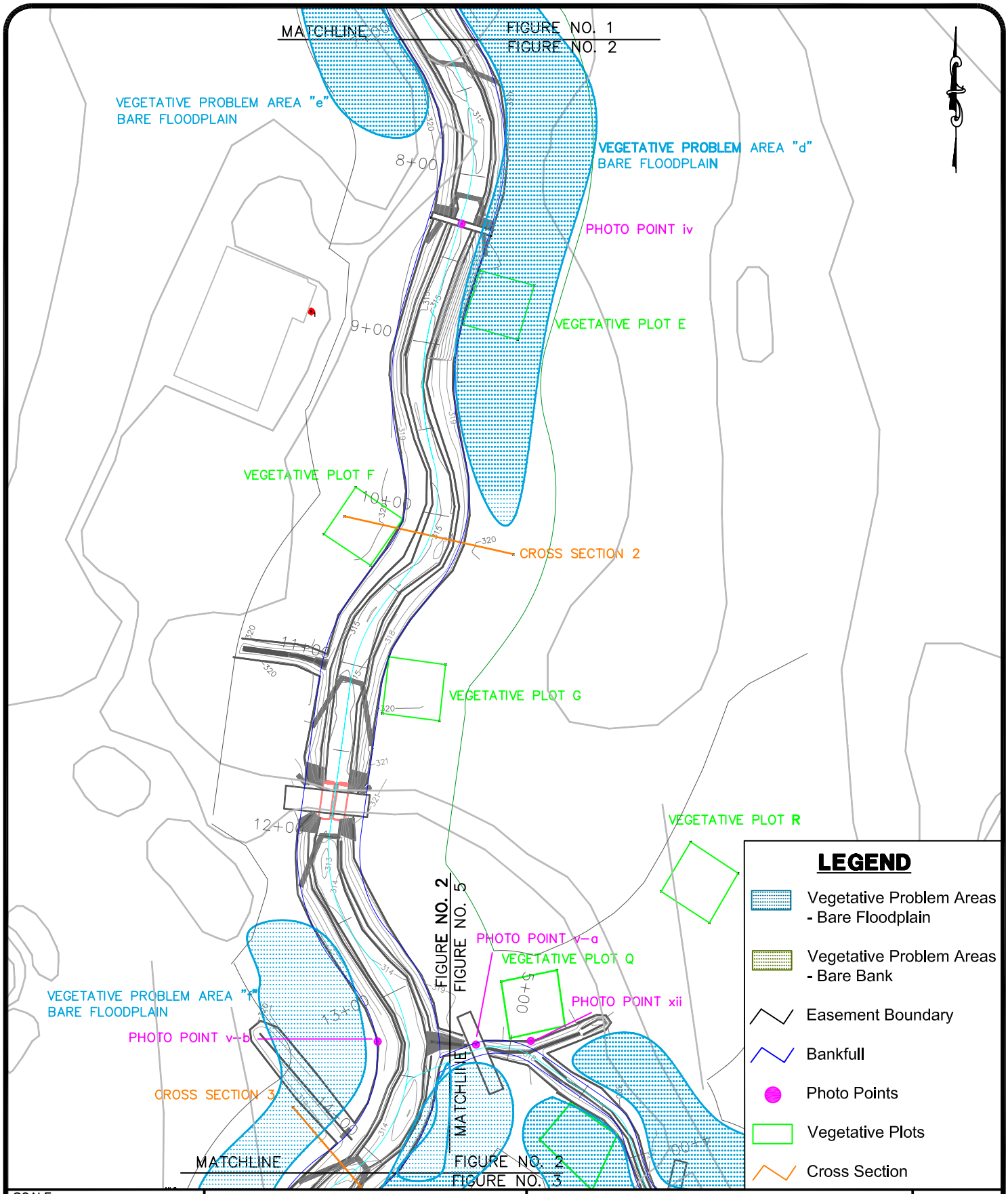
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

VEGETATIVE PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
2 of 5



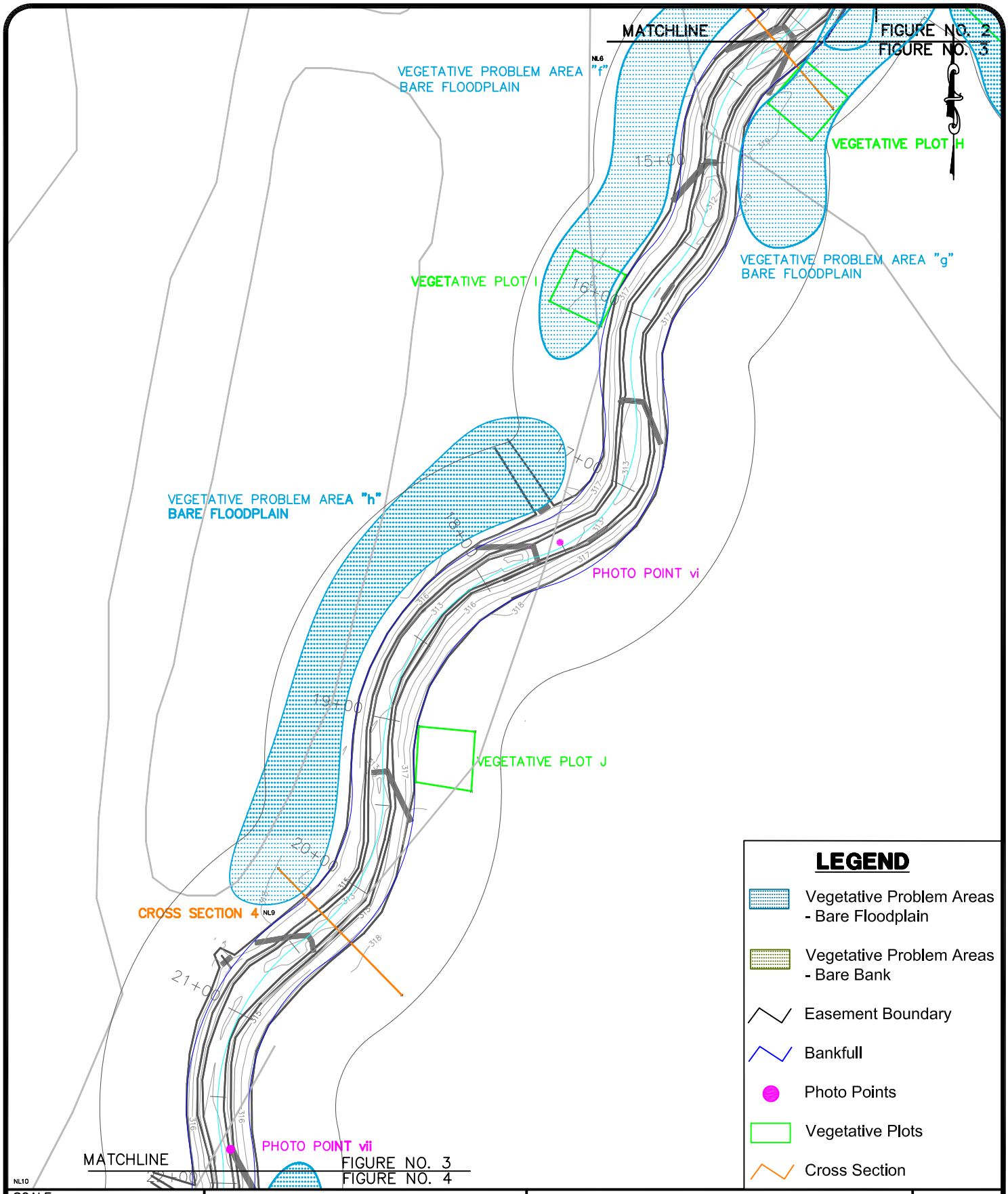
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

VEGETATIVE PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
2 of 5

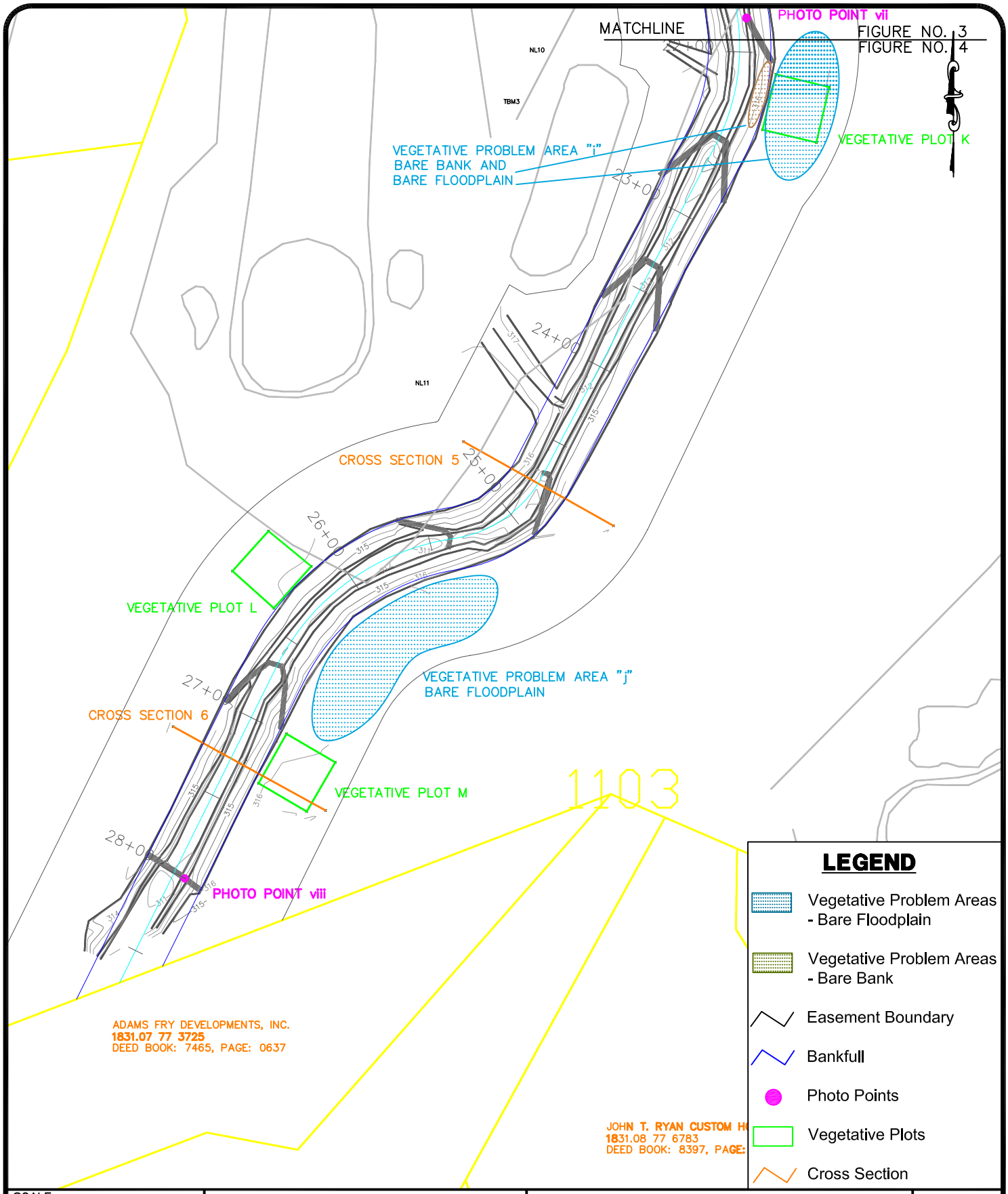


SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

VEGETATIVE PROBLEM AREAS
YEAR 1 MONITORING
Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
3 of 5



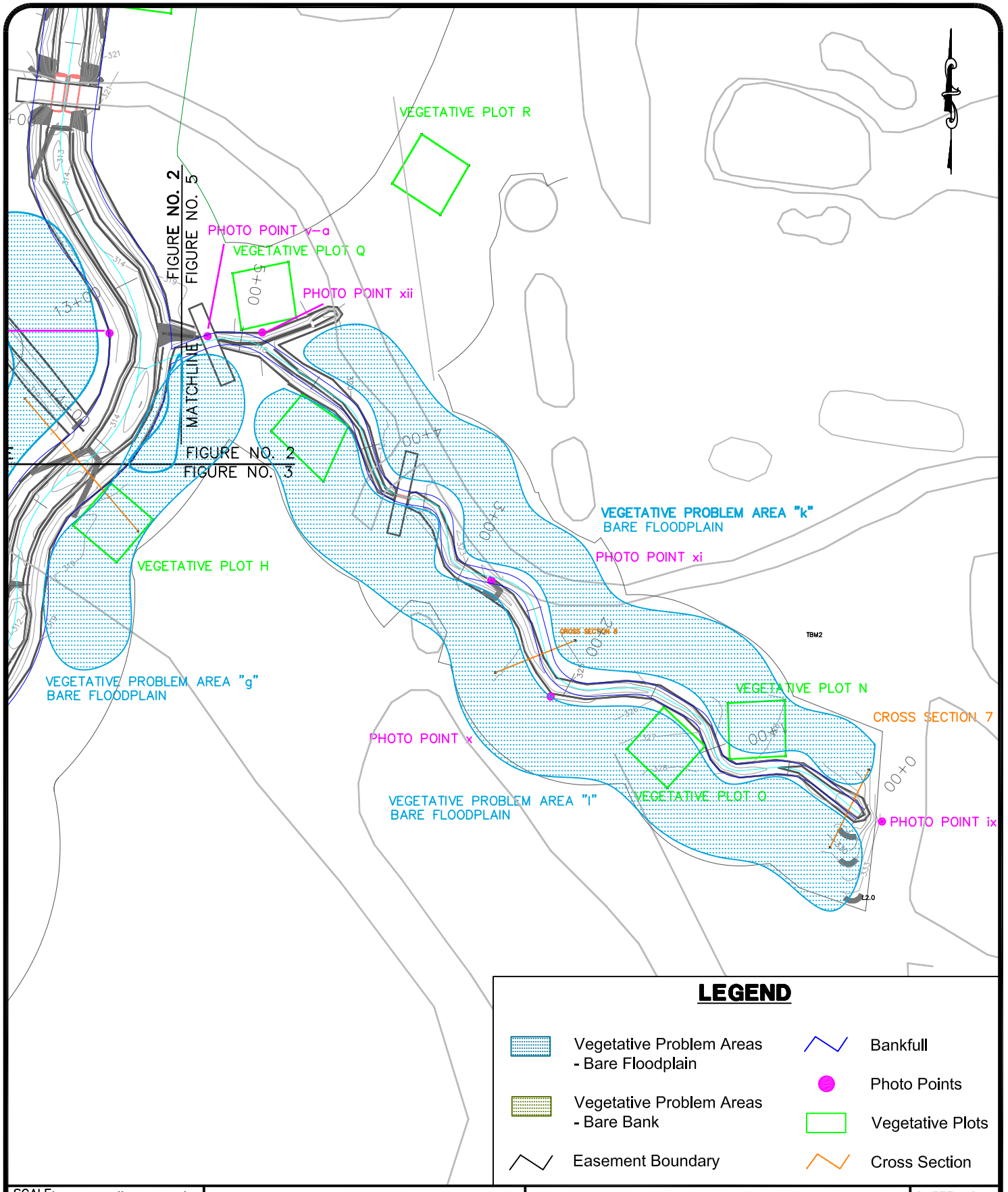
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

VEGETATIVE PROBLEM AREAS YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
4 of 5



SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

VEGETATIVE PROBLEM AREAS
YEAR 1 MONITORING
Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
5 of 5

Appendix A.4

Photos of Vegetation Monitoring Plots

Vegetative Plot A 7/31/06 Year 01
0+90 - 1+60 Looking from stream

Vegetative Plot A 7/31/06 Year 01
0+90 - 1+60 Looking toward stream

Vegetative Plot B 7/31/06 Year 01
3+30 - 3+60 Looking from stream

Vegetative Plot B 7/31/06 Year 01
3+30 - 3+60 Looking toward stream

Vegetative Plot C 7/31/06 Year 01
3+30 - 3+60 Looking from stream

Vegetative Plot C 7/31/06 Year 01
3+30 - 3+60 Looking toward stream

Vegetative Plot D 7/31/06 Year 01
5+90 - 6+20 Looking from stream

Vegetative Plot D 7/31/06 Year 01
5+90 - 6+20 Looking toward stream

Vegetative Plot E 7/31/06 Year 01
8+70 - 9+00 Looking from stream

Vegetative Plot E 7/31/06 Year 01
8+70 - 9+00 Looking toward stream

Vegetative Plot F 7/31/06 Year 01
10+40 - 10+70 Looking from stream

Vegetative Plot F 7/31/06 Year 01
10+40 - 10+70 Looking toward stream

Vegetative Plot G 7/31/06 Year 01
11+10 - 11+40 Looking from stream

Vegetative Plot G 7/31/06 Year 01
11+10 - 11+40 Looking toward stream

Vegetative Plot H 7/31/06 Year 01
14+40 - 14+70 Looking from stream

Vegetative Plot H 7/31/06 Year 01
14+40 - 14+70 Looking toward stream

Vegetative Plot I 7/31/06 Year 01
16+00 - 16+30 Looking from stream

Vegetative Plot I 7/31/06 Year 01
16+00 - 16+30 Looking toward stream

Vegetative Plot J 7/31/06 Year 01
19+20 - 19+50 Looking from stream

Vegetative Plot J 7/31/06 Year 01
19+20 - 19+50 Looking toward stream

Vegetative Plot K 7/31/06 Year 01
22+30 - 22+60 Looking from stream

Vegetative Plot K 7/31/06 Year 01
22+30 - 22+60 Looking toward stream

Vegetative Plot L 7/31/06 Year 01
26+30 - 26+60 Looking from stream

Vegetative Plot L 7/31/06 Year 01
26+30 - 26+60 Looking toward stream

Vegetative Plot M 7/31/06 Year 01
27+20 - 27+50 Looking from stream

Vegetative Plot M 7/31/06 Year 01
27+20 - 27+50 Looking toward stream

Vegetative Plot N 8/1/06 Year 01
0+60 - 0+90 UT Looking from stream

Vegetative Plot N 8/1/06 Year 01
0+60 - 0+90 UT Looking toward stream

Vegetative Plot O 8/1/06 Year 01
1+40 - 1+70 UT Looking from stream

Vegetative Plot O 8/1/06 Year 01
1+40 - 1+70 UT Looking toward stream

Vegetative Plot P 8/1/06 Year 01
4+40 - 4+50 UT Looking from stream

Vegetative Plot P 8/1/06 Year 01
4+40 - 4+50 UT Looking toward stream

Vegetative Plot Q 8/1/06 Year 01
4+80 - 4+50 UT Looking from stream

Vegetative Plot Q 8/1/06 Year 01
4+80 - 4+50 UT Looking toward stream

Vegetative Plot R 8/1/06 Year 01
4+80-4+50 UT Looking from stream

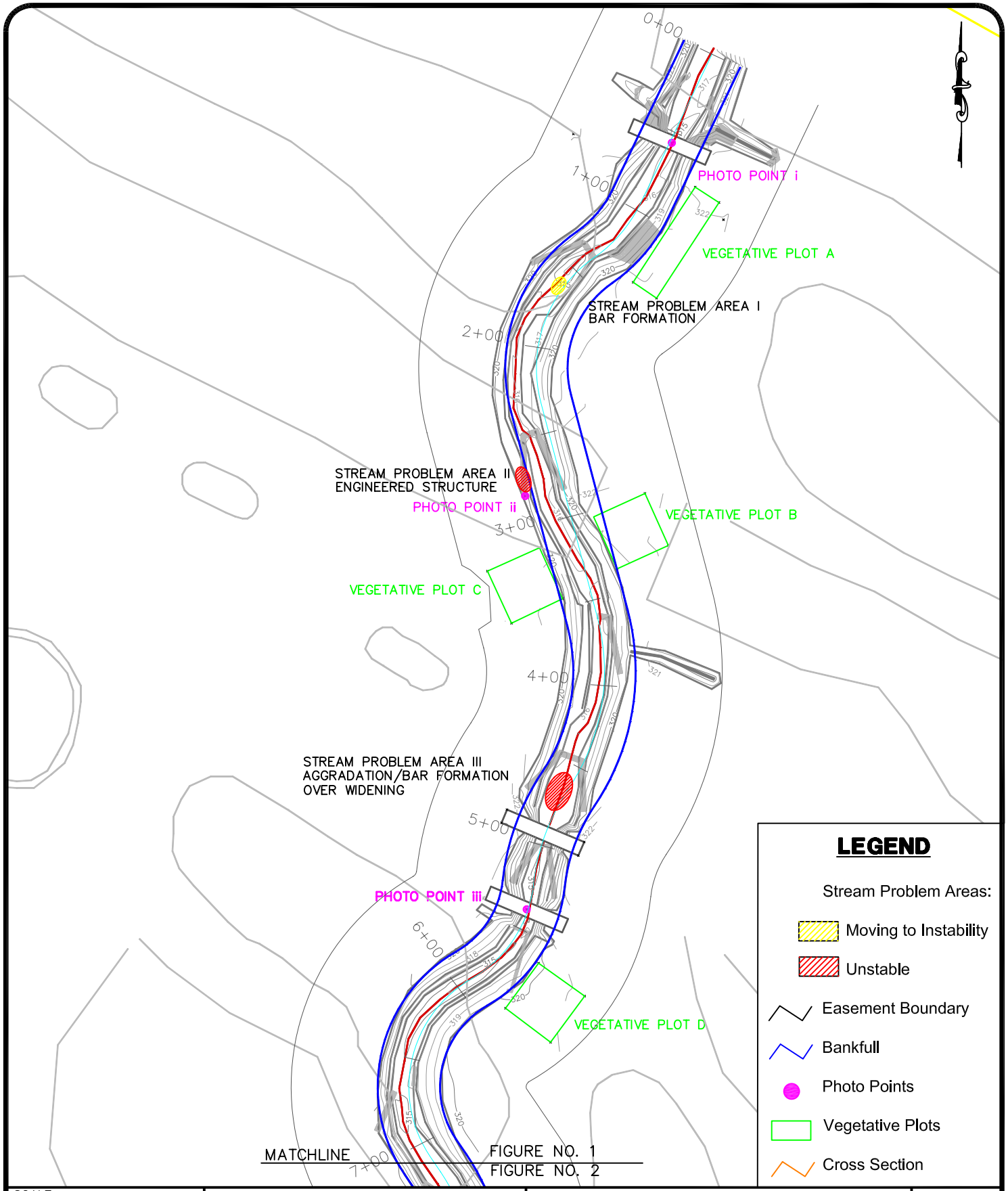
Vegetative Plot R 8/1/06 Year 01
4+80 - 4+50 UT Looking toward stream

APPENDIX B

GEOMORPHOLOGIC RAW DATA

Appendix B.1

Plan View of Stream Problem Areas



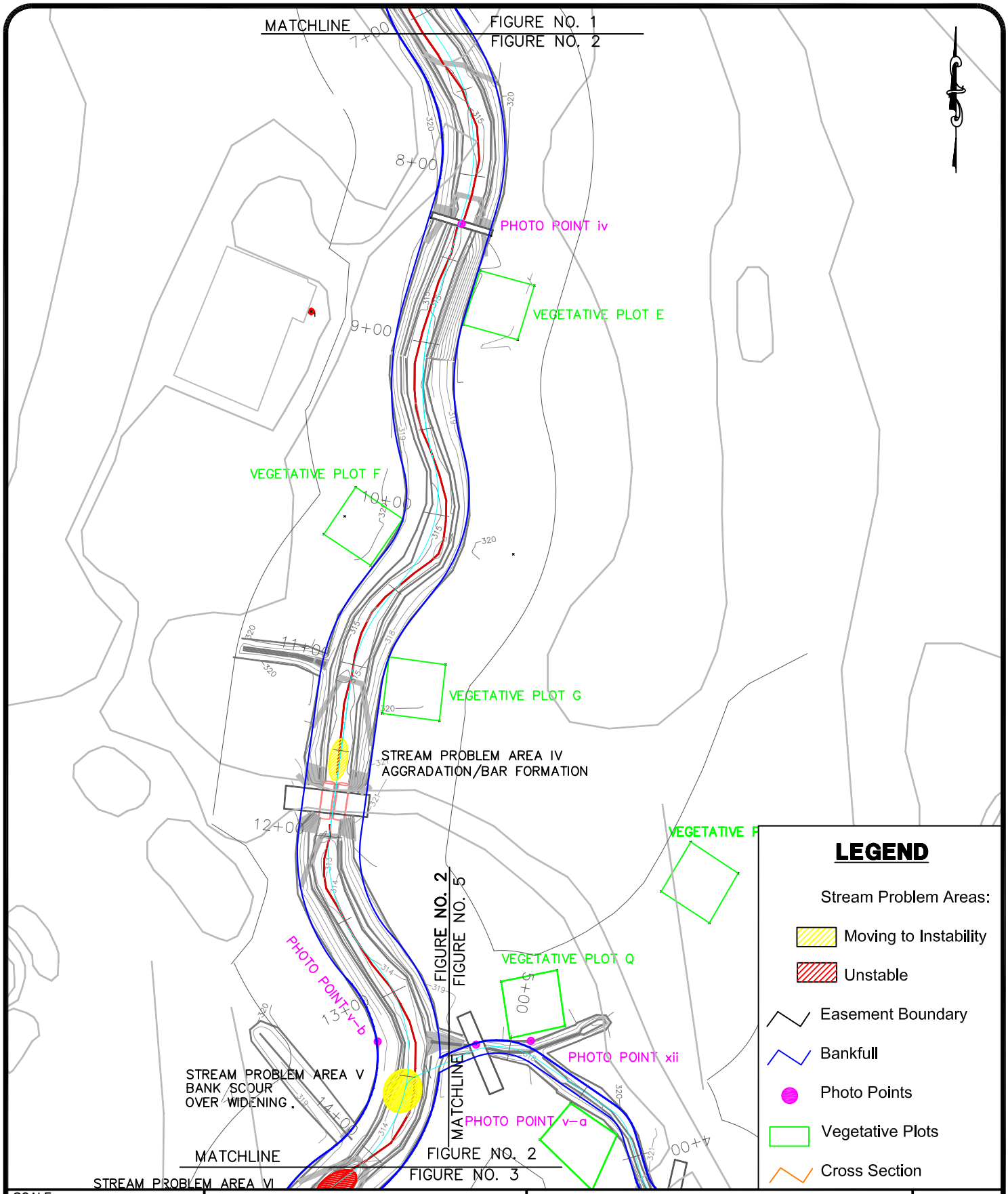
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

STREAM PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
1 of 5



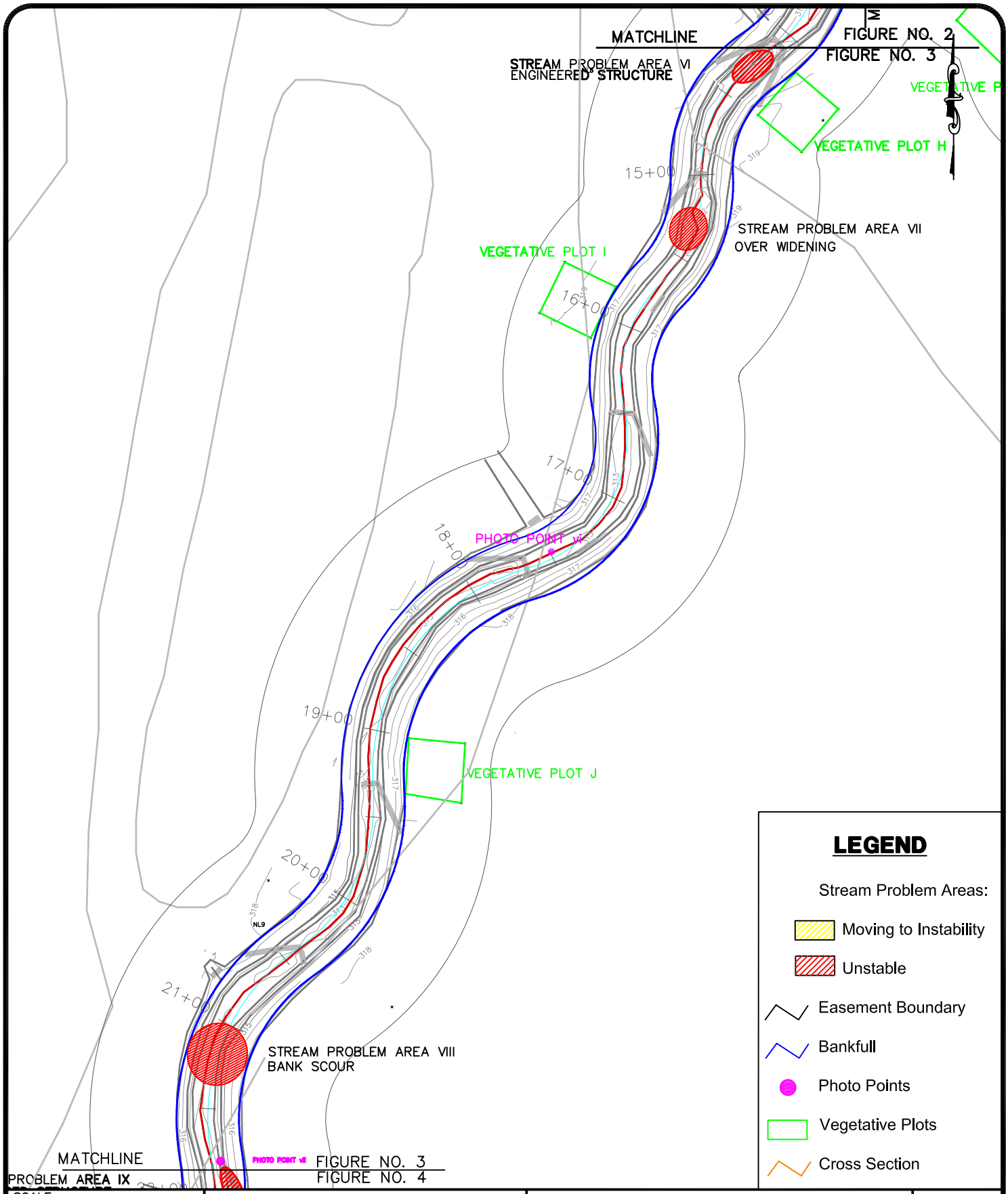
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

STREAM PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
2 of 5



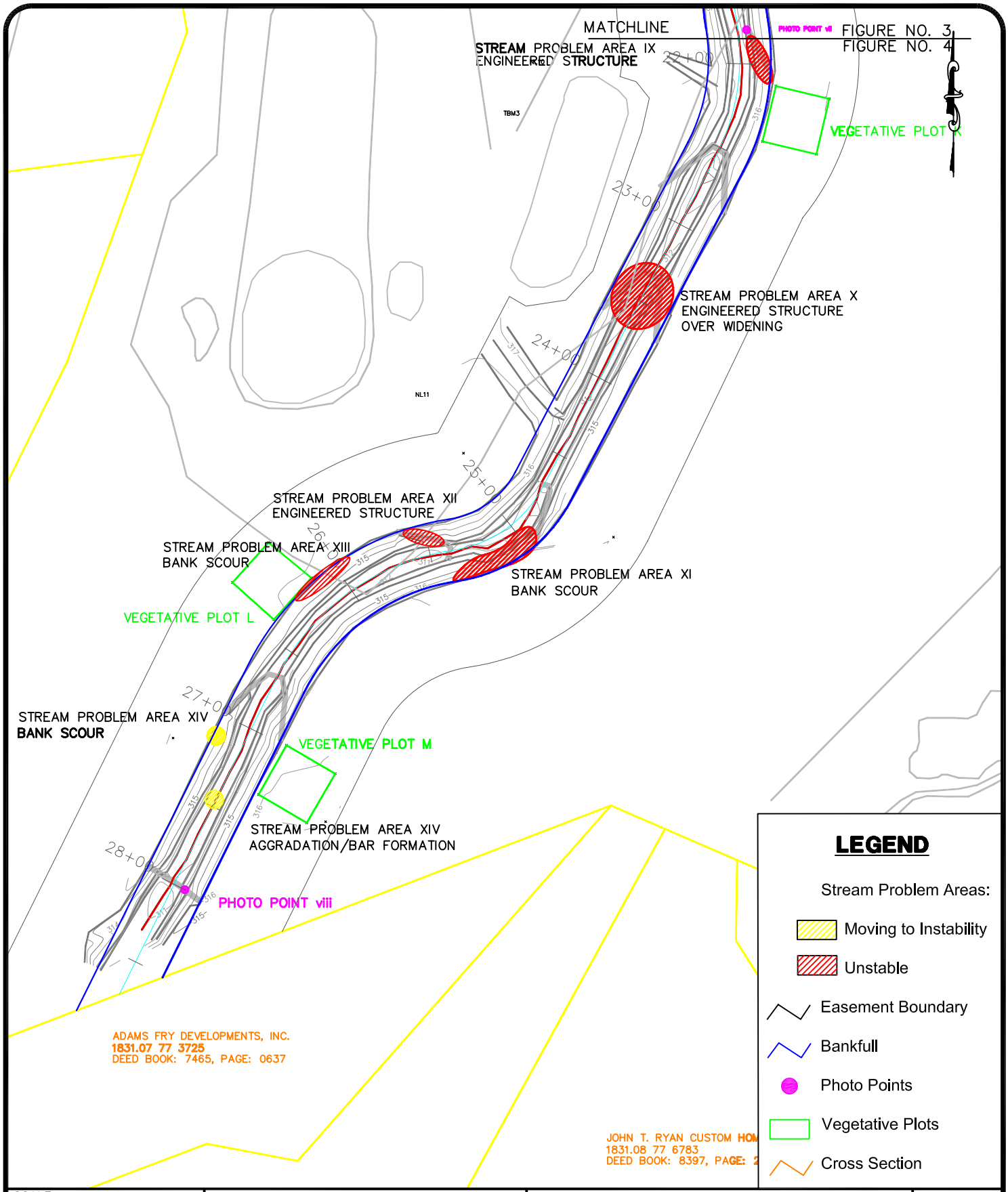
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

STREAM PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
3 of 5



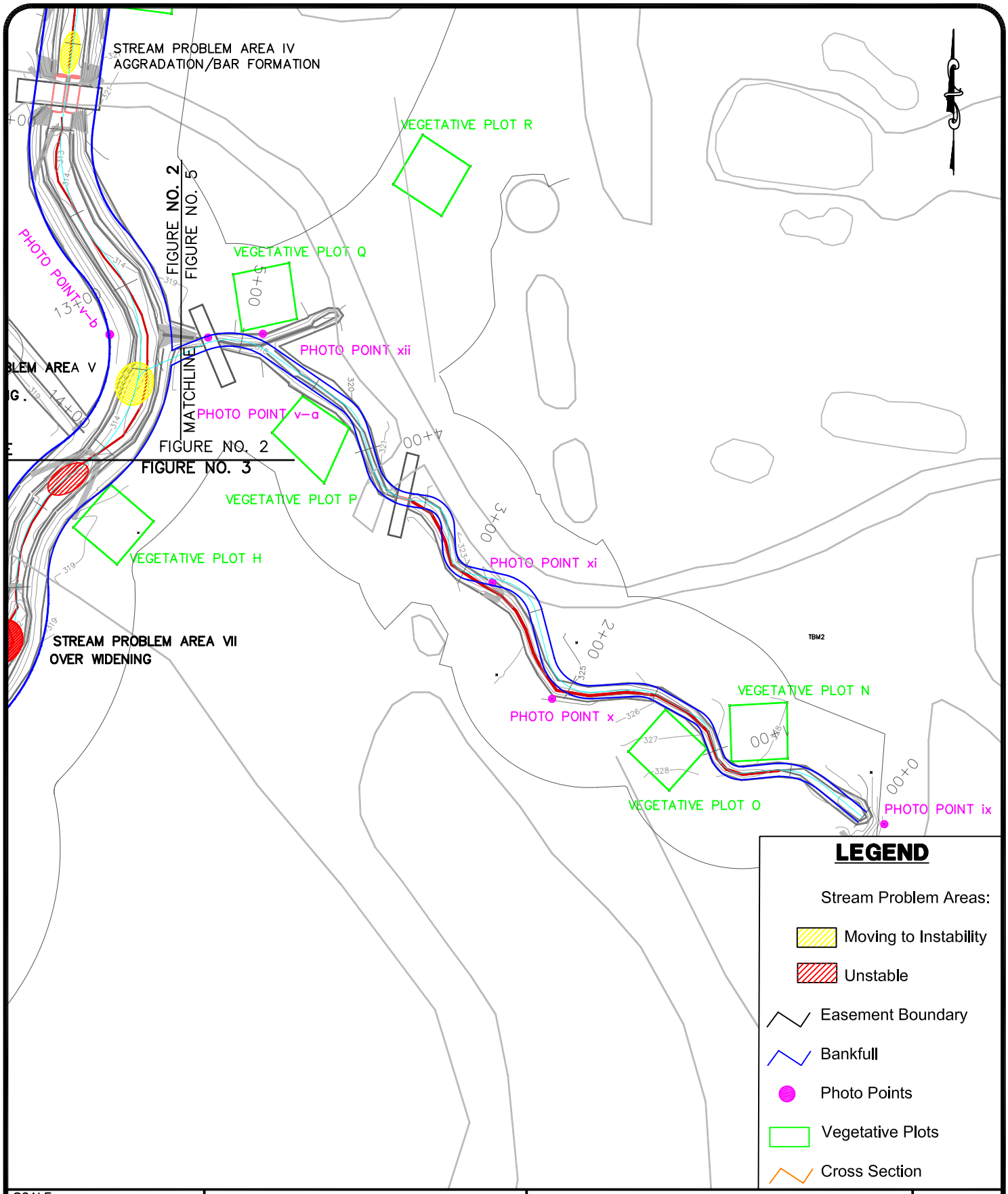
SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

STREAM PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
4 of 5



SCALE:	1" = 75'
DATE:	08-15-06
DRAWN BY:	PAK
PROJECT NO:	1357-06-571

S&ME
WWW.SMEINC.COM

STREAM PROBLEM AREAS
YEAR 1 MONITORING

Horse Creek Stream Restoration
Wake Forest, Wake Co., North Carolina

SHEET NO.
5 of 5

Appendix B.2

Representative Photos of Stream Problem Areas

Photograph SPA-1: Aggradation/Bar Formation, 4+90, 8.01.06

Photograph SPA-2: Bank Scour, 25+10, 8.01.06

Photograph SPA-3: Engineered Structure - Back or Arm Scour, 2+85, 8.01.06

Photograph SPA-4: Channel Over-widening, 22+00, 8.01.06

Appendix B.3

Photos of Photo-station Locations

Photo Point i - Upstream 0+50

Photo Point i - Downstream 0+50

Photo Point ii - Upstream 2+50

Photo Point ii - Downstream 2+50

Photo Point iii - Upstream 5+40

Photo Point iii - Downstream 5+40

Photo Point iv - Upstream 8+00

Photo Point iv - Downstream 8+00

Photo Point v-a Upstream 13+50

Photo Point v-b Downstream 13+50

Photo Point vi - Upstream 17+50

Photo Point vi - Downstream 17+50

Photo Point vii - Upstream 21+50

Photo Point vii - Downstream 21+50

Photo Point viii - Upstream 28+00

Photo Point viii - Downstream 28+00

Photo Point ix Downstream 0+00 UT

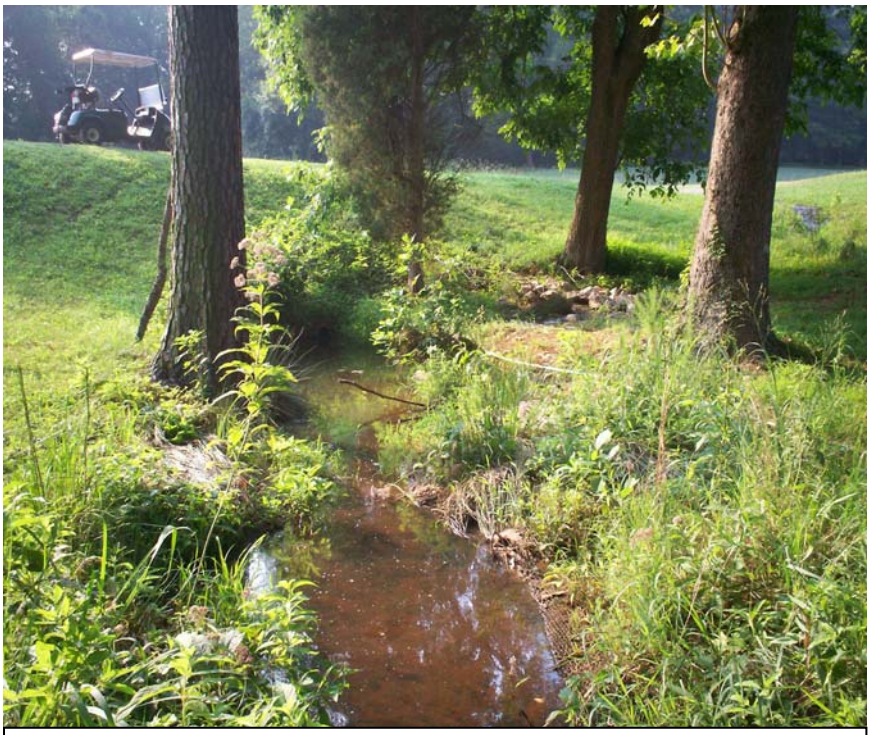


Photo Point ix Upstream 0+00 UT

Photo Point x Downstream 2+08 UT

Photo Point x Upstream 2+08 UT

Photo Point xi Upstream 3+48 UT

Photo Point xi Downstream 3+48 UT

Photo Point xii Downstream 5+18 UT

Photo Point xii Upstream into UT to UT 5+ 18 UT

Appendix B.4

Qualitative Visual Stability Assessment

Categorical Stream Feature Visual Stability Assessment Project Number 71082 (Horse Creek) Segment/Reach: Horse Creek						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	65%	59%				
B. Pools	50%	54%				
C. Thalweg	80%	74%				
D. Meanders	80%	70%				
E. Bed General	95%	93%				
F. Vanes / J Hooks etc.	60%	60%				
G. Wads and Boulders	NA	NA				
*Evaluation based on As-built features and not design features						

Visual Morphological Stability Assessment
Horse Creek - 71082
Segment/Reach: Horse Creek (2,285 lf)

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	% Performing in Stable Condition	Feature Performance Mean or Total
A. Riffles	1. Present?	19	31	NA	61	
	2. Armor stable (e.g. no displacement)?	17	31	NA	55	
	3. Facet grade appears stable?	18	31	NA	58	
	4. Minimal evidence of embedding/fining?	18	31	NA	58	
	5. Length appropriate?	19	31	NA	61	**59**
B. Pools	1. Present? (e.g not subject to severe aggrad. or migrat.?)	18	30	NA	60	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	16	30	NA	53	
	3. Length appropriate?	15	30	NA	50	**54**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	12	15	NA	80	
	2. Downstream of meander (glide/inflection) centering?	11	16	NA	69	**74**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	24	30	NA	80	
	2. Of those eroding, # w/concomitant point bar formation?	2	NA	NA	NA	
	3. Apparent Rc within spec?	31	31	NA	100	
	4. Sufficient floodplain access and relief?	31	31	NA	100	**70**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	5/200	95	
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	0	**93**
F. Vanes	1. Free of back or arm scour?	13	24	NA	54	
	2. Height appropriate?	14	24	NA	58	
	3. Angle and geometry appear appropriate?	16	24	NA	67	
	4. Free of piping or other structural failures?	15	24	NA	63	**60**
G. Wads/ Boulders	1. Free of back or scour?	NA	NA	NA		**NA**
	2. Footing stable?	NA	NA	NA		

Categorical Stream Feature Visual Stability Assessment						
Project Number 71082 (Horse Creek) Segment/Reach: Unnamed Tributary						
Feature	**Initial***	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	90%	90%				
B. Pools	80%	83%				
C. Thalweg	100%	100%				
D. Meanders	100%	100%				
E. Bed General	100%	100%				
F. Vanes / J Hooks etc.	NA	NA				
G. Wads and Boulders	NA	NA				
*Evaluation based on As-built features and not design features						

Visual Morphological Stability Assessment
Horse Creek - 71082
Segment/Reach: Unnamed Tributary (550 lf)

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	% Performing in Stable Condition	Feature Performance Mean or Total
A. Riffles	1. Present?	12	12	NA	100	
	2. Armor stable (e.g. no displacement)?	10	12	NA	83	
	3. Facet grade appears stable?	12	12	NA	100	
	4. Minimal evidence of embedding/fining?	9	12	NA	75	
	5. Length appropriate?	11	12	NA	92	**90**
B. Pools	1. Present? (e.g not subject to severe aggrad. or migrat.?)	12	12	NA	100	
	2. Sufficiently deep (Max Pool D:Mean Bkf >1.6?)	8	12	NA	67	
	3. Length appropriate?	10	12	NA	83	**83**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering?	6	6	NA	100	
	2. Downstream of meander (glide/inflection) centering?	6	6	NA	100	**100**
D. Meanders	1. Outer bend in state of limited/controlled erosion?	11	11	NA	100	
	2. Of those eroding, # w/concomitant point bar formation?	11	11	NA	100	
	3. Apparent Rc within spec?	11	11	NA	100	
	4. Sufficient floodplain access and relief?	11	11	NA	100	**100**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	0	0	
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	0	**100**
F. Vanes	1. Free of back or arm scour?			NA		
	2. Height appropriate?			NA		
	3. Angle and geometry appear appropriate?			NA		
	4. Free of piping or other structural failures?			NA		
				NA		
G. Wads/ Boulders	1. Free of back or scour?	NA	NA	NA		
	2. Footing stable?	NA	NA	NA		

NA = Not applicable

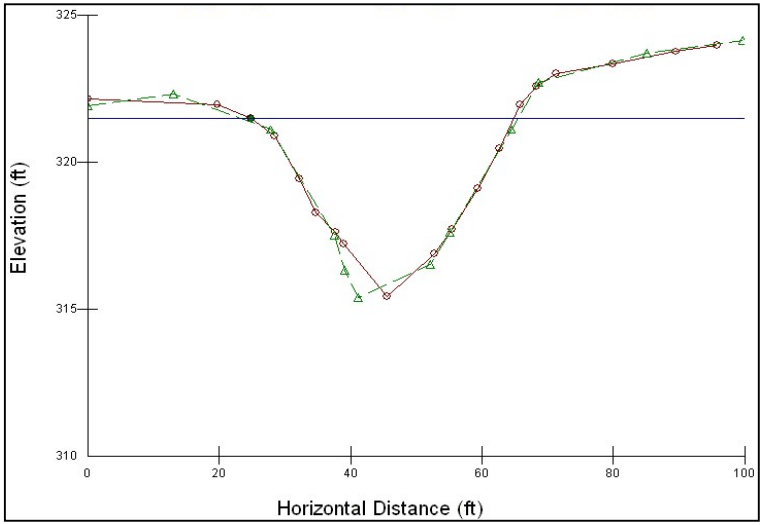
Appendix B.5

Cross-section Plots and Raw Data Tables

Cross Section 1 - Riffle, 0+83

Station	Elevation	Feature
0	322.15	
19.71	321.94	BKF
24.9	321.49	
28.41	320.88	
32.2	319.44	
34.72	318.26	
37.71	317.62	
39	317.2	
45.53	315.41	
52.84	316.89	
55.5	317.72	
59.44	319.09	
62.66	320.46	
65.87	321.95	
68.33	322.57	
71.3	323	
79.91	323.34	
89.52	323.75	
95.81	323.97	

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data	
Bankfull Cross-Sectional Area:	131.49
Bankfull Width:	39.98
Bankfull Mean Depth:	3.29
Bankfull Max Depth:	6.08
Width/Depth Ratio:	12.15
Entrenchment Ratio:	2.4
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

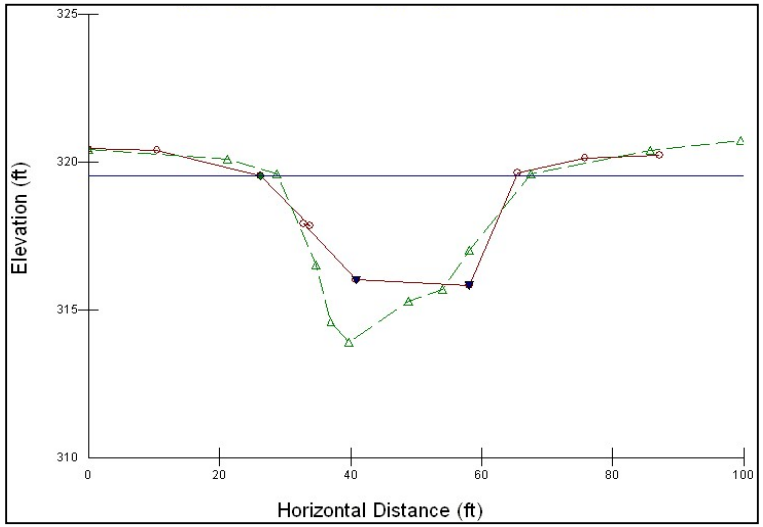
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 2 - Pool, 10+46

Station	Elevation	Feature
0	320.436	FP
10.43	320.3748	
26.25	319.5311	BKF
33.77	317.8252	
32.85	317.9082	
40.85	315.9997	REW
58.18	315.8198	LEW
65.55	319.6318	
75.8	320.1293	
87.21	320.231	FP

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data	
Bankfull Cross-Sectional Area:	101.53
Bankfull Width:	39.1
Bankfull Mean Depth:	2.6
Bankfull Max Depth:	3.71
Width/Depth Ratio:	15.04
Entrenchment Ratio:	2.23
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

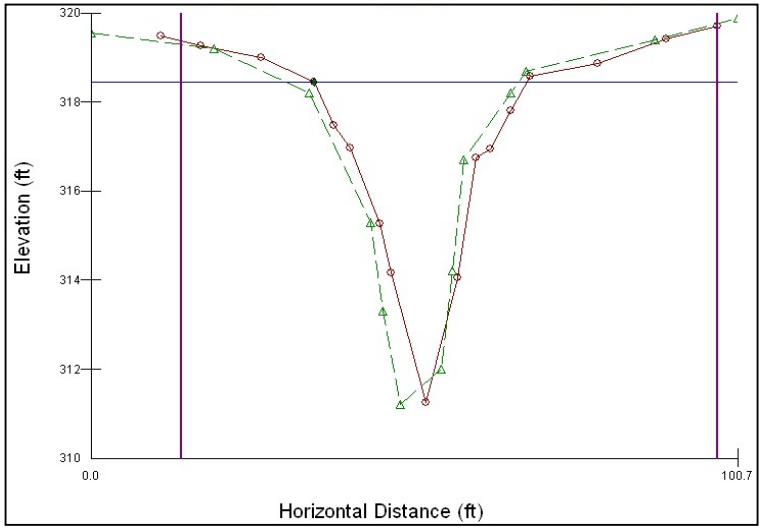
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 3 - Pool, 14+65

Station	Elevation	Feature
14.07	319.48	
20.33	319.27	
29.6	319	
37.88	318.44	BKF
40.96	317.48	
43.51	316.97	
48.11	315.27	
49.93	314.16	
55.38	311.25	
60.23	314.05	
63.15	316.75	
65.35	316.95	
68.64	317.8	
71.55	318.58	
82.14	318.86	
92.84	319.42	
100.75	319.7	

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data

Bankfull Cross-Sectional Area:	98.01
Bankfull Width:	86.68
Bankfull Mean Depth:	2.96
Bankfull Max Depth:	7.19
Width/Depth Ratio:	11.2
Entrenchment Ratio:	2.61
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

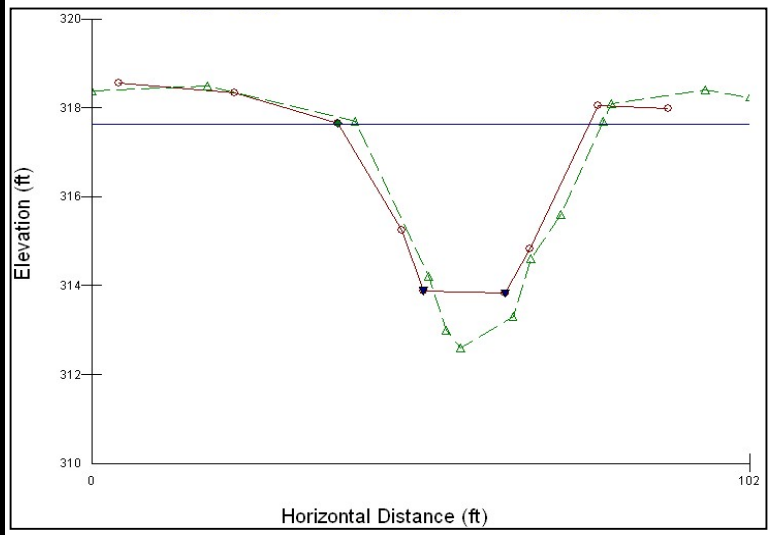
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 4 - Riffle, 20+81

Station	Elevation	Feature
4.1	318.568	FP
22.05	318.3385	
38.15	317.645	BKF
48.07	315.2516	
51.48	313.8833	LEW
64.11	313.8239	REW
67.95	314.8274	
78.45	318.0579	RB
89.45	317.9916	FP

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data	
Bankfull Cross-Sectional Area:	95.7
Bankfull Width:	38.92
Bankfull Mean Depth:	2.46
Bankfull Max Depth:	3.82
Width/Depth Ratio:	15.82
Entrenchment Ratio:	2.19
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

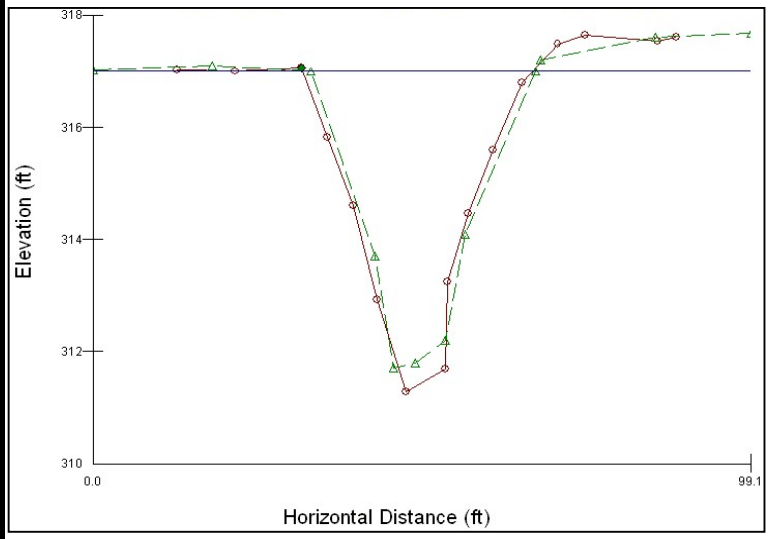
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 5 - Riffle, 25+38

Station	Elevation	Feature
12.62	317.03	
21.35	317	
31.31	317.06	BKF
35.24	315.83	
39.22	314.6	
42.73	312.93	
47.12	311.28	
53	311.69	
53.39	313.24	
56.49	314.47	
60.23	315.6	
64.58	316.8	
69.99	317.48	
74.11	317.65	
85.01	317.53	
87.87	317.6	

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data	
Bankfull Cross-Sectional Area:	97.44
Bankfull Width:	39.35
Bankfull Mean Depth:	2.48
Bankfull Max Depth:	5.73
Width/Depth Ratio:	15.87
Entrenchment Ratio:	1.91
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

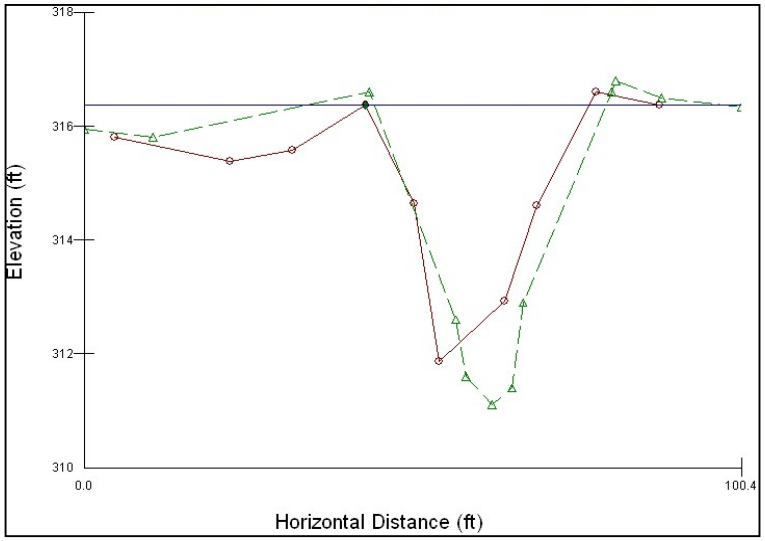
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 6 - Riffle, 27+93

Station	Elevation	Feature
4.6	315.8022	FP
22.26	315.378	FP
31.79	315.5779	FP
43.01	316.375	BKF
50.4	314.6371	
54.25	311.8663	
64.25	312.9294	
69.11	314.612	
78.23	316.6021	RB
87.95	316.371	FP

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data	
Bankfull Cross-Sectional Area:	78.21
Bankfull Width:	35.21
Bankfull Mean Depth:	2.22
Bankfull Max Depth:	4.51
Width/Depth Ratio:	15.86
Entrenchment Ratio:	2.37
Classification:	C5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

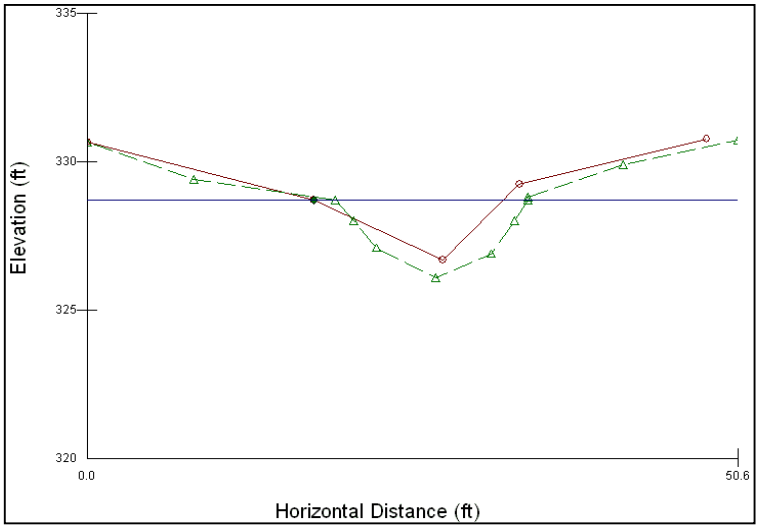
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Horse Creek Reach

Cross Section 7 - Riffle, 0+08

Station	Elevation	Feature
0	330.65	FP
17.61	328.69	BKF
27.67	326.68	LB
33.59	329.23	
48.16	330.76	

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data

Bankfull Cross-Sectional Area:	14.8
Bankfull Width:	14.72
Bankfull Mean Depth:	1
Bankfull Max Depth:	2.01
Width/Depth Ratio:	14.72
Entrenchment Ratio:	3.23
Classification:	E5

Prepared for: Ecosystem Enhancement Program

Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

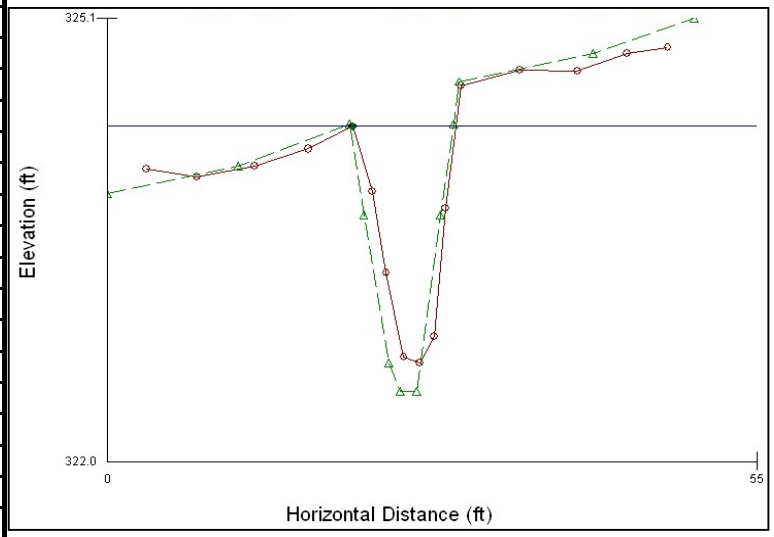
Project No. 71082

Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Unnamed Tributary Reach

Cross Section 8 - Riffle, 2+18

Station	Elevation	Feature
3.3	324.08	
7.62	324.02	
12.46	324.1	
17.03	324.22	
20.79	324.38	BKF
22.43	323.92	
23.61	323.34	
25.09	322.74	
26.45	322.7	
27.64	322.89	
28.61	323.8	
29.91	324.67	
34.9	324.78	
39.77	324.77	
44.01	324.9	
47.44	324.94	

Cross Section Plot - Looking Downstream



Cross Section Photo - Looking Downstream

Summary Data

Bankfull Cross-Sectional Area:	8.66
Bankfull Width:	9.48
Bankfull Mean Depth:	0.91
Bankfull Max Depth:	1.68
Width/Depth Ratio:	10.42
Entrenchment Ratio:	4.66
Classification:	E5

Prepared for: Ecosystem Enhancement Program

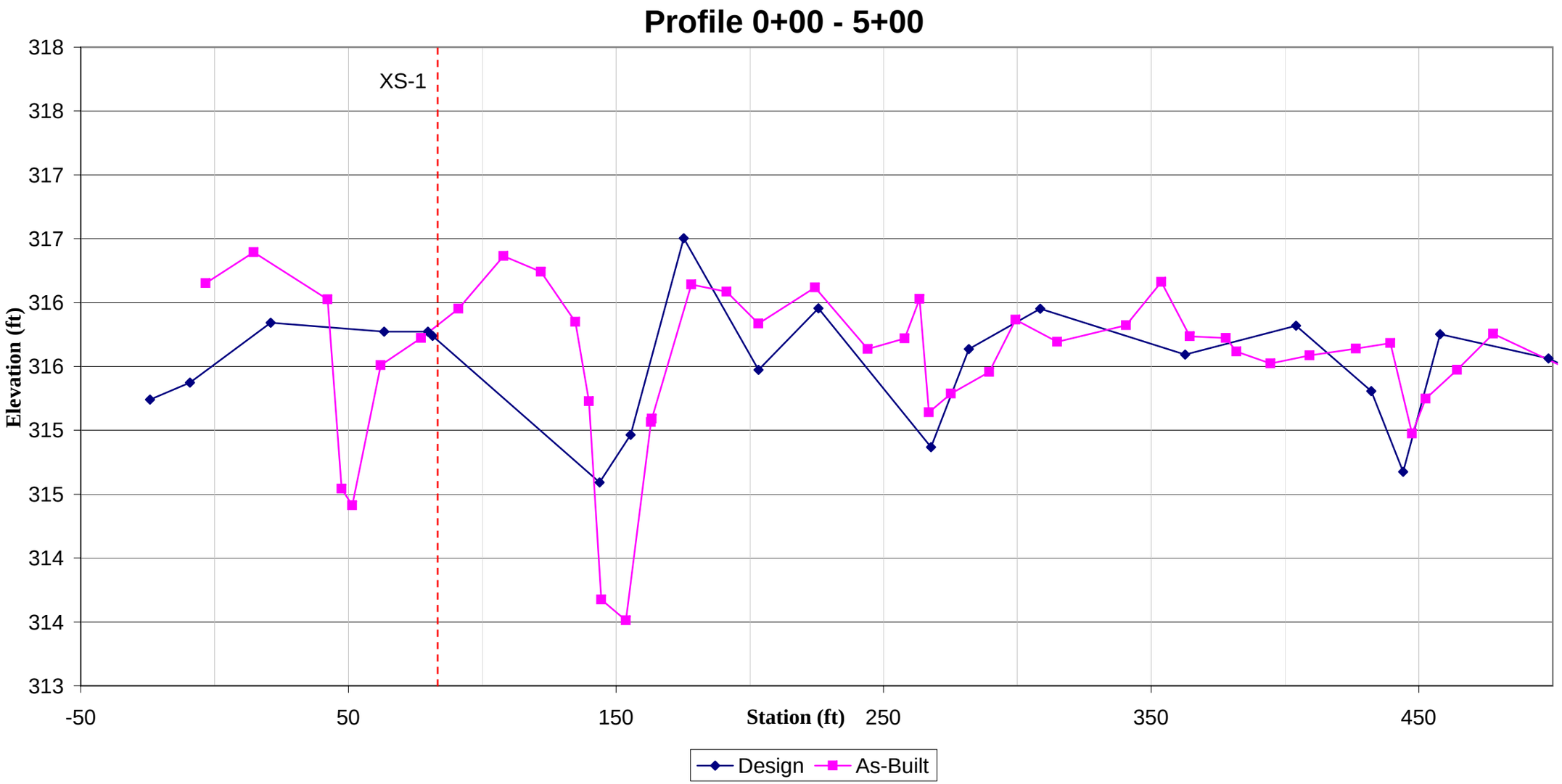
Project: **HORSE CREEK STREAM RESTORATION PROJECT**
WAKE FOREST, NC

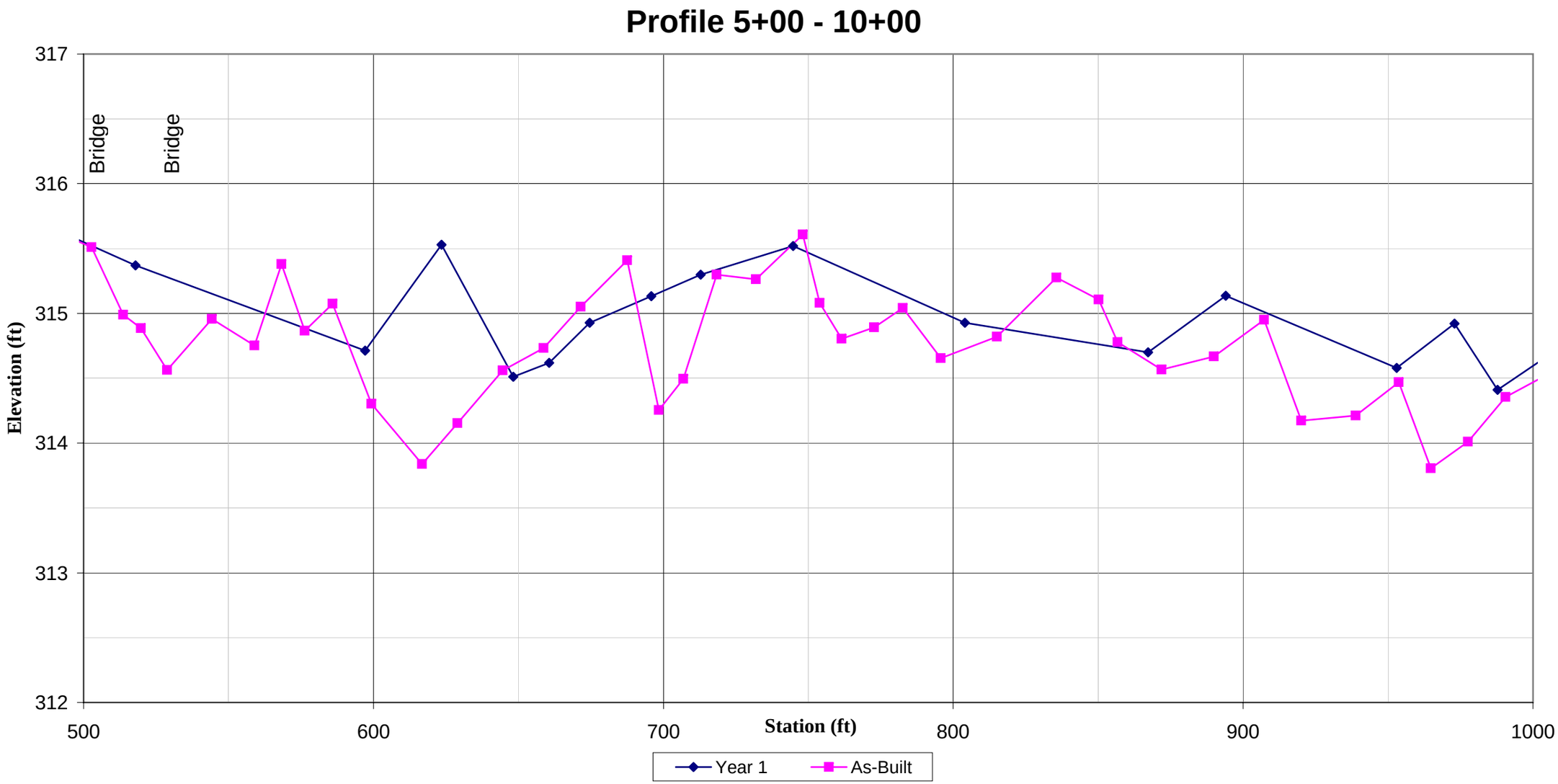
Project No. 71082

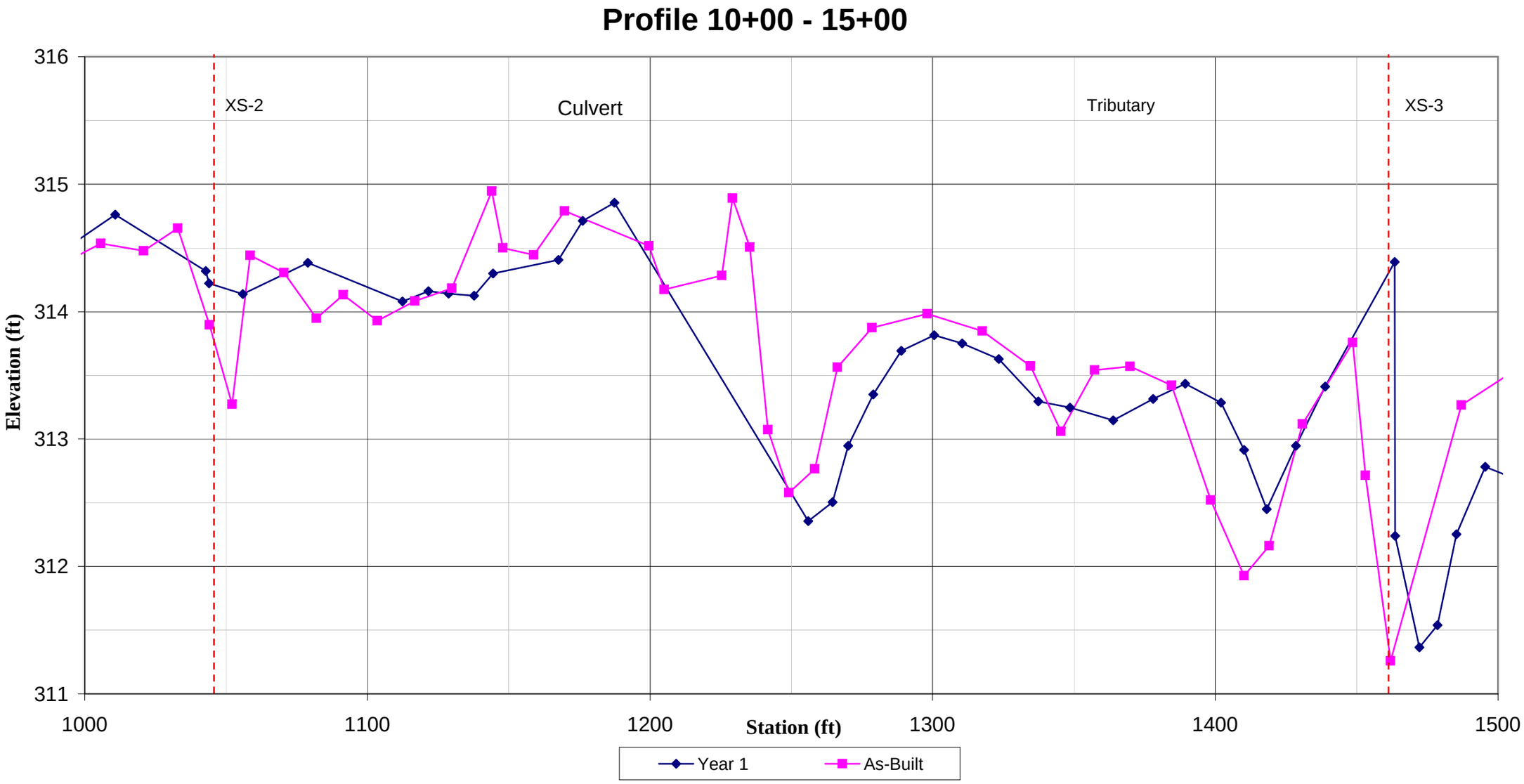
Survey Date:	Survey Weather:	Field Team:	Location:
1-Aug-06	Sunny, 96 ^{o} F	Lawler/Knudsen	Unnamed Tributary Reach

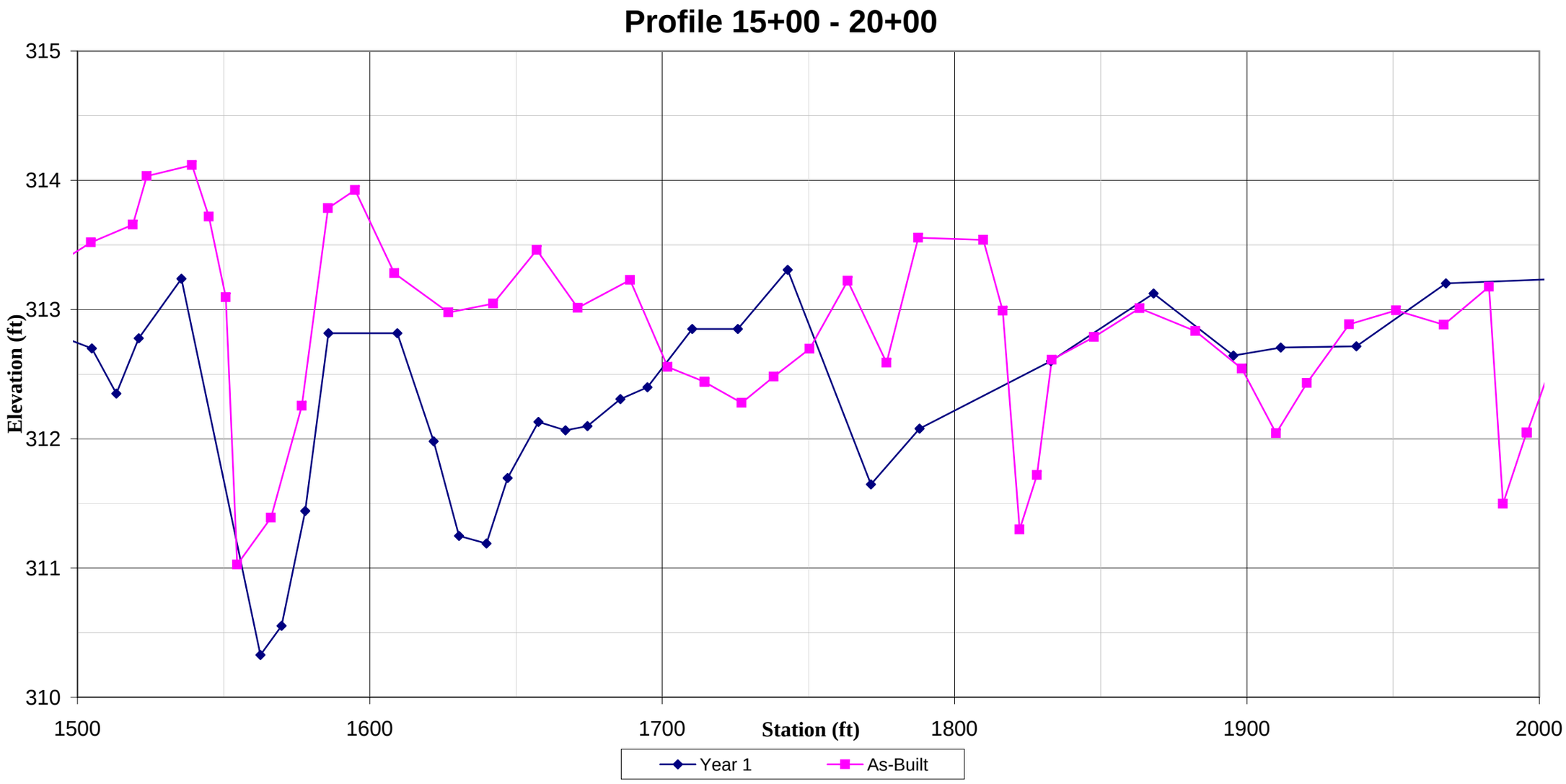
Appendix B.6

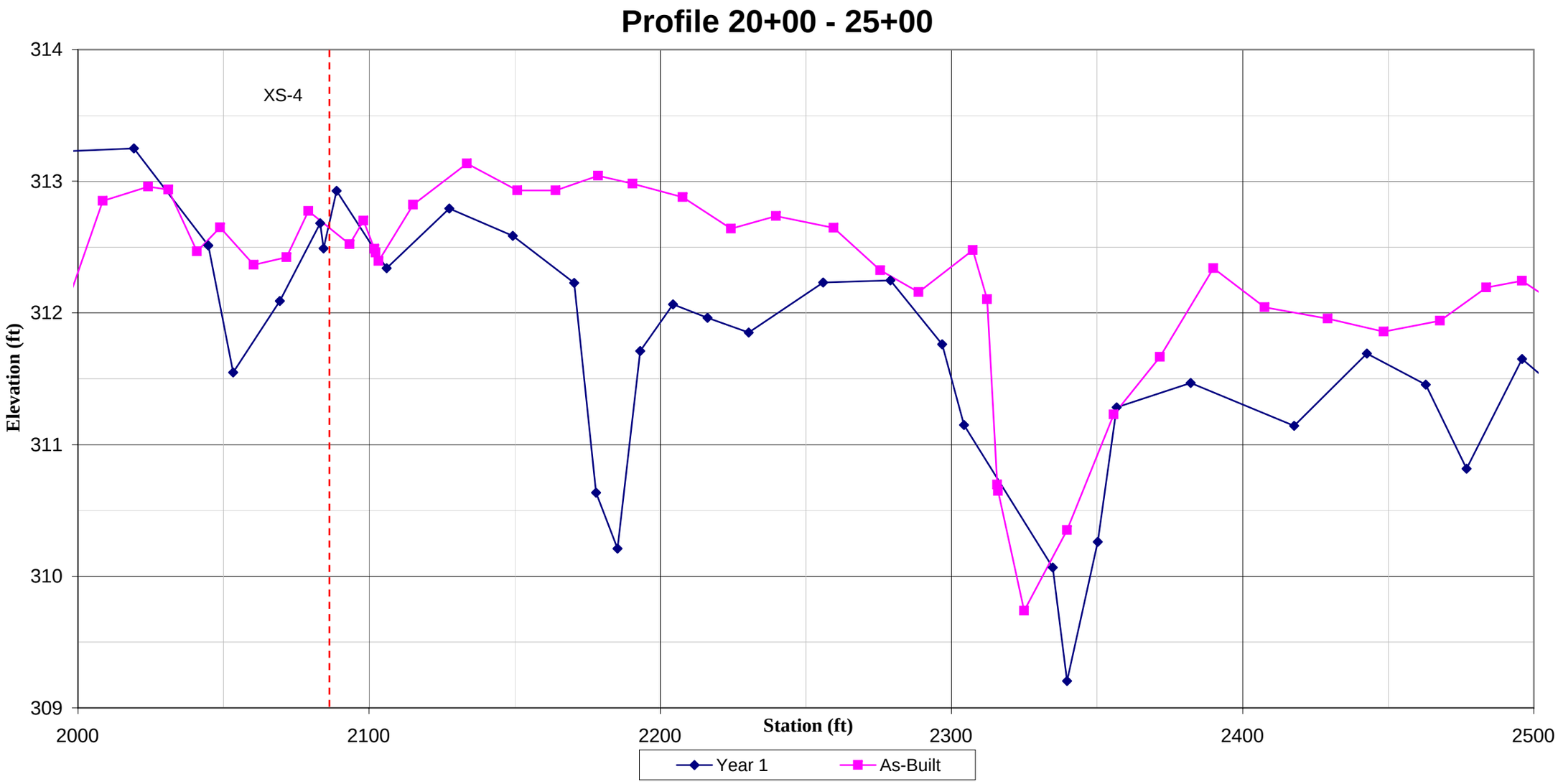
Longitudinal Plots and Raw Data Tables

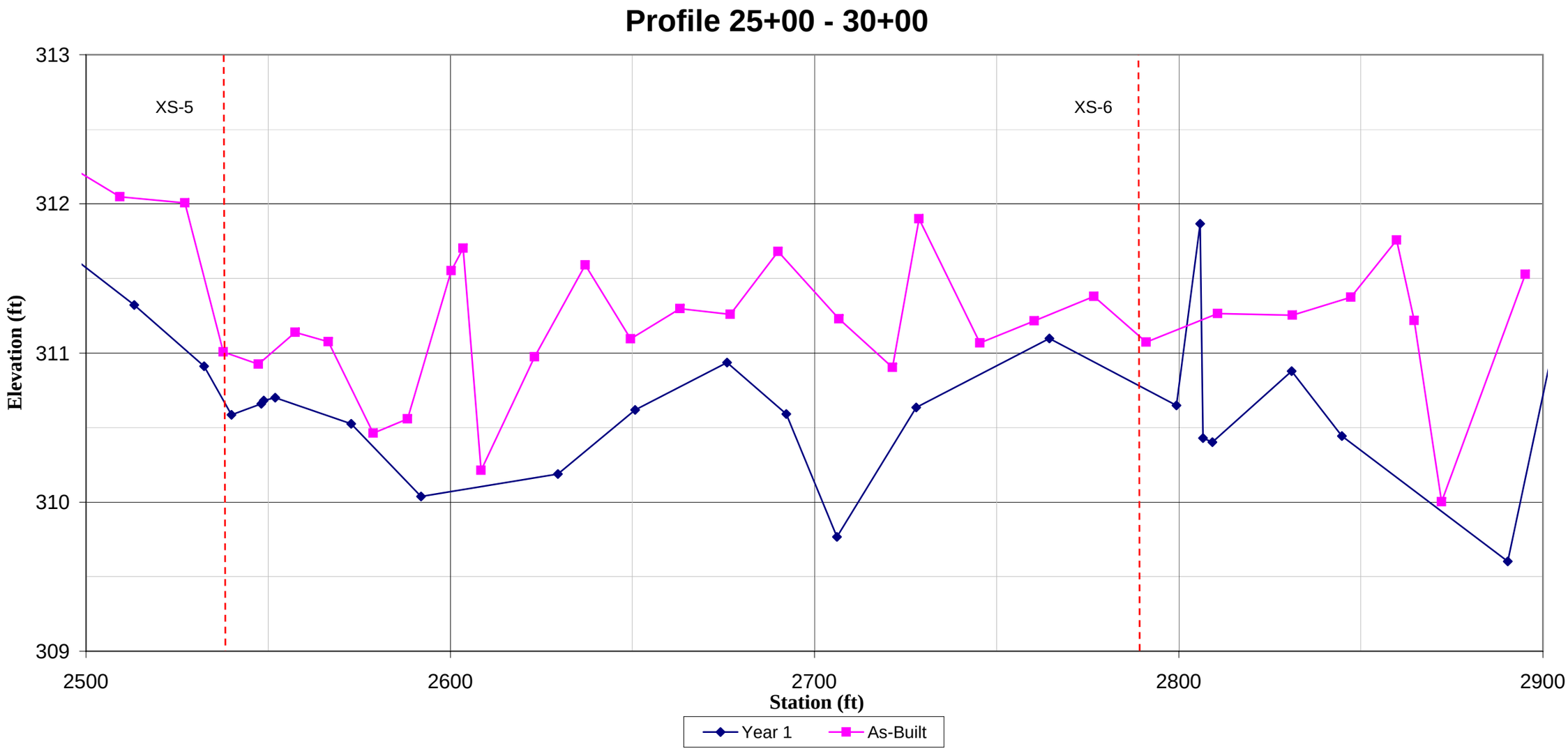

Profile 0+00 - 5+00
XS-1
318
318
317
317
316
316
315
315
314
314
313
Elevation (ft)
-50
50
150
Station (ft)
250
350
450
Design
As-Built


Profile 5+00 - 10+00
317
316
315
314
313
312
Elevation (ft)
Bridge
Bridge
500
600
700
800
900
1000
Station (ft)
Year 1
As-Built


Profile 10+00 - 15+00
316
315
314
313
312
311
Elevation (ft)
XS-2
Culvert
Tributary
XS-3
1000
1100
1200
1300
1400
1500
Station (ft)
Year 1
As-Built


Profile 15+00 - 20+00
315
314
313
312
311
310
Elevation (ft)
1500
1600
1700
1800
1900
2000
Station (ft)
Year 1
As-Built


Profile 20+00 - 25+00
XS-4
Elevation (ft)
314
313
312
311
310
309
2000
2100
2200
2300
2400
2500
Station (ft)
Year 1
As-Built

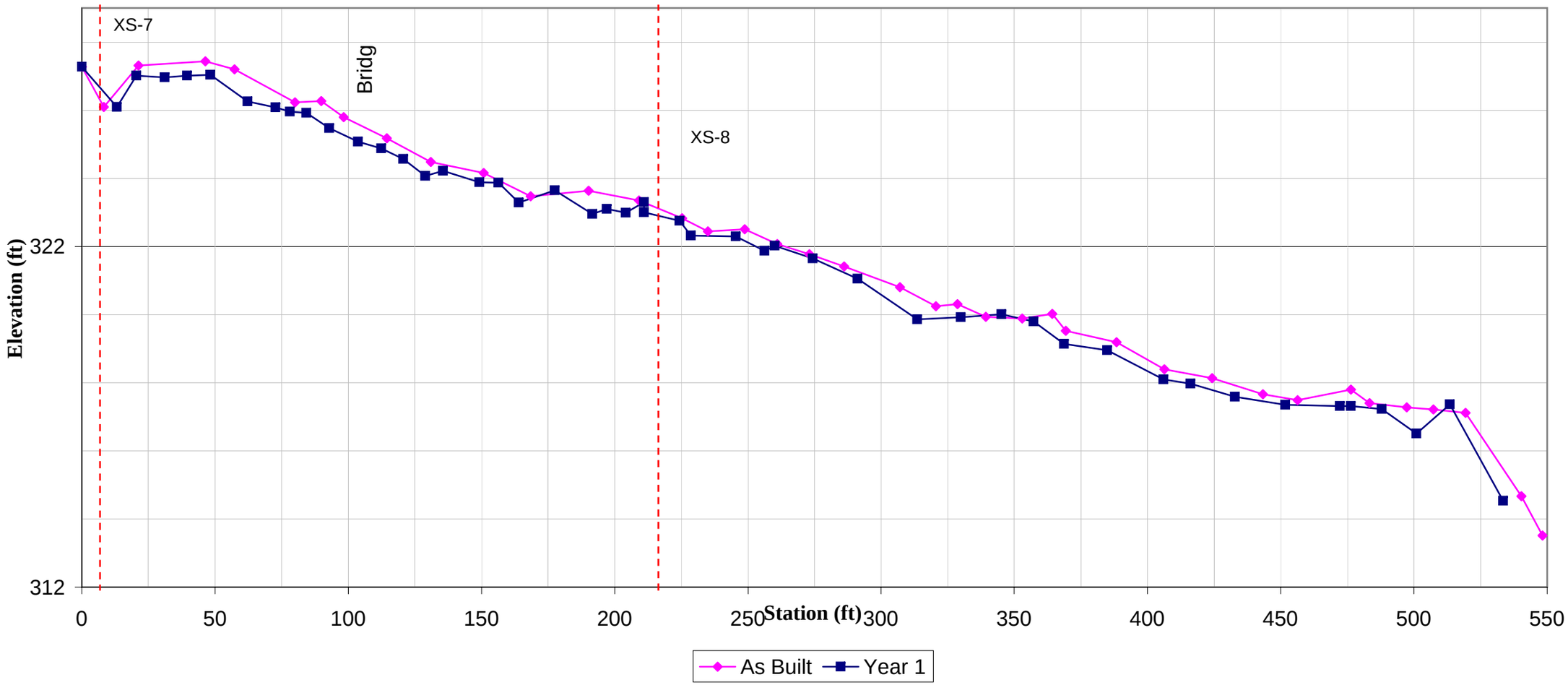

Profile 25+00 - 30+00
313
312
311
310
309
Elevation (ft)
XS-5
XS-6
2500
2600
2700
2800
2900
Station (ft)
Year 1
As-Built

YEAR 1		AS-BUILT		YEAR 1		AS-BUILT	
Station	**Elevation**	**STA**	**ELEV**	**Station**	**Elevation**	**STA**	**ELEV**
-24.08	315.242	-3.38	316.150	498.371	315.564	477.79	315.755
-9.24	315.373	14.70	316.393	517.876	315.371	502.71	315.510
21.012	315.844	42.27	316.026	597.086	314.714	513.67	314.989
63.396	315.773	47.55	314.542	623.475	315.53	519.86	314.887
79.744	315.773	51.47	314.413	648.212	314.51	528.79	314.564
81.512	315.739	62.02	315.509	660.585	314.62	544.21	314.958
143.822	314.591	77.14	315.722	674.577	314.927	558.90	314.753
155.429	314.964	91.20	315.951	695.783	315.132	568.33	315.381
175.361	316.503	108.03	316.365	712.813	315.298	576.35	314.867
203.326	315.475	121.98	316.242	744.734	315.521	585.96	315.075
225.654	315.954	134.85	315.850	804	314.929	599.32	314.303
267.638	314.868	139.84	315.229	867.146	314.7	616.74	313.839
281.768	315.636	144.45	313.676	894.062	315.136	628.94	314.153
308.532	315.952	153.64	313.513	952.951	314.581	644.56	314.560
362.717	315.594	163.02	315.066	972.89	314.922	658.64	314.732
404.132	315.82	163.36	315.090	987.769	314.412	671.48	315.050
432.203	315.307	178.12	316.140	1010.814	314.76	687.57	315.410
444.121	314.676	191.30	316.086			698.49	314.254
457.889	315.753	203.32	315.836			706.88	314.495
498.371	315.564	224.35	316.120			718.41	315.298
517.876	315.371	244.08	315.637			731.93	315.262
597.086	314.714	257.84	315.720			748.04	315.609
623.475	315.53	263.35	316.028			754.00	315.082
648.212	314.51	266.91	315.140			761.48	314.805
660.585	314.62	275.23	315.288			772.64	314.893
		289.42	315.457			782.59	315.041
		299.39	315.867			795.74	314.656
		314.81	315.692			815.09	314.820
		340.61	315.821			835.55	315.276
		353.74	316.161			850.18	315.107
		364.34	315.737			856.72	314.777
		377.93	315.724			871.88	314.567
		381.94	315.618			889.87	314.669
		394.60	315.523			907.19	314.951
		409.20	315.588			920.07	314.174
		426.53	315.638			938.86	314.213
		439.32	315.683			953.76	314.469
		447.45	314.975			964.75	313.805
		452.56	315.246			977.54	314.011
		464.27	315.472			990.54	314.356
		477.79	315.755			1005.69	314.536
		502.71	315.510				

YEAR 1		AS-BUILT		YEAR 1		AS-BUILT	
Station	**Elevation**	**STA**	**ELEV**	**Station**	**Elevation**	**STA**	**ELEV**
987.769	314.412	990.54	314.356	1495.472	312.781	1487.05	313.267
1010.814	314.76	1005.69	314.536	1504.939	312.698	1504.56	313.519
1042.864	314.319	1020.81	314.476	1513.25	312.351	1518.93	313.657
1043.935	314.22	1032.91	314.653	1520.941	312.779	1523.64	314.033
1055.929	314.138	1044.05	313.895	1535.614	313.239	1539.21	314.119
1078.906	314.383	1052.15	313.274	1562.631	310.326	1544.87	313.718
1112.407	314.079	1058.50	314.441	1569.771	310.551	1550.70	313.095
1121.649	314.159	1070.40	314.306	1577.836	311.44	1554.69	311.025
1128.715	314.14	1081.91	313.948	1585.842	312.817	1566.19	311.388
1137.67	314.124	1091.48	314.130	1609.425	312.816	1576.67	312.255
1144.389	314.3	1103.53	313.927	1621.822	311.98	1585.69	313.783
1167.574	314.405	1116.85	314.084	1630.554	311.249	1594.99	313.925
1176.119	314.712	1129.93	314.182	1639.848	311.188	1608.36	313.282
1187.448	314.855	1143.98	314.946	1647.122	311.696	1626.83	312.976
1255.943	312.355	1147.94	314.498	1657.716	312.132	1642.24	313.046
1264.556	312.505	1158.86	314.443	1666.954	312.064	1657.06	313.462
1270.156	312.947	1169.73	314.791	1674.488	312.097	1671.14	313.013
1278.982	313.349	1199.68	314.515	1685.736	312.307	1689.02	313.230
1288.921	313.693	1204.98	314.174	1694.923	312.398	1701.93	312.554
1300.482	313.816	1225.37	314.283	1710.274	312.85	1714.51	312.440
1310.421	313.749	1229.21	314.891	1725.859	312.85	1714.55	312.439
1323.328	313.627	1235.33	314.506	1742.922	313.308	1727.19	312.279
1337.374	313.295	1241.72	313.072	1771.391	311.646	1738.11	312.482
1348.639	313.248	1249.18	312.580	1787.941	312.08	1750.43	312.695
1363.792	313.147	1258.25	312.765	1832.973	312.601	1763.39	313.223
1378.009	313.316	1266.38	313.562	1868.042	313.124	1776.72	312.587
1389.356	313.433	1278.53	313.873	1895.424	312.643	1787.53	313.555
1402.017	313.284	1298.09	313.984	1911.588	312.705	1809.89	313.539
1410.207	312.914	1317.58	313.847	1937.427	312.716	1816.49	312.991
1418.179	312.45	1334.65	313.572	1968.067	313.201	1822.19	311.297
1428.509	312.947	1345.36	313.059	2019.191	313.249	1828.16	311.719
1438.827	313.411	1357.33	313.541			1833.22	312.611
1463.419	314.39	1369.82	313.569			1847.62	312.788
1463.598	312.24	1384.53	313.421			1863.36	313.011
1472.137	311.365	1398.39	312.519			1882.31	312.832
1478.528	311.54	1410.19	311.926			1898.24	312.544
1485.225	312.252	1419.04	312.162			1910.03	312.042
1495.472	312.781	1430.91	313.118			1920.51	312.430
1504.939	312.698	1448.58	313.757			1935.01	312.885
		1453.07	312.714			1951.02	312.992
		1462.06	311.258			1967.33	312.883
		1487.05	313.267			1982.82	313.178
		1504.56	313.519			1987.51	311.496
						1995.64	312.050
						1995.77	312.045
						1995.84	312.044
						2008.53	312.849

YEAR 1		AS-BUILT		YEAR 1		AS-BUILT	
Station	**Elevation**	**STA**	**ELEV**	**Station**	**Elevation**	**STA**	**ELEV**
1968.067	313.201	1995.84	312.044	2495.905	311.65	2495.92	312.245
2019.191	313.249	2008.53	312.849	2513.289	311.323	2509.32	312.046
2044.761	312.513	2024.06	312.959	2532.422	310.912	2527.16	312.007
2053.319	311.549	2031.00	312.937	2539.971	310.586	2537.65	311.008
2069.348	312.092	2040.85	312.466	2548.14	310.66	2547.34	310.925
2083.161	312.68	2048.86	312.651	2548.765	310.68	2557.45	311.138
2084.375	312.49	2060.35	312.364	2551.946	310.701	2566.51	311.076
2088.869	312.928	2071.68	312.424	2572.759	310.525	2578.80	310.461
2106.061	312.339	2079.16	312.775	2591.932	310.038	2588.24	310.558
2127.48	312.794	2093.36	312.521	2629.517	310.188	2600.31	311.551
2149.317	312.587	2098.10	312.701	2650.761	310.619	2603.48	311.703
2170.482	312.229	2101.84	312.488	2675.96	310.935	2608.43	310.212
2177.919	310.636	2102.26	312.458	2692.272	310.592	2623.11	310.974
2185.27	310.209	2103.29	312.394	2706.186	309.767	2637.07	311.591
2193.147	311.711	2115.12	312.821	2727.938	310.634	2649.50	311.095
2204.418	312.065	2133.61	313.136	2764.464	311.098	2663.09	311.297
2216.14	311.963	2150.99	312.930	2799.398	310.647	2676.89	311.260
2230.424	311.851	2164.08	312.931	2805.934	311.866	2690.02	311.681
2255.979	312.231	2178.60	313.041	2806.686	310.43	2706.74	311.229
2279.006	312.246	2190.53	312.981	2809.209	310.401	2721.44	310.903
2296.825	311.761	2207.75	312.880	2831.013	310.877	2728.66	311.900
2304.308	311.149	2224.33	312.639	2844.798	310.442	2745.44	311.066
2334.799	310.065	2239.81	312.735	2890.368	309.602	2760.38	311.214
2339.683	309.203	2259.57	312.647	2904.344	311.22	2776.68	311.378
2350.248	310.26	2275.63	312.323	2934.176	311.132	2791.06	311.072
2356.719	311.284	2288.72	312.157	2979.209	310.598	2810.68	311.263
2382.118	311.468	2307.40	312.478			2831.28	311.252
2417.655	311.142	2312.22	312.103			2847.30	311.374
2442.702	311.693	2315.77	310.695			2859.89	311.756
2462.846	311.456	2316.07	310.649			2864.68	311.219
2476.889	310.816	2324.97	309.738			2872.23	310.003
2495.905	311.65	2339.75	310.349			2895.16	311.527
2513.289	311.323	2355.71	311.230				
		2371.66	311.667				
		2390.02	312.341				
		2407.54	312.043				
		2429.21	311.958				
		2448.48	311.858				
		2467.78	311.942				
		2483.65	312.192				
		2495.92	312.245				
		2509.32	312.046				

Profile 0+00 - 5+50



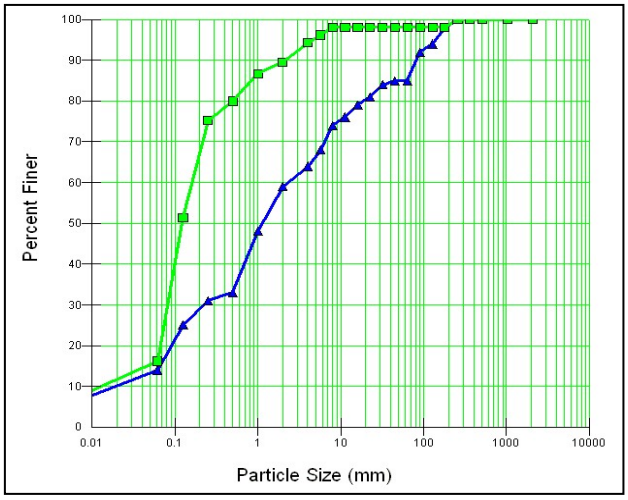
YEAR 1		AS-BUILT	
Station	**Elevation**	**STA**	**ELEV**
0	327.28	0.00	327.28
13.1	326.09	8.31	326.09
20.447	327.02	21.31	327.31
31.096	326.96	46.31	327.44
39.501	327.01	57.31	327.2
48.314	327.03	80.06	326.23
62.25	326.25	89.85	326.27
72.74	326.08	98.34	325.79
78.106	325.96	114.48	325.18
84.337	325.92	131	324.48
92.901	325.48	150.9	324.16
103.74	325.07	168.49	323.47
112.367	324.88	190.18	323.63
120.635	324.57	209.16	323.35
128.91	324.07	225.24	322.83
135.575	324.21	234.91	322.44
149.274	323.89	248.8	322.5
156.384	323.88	260.95	322.07
164.074	323.29	273.17	321.77
177.546	323.65	286.19	321.41
191.618	322.95	307.09	320.8
197.047	323.10	320.6	320.24
204.246	322.98	328.72	320.31
211.089	323.30	339.29	319.94
211.089	323.00	353.01	319.89
224.346	322.75	364.31	320.02
228.633	322.32	369.31	319.53
245.465	322.29	388.31	319.19
256.23	321.87	406.31	318.39
260.052	322.02	424.31	318.14
274.355	321.65	443.31	317.66
291.213	321.05	456.31	317.49
313.506	319.86	476.31	317.8
329.869	319.92	483.31	317.4
345.13	320.01	497.31	317.28
357.269	319.79	507.31	317.21
368.754	319.15	519.31	317.11
384.83	318.95	540.31	314.67
405.959	318.10	548.31	313.52
416.194	317.98		
432.847	317.59		
451.64	317.35		
472.173	317.32		
476.322	317.32		
487.865	317.23		
500.913	316.51		
513.547	317.37		
533.43	314.54		

Appendix B.7

Pebble Count Plots and Raw Data Tables

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	1 - Riffle	
Date:	07.31.06			Station No:	0+83	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	14	14%	14%
Very Fine	0.061	0.125	Sand	11	11%	25%
Fine	0.125	0.25		6	6%	31%
Medium	0.25	0.5		2	2%	33%
Coarse	0.5	1		15	15%	48%
Very Coarse	1	2		11	11%	59%
Very Fine	2	4	Gravel	5	5%	64%
Fine	4	5.7		4	4%	68%
Fine	5.7	8		6	6%	74%
Medium	8	11.3		2	2%	76%
Medium	11.3	16		3	3%	79%
Coarse	16	22.6		2	2%	81%
Coarse	22.6	32		3	3%	84%
Very Coarse	32	45		1	1%	85%
Very Coarse	45	64		0	0%	85%
Small	64	90	Cobble	7	7%	92%
Small	90	128		2	2%	94%
Large	128	180		4	4%	98%
Large	180	256		2	2%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	1.18		
			D_{84}	32		

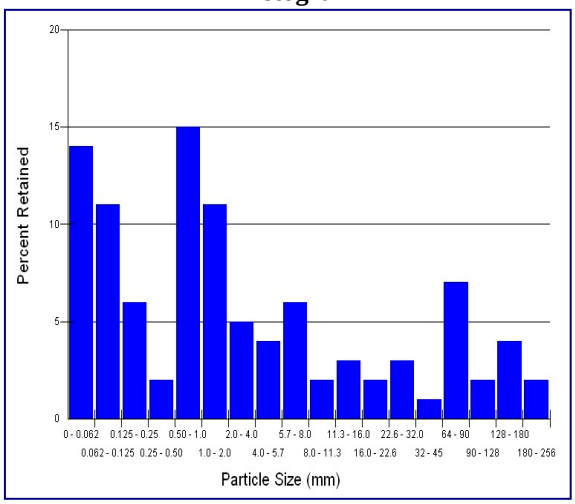
Particle Size Distribution



As-Built (Year 0)

Year 1

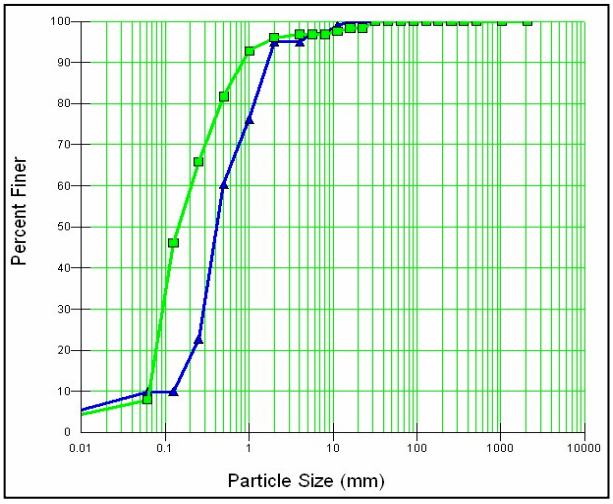
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	2 - Pool	
Date:	07.31.06			Station No:	10+46	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	10	10%	10%
Very Fine	0.061	0.125	Sand	0	0%	10%
Fine	0.125	0.25		13	13%	22%
Medium	0.25	0.5		38	37%	59%
Coarse	0.5	1		16	16%	75%
Very Coarse	1	2		19	18%	93%
Very Fine	2	4	Gravel	0	0%	93%
Fine	4	5.7		2	2%	95%
Fine	5.7	8		0	0%	95%
Medium	8	11.3		2	2%	97%
Medium	11.3	16		1	1%	98%
Coarse	16	22.6		0	0%	98%
Coarse	22.6	32		2	2%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	103	100%	---
			D_{50}	0.43		
			D_{84}	1.41		

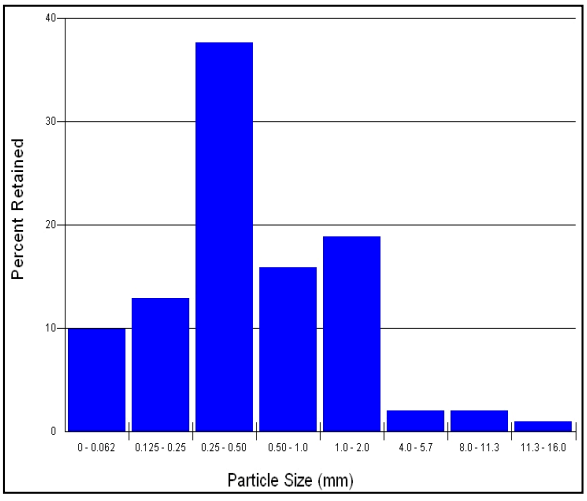
Particle Size Distribution



As-Built (Year 0)

Year 1

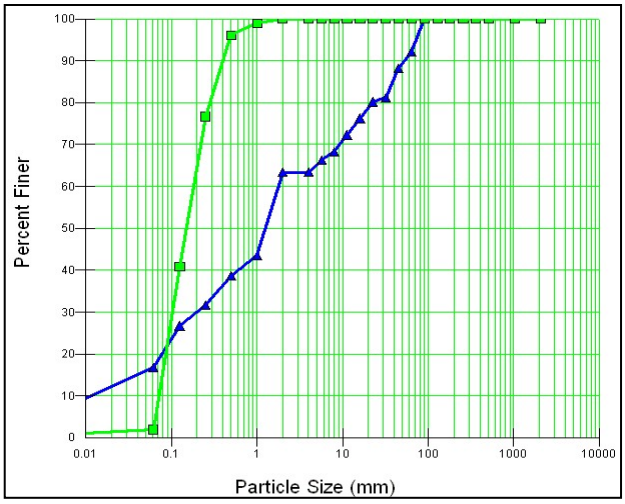
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	3 - Pool	
Date:	07.31.06			Station No:	14+65	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	17	17%	17%
Very Fine	0.061	0.125	Sand	10	10%	27%
Fine	0.125	0.25		5	5%	32%
Medium	0.25	0.5		7	7%	39%
Coarse	0.5	1		5	5%	44%
Very Coarse	1	2		20	20%	63%
Very Fine	2	4	Gravel	0	0%	63%
Fine	4	5.7		3	3%	66%
Fine	5.7	8		2	2%	68%
Medium	8	11.3		4	4%	72%
Medium	11.3	16		4	4%	76%
Coarse	16	22.6		4	4%	80%
Coarse	22.6	32		1	1%	81%
Very Coarse	32	45		7	7%	88%
Very Coarse	45	64		4	4%	92%
Small	64	90	Cobble	8	8%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	101	100%	---
			D_{50}	1.33		
			D_{84}	37.27		

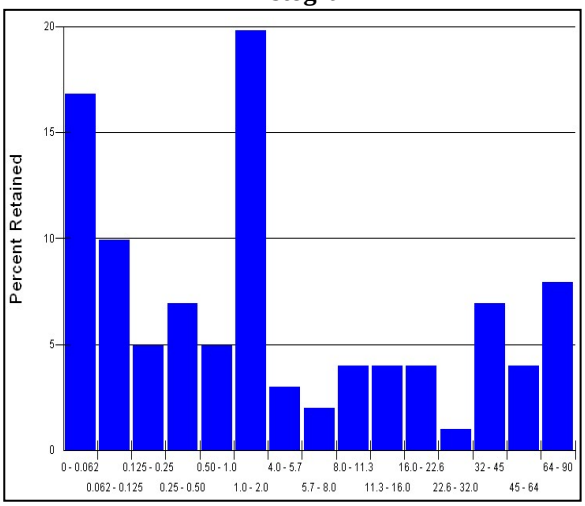
Particle Size Distribution



As-Built (Year 0)

Year 1

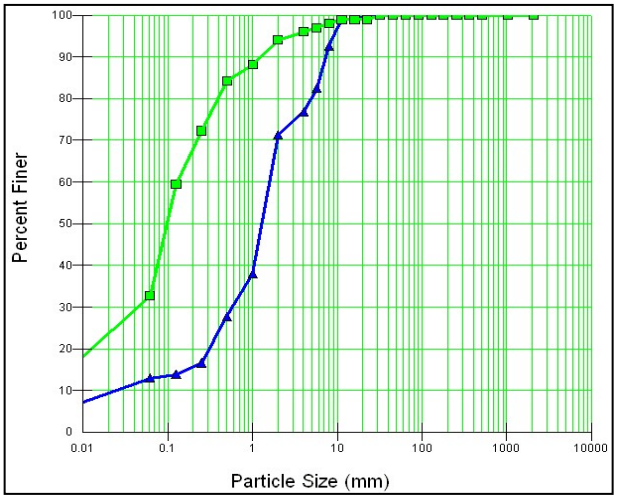
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	4 - Riffle	
Date:	07.31.06			Station No:	20+81	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	14	13%	13%
Very Fine	0.061	0.125	Sand	1	1%	14%
Fine	0.125	0.25		3	3%	17%
Medium	0.25	0.5		12	11%	28%
Coarse	0.5	1		11	10%	38%
Very Coarse	1	2		36	33%	71%
Very Fine	2	4	Gravel	6	6%	77%
Fine	4	5.7		6	6%	82%
Fine	5.7	8		11	10%	93%
Medium	8	11.3		7	6%	99%
Medium	11.3	16		0	0%	99%
Coarse	16	22.6		1	1%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	108	100%	---
			D_{50}	1.36		
			D_{84}	6.06		

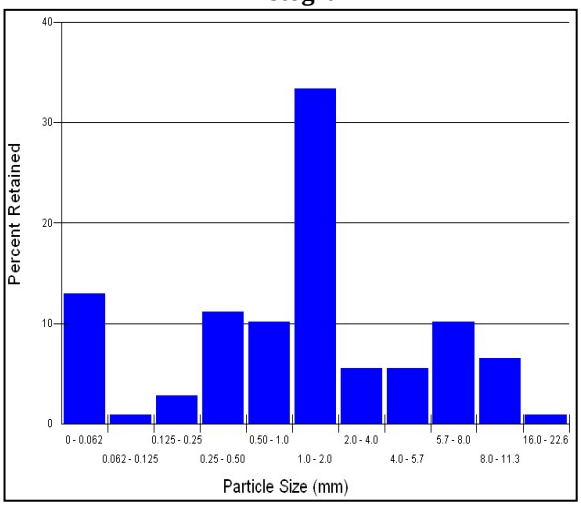
Particle Size Distribution



As-Built (Year 0)

Year 1

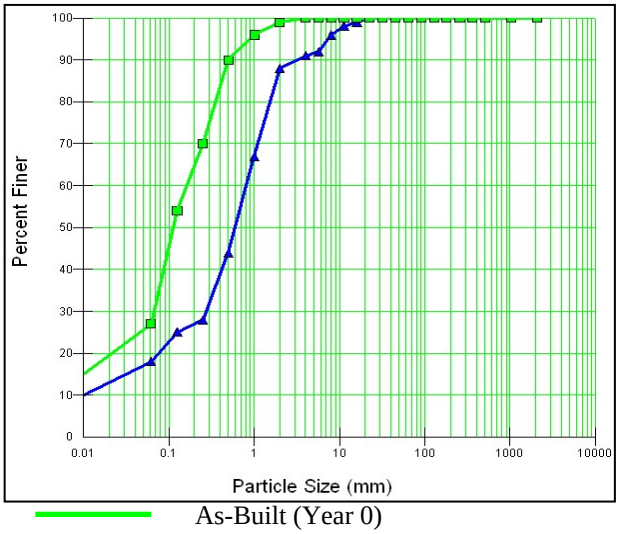
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	5 - Pool	
Date:	07.31.06			Station No:	25+38	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	18	18%	18%
Very Fine	0.061	0.125	Sand	7	7%	25%
Fine	0.125	0.25		3	3%	28%
Medium	0.25	0.5		16	16%	44%
Coarse	0.5	1		23	23%	67%
Very Coarse	1	2		21	21%	88%
Very Fine	2	4	Gravel	3	3%	91%
Fine	4	5.7		1	1%	92%
Fine	5.7	8		4	4%	96%
Medium	8	11.3		2	2%	98%
Medium	11.3	16		1	1%	99%
Coarse	16	22.6		1	1%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.63		
			D_{84}	1.81		

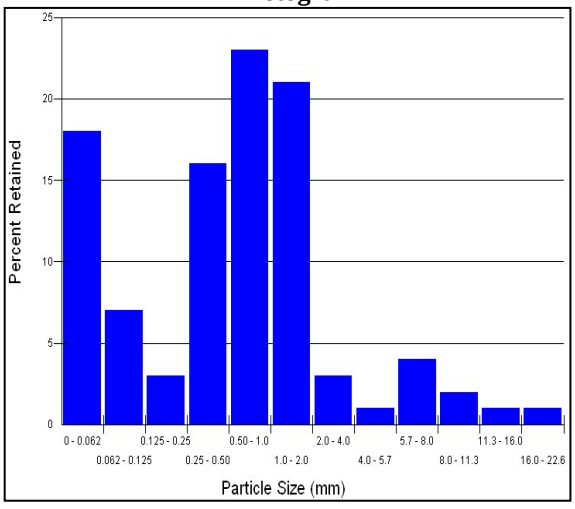
Particle Size Distribution



As-Built (Year 0)

Year 1

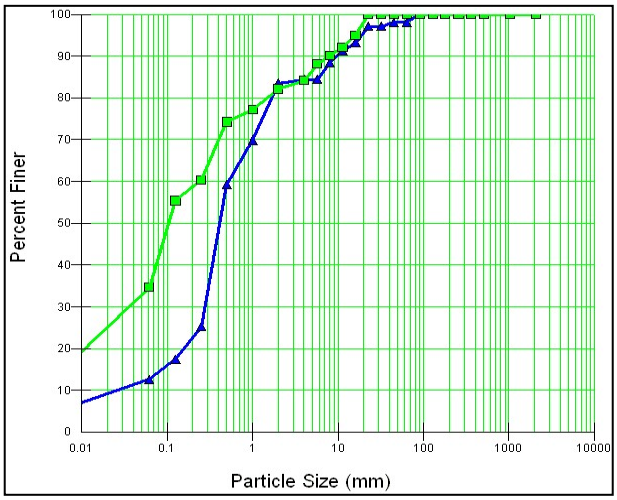
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	6 - Riffle	
Date:	07.31.06			Station No:	27+93	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	13	13%	13%
Very Fine	0.061	0.125	Sand	5	5%	17%
Fine	0.125	0.25		8	8%	25%
Medium	0.25	0.5		35	34%	59%
Coarse	0.5	1		11	11%	70%
Very Coarse	1	2		14	14%	83%
Very Fine	2	4	Gravel	1	1%	84%
Fine	4	5.7		0	0%	84%
Fine	5.7	8		4	4%	88%
Medium	8	11.3		3	3%	91%
Medium	11.3	16		2	2%	93%
Coarse	16	22.6		4	4%	97%
Coarse	22.6	32		0	0%	97%
Very Coarse	32	45		1	1%	98%
Very Coarse	45	64		0	0%	98%
Small	64	90	Cobble	2	2%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	103	100%	---
			D_{50}	0.43		
			D_{84}	3.03		

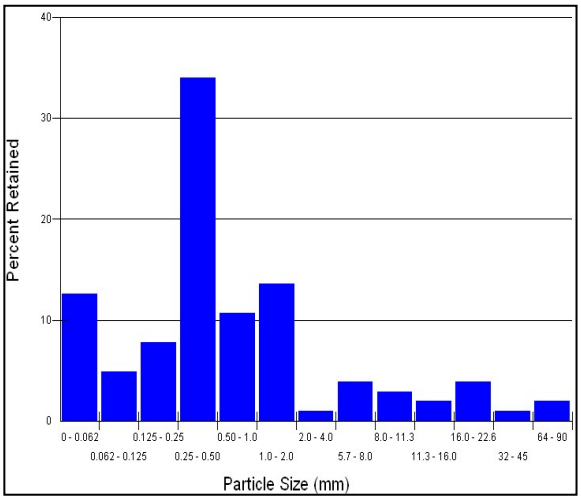
Particle Size Distribution



As-Built (Year 0)

Year 1

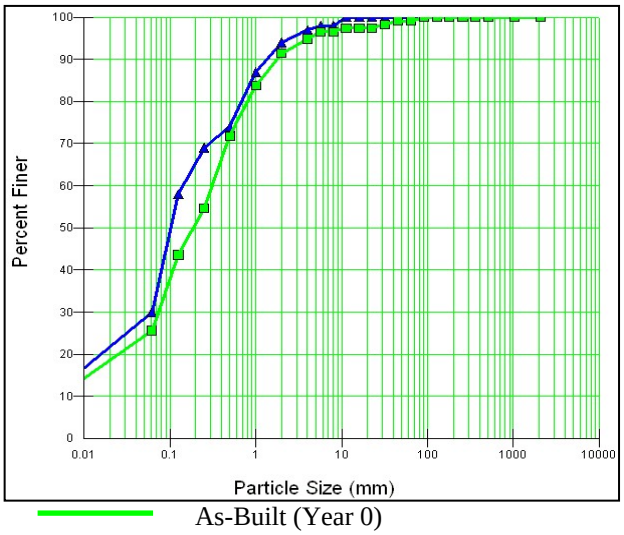
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	7 - Pool	
Date:	07.31.06			Station No:	0+08	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	30	30%	30%
Very Fine	0.061	0.125	Sand	28	28%	58%
Fine	0.125	0.25		11	11%	69%
Medium	0.25	0.5		5	5%	74%
Coarse	0.5	1		13	13%	87%
Very Coarse	1	2		7	7%	94%
Very Fine	2	4	Gravel	3	3%	97%
Fine	4	5.7		1	1%	98%
Fine	5.7	8		0	0%	98%
Medium	8	11.3		2	2%	100%
Medium	11.3	16		0	0%	100%
Coarse	16	22.6		0	0%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.11		
			D_{84}	0.88		

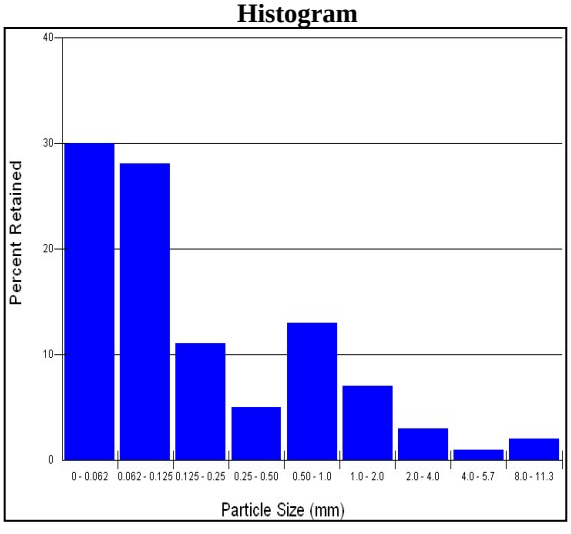
Particle Size Distribution



As-Built (Year 0)

Year 1

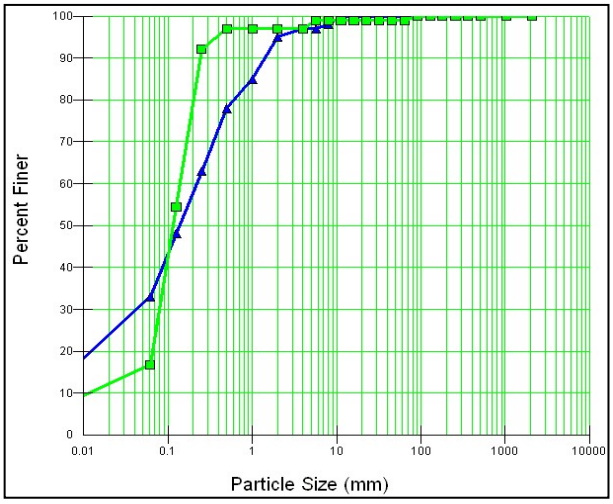
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082			X Sec:	8 - Riffle	
Date:	07.31.06			Station No:	2+18	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	33	33%	33%
Very Fine	0.061	0.125	Sand	15	15%	48%
Fine	0.125	0.25		15	15%	63%
Medium	0.25	0.5		15	15%	78%
Coarse	0.5	1		7	7%	85%
Very Coarse	1	2		10	10%	95%
Very Fine	2	4	Gravel	2	2%	97%
Fine	4	5.7		0	0%	97%
Fine	5.7	8		1	1%	98%
Medium	8	11.3		2	2%	100%
Medium	11.3	16		0	0%	100%
Coarse	16	22.6		0	0%	100%
Coarse	22.6	32		0	0%	100%
Very Coarse	32	45		0	0%	100%
Very Coarse	45	64		0	0%	100%
Small	64	90	Cobble	0	0%	100%
Small	90	128		0	0%	100%
Large	128	180		0	0%	100%
Large	180	256		0	0%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.14		
			D_{84}	0.93		

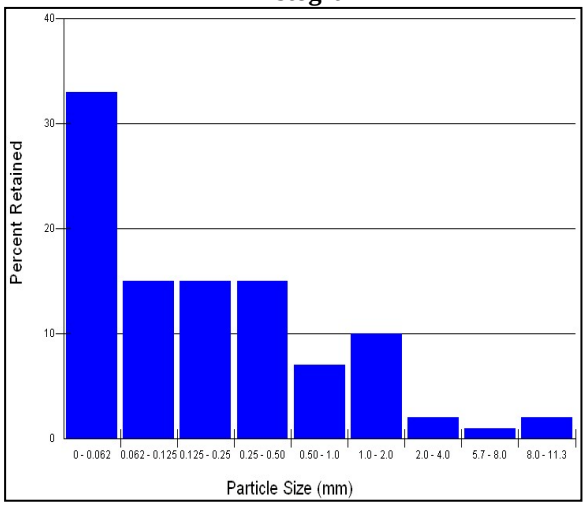
Particle Size Distribution



As-Built (Year 0)

Year 1

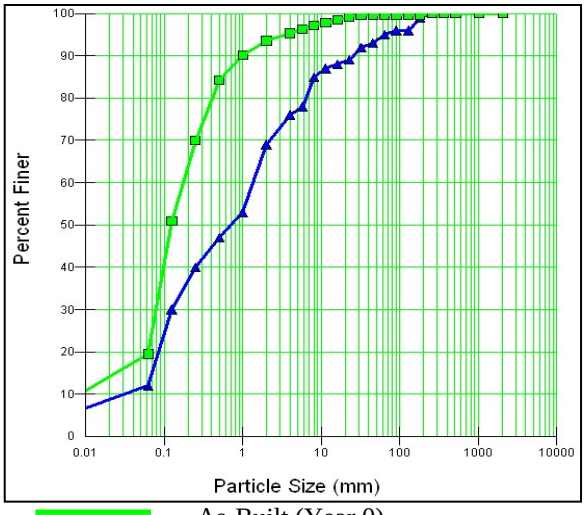
Histogram



Year 1

Site Name:	Horse Creek			Pebble Count Data Sheet		
Project No:	71082				Longitudinal	
Date:	07.31.06			Station No:	N/A	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	12	12%	12%
Very Fine	0.061	0.125	Sand	18	18%	30%
Fine	0.125	0.25		10	10%	40%
Medium	0.25	0.5		7	7%	47%
Coarse	0.5	1		6	6%	53%
Very Coarse	1	2		16	16%	69%
Very Fine	2	4	Gravel	7	7%	76%
Fine	4	5.7		2	2%	78%
Fine	5.7	8		7	7%	85%
Medium	8	11.3		2	2%	87%
Medium	11.3	16		1	1%	88%
Coarse	16	22.6		1	1%	89%
Coarse	22.6	32		3	3%	92%
Very Coarse	32	45		1	1%	93%
Very Coarse	45	64		2	2%	95%
Small	64	90	Cobble	1	1%	96%
Small	90	128		0	0%	96%
Large	128	180		3	3%	99%
Large	180	256		1	1%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.14		
			D_{84}	0.93		

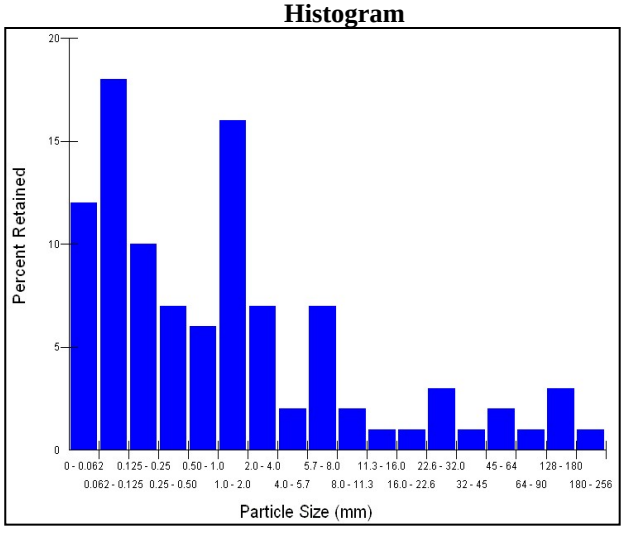
Particle Size Distribution



As-Built (Year 0)

Year 1

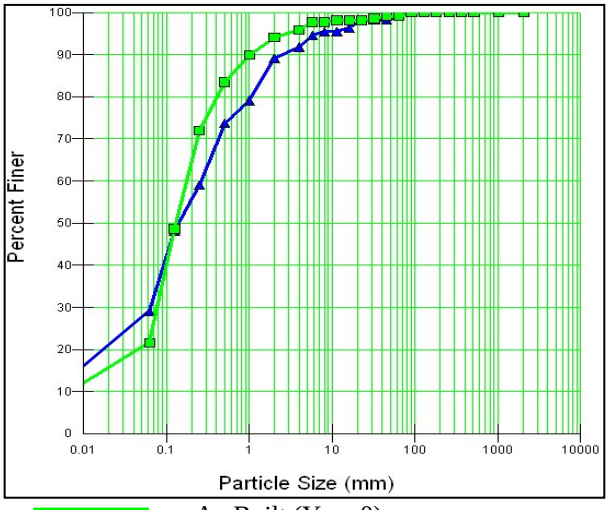
Histogram



Year 1

Site Name:	Unnamed Tributary			Pebble Count Data Sheet		
Project No:	71082				Longitudinal	
Date:	07.31.06			Station No:	N/A	
Particle	**Range (mm)**			**Total #**	**% in Range**	**% Cumulative**
Silt/Clay	0	0.061	S/C	12	12%	12%
Very Fine	0.061	0.125	Sand	18	18%	30%
Fine	0.125	0.25		10	10%	40%
Medium	0.25	0.5		7	7%	47%
Coarse	0.5	1		6	6%	53%
Very Coarse	1	2		16	16%	69%
Very Fine	2	4	Gravel	7	7%	76%
Fine	4	5.7		2	2%	78%
Fine	5.7	8		7	7%	85%
Medium	8	11.3		2	2%	87%
Medium	11.3	16		1	1%	88%
Coarse	16	22.6		1	1%	89%
Coarse	22.6	32		3	3%	92%
Very Coarse	32	45		1	1%	93%
Very Coarse	45	64		2	2%	95%
Small	64	90	Cobble	1	1%	96%
Small	90	128		0	0%	96%
Large	128	180		3	3%	99%
Large	180	256		1	1%	100%
Small	256	362	Boulder	0	0%	100%
Small	362	512		0	0%	100%
Medium	512	1024		0	0%	100%
Large - V Lrg	1024	2048		0	0%	100%
Bedrock	2048	2100	Rock	0	0%	100%
			Totals	100	100%	---
			D_{50}	0.14		
			D_{84}	0.93		

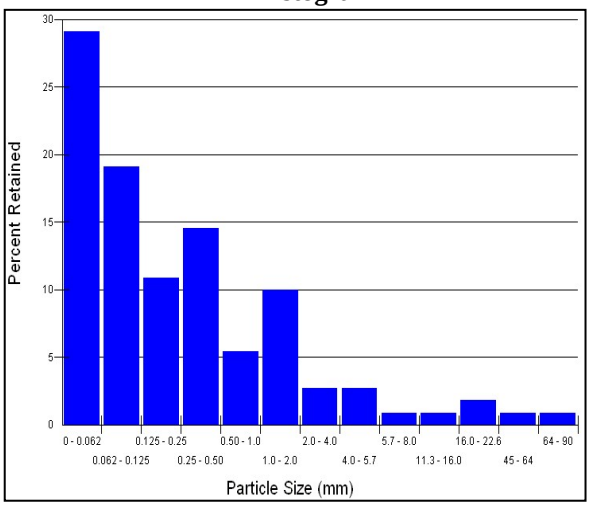
Particle Size Distribution



As-Built (Year 0)

Year 1

Histogram



Year 1