HORSE CREEK (WAKE FOREST COUNTRY CLUB)
FINAL MONTORING REPORT
YEAR 3
2008

EEP Project # 409

Wake County, North Carolina

Submitted to:

NCDENR-EEP

1652 Mail Service Center

Raleigh, NC 27699

HORSE CREEK (WAKE FOREST COUNTRY CLUB)
FINAL MONTORING REPORT
YEAR 3
2008

EEP Project # 409
Wake County, North Carolina

Original Design Firm:
Dewberry and Davis, Inc.
2301 Rexwoods Drive, Suite 200
Raleigh, NC 27607-3366

Submitted to:

Ecosystem Enhancement Program

NCDENR-EEP
1652 Mail Service Center
Raleigh, NC 27699

Monitoring Firm:

SEPI Engineering Group

1025 Wade Avenue
Raleigh, North Carolina 27605
Phone: (919)789-9977
Project Manager:
Phillip Todd
ptodd@sepiengineering.com

Executive Summary

The Ecosystem Enhancement Program identified Horse Creek (Wake Forest Country Club), as a stream restoration site. The project includes 2,825 linear feet (lf) of Horse Creek and 550 lf of an Unnamed Tributary (UT) to Horse Creek. Prior to restoration the stream was classified as a Rosgen C/E5 stream. The majority of the pre-construction stream bank lacked natural vegetation which resulted in increased bank erosion and reduced buffer filtration rates. Restoration of Horse Creek called for a Rosgen C5 stream, reconnected the stream to its original floodplain in a new alignment, and increased stream length and sinuosity. The UT was an entrenched, under-sinuous, G5e. The design for the UT called for a Rosgen E5 channel, raised the profile, and reconnected the stream to its floodplain along a new alignment.

Current monitoring for the site consists of evaluating stream morphology and riparian vegetation. The stream monitoring included a longitudinal survey, cross section surveys, problem area identification, and photo documentation. The vegetation assessment included the 2006 CVS protocol for vegetation plots stem counts, vegetation-specific problem area identification, and photo documentation. All morphological data, vegetation plot counts, cross section surveys, longitudinal profile, and plan view features were compared between monitoring years to assess project performance.

Monitoring Year 3 monitoring showed that the Horse Creek mainstem section had a stable dimension and pattern, with the exception of extensive areas of bank slumping. The bank slumping areas were concentrated downstream of Station 26+25. There are two crossvanes and two J-hooks that have piping and/or backarm scour that may warrant repair assessment. There have been changes in profile, presumably as a result of the construction of beaver dams in Monitoring Year 3. The result of this damming has been an 30% increase in the total length of pool habitat and a 43% reduction in total length of riffle habitat. Removal of the beaver dams may be warranted.

The UT Horse Creek reach has remained stable for Monitoring year 3. The headcut observed in Monitoring Year 2 has not progressed upstream, but will be observed closely during Monitoring Year 4. A long aggradational section toward the downstream end of the UT reach may need attention as it appears to have extended downstream by an additional 48 feet. In addition, all three crossvanes had water piping around and/or under some part of the structure. The crossvane located at Station 12+27 along UT Horse Creek has piping of water around the right arm (facing downstream), a rock missing from the right arm, and the pool is filled in with sediment.

The most extensive vegetation problem areas were long sections of past-mowed floodplain that had been mowed as part of regular fairway maintenance before the country club closed. These areas are located along the upper two thirds of the Horse Creek mainstem and along the entire UT section. Supplemental plantings may be necessary to boost succession in these areas. In addition, the lower portion of Horse Creek has stands of invasive Chinese Privet (*Ligustrum sinense*).

The vegetation plots (VP) impacted by past-mowing (i.e., VP C, E, and O) have stem densities below 260 stems/acre (Monitoring Year 5 goal). However, if natural volunteer stems are included in the density calculations, all vegetation plots pass the Monitoring Year 5 stem density goal. Therefore, planted stem densities of less than the Monitoring Year 5 goal should not be interpreted as an indication of the planted species being completely inappropriate, or the growing conditions being severely inhospitable. In fact, the evidence of naturalization of volunteer stems suggests the growing conditions are suitable for good herbaceous and woody vegetative growth

without supplemental plantings. However, supplemental plantings may be necessary to boost species diversity and/or the prevalence of a certain target species.

HORSE CREEK (WAKE FOREST COUNTRY CLUB) STREAM RESTORATION MONITORING YEAR 3 REPORT

CONDUCTED FOR:
NCDENR ECOSYSTEM ENHANCEMENT PROGRAM

TABLE OF CONTENTS

TABLES

FIGURES

APPENDICES

1.0 PROJECT BACKGROUND

1.1 Project Objectives

The stream restoration goals of the Horse Creek project included following:

- Reduce downstream sedimentation by stabilizing eroding stream banks within the Wake Forest Country Club (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 was aimed at having the following benefits:

- Reduce nutrient inputs to Falls Lake and the Neuse River;
- Provide additional source water protection for Falls Lake, Raleigh's water supply; and,
- Establish a riparian corridor for wildlife between existing wooded areas.

1.2 Project Structure, Restoration Type, and Approach

Prior to restoration, the Horse Creek mainstem was a Rosgen Type C/E5 stream moving toward instability. The site was identified as a stream restoration site by the North Carolina Ecosystem Enhancement Program (EEP). Degradation of the stream and lack of naturally occurring vegetation on the stream banks resulted in bank erosion, reduced buffer filtration rates, sediment deposition, undercutting of stream bank trees, and a loss of in-stream habitat. In addition, recent upstream development has placed increased stress on the channel. The restoration design for Horse Creek mainstem called for a Rosgen C5 stream. The overall mitigation strategy for Horse Creek called for improved pattern, dimension, and profile, and restoration of the riparian buffer along the project reach. This effort was limited by several on-site physical constraints, including three existing bridges, a double culvert, and several areas within fairways that were identified as landing zones for golfers. The Priority Level I stream restoration was designed to improve bank stability, reduce erosion rates, improve aquatic habitat, and replace or augment the vegetated riparian buffer.

The unnamed tributary (UT) section was a G5e type stream channel and was restored to an E5 stream type. The Priority Level I resotoration improved the channel pattern, profile, and dimension. The channel bed elevation was raised to reconnect the stream to its floodplain along the new alignment. The riparian areas along Horse Creek and the UT were planted upon completion of construction. See Table I for specific project restoration components.

Table I. Project Restoration Components Horse Creek/EEP Project Number 409							
Project Segment or Reach ID	**Pre-Existing Footage**	**Type**	**Approach**	**As-Built Footage**	**As-Built Stationing**	**Monitoring Year 4 Stationing**	**Comments**
Horse Creek	2,890	R^	PI & PII*	2,899	0+00 – 28+99	10+00 – 39+69	Channel relocation.
UT to Horse Creek	612	R^	PI	548	0+00 – 5+48	10+00 – 15+52	Channel relocation.

* denotes that the Restoration Plan states Priority 1 for the stream, except "at the intersections, the proposed reach will be Priority 2".
"P" in the Approach column refers to Priority Level.
^ denotes that the Restoration Plan states the stream channel was elevated and reattached to its flood plain.
PI denotes Priority I
PII denotes Priority 2II
R denotes Restoration

1.3 Project 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). To reach the site from Raleigh, follow US 1 (Capital Boulevard) North to Wake Forest. The Wake Forest Country Club is on the left side of the road at 13239 Capital Boulevard.

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, US 1 to the east, NC 96 to the north, and SR 1922, SR 1923, and SR 1139 along its western boundary. The northern watershed limits along NC 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 drains approximately 9.8 square miles.

1.4 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. Prior to restoration, Horse Creek was a C/E5 stream that was moving towards instability from various on-site and off-site factors. Removal of vegetation along the creek had resulted in increased opportunity for bank erosion and reduced filtration rates. Scour pools had developed immediately downstream of flow constrictions caused by the golf cart bridges and a large metal double culvert. A wooded area along the eastern side of the downstream portion of Horse Creek contained a large number of invasive plant species. The pre-existing channel for the UT was entrenched and lacked sinuosity. Although the riparian area around the UT contained several mature overstory trees, the understory was virtually non-existent.

The Horse Creek Stream Restoration Project encompassed two restored stream reaches and restoration of the riparian buffer along as much of the project as possible. Other project details area listed in the following tables: Table II lists the project activity and reporting history; Table III provides contact information for the various contractors associated with the project; and, Table IV provides background information about the project site.


PROJECT LOCATION
PURNELL RD
CAPITAL BLVD
CLUB VILLAS DR
JENKINS RD
DIRECTIONS: From Raleigh: Take US-1 (Capitol Blvd.) toward Wake Forest. Turn Left on Club Villas Drive. Property is at terminus of Club Villas Drive.
UT HORSE CREEK
WAKE FOREST COUNTRY CLUB
SITE VICINITY MAP
Ecosystem Enhancement PROGRAM
FIGURE 1
WAKE COUNTY NC
N
W
E
S
300 150 0 300 Feet
Horse Creek
UT Horse Creek
WAKE

Table II. Project Activity and Reporting History			
Horse Creek Stream Restoration/EEP Project Number 409			
Activity or Report	**Scheduled Completion**	**Data Collection Complete**	**Actual Completion or Delivery**
Restoration Plan	2002		November 22, 2002
Final Design - 90%	2003		March 27, 2003
Construction	2003		April 1, 2005
Temporary S&E mix applies to entire project area	2003		April 1, 2005
Permanent seed mix applies to reach/segments 1&2	2003		April 1, 2005
Containerized and B&B plantings for reach/segments 1&2	2003		April 1, 2005
Mitigation Plan/ As-built (Year 0 Monitoring - baseline)	2003		
Year 1 monitoring	December 2006	August 2006	August 1, 2006
Year 2 monitoring	December 2007	November 2007	December 21, 2007
Year 3 monitoring	December 2008	November 2008	December 5, 2008
Year 4 monitoring	December 2009	NA	
Year 5 monitoring	December 2010	NA	

*Wake Forest Country Club closed in 2007 (Monitoring Year 2) and, as a result, golf course maintenance was discontinued at that time.

Table III. Project Contact Table	
Horse Creek (Wake Forest Country Club) /EEP Project Number 71082	
Designer Kenneth Ashe, PE	Dewberry & Davis, Inc 2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607 919-881-9939
Construction Contractor Allen Eudy	Contaminant Control, Inc 438-C Robeson Street Fayetteville, NC 28301 910-484-7000
Planting Contractor Jim Matthews, Ph.D.	HARP 9305-D Monroe Road Charlotte, NC 28270 704-687-4061
Seeding Contractor Andrew Van Vlack	705 Comphrey Court Wake Forest, NC 27587 919-570-6163
Seed Source	Mellow Marsh Farm 1312 Woody Store Road Siler City, NC 27344 919-742-1200
Nursery Stock Suppliers	Mellow Marsh Farm 1312 Woody Store Road Siler City, NC 27344 919-742-1200
2006 (Year 1) Monitoring Performers Kenneth Ashe, PE	Dewberry & Davis, Inc 2301 Rexwoods Drive, Suite 200 Raleigh, NC 27607 919-881-9939
2007-2008 (Year 2 & 3) Monitoring Performers Phillip Todd	SEPI Engineering Group 1025 Wade Avenue Raleigh, NC 27605 919-789-9977
2008 Stream Monitoring POC	Ira Poplar-Jeffers (919) 789-9977
2008 Vegetation Monitoring POC	Phil Beach (919) 789-9977
Wetland Monitoring POC	N/A

Table IV. Project Background Table		
Horse Creek (Wake Forest Country Club) /EEP Project Number 71082		
	Horse Creek	**UT to Horse Creek**
Project County	Wake	Wake
Drainage Area	7.9 square miles	1.6 square miles
Drainage impervious cover estimate (%)	7.8%	<5%
Stream Order	3rd	1st
Physiographic Region	Piedmont	Piedmont
Ecoregion	45f	45f
Rosgen Classification of As-built	C5	E5
Cowardin Classification	N/A	N/A
Dominant soil types	Chewacla	Chewacla
Reference site ID	Little Beaver Dam	UT to Barton Creek
USGS HUC for Project and Reference	03020102	03020102
NCDWQ Sub-basin for Project and Reference	03-04-01	03-04-01
NCDWQ classification for Project and Reference	WS-IV	WS-IV
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	N/a	N/A
% of project easement fenced	0	0
% of project easement demarcated with bollards (if not fenced)	0	0

2.0 PROJECT MONITORING METHODOLOGY

2.1 Vegetation Methodology

The following methodology was used for the stem count. The configuration of the seven (7) vegetation plots was marked out with tape to measure 10 meters by 10 meters (or equivalent to 100 square meters) depending on buffer width. The planted and naturalized woody material in the plot was marked with flagging. Plot inventories were conducted per the 2006 CVS-EEP Level II Protocol for Recording Vegetation (EEP 2006).In 2007, EEP requested that only vegetation plots C, E, F, I, K, L, and O be monitored. These plots were carried forward for the 2008 monitoring year.

2.2 Stream Methodology

The project monitoring for the stream channel included a longitudinal survey, cross-sectional surveys, and photo documentation. These measurements were taken at each reach. The stationing was based on thalweg. The methodology for each portion of the stream monitoring is described in detail below.

2.2.1 Longitudinal Profile and Plan View

A longitudinal profile was surveyed for both reaches with a Nikon DTM-520 Total Station, prism, and a TDS Recon Pocket PC. The heads of features (i.e., riffles, runs, and pools) were surveyed, as well as the point of maximum depth of each pool, boundaries of problem areas, and any other significant slope-breaks or points of interest. At the head of each feature and maximum pool depth, the thalweg, water surface, edge of water, left and right bankfull, and left and right top of bank (if different than bankfull) were surveyed. All profile measurements were extracted from this survey, including channel and valley length and length of each feature, water surface slope for each reach and feature, bankfull slope for the reach, and pool spacing. This survey also was used to draw plan view figures with Microstation v8 (Bentley Systems, Inc., Exton, PA) for each reach, and all pattern measurements (i.e. meander length, radius of curvature, belt width, meander width ratio, and sinuosity) were extracted from the plan view. Stationing was calculated along the thalweg.

2.2.2 Permanent Cross Sections

Six permanent cross sections (three riffles and three pools) were surveyed along Horse Creek and two permanent cross sections (one riffle and one pool) were surveyed along the UT. The beginning (i.e., left bank facing downstream) and end of each permanent cross section were originally marked with a wooden stake and metal conduit. Cross sections were installed perpendicular to the stream flow. Each survey noted all changes in slope, tops of both banks, left and right bankfull, edges of water, thalweg, and water surface. The cross sections were then plotted, and Monitoring Year 3 data was overlain on Monitoring Years 0 and 2 for comparison. Monitoring Year 1 cross sections were not included per a 2007 EEP comment asking SEPI to remove these from the overlay figures based on the low survey accuracy. All dimension parameters (i.e. bankfull width, floodprone width, bankfull mean depth, cross sectional area, width-to-depth ratio, entrenchment ratio, bank height ratio, wetted perimeter, and hydraulic radius) were extracted from these plots and compared to data from all previous monitoring years.

2.2.3 Pebble Counts

Based on the fact that Horse Creek and UT to Horse Creek are sandbed streams, it was determined that pebble counts were unnecessary as they would fail to detect increases in fine sediments. Therefore, pebble counts were not performed for Monitoring Year 3.

2.3 Photo Documentation

Permanent photo points were established during Monitoring Year 1. A set of three photographs (facing upstream, facing downstream, and facing the channel) were taken at each photo point with a digital camera. Two photographs were taken at each cross-section (facing upstream and downstream). A representative photograph of each vegetation plot was taken southern-most corner closest to the channel.

3.0 PROJECT CONDITION AND MONITORING RESULTS

3.1 Vegetation Assessment

3.1.1 Soils Data

Preliminary Soil Data					
Series	**Max Depth (in.)**	**% Clay on Surface**	**K**	**T**	**OM %**
Chewacla (Cm)	65	10.0 27.0	0.28	5	1.0-4.0

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.

3.1.2 Vegetative Problem Area Plan View

There is good herbaceous vegetation growth along all portions of the project not impacted by past golf course maintenance practices. The most extensive vegetation problem areas were long sections of past-mowed floodplain that had been mowed as part of regular fairway maintenance before the country club closed. These areas are located along the upper two thirds of the Horse Creek mainstem and along the entire UT section. Vegetation plots (VP) impacted by this maintenance include: C, E, I, and O. Since the golf course was closed and maintenance ceased vegetative growth in these areas has started recovering, however species diversity is significantly lower in these areas compared to the unimpacted areas of the project. For example, very few, if any, woody stems can be found in the past-mowed areas. Supplemental plantings may be necessary to boost succession in these areas. In addition, the lower portion of the mainstem Horse Creek has been invaded by stands of Chinese Privet (*Ligustrum sinense*). These areas will be monitoring closely in future monitoring years to document the spread of this population.

3.1.3 Stem Counts

Those vegetation plots with little or no impact from past mowing (i.e., vegetation plots F, I, K, and L) have planted stem densities above the Monitoring Year 5 goal of 260 stems/acre and are of no concern at this point. The remaining plots (i.e., VP C, E, and O) have densities below 260 stems/acre. However, if natural volunteer stems are included in the density calculations, all vegetation plots pass the Monitoring Year 5 stem density goal. Therefore, planted stem densities of less than the Monitoring Year 5 goal should not be interpreted as an indication of the species being completely inappropriate, or the growing conditions being severely inhospitable. In fact, the evidence of naturalization of volunteer stems suggests the growing conditions are suitable for good herbaceous and woody vegetative growth without supplemental plantings. However,

supplemental plantings may be necessary to boost species diversity and/or the prevalence of a certain target species.

Few planted stems were located in VP C, E, and O. The densities in these plots are below 260 stems/acre. Vegetation plot I is a "watch" area based on a planted stem density of 364 stems/acre. As described in Section 3.1.2, the main impact to the vegetation plots with low stem densities was past-mowing practices. The fact that stem densities of all plots are above the Monitoring Year 5 goal if natural volunteer stems are included serves as evidence that these plots are starting to recover from the past-mowing. It is expected that good recruitment of natural volunteer species from surrounding areas will occurr.

3.2 Stream Assessment

Considering the 5 year timeframe of standard mitigation monitoring, restored streams should demonstrate morphologic stability in order to be considered successful. Stability does not equate to an absence of change, but rather to sustainable rates of change or stable patterns of variation. Restored streams often demonstrate some level of initial adjustment in the several months that follow construction and some change/variation subsequent to that is to also be expected. However, the observed change should not indicate a high rate or be unidirectional over time such that a robust trend is evident. If some trend is evident, it should be very modest or indicate migration to another stable form. Examples of the latter include depositional processes resulting in the development of constructive features on the banks and floodplain, such as an inner berm, slight channel narrowing, modest natural levees, and general floodplain deposition. Annual variation is to be expected, but over time this should demonstrate maintenance around some acceptable central tendency while also demonstrating consistency or a reduction in the amplitude of variation. Lastly, all of this must be evaluated in the context of hydrologic events to which the system is exposed over the monitoring period.

For channel dimension, cross-sectional overlays and key parameters such as cross-sectional area and the channel's width to depth ratio should demonstrate modest overall change and patterns of variation that are in keeping with above. For the channels' profile, the reach under assessment should not demonstrate any consistent trends in thalweg aggradation or degradation over any significant continuous portion of its length. Over the monitoring period, the profile should also demonstrate the maintenance or development of bedform (facets) more in keeping with reference level diversity and distributions for the stream type in question. It should also provide a meaningful contrast in terms of bedform diversity against the pre-existing condition. Bedform distributions, riffle/pool lengths and slopes will vary, but should do so with maintenance around design/As-built distributions. This requires that the majority of pools are maintained at greater depths with lower water surface slopes and riffles are shallow with greater water surface slopes. Substrate measurements should indicate the progression towards, or the maintenance of, the known distributions from the design phase.

In addition to these geomorphic criteria, a minimum of two bankfull events must be documented during separate monitoring years within the five year monitoring period for the monitoring to be considered complete. Table VIII documents all bankfull events recorded since the start of Monitoring Year 1.

Table V. Verification of Bankfull Events			
Date of Data Collection	**Date of Occurrence**	**Method**	**Photo # (if available)**
7/31/2006	6/14/2006	Large amount of fresh sediment observed on floodplain. Event observed by golf course personnel.	None
6/3/2007	6/3/2007	Result of approximate 1.5" rainfall event. Wrack lines observed.	None
6/30/2008	7/1/2008	According to NCDC Station Coop ID 312993 - FALLS LAKE, NC , 2.08 inches of precipitation fell over this 48 hour period. It was assumed, but not verified, that this rainfall produced a bankfull event.	None
9/6/2008	9/7/2008	According to NCDC Station Coop ID 312993 - FALLS LAKE, NC , 4.37 inches of precipitation fell over this 48 hour period. It was assumed, but not verified, that this rainfall produced a bankfull event.	None

3.2.1 Longitudinal Profile and Plan View

The overall water surface slope for both streams remained consistent since Monitoring Year 2. The main development in Monitoring Year 3 has been the building of beaver dams at 4 locations along the Horse Creek mainstem. These dams have effectively caused an increase in total pool length of 30% in mainstem Horse Creek reach (i.e., from 2,028 ft to 2,626 ft) and reduced the total length of riffle habitat by 43% (i.e., from 585 ft to 331 ft) between Monitoring Years 2 and 3. Median pool length increased from 57.4 ft to 89.9 ft, and median riffle length decreased from 20.3 ft to 12.2 ft between Monitoring Years 2 and 3. In addition, water surface slopes of the remaining riffles have increased as a result of the beaver dams (i.e., slope increased as a function of decreased riffle length).

Overall, the UT reach profile has remained vertically stable. There is one area between Stations 14+18 and 15+14 where the bed appears to have risen since Monitoring Year 1. However, the amount of elevational change between Monitoring Years 2 and 3 appears to be much less than the initial rise. The only observable change to note about this area for this year is that this aggradation has extended downstream for an additional 48 feet. There is no obvious reason for this aggradation, however, one potential explanation is the drought that occurred in 2007. The drought left the UT channel dry most of the time, allowing grass to cover the entire channel along this aggradation section. The grass probably aided in the collection of excess fine sediments on the streambed. There also is a headcut located at Station 10+59 along the UT; however, it appears to have stabilized as it has not proceeded any further upstream since Monitoring Year 2.

It appears, based on the consistency of the pattern parameters and the plan view overlay between monitoring years, that the overall pattern of Horse Creek and UT Horse Creek has remained stable. The longitudinal profile is shown in Appendix B5 and the problem area plan views are located in Appendix C.

3.2.2 Permanent Cross Sections

All cross sections were fairly consistent between monitoring years. All cross sections displayed at least a small amount of channel bed shifting, however, this result is nothing out of the ordinary for a sand-bed stream. Profiles of these types of streams tend to be very dynamic. It appears that the downcutting of the lower section of Horse Creek, observed in Monitoring Year 2, has slowed or ceased in Monitoring Year 3. None of the cross sections overlay figures show any significant evidence of downcutting between Monitoring Years 2 and 3, and the longitudinal profile from Monitoring Year 3 was consistent with Montioring Year 2. It appears that most of this

downcutting occurred between Monitoring Years 0 and 2. This downcutting may be one of the causes of the significant amount of on-going bank erosion observed in this section of the project (i.e. as stream downcuts width/depth ratio decreases, leaving the reach prone to widening). The cross-section graphs are located in Appendix B4.

3.2.3 Pebble Counts

Based on the fact that Horse Creek and UT to Horse Creek are sandbed streams, it was determined that pebble counts were unnecessary as they would fail to detect increases in fine sediments. Therefore, pebble counts were not performed for Monitoring Year 3.

3.2.4 Stream Problem Areas

Table X, located in Appendix B3, describes the problem areas, station numbers, and respective probable causes. The most major problem along mainstem Horse Creek was the slumping of banks along the bottom third of the reach. Most bank erosion upstream of the UT Horse Creek confluence has healed over with new vegetation. Much of the bank erosion observed in the lower mainstem was rated severe. It appears that the main causes of erosion were a lack of deeply rooted vegetation at stress points, soil stablility, bank angle, and/or overwidening due to possible downcutting along this section of the project. In addition, beaver dams have been a new development in Monitoring Year 3. There are four dams, located at Stations 10+98, 11+66, 22+56, and 25+14. As described in Section 3.2.1, the result has been an 30% increase in the total length of pool habitat and a 43% reduction in total length of riffle habitat. In addition, median pool length and median riffle slope have both increased, and median riffle length has decreased, presumably as a result of beaver damming. In addition, there were two problem crossvanes and two problem j-hooks noted in Monitoring Year 3. The most severe of these was a crossvane located at Station 34+07 where piping and back arm scour of the right arm (facing downstream). The crossvane located at Station 34+91 had significant piping and back arm scour of the left arm (facing downstream). The problem j-hooks are located at Stations 36+28 and 37+07 and had piping of water/scour around a piece of the structure.

The most major problem to note along UT Horse Creek was a long section of aggradation between Stations 14+18 and 15+14. This area will be observed during future monitoring efforts. In addition, the crossvane at Station 12+27 along UT Horse Creek has piping of water around the right arm (facing downstream), a rock missing from the right arm, and the pool is filled in with sediment. The other two crossvanes (i.e., Station 12+75 and 14+00) both have piping of water around or under a piece of the structure. The stream problem area plan view, located in Appendix C, shows the locations and severity of these problem area.

Table VII a. Categorical Stream Feature Visual Stability Assessment

Horse Creek						
Segment/Reach: Mainstem						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	65%	59%	73%	57%		
B. Pools	50%	54%	90%	87%		
C. Thalweg	80%	74%	94%	100%		
D. Meanders	80%	70%	64%	77%		
E. Bed General	95%	93%	96%	100%		
F. Bank Condition	*	*	85%	88%		
G. Vanes / J Hooks etc.	60%	60%	94%	93%		
H. Wads and Boulders	NA	NA	NA	NA		

*Data not reported in past reports.

Table VII b. Categorical Stream Feature Visual Stability Assessment						
Horse Creek						
Segment/Reach: Unnamed Tributary						
Feature	**Initial**	**MY-01**	**MY-02**	**MY-03**	**MY-04**	**MY-05**
A. Riffles	90%	90%	83%	95%		
B. Pools	80%	83%	92%	100%		
C. Thalweg	100%	100%	100%	100%		
D. Meanders	100%	100%	97%	97%		
E. Bed General	100%	100%	92%	89%		
F. Bank Condition	*	*	94%	100%		
G. Vanes / J Hooks etc.	*	*	83%	58%		
H. Wads and Boulders	NA	NA	NA	NA		

*Data not reported in past reports.

3.3 Photo Documentation

Photos taken of the vegetation problem areas and photos of the vegetation plots are in Appendix A. Stream problem area photographs are provided in Appendix B. The photographs taken at the marked photo point locations and at the cross-sections are provided in Appendix B.

4.0 RECOMMENDATIONS AND CONCLUSIONS

Overall, monitoring for Monitoring Year 3 showed that the Horse Creek mainstem section had a stable dimension and pattern, with the exception of extensive areas of bank slumping. The bank slumping areas were mainly concentrated downstream of Station 26+25. The major bank slumping areas may need maintenance and will be observed closely during Monitoring Year 4. In addition there are two crossvanes and two J-hooks that have piping and/or backarm scour that may be in need of repair. There have been some apparent changes in profile, presumably as a result of the construction of beaver dams in Monitoring Year 3. The result of this damming has been an 30% increase in the total length of pool habitat and a 43% reduction in total length of riffle habitat. In addition, median pool length and median riffle slope have both increased, and median riffle length has decreased. However, it should be noted that the overall water surface remained consistent in Monitoring Year 3.

The UT Horse Creek reach has remained stable for Monitoring year 3. The headcut observed in Monitoring Year 2, located at Station 10+59, has not progressed upstream, and is not considered to be a concern at this time. However, this headcut will be observed closely during Monitoring Year 4. A long aggradational section toward the downstream end of the reach may need attention as it appears to have extended downstream by an additional 48 feet. In addition, all three crossvanes had water piping around and/or under some part of the structure. The crossvane located at Station 12+27 along UT Horse Creek has piping of water around the right arm (facing downstream), a rock missing from the right arm, and the pool is filled in with sediment. This crossvane may warrant repair assessment.

The most extensive vegetation problem areas were long sections of past-mowed floodplain that had been mowed as part of regular fairway maintenance before the country club closed. These areas are located along the upper two thirds of the Horse Creek mainstem and along the entire UT section. It should be noted that, since the golf course was closed and maintenance of fairways and play-through areas has ceased, it is visually apparent that vegetative growth in these areas has

started recovering; however, species diversity is still significantly lower in these areas compared to the unimpacted areas of the project. For example, very few, if any, woody stems can be found in the past-mowed areas. Supplemental plantings may be necessary to boost succession in these areas. In addition, the lower portion of the mainstem Horse Creek has been invaded by stands of Chinese Privet (*Ligustrum sinense*). These areas will be monitoring closely in future monitoring years to document the spread of this population.

There are several concern areas with regard to the vegetation plots. The plots impacted by past-mowing (i.e., VP C, E, and O) have densities below 260 stems/acre (Monitoring Year 5 stem density goal). However, if natural volunteer stems are included in the density calculations, all vegetation plots pass the Monitoring Year 5 stem density goal. Therefore, planted stem densities of less than the Monitoring Year 5 goal should not be interpreted as an indication of the species being completely inappropriate, or the growing conditions being severely inhospitable. In fact, the evidence of naturalization of volunteer stems suggests the growing conditions are suitable for good herbaceous and woody vegetative growth without supplemental plantings. However, supplemental plantings may be necessary to boost species diversity and/or the prevalence of a certain target species.

REFERENCES

Dewberry & Davis. September 2002. *Stream Restoration Plan Horse Creek at Wake Forest Country Club.* November 2003

Dewberry & Davis. *Horse Creek Stream Restoration Monitoring Report EEP Project Number 71082 Monitoring Year – 01 200.* September 2006

DeLorme. 1997. *The North Carolina Atlas and Gazateer*.

Harman, W.H., et al. 1999. *Bankfull Hydraulic Geometry Relationships for North Carolina Streams*. AWRA Wildland Hydrology Symposium Proceedings. Edited by D.S. Olson and J.P. Potyondy. AWRA Summer Synposium. Bozeman, MT.

Lee, M.T., R.K. Peet, S.D. Roberts, and T.R. Wentworth. 2006. *CVS-EEP Protocol for Recording Vegetation*. Available at < http://cvs.bio.unc.edu/protocol/cvs-eep-manual-v4_lev1-2.pdf>. 11 pp.

North Carolina Ecosystem Enhancement Program. September 2005. *Content, Format and Data Requirements for EEP Monitoring Reports*.

Rosgen, D.L. 1994. *A Classification of Natural River*. Catena, Volume 22: 166-169.

SEPI Engineering Group. January 2008. *Horse Creek (Wake Forest Country Club) Final Monitoring Report Year 2 of 5 2007.*

U.S. Department of Army, Corps of Engineers. 2003. *Stream Mitigation Guidelines*. http://www.saw.usace.army.mil/wetlands/Mitigation/stream_mitigation.html

APPENDIX A1

VEGETATION DATA TABLES

Report Prepared By	PHILIP BEACH
Date Prepared	11/24/2008 9:44

database name	WFCC CVS Data 2008.mdb
database location	G:\Environmental\EN08.004 - EEP Monitoring 2008-09\CVS-EEP DATABASE - 2008 VERSION
computer name	W08

DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT----------

Metadata	This worksheet, which is a summary of the project and the project data.
Proj, planted	Each project is listed with its PLANTED stems, for each year. This excludes live stakes and lists stems per acre.
Proj, total stems	Each project is listed with its TOTAL stems, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems. Listed in stems per acre.
Plots	List of plots surveyed.
Vigor	Frequency distribution of vigor classes.
Vigor by Spp	Frequency distribution of vigor classes listed by species.
Damage	List of most frequent damage classes with number of occurrences and percent of total stems impacted by each.
Damage by Spp	Damage values tallied by type for each species.
Damage by Plot	Damage values tallied by type for each plot.
ALL Stems by Plot and spp	Count of total living stems of each species (planted and natural volunteers combined) for each plot; dead and missing stems are excluded.

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

Project Code	WFGC 08
project Name	WFGC
Description	WFGC CVS MONITORING 2008
River Basin	Neuse
length(ft)	3,502 (as-built)
stream-to-edge width (ft)	
area (sq m)	
Required Plots (calculated)	7
Sampled Plots	7

Vigor By Species - WFCC 2008 (Monitoring Year 3)

	Species	4	3	2	1	0	Missing
	Acer saccharinum		2				3
	Aronia arbutifolia		1				1
	Baccharis halimifolia	8					1
	Betula nigra	1	9				5
	Cephalanthus occidentalis						1
	Cornus alternifolia				1		
	Diospyros virginiana						1
	Fraxinus pennsylvanica	1	3	2			6
	Ilex verticillata	1					
	Juglans nigra		1	1			
	Liquidambar styraciflua	12	10				9
	Pinus taeda	7	1				2
	Quercus georgiana	1					
	Salix nigra	1	1				
	Sambucus canadensis	2	1		1		
	Sassafras albidum	1					
	Ulmus alata		1				3
	Morella cerifera	2					
	Malus angustifolia		1				
	Carpinus caroliniana						6
	Magnolia virginiana			1			
	Platanus occidentalis	1	12				16
	Prunus serotina	1	3		1		4
TOT:	**23**	**39**	**46**	**4**	**3**		**58**

Damage By Species - WFCC 2008 (Monitoring Year 3)

	Species	All Damage Categories	(no damage)	Beaver	Cut	Game	Human Trampled	Insects	Vine Strangulation
	Acer saccharinum	5	3				1	1	
	Aronia arbutifolia	2	2						
	Baccharis halimifolia	9	9						
	Betula nigra	15	8			1		6	
	Carpinus caroliniana	6	6						
	Cephalanthus occidentalis	1	1						
	Cornus alternifolia	1						1	
	Diospyros virginiana	1	1						
	Fraxinus pennsylvanica	12	8					4	
	Ilex verticillata	1	1						
	Juglans nigra	2	1					1	
	Liquidambar styraciflua	31	28					3	
	Magnolia virginiana	1		1					
	Malus angustifolia	1						1	
	Morella cerifera	2	2						
	Pinus taeda	10	10						
	Platanus occidentalis	29	17		2			10	
	Prunus serotina	9	6					2	1
	Quercus georgiana	1	1						
	Salix nigra	2			1			1	
	Sambucus canadensis	4	2			1		1	
	Sassafras albidum	1	1						
	Ulmus alata	4	3					1	
TOT:	**23**	**150**	**110**	**1**	**3**	**2**	**1**	**32**	**1**

Damage By Plot - WFCC 2008 (Monitoring Year 3)

	plot	All Damage Categories	(no damage)	Beaver	Cut	Game	Human Trampled	Insects	Vine Strangulation
	WFGC 08-01-C-year:3	4	4						
	WFGC 08-01-E-year:3	8	7					1	
	WFGC 08-01-F-year:3	39	28	1				9	1
	WFGC 08-01-I-year:3	10	9					1	
	WFGC 08-01-K-year:3	56	39		2		1	14	
	WFGC 08-01-L-year:3	30	20		1	2		7	
	WFGC 08-01-O-year:3	3	3						
TOT:	**7**	**150**	**110**	**1**	**3**	**2**	**1**	**32**	**1**

Planted Stems By Plot and Species - WFCC 2008 (Monitoring Year 3)

	Species	Total Planted Stems	# plots	avg# stems	plot WFGC 08-01-C-year:3	plot WFGC 08-01-E-year:3	plot WFGC 08-01-F-year:3	plot WFGC 08-01-I-year:3	plot WFGC 08-01-K-year:3	plot WFGC 08-01-L-year:3	plot WFGC 08-01-O-year:3
	Acer saccharinum	2	1	2					2		
	Aronia arbutifolia	1	1	1			1				
	Baccharis halimifolia	8	3	2.67			5	1	2		
	Betula nigra	10	2	5						9	1
	Cornus alternifolia	1	1	1			1				
	Fraxinus pennsylvanica	6	3	2			4		1	1	
	Ilex verticillata	1	1	1			1				
	Juglans nigra	2	1	2			2				
	Liquidambar styraciflua	22	5	4.4	1	2	6		7	6	
	Magnolia virginiana	1	1	1			1				
	Malus angustifolia	1	1	1			1				
	Morella cerifera	2	1	2				2			
	Pinus taeda	8	4	2				5	1	1	1
	Platanus occidentalis	13	5	2.6		1	1	1	9	1	
	Prunus serotina	5	2	2.5		2	3				
	Quercus georgiana	1	1	1	1						
	Salix nigra	2	1	2					2		
	Sambucus canadensis	4	3	1.33	2		1			1	
	Sassafras albidum	1	1	1							1
	Ulmus alata	1	1	1					1		
TOT:	**20**	**92**	**20**		**4**	**5**	**27**	**9**	**25**	**19**	**3**

Table 6. Vegetative Problem Areas

Feature/Issue	Station # / Range	Probable Cause	Photo #
Past mowing maintenance (Horse Creek)	Multiple Sections from 10+00 to 35+96, both sides	Past fairway maintenance (mowing)	1
Past mowing maintenance (UT)	Entire Reach, both sides	Past fairway maintenance (mowing)	
Past mowing maintenance (Horse Creek)	16+56 (Left Bank)	Past fairway maintenance (mowing)	3
Chinese privet *(Ligustrum sinense)* growth- Horse Creek	Station 33+68 to 44+10 (Left Bank)	Invasive vegetative opportunism	2
Chinese privet *(Ligustrum sinense)* growth- Horse Creek	Station 37+93 to 39+69 (Left Bank)	Invasive vegetative opportunism	
Chinese privet *(Ligustrum sinense)* growth- Horse Creek	Station 38+11 to 39+69 (Right Bank)	Invasive vegetative opportunism	

APPENDIX A2

PHOTOLOG VEGETATION PROBLEM AREAS

APPENDIX A2
PHOTOLOG – HORSE CREEK (WAKE FOREST COUNTRY CLUB)

PROBLEM AREAS (Vegetation)

Photo 1: Representative past mowed/maintained floodplain problem area (Approximate Station 11+00 view upstream along main stem; 2-15-2008).

Photo 2. Representative *Ligustrum sinense* (Chinese privet) problem area (Station 33+68; privet is in background above shrub level; 9-30-2008).

Photo 3. Representative bare bench/bank problem area (Station 16+56; view of left bank on main stem; 9-30-2008).

APPENDIX A3

PHOTOLOG VEGETATION PLOTS

APPENDIX A3
PHOTOLOG HORSE CREEK (WAKE FOREST COUNTRY CLUB)

VEGETATION PLOTS


Photo 1: Vegetation Plot C (10-15-2008).


Photo 2: Vegetation Plot E (10-15-2008).


Photo 3: Vegetation Plot F (10-15-2008).


Photo 4: Vegetation Plot I (10-15-2008).


Photo 5: Vegetation Plot K (10-16-2008).


Photo 6: Vegetation Plot L (10-29-2008).


Photo 7: Vegetation Plot O (10-16-2008).

APPENDIX B1

PHOTOLOG STREAM PROBLEM AREAS

APPENDIX B1
PHOTOLOG – HORSE CREEK (WAKE FOREST COUNTRY CLUB)

STREAM PROBLEM AREAS

Photo 1: Representative beaver-dam problem area (Station 10+98; view downstream along Horse Creek; 9-30-2008).

Photo 2: Representative severe bank erosion problem area (Station 29+65; view upstream of right bank along Horse Creek; 10-15-2008).

Photo 3: Representative severe bank erosion problem area (Station 34+28; view upstream of left bank along Horse Creek; 10-29-2008).

Photo 4: Representative cross-vane problem area, Horse Creek (Station 34+91 view downstream of piping on right arm; 2-15-2008).

Photo 5: Representative j-hook problem area, Horse Creek (Station 37+07 view upstream of piping along left side of structure; 2-15-2008).

APPENDIX B2

PHOTOLOG OF CROSS-SECTIONS AND PHOTO POINTS

APPENDIX B2
PHOTOLOG –HORSE CREEK (WAKE FOREST COUNTRY CLUB)

CROSS-SECTIONS & PHOTOPOINTS

Cross-Section 1: View downstream. Horse Creek (9-30-2008). Note beaver dam at Station 10+98.

Cross-Section 1: View upstream. Horse Creek (9-30-2008). Note beaver dam at Station 10+98.

Cross-Section 2: View Downstream. Horse Creek (10-28-2008)

Cross-Section 2: View upstream. Horse Creek (10-28-2008)

Cross-Section 3: View downstream. Horse Creek (10-28-2008). Note beaver dam at Station 25+14.

Cross-Section 3: View upstream. Horse Creek (10-28-2008). Note beaver dam at Station 25+14.

Cross-Section 4: View downstream. Horse Creek (10-29-2008).

Cross-Section 4: View upstream. Horse Creek (10-29-2008).

Cross-Section 5: View downstream. Horse Creek (10-29-2008).

Cross-Section 5: View upstream. Horse Creek (10-29-2008).

Cross-Section 6: View downstream. Horse Creek (10-29-2008).

Cross-Section 6: View upstream. Horse Creek (10-29-2008).

Cross-Section 7: View downstream. UT Horse Creek (10-30-2008).

Cross-Section 7: View upstream. UT Horse Creek (10-30-2008).

Cross-Section 8: View downstream. UT Horse Creek (10-30-2008).

Cross-Section 8: View upstream. UT Horse Creek (10-30-2008).

Photo-Point 1: View downstream. Horse Creek (9-30-2008).

Photo-Point 1: View upstream. Horse Creek (9-30-2008).

Photo-Point 2: View downstream. Horse Creek (9-30-2008).

Photo-Point 2: View upstream. Horse Creek (9-30-2008).

Photo-Point 3: View downstream Horse Creek. (9-30-2008)

Photo-Point 3: View upstream Horse Creek. (9-30-2008)

Photo-Point 4: View downstream. Horse Creek (9-30-2008).

Photo-Point 4: View upstream. Horse Creek (9-30-2008).

Photo-Point 5a: View downstream. UT Horse Creek (10-16-2008).

Photo-Point 5a: View upstream. UT Horse Creek (10-16-2008).

Photo-Point 5b: View downstream. Horse Creek (10-28-2008).

Photo-Point 5b: View upstream. Horse Creek (10-28-2008).

Photo-Point 6: View downstream. Horse Creek (10-16-2008).

Photo-Point 6: View upstream. Horse Creek (10-16-2008).

Photo-Point 7: View downstream. Horse Creek (10-16-2008).

Photo-Point 7: View upstream. Horse Creek (10-16-2008).

Photo-Point 8: View downstream. Horse Creek (10-16-2008).

Photo-Point 8: View upstream. Horse Creek (10-16-2008).

Photo-Point 9: View downstream. UT Horse Creek (10-16-2008).

Photo-Point 9: View upstream. UT Horse Creek (10-16-2008).


Photo-Point 10: View downstream. UT Horse Creek (10-16-2008).


Photo-Point 10: View upstream. UT Horse Creek (10-16-2008).


Photo-Point 11: View downstream. UT Horse Creek (10-16-2008).


Photo-Point 11: View upstream. UT Horse Creek (10-16-2008).


Photo-Point 12: View downstream. UT Horse Creek (10-16-2008).


Photo-Point 12: View upstream. UT Horse Creek (10-16-2008).

APPENDIX B3

STREAM DATA TABLES

Table VIII a. Baseline Morphology and Hydraulic Summary

Horse Creek - Mainstem

Project Number 435

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Dimension																		
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		
BFCross Sectional Area (ft)	NA	NA	NA	98.3			61.9	98.5	82.5	56.2	59	57.4	107	106.5	106.5	110.1	126	119
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
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	2.6	2.7	2.7
Bank Height Ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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																		
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 Wavelenght (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																		
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	0.01	0.013	0	0.032	0.008	0.003	0.09	0.03
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																		
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 Parameters																		
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		
*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 VIII b. Baseline Morphology and Hydraulic Summary

Horse Creek - Unnamed Tributary

Project Number 435

Parameter	USGS Gage Data			Regional Curve Interval			Pre-Existing Condition			Project Reference Stream			Design			As-built		
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Dimension																		
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	
BFCross Sectional Area (ft)	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
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
Bank Height Ratio	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
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																		
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 Wavelenght (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																		
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																		
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 Parameters																		
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	
*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

Table IX a. Morphology and Hydraulic Monitoring Summary

Horse Creek

Segment/Reach: Mainstem

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					
Dimension	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
BF Width (ft)	37	40	37.3	37			39	39	37.7	38.6			31	33.2	33.3	34.8			39	38.9	36.4	38.4			34	39	35.1	35.1			37	35	32.6	33.5		
Floodporne Width (ft)	600+	600	100+	100+			600+	600	NA	NA			600+	600	NA	NA			600+	600	102+	100+			600	600	NA	NA			600+	600	101+	100+		
BFCross Sectional Area (ft)	120	131	118.3	118.1			126	101	104.5	103.5			99	98	101.3	110.1			110	96	111.3	112.1			95	97	101.6	99			126	78	95	100.5		
BF Mean Depth (ft)	3.3	3.3	3.2	3.2			3.2	2.6	2.8	2.7			3.2	2.9	3.0	3.2			2.9	2.5	3.1	2.9			2.8	2.5	2.9	2.8			3.4	2.2	2.9	3		
Width/Depth Ratio	11	12.2	11.8	11.6			12	15	NA	NA			9.9	11.2	NA	NA			14	16	11.9	13.2			12	16	NA	NA			11	16	11.2	11.1		
Entrenchment Ratio	2.7+	2.4	2.7+	2.7+			--	2.2	NA	NA			--	2.6	NA	NA			2.6+	2.2	2.8+	2.6+			--	1.9	NA	NA			2.7+	2.4	3.1+	3.0+		
Bank Height Ratio	1	1	1	1.09			1	1	NA	NA			1	1	NA	NA			1	1	1	1.01			1	1	NA	NA			1	1	1	1.03		
Wetted Perimeter (ft)	34	42	40	41			41	42	40.5	41.4			36	36	38.2	43			40	40	40.3	42.2			36	42	39	39			39	37	36.9	38.6		
Hydraulic radius (ft)	3.5	3.1	3	2.9			3.1	2.4	2.6	2.5			2.8	2.6	2.7	2.6			2.7	2.4	2.8	2.7			2.6	2.3	2.6	2.6			3.2	2.12	2.6	2.6		
Substrate																																				
d50 (mm)	0.1	1.2	1.3	NA			0.15	0.43	1.5	NA			0.16	1.33	1.4	NA			0.1	1.06	1.4	NA			0.12	0.63	6.3	NA			0.12	0.43	0.55	NA		
d84 (mm)	0.8	32.0	10.0	NA			0.50	1.41	7	NA			0.35	37	58	NA			0.5	6.6	5.1	NA			0.37	1.81	71	NA			4	3.03	1.7	NA		

Parameter	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05(2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	47.0	97.0	69.0	47.0	97.0	69.0	47.1	113.1	89.1	46.2	110.1	76.9						
Radius of Curvature (ft)	32.0	132.0	76.0	32.0	132.0	76.0	46.0	185.8	71.0	47.5	204.2	80.8						
Meander Wavelenght (ft)	131.0	369.0	212.0	131.0	369.0	212.0	148.1	542.0	283.1	128.5	567.2	220.8						
Meander Width Ratio	3.50	9.90	5.70	3.50	9.90	5.70	1.33	3.19	2.51	1.27	3.03	2.40						
Profile																		
Riffle length (ft)	5.0	59.0	22.0	15.7	56.5	33.7	4.9	62.7	20.3	4.0	39.1	12.2						
Riffle slope (ft/ft)	0.003	0.087	0.027	0.002	0.014	0.007	0.000	0.077	0.006	0.000	0.333	0.013						
Pool length (ft)	26.0	131.0	70.0	18.5	74.3	46.1	17.7	280.1	57.4	13.2	626.6	79.9						
Pool spacing (ft)	38.0	325.0	129.0	45.1	204.0	45.1	55.1	305.8	103.8	20.9	663.3	92.2						
Additional Reach Parameters																		
Valley Length (ft)	2645			2645			2651			2638								
Channel Length (ft)	2899			2899			2970			2969								
Sinuosity	1.1			1.1			1.1			1.1								
Water Surface Slope (ft/ft)	--			0.002			0.002			0.002								
BF slope (ft/ft)	--			0.002			0.002			0.002								
Rosgen Classification	C/E5			C/E5			C5			C5								
Habitat Index	NA			NA			NA			NA								
Macrobenthos	NA			NA			NA			NA								

Table IX b. Morphology and Hydraulic Monitoring Summary

Horse Creek

Segment/Reach: Unnamed Tributary

Parameter	Cross Section 7 Pool						Cross Section 8 Riffle					
Dimension	MY0	MY1	MY2	MY3	MY4	MY5	MY0	MY1	MY2	MY3	MY4	MY5
BF Width (ft)	15	14.7	13.5	13.4			6.5	9.5	8.5	8.2		
Floodporne Width (ft)	200+	200+	NA	NA			200+	200+	45+	45+		
BFCross Sectional Area (ft)	21	14.8	21.4	20.5			5.3	8.7	8.5	8.0		
BF Mean Depth (ft)	1.4	1	1.6	1.5			0.8	0.9	1.0	1.0		
Width/Depth Ratio	11	14.7	NA	NA			8	10.4	8.5	8.5		
Entrenchment Ratio	--	13.6	NA	NA			20+	21	5.3+	5.5+		
Bank Height Ratio	1	1	NA	NA			1	1	1	1.13		
Wetted Perimeter (ft)	28	15.3	14.6	15.1			10.4	10.4	9.6	9.2		
Hydraulic radius (ft)	0.7	0.96	1.5	1.4			1.3	0.8	0.9	0.9		
Substrate												
d50 (mm)	0.19	0.96	1.4	NA			0.12	0.14	0.48	NA		
d84 (mm)	1	0.85	7.9	NA			0.18	0.93	1.5	NA		

Parameter	MY-00 (2005)			MY-01 (2006)			MY-02 (2007)			MY-03 (2008)			MY-04 (2009)			MY-05(2010)		
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med
Channel Beltwidth (ft)	7.6	28.2	15.9	7.6	28.2	15.9	19.5	39.3	23.6	19.1	38.4	21.5						
Radius of Curvature (ft)	15.8	61.0	31.2	15.8	61.0	31.2	16.3	81.6	33.1	17.0	49.5	30.9						
Meander Wavelenght (ft)	54.1	107.2	81.4	54.1	107.2	81.4	63.8	162.4	79.0	62.9	154.1	86.7						
Meander Width Ratio	5.8	12.0	8.6	5.8	12.0	8.6	2.3	4.6	2.8	2.3	4.7	2.6						
Profile																		
Riffle length (ft)	92.0	216.2	151.4	63.6	133.9	84.5	3.7	73.0	25.1	3.9	51.3	22.8						
Riffle slope (ft/ft)	0.024	0.043	0.031	0.027	0.044	0.033	0.006	0.108	0.039	0.014	0.147	0.034						
Pool length (ft)	21.3	39.3	30.9	11.2	36.3	22.7	6.9	23.8	14.1	3.8	30.3	10.7						
Pool spacing (ft)	150.9	273.4	212.2	147.4	161.6	187.3	13.7	88.4	38.9	11.1	86.7	30.9						
Additional Reach Parameters																		
Valley Length (ft)	499			499			493			494								
Channel Length (ft)	540			540			551			554								
Sinuosity	1.1			1.1			1.1			1.1								
Water Surface Slope (ft/ft)	--			0.019			0.020			0.022								
BF slope (ft/ft)	--			0.019			0.017			0.019								
Rosgen Classification	E5			E5			E5			E5b								
*Habitat Index	NA			NA			NA			NA								
*Macrobenthos	NA			NA			NA			NA								

Table B1. Stream Problem Areas

Horse Creek

Feature Issue	Station numbers	Suspected Cause	Photo #
Beaver Dam	10+98	Beaver dam construction.	1
Beaver Dam	11+66	Beaver dam construction.	
Bank Erosion (right)	13+33 13+42	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Beaver Dam	22+56	Beaver dam construction.	
Beaver Dam	25+14	Beaver dam construction.	
Bank Erosion (left)	26+25 26+39	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Undercut Bank (left)	26+39 26+57	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (right)	26+29 26+62	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right)	27+22 27+44	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (left)	28+64 28+71	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (right, severe)	29+65 29+97	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	2
Bank Erosion (left, severe)	31+44 31+66	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (right, severe)	32+51 32+75	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Aggradation/Bar Formation	32+83 33+06	Adjacent bank erosion resulted in sediment deposition/bar formation in stream channel.	
Bank Erosion left)	32+88 33+10	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (right)	33+06 33+40	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Bank Erosion (left, severe)	33+78 34+09	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Crossvane (Severe)	34+07	Significant piping and backarm scour of left arm.	
Bank Erosion (left, severe)	34+28 34+88	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	3
Bank Erosion (right)	34+38 34+47	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right)	34+59 34+71	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right)	34+88 34+93	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Crossvane	34+91	Piping and back arm scour of right arm.	4
Bank Erosion (right)	35+14 35+43	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right)	34+54 35+70	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right, severe)	35+86 36+34	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Jhook	36+28	Piping around/under structure.	
Bank Erosion (left, severe)	36+64 37+17	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Jhook	37+07	Piping around/under structure.	5
Bank Erosion (right severe)	37+53 37+83	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (left)	37+79 38+33	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right, severe)	37+86 38+19	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right, severe)	38+73 38+87	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (left, severe)	38+88 39+16	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (left, severe)	39+24 39+58	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Bank Erosion (right)	39+29 39+43	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation).	
Headcut	10+59 UT	Grade adjustment after constuction.	
Crossvane	12+27 UT	Piping around right arm; large rock from right arm in channel; pool is filled in.	
Crossvane	12+75 UT	Piping around/under structure.	
Bank Erosion (right)	12+83 UT 12+87 UT	Soil stability issues and lack of bank protection (i.e. deep rooted vegetation) on outside of meander.	
Crossvane	14+00 UT	Piping around/under structure.	
Aggradation	14+18 UT 15+14 UT	Adjacent bank erosion resulted in sediment deposition/bar formation in stream channel. Cattails growing on edge of bar in stream channel.	

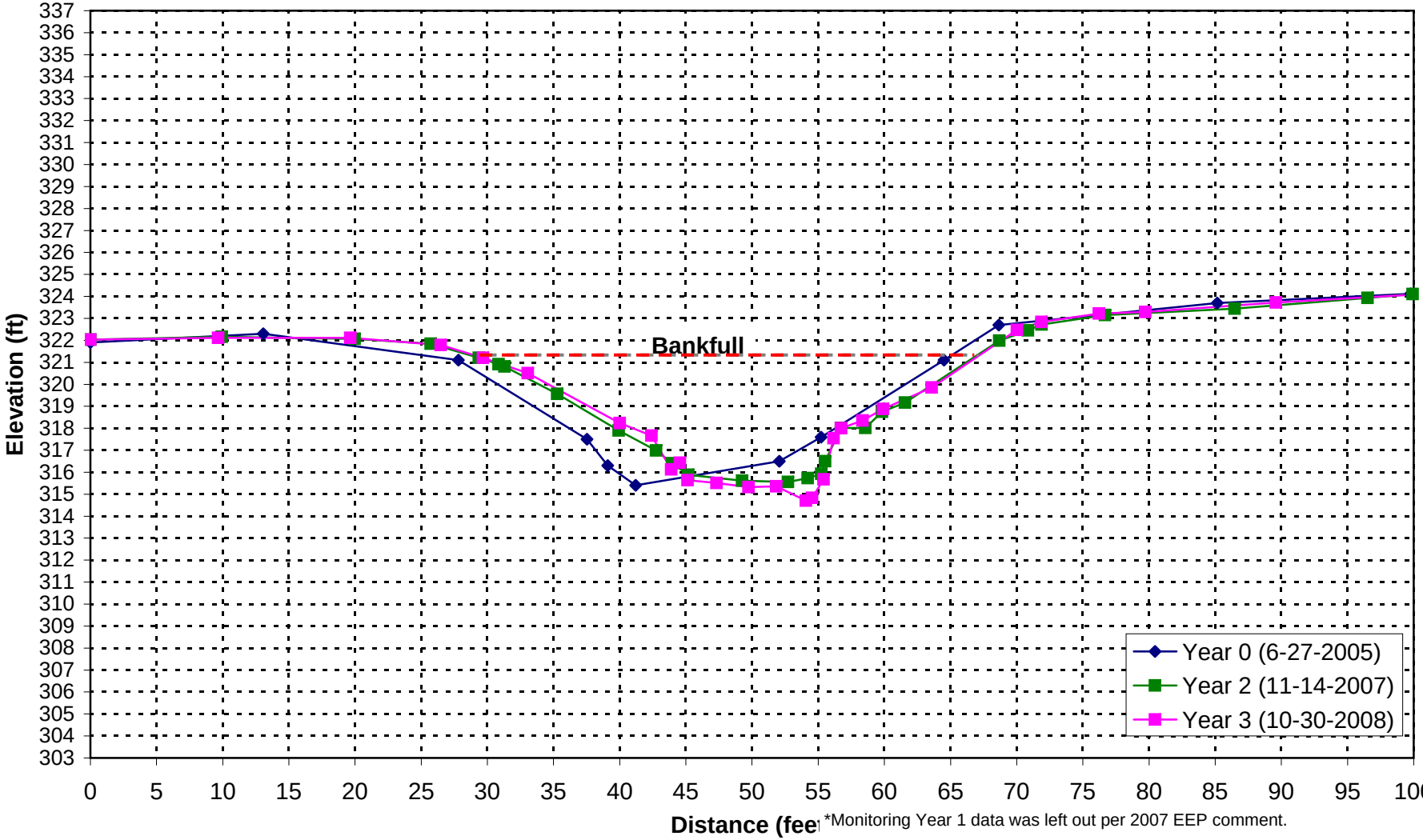
Table B2. Visual Morphological Stability Assessment						
Horse Creek						
Segment/Reach: Mainstem						
Feature Category	**Metric (per As-built and reference baselines)**	**(#Stable) Number Performing as Intended**	**Total Number per As-built**	**Total Number / feet in unstable state**	**% Performing in Stable Condition**	**Feature Performance Mean or Total**
A. Riffles	1. Present	19	31	NA	61%	
	2. Armor stable	19	31	NA	61%	
	3. Facet grade appears stable	16	31	NA	52%	
	4. Minimal evidence of embedding/fining	18	31	NA	58%	
	5. Length appropriate	16	31	NA	52%	**57%**
B. Pools	1. Present	26	30	NA	87%	
	2. Sufficiently deep	26	30	NA	87%	
	3. Length appropriate	26	30	NA	87%	**87%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	9	9	NA	100%	
	2. Downstream of meander (glide/inflection) centering	9	9	NA	100%	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion	10	18	NA	56%	
	2. Of those eroding, # w/concomitant point bar formation	5	8	NA	63%	
	3. Apparent Rc within specifications	16	18	NA	89%	
	4. Sufficient floodplain access and relief	18	18	NA	100%	**77%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	1/23	99%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting	NA	NA	0/0	100%	**100%**
F. Bank Condition	1. Actively eroding, wasting, or slumping bank	NA	NA	27/707	88%	**88%**
G. Vanes / J Hooks etc.	1. Free of back or arm scour	21	24	NA	88%	
	2. Height appropriate	24	24	NA	100%	
	3. Angle and geometry appear appropriate	24	24	NA	100%	
	4. Free of piping or other structural failures	20	24	NA	83%	**93%**
H. Wads and Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

Table B2. Visual Morphological Stability Assessment						
Horse Creek						
Segment/Reach: Unnamed Tributary						
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	12	12	NA	100%	
	3. Facet grade appears stable	12	12	NA	100%	
	4. Minimal evidence of embedding/fining	10	12	NA	83%	
	5. Length appropriate	11	12	NA	92%	**95%**
B. Pools	1. Present	12	12	NA	100%	
	2. Sufficiently deep	12	12	NA	100%	
	3. Length appropriate	12	12	NA	100%	**100%**
C. Thalweg	1. Upstream of meander bend (run/inflection) centering	5	5	NA	100%	
	2. Downstream of meander (glide/inflection) centering	5	5	NA	100%	**100%**
D. Meanders	1. Outer bend in state of limited/controlled erosion	9	9	NA	100%	
	2. Of those eroding, # w/concomitant point bar formation	0	0	NA	100%	
	3. Apparent Rc within specifications	8	9	NA	89%	
	4. Sufficient floodplain access and relief	9	9	NA	100%	**97%**
E. Bed General	1. General channel bed aggradation areas (bar formation)	NA	NA	1/96	83%	
	2. Channel bed degradation - areas of increasing down cutting or head cutting	NA	NA	1/24	96%	**89%**
F. Bank Condition	1. Actively eroding, wasting, or slumping bank	NA	NA	1/4	100%	**100%**
G. Vanes / J Hooks etc.	1. Free of back or arm scour	3	3	NA	100%	
	2. Height appropriate	2	3	NA	67%	
	3. Angle and geometry appear appropriate	2	3	NA	67%	
	4. Free of piping or other structural failures	0	3	NA	0%	**58%**
H. Wads and Boulders	1. Free of scour	NA	NA	NA	NA	
	2. Footing stable	NA	NA	NA	NA	**NA**

APPENDIX B4

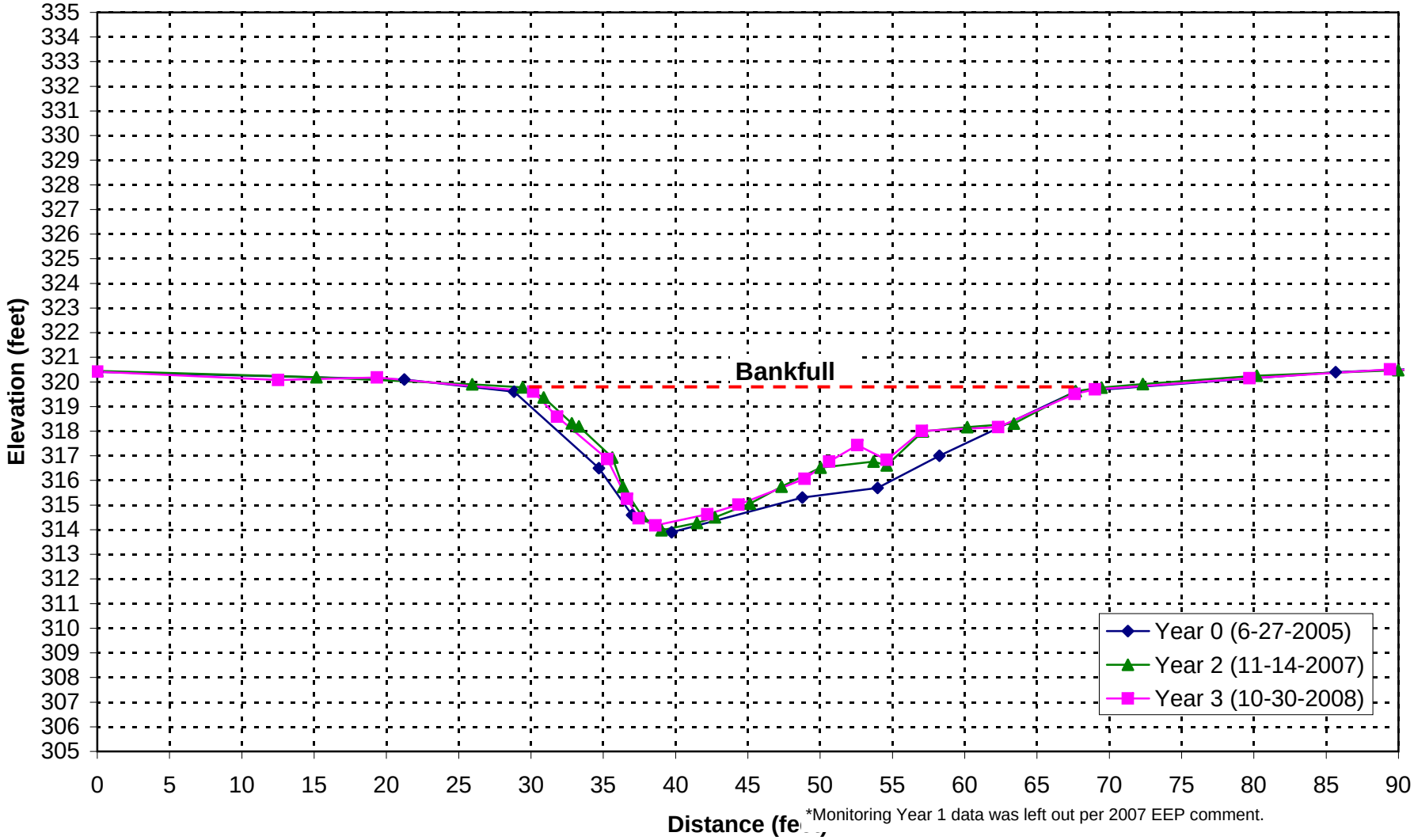
STREAM CROSS-SECTIONS

Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #1 (Riffle)



*Monitoring Year 1 data was left out per 2007 EEP comment.

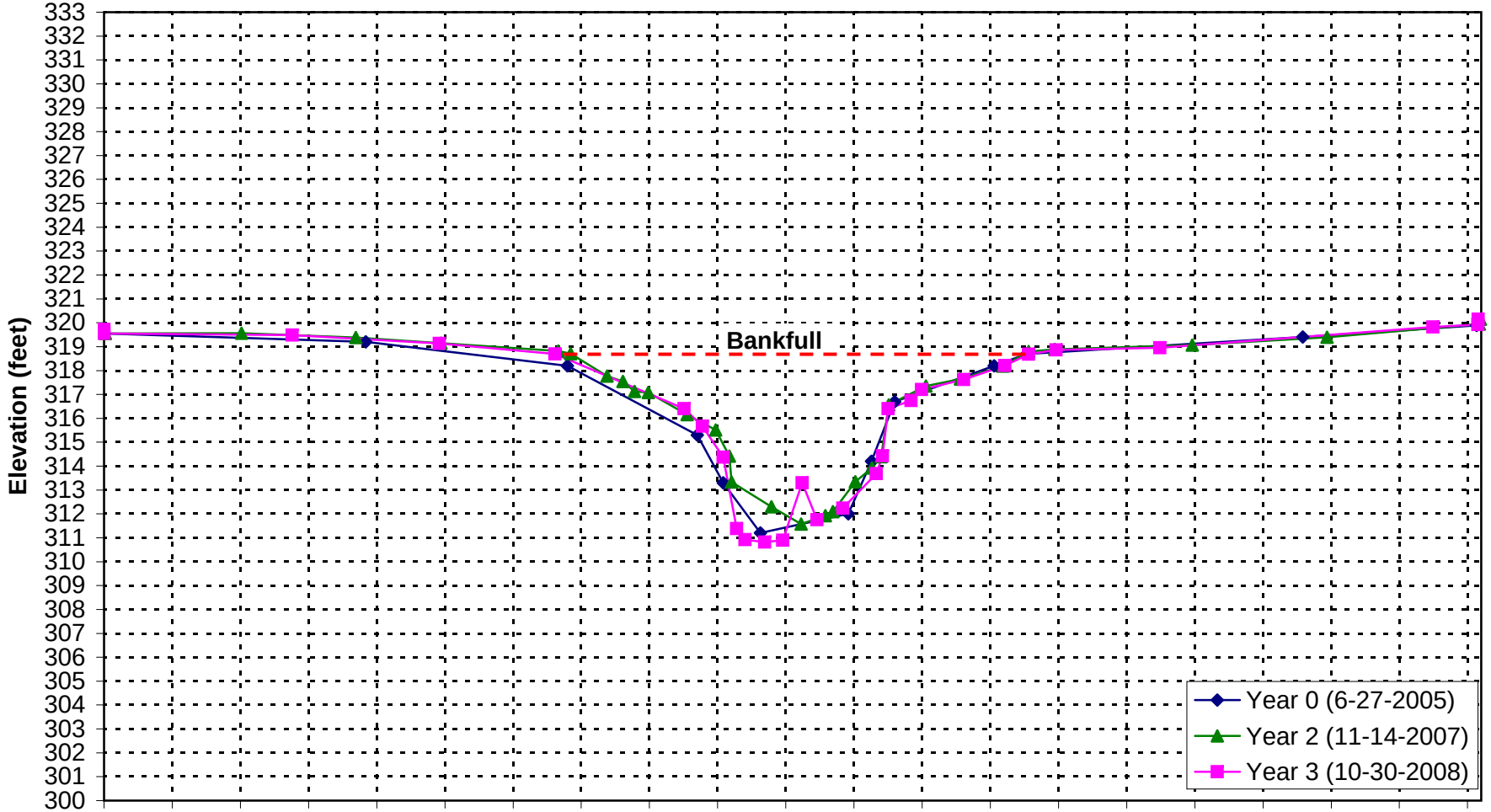
Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #2 (Pool)



Distance (fe

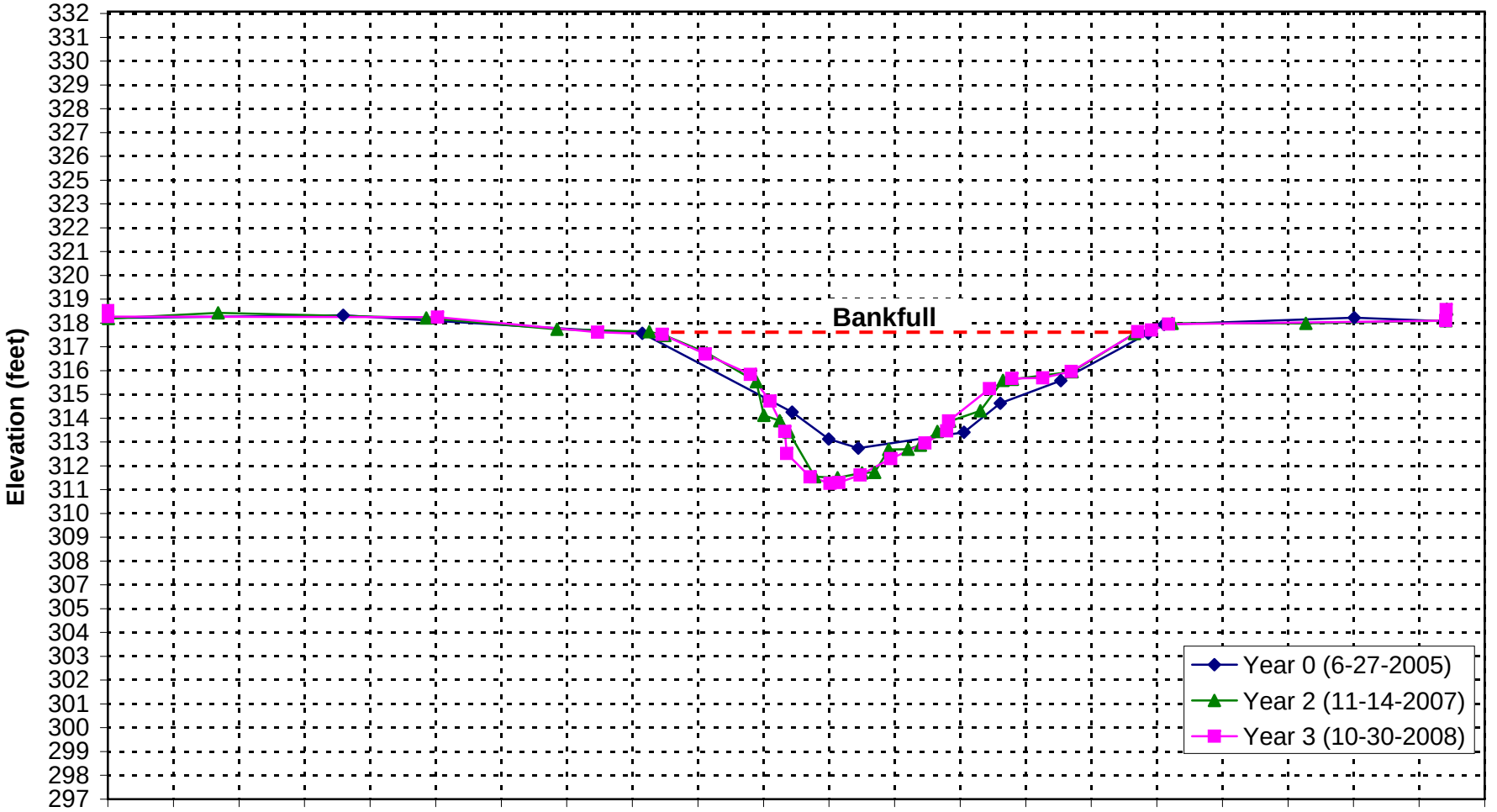
*Monitoring Year 1 data was left out per 2007 EEP comment.

Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #3 (Pool)

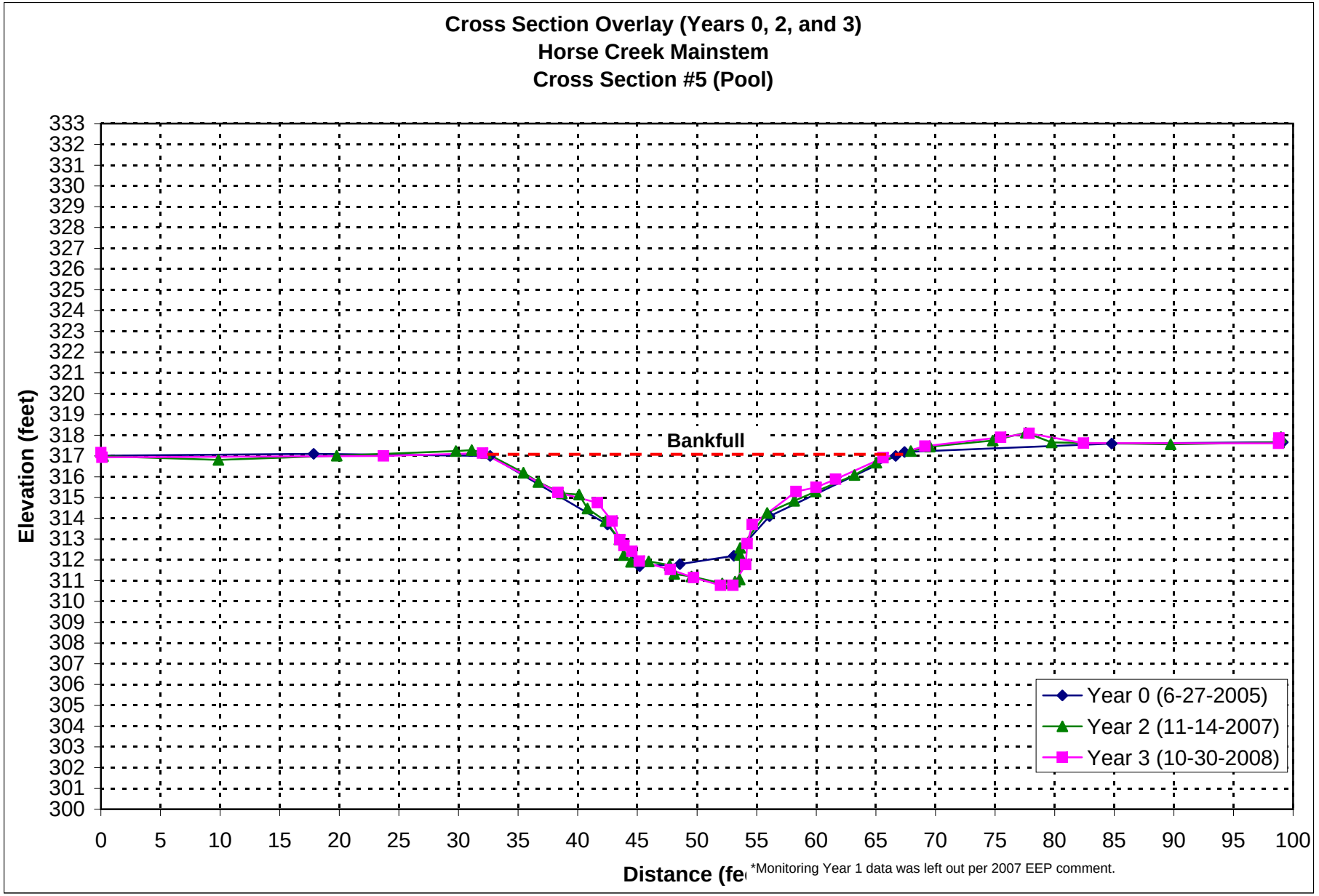


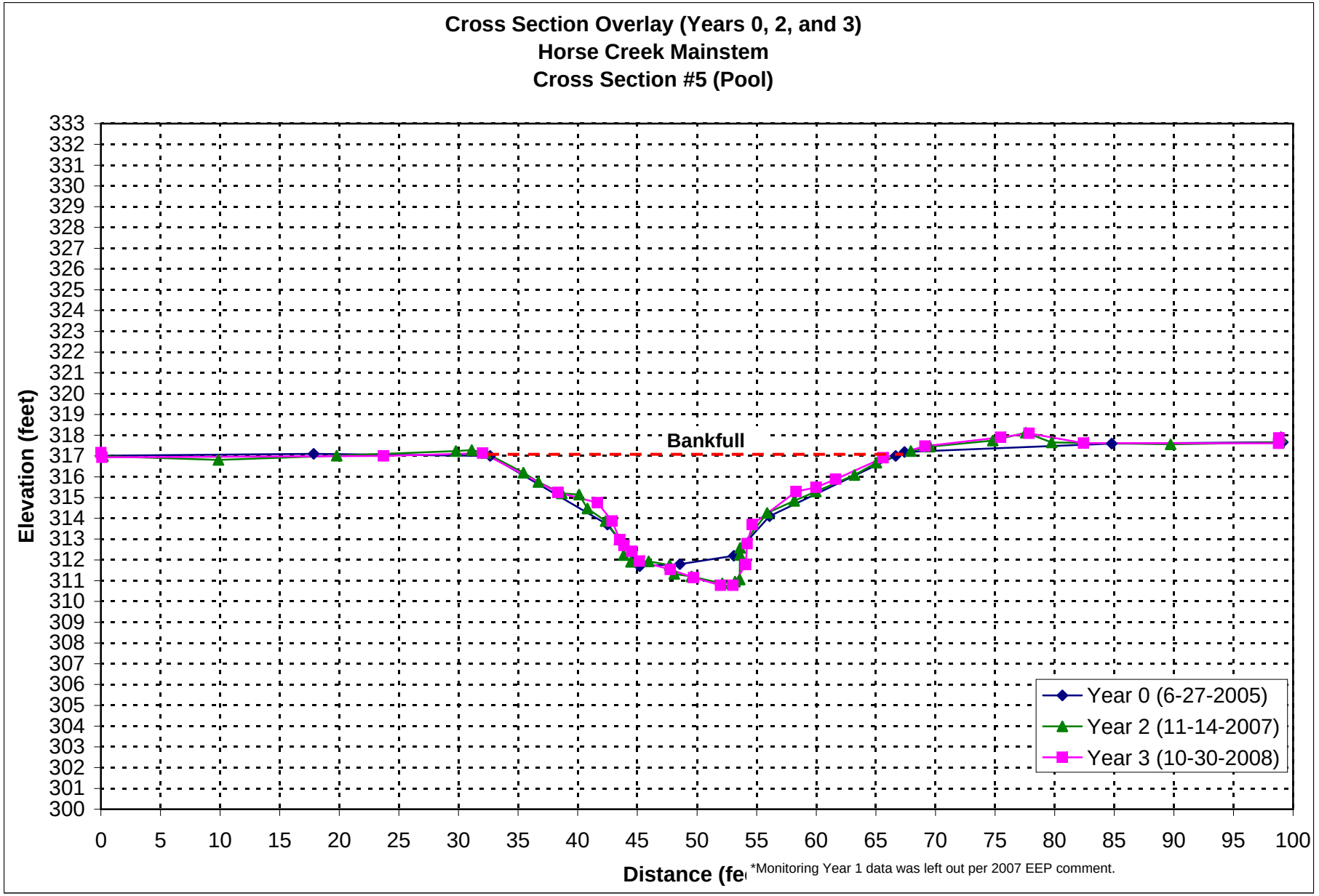
*Monitoring Year 1 data was left out per 2007 EEP comment.

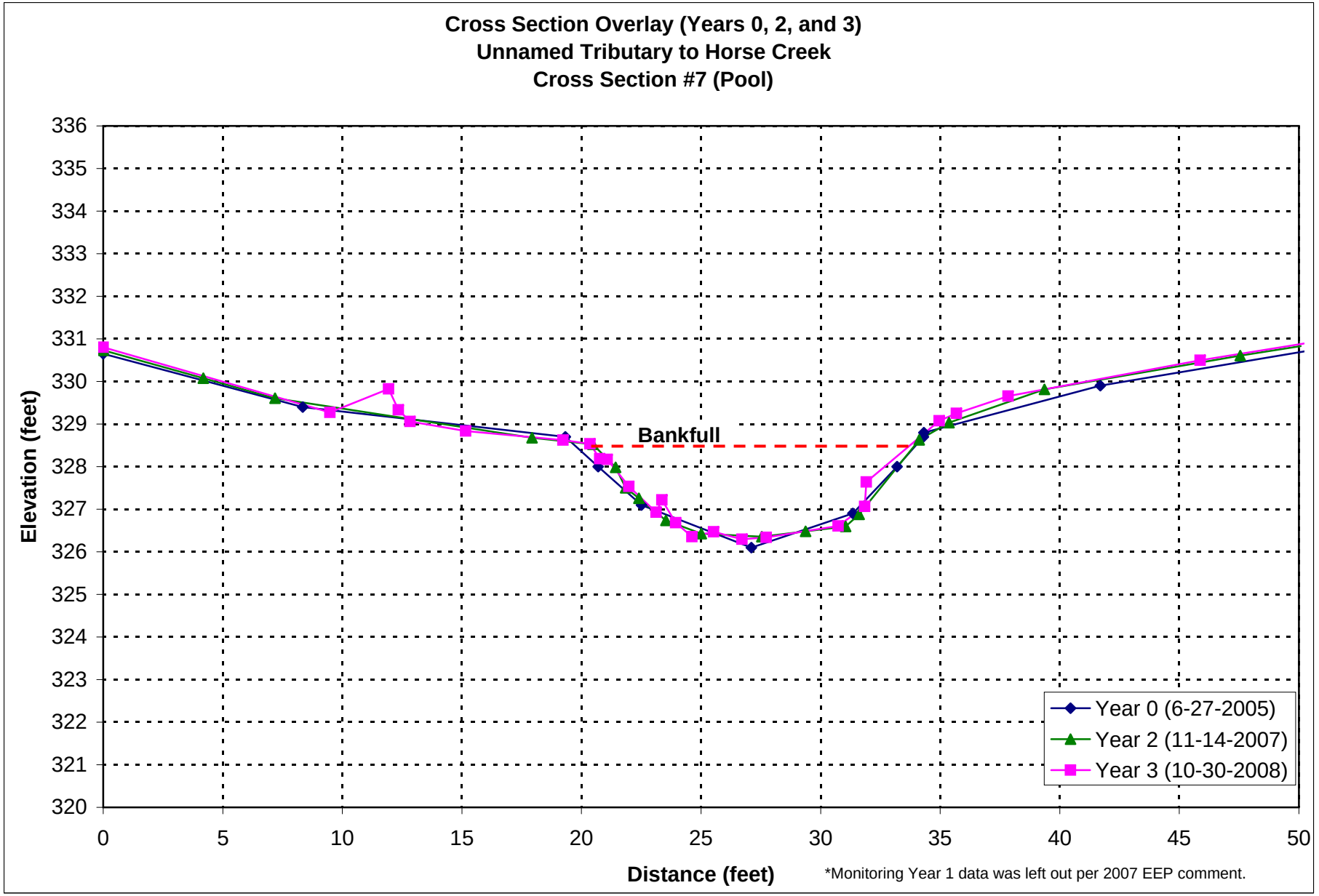
Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #4 (Riffle)

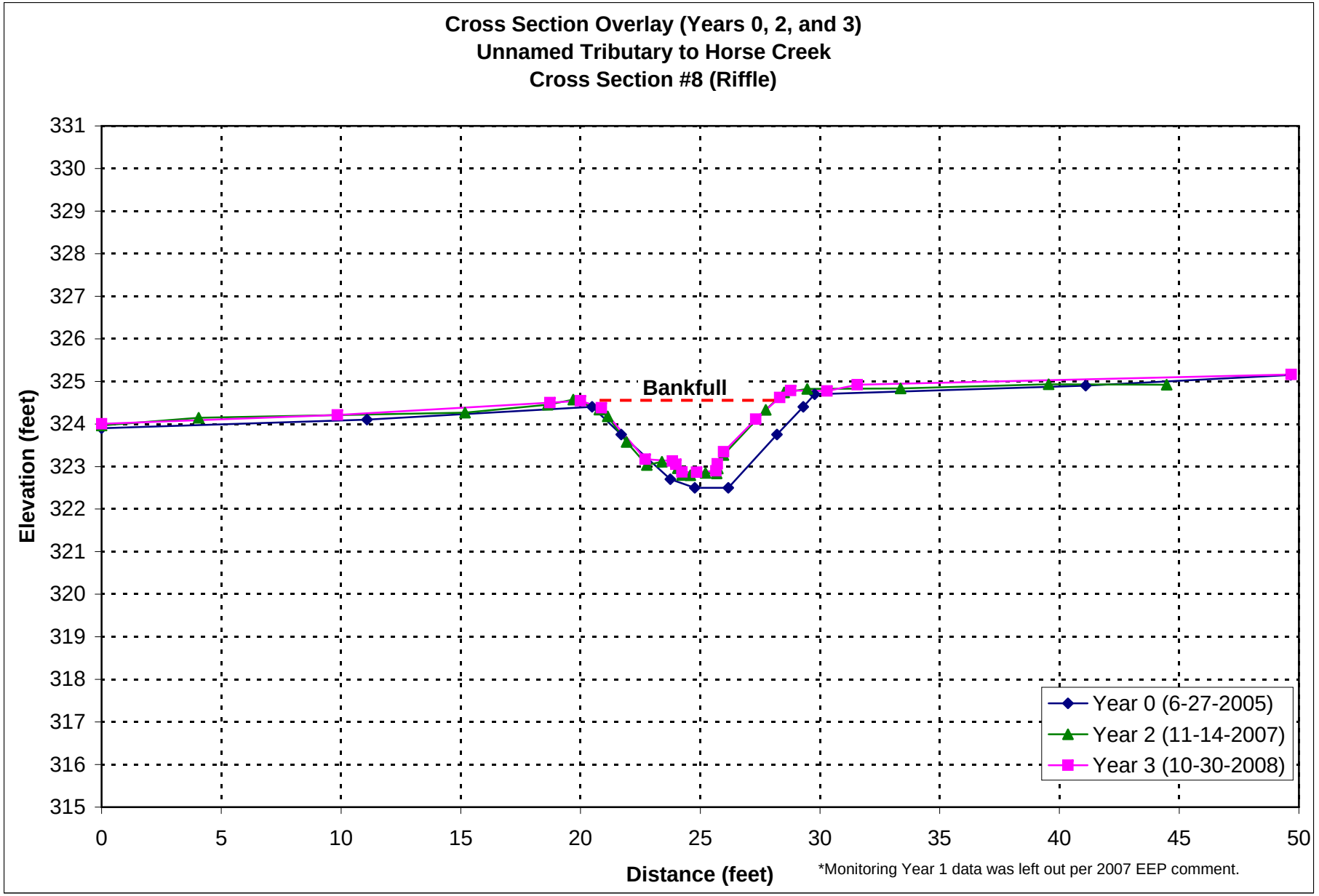


*Monitoring Year 1 data was left out per 2007 EEP comment.


Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #5 (Pool)
Elevation (feet)
333
332
331
330
329
328
327
326
325
324
323
322
321
320
319
318
317
316
315
314
313
312
311
310
309
308
307
306
305
304
303
302
301
300
Bankfull
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Distance (fe
Year 0 (6-27-2005)
Year 2 (11-14-2007)
Year 3 (10-30-2008)
*Monitoring Year 1 data was left out per 2007 EEP comment.


Cross Section Overlay (Years 0, 2, and 3)
Horse Creek Mainstem
Cross Section #5 (Pool)
Elevation (feet)
333
332
331
330
329
328
327
326
325
324
323
322
321
320
319
318
317
316
315
314
313
312
311
310
309
308
307
306
305
304
303
302
301
300
Bankfull
0
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
Distance (fe
Year 0 (6-27-2005)
Year 2 (11-14-2007)
Year 3 (10-30-2008)
*Monitoring Year 1 data was left out per 2007 EEP comment.


Cross Section Overlay (Years 0, 2, and 3)
Unnamed Tributary to Horse Creek
Cross Section #7 (Pool)
Elevation (feet)
336
335
334
333
332
331
330
329
328
327
326
325
324
323
322
321
320
Bankfull
0
5
10
15
20
25
30
35
40
45
50
Distance (feet)
Year 0 (6-27-2005)
Year 2 (11-14-2007)
Year 3 (10-30-2008)
*Monitoring Year 1 data was left out per 2007 EEP comment.


Cross Section Overlay (Years 0, 2, and 3)
Unnamed Tributary to Horse Creek
Cross Section #8 (Riffle)
Elevation (feet)
331
330
329
328
327
326
325
324
323
322
321
320
319
318
317
316
315
Bankfull
0
5
10
15
20
25
30
35
40
45
50
Distance (feet)
Year 0 (6-27-2005)
Year 2 (11-14-2007)
Year 3 (10-30-2008)
*Monitoring Year 1 data was left out per 2007 EEP comment.

Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION (Feet)	NOTES
0.00	322.03	
9.65	322.11	
19.64	322.11	
26.48	321.78	
29.67	321.20	
33.05	320.51	
40.00	318.24	
42.40	317.67	
43.89	316.13	
44.56	316.43	
45.14	315.64	
47.31	315.51	
49.74	315.32	
51.83	315.36	
54.07	314.71	
54.54	314.84	
55.40	315.68	
56.17	317.55	
56.73	318.00	
58.36	318.35	
59.90	318.88	
63.58	319.86	
70.02	322.48	
71.88	322.83	
76.21	323.22	
79.72	323.29	
89.58	323.72	
100.06	324.09	

Bankfull/Top of Bank Hydraulic Geometry

Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
0.0	0.0	0.00	0.0
3.4	0.7	3.45	1.2
7.0	3.0	7.31	12.7
2.4	3.5	2.47	7.8
1.5	5.1	2.14	6.4
0.7	4.8	0.74	3.3
0.6	5.6	0.98	3.0
2.2	5.7	2.17	12.2
2.4	5.9	2.44	14.1
2.1	5.8	2.09	12.3
2.2	6.5	2.33	13.8
0.5	6.4	0.49	3.0
0.9	5.5	1.20	5.1
0.8	3.7	2.02	3.5
0.6	3.2	0.72	1.9
1.6	2.8	1.67	4.9
1.5	2.3	1.63	4.0
3.7	1.3	3.81	6.7
3.1	0.0	3.38	2.1
TOTALS 37.0		41.0	118.1

SUMMARY DATA (BANKFULL)

A(BKF)	118.1	W(FPA)	100+
W(BKF)	37.0	WP	41.0
Max d	6.49	Hydraulic Radius	2.88
Mean d	3.19	Wetted Perimeter=	WP
W/D	11.6	Area=	A
Bank Height	7.07	Width=	W
Entrenchment	2.7+	Depth=	D
Stream Type	C/E	Bankfull=	BKF
Area from Rural Regional Curve			98.3

Bankfull datum* = 321.20

*Datum reset during Monitoring Year 2.

Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION (Feet)	NOTES
0.00	320.42	
12.52	320.08	
19.34	320.18	
30.15	319.60	
31.80	318.58	
35.27	316.87	
36.65	315.26	
37.44	314.47	
38.61	314.17	
42.20	314.63	
44.36	315.01	
48.93	316.07	
50.63	316.77	
52.57	317.43	
54.60	316.83	
57.04	318.02	
62.32	318.16	
67.61	319.51	
69.00	319.70	
79.70	320.15	
89.42	320.50	
98.18	320.35	
98.30	320.74	

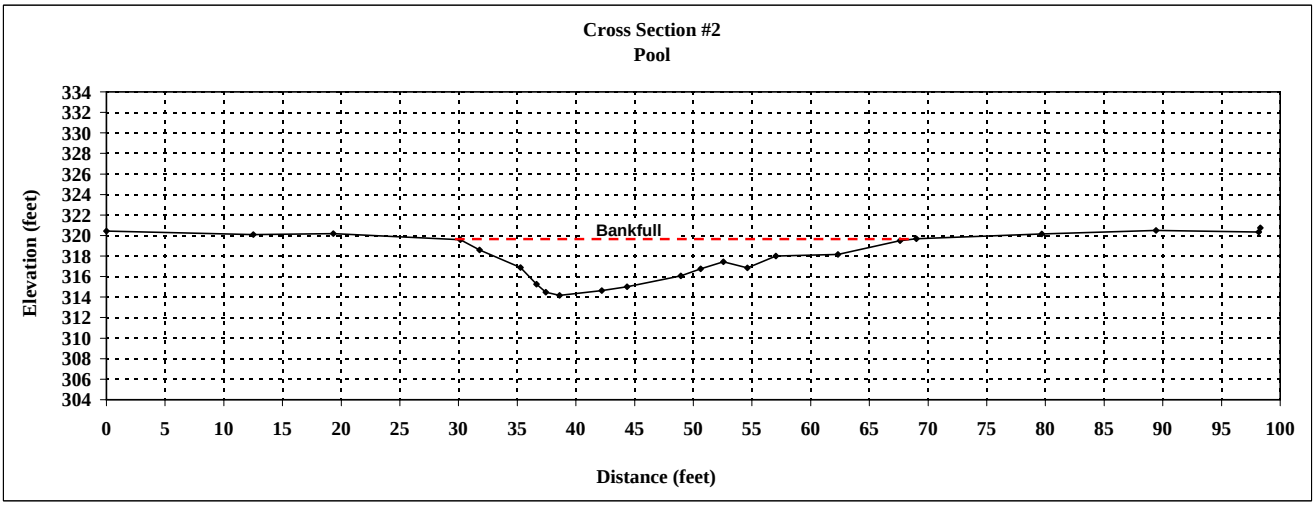
Bankfull/Top of Bank Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	0.1	0.0	0.15	0.0
	1.7	1.0	1.94	0.9
	3.5	2.8	3.87	6.6
	1.4	4.4	2.12	4.9
	0.8	5.2	1.12	3.8
	1.2	5.5	1.21	6.2
	3.6	5.0	3.62	18.8
	2.2	4.6	2.19	10.4
	4.6	3.6	4.69	18.7
	1.7	2.9	1.84	5.5
	1.9	2.2	2.05	4.9
	2.0	2.8	2.12	5.1
	2.4	1.6	2.71	5.4
	5.3	1.5	5.28	8.1
	5.3	0.1	5.46	4.2
	1.0	0.0	1.00	0.1
TOTALS	38.6		41.4	103.5

SUMMARY DATA

A(BKF)	103.5
W(BKF)	38.6
Max d	5.46
Mean d	2.68
Wet. P	41.4
Hyd. R	2.50

Bankfull datum* = 319.63
*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION (Feet)	NOTES
0.00	319.72	
0.00	319.56	
13.80	319.49	
24.59	319.14	
33.08	318.70	
42.55	316.41	
43.89	315.67	
45.40	314.38	
46.40	311.39	
47.02	310.92	
48.45	310.82	
49.78	310.90	
51.20	313.30	
52.29	311.76	
54.19	312.24	
56.64	313.68	
57.09	314.43	
57.50	316.40	
59.18	316.74	
59.96	317.20	
63.04	317.62	
66.07	318.21	
67.81	318.69	
69.83	318.87	
77.43	318.95	
97.47	319.83	
100.77	319.93	
100.78	320.15	

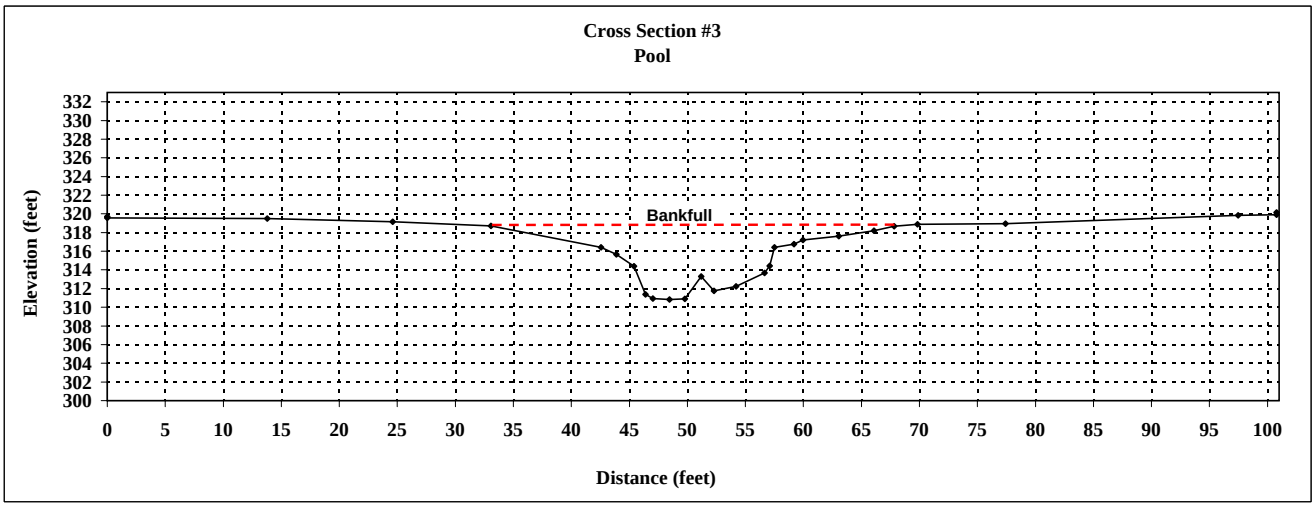
Bankfull/Top of Bank Hydraulic Geometry

	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	9.5	2.3	9.74	10.8
	1.3	3.0	1.53	3.6
	1.5	4.3	1.99	5.5
	1.0	7.3	3.15	5.8
	0.6	7.8	0.78	4.7
	1.4	7.9	1.43	11.2
	1.3	7.8	1.33	10.4
	1.4	5.4	2.79	9.4
	1.1	6.9	1.89	6.7
	1.9	6.5	1.96	12.7
	2.5	5.0	2.84	14.1
	0.5	4.3	0.87	2.1
	0.4	2.3	2.01	1.3
	1.7	2.0	1.71	3.6
	0.8	1.5	0.91	1.3
	3.1	1.1	3.11	4.0
	3.0	0.5	3.09	2.4
	1.7	0.0	1.81	0.4
	0.0	0.0	0.02	0.0
TOTALS	34.8		43.0	110.1

SUMMARY DATA

A(BKF)	110.1
W(BKF)	34.8
Max d	7.88
Mean d	3.17
Wet. P	43.0
Hyd. R	2.56

Bankfull datum* = 318.70
*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION* (Feet)	NOTES
0.00	318.71	
0.00	318.45	
25.15	318.42	
37.35	317.75	
42.28	317.65	
45.56	316.78	
49.01	315.88	
50.50	314.70	
51.62	313.34	
51.77	312.36	
53.55	311.32	
55.07	311.03	
55.76	311.07	
57.38	311.40	
59.71	312.14	
62.31	312.82	
63.98	313.36	
64.12	313.81	
67.24	315.24	
68.93	315.69	
71.30	315.72	
73.47	316.01	
78.55	317.78	
79.59	317.85	
80.90	318.11	
102.03	318.27	
102.06	318.75	

Bankfull/Top of Bank Hydraulic Geometry

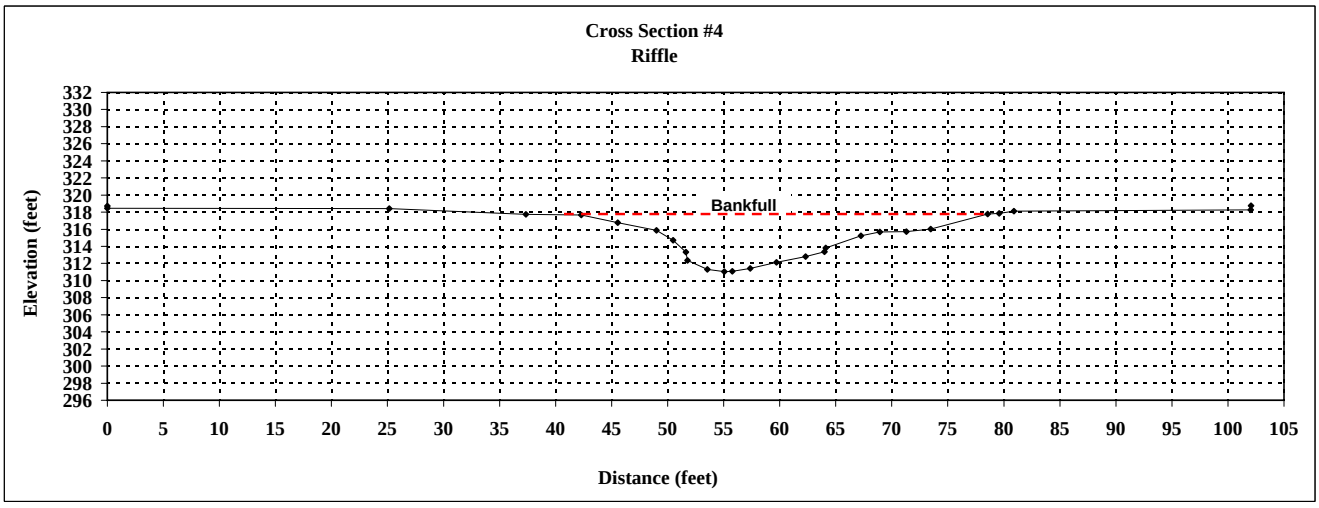
	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	2.3	0.0	2.28	0.0
	3.3	0.9	3.39	1.6
	3.5	1.8	3.57	4.7
	1.5	3.0	1.90	3.6
	1.1	4.3	1.76	4.1
	0.2	5.3	0.99	0.7
	1.8	6.4	2.06	10.4
	1.5	6.7	1.55	9.9
	0.7	6.6	0.69	4.6
	1.6	6.3	1.65	10.5
	2.3	5.6	2.44	13.8
	2.6	4.9	2.69	13.5
	1.7	4.3	1.76	7.7
	0.1	3.9	0.47	0.6
	3.1	2.5	3.43	9.9
	1.7	2.0	1.75	3.8
	2.4	2.0	2.37	4.7
	2.2	1.7	2.19	4.0
	4.9	0.0	5.21	4.1
TOTALS	38.4		42.2	112.1

SUMMARY DATA (BANKFULL)

A(BKF)	112.1	W(FPA)	100+
W(BKF)	38.4	WP	42.2
Max d	6.66	Hydraulic Radius	2.66
Mean d	2.92	Wetted Perimeter=	WP
W/D	13.2	Area=	A
Bank Height	6.74	Width=	W
Entrenchment	2.6+	Depth=	D
Stream Type	C	Bankfull=	BKF
Area from Rural Regional Curve			98.3

Bankfull datum* = 317.69

*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION* (Feet)	NOTES
0.00	317.16	
0.09	316.94	
23.70	317.01	
32.03	317.14	
38.33	315.24	
41.66	314.75	
42.89	313.87	
43.52	312.97	
43.87	312.69	
44.54	312.41	
45.17	311.94	
47.77	311.53	
49.72	311.15	
51.99	310.78	
53.01	310.78	
54.10	311.78	
54.21	312.78	
54.63	313.70	
58.30	315.29	
59.98	315.50	
61.63	315.88	
65.62	316.91	
69.13	317.48	
75.47	317.91	
77.85	318.09	
82.43	317.62	
98.79	317.61	
98.81	317.87	

Bankfull/Top of Bank Hydraulic Geometry

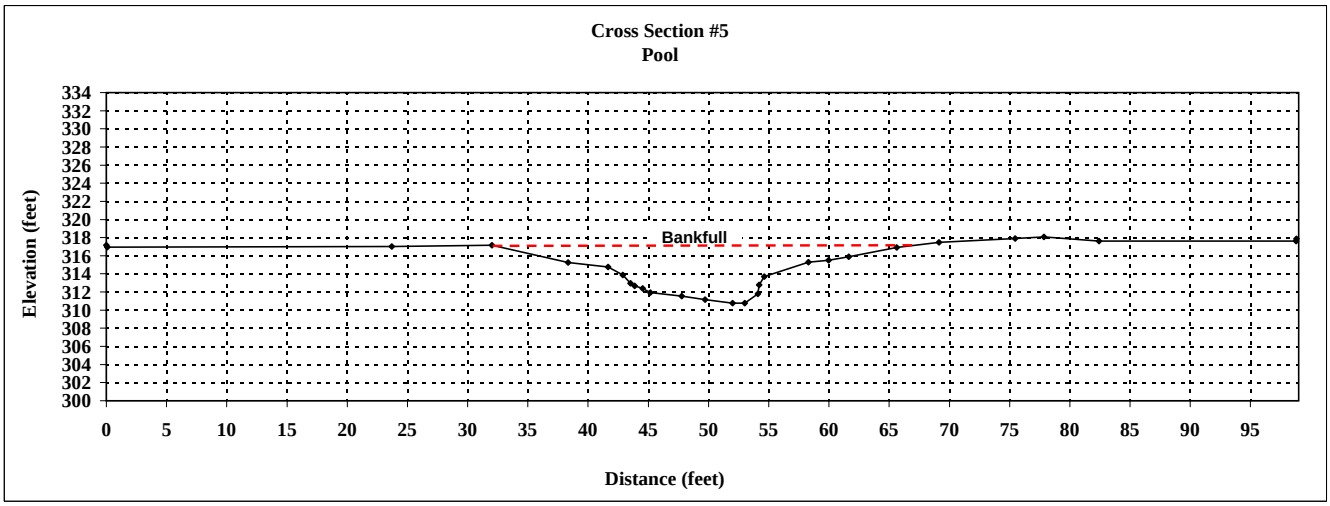
	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	6.3	1.9	6.58	6.0
	3.3	2.4	3.37	7.2
	1.2	3.3	1.51	3.5
	0.6	4.2	1.10	2.3
	0.3	4.5	0.45	1.5
	0.7	4.7	0.73	3.1
	0.6	5.2	0.79	3.1
	2.6	5.6	2.63	14.1
	2.0	6.0	1.99	11.3
	2.3	6.4	2.30	14.0
	1.0	6.4	1.02	6.5
	1.1	5.4	1.48	6.4
	0.1	4.4	1.01	0.5
	0.4	3.4	1.01	1.6
	3.7	1.9	4.00	9.7
	1.7	1.6	1.69	2.9
	1.7	1.3	1.69	2.4
	4.0	0.2	4.12	3.0
	1.5	0.0	1.50	0.2
TOTALS	35.1		39.0	99.4

SUMMARY DATA

A(BKF)	99.4
W(BKF)	35.1
Max d	6.37
Mean d	2.83
Wet. P	39.0
Hyd. R	2.55

Bankfull datum* = 317.14

*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION* (Feet)	NOTES
0.00	316.10	
0.08	315.88	
25.82	315.37	
39.83	316.05	
43.51	316.50	
45.51	316.29	
51.45	315.20	
52.47	314.89	
53.29	313.96	
53.30	311.38	
55.35	310.23	
56.88	310.48	
61.77	310.09	
62.43	310.28	
64.46	310.77	
65.18	311.00	
66.22	311.86	
66.30	312.26	
66.60	312.86	
67.73	313.36	
71.92	314.97	
73.13	315.04	
78.68	316.38	
80.34	316.64	
100.33	316.26	
100.43	316.54	

Bankfull/Top of Bank Hydraulic Geometry

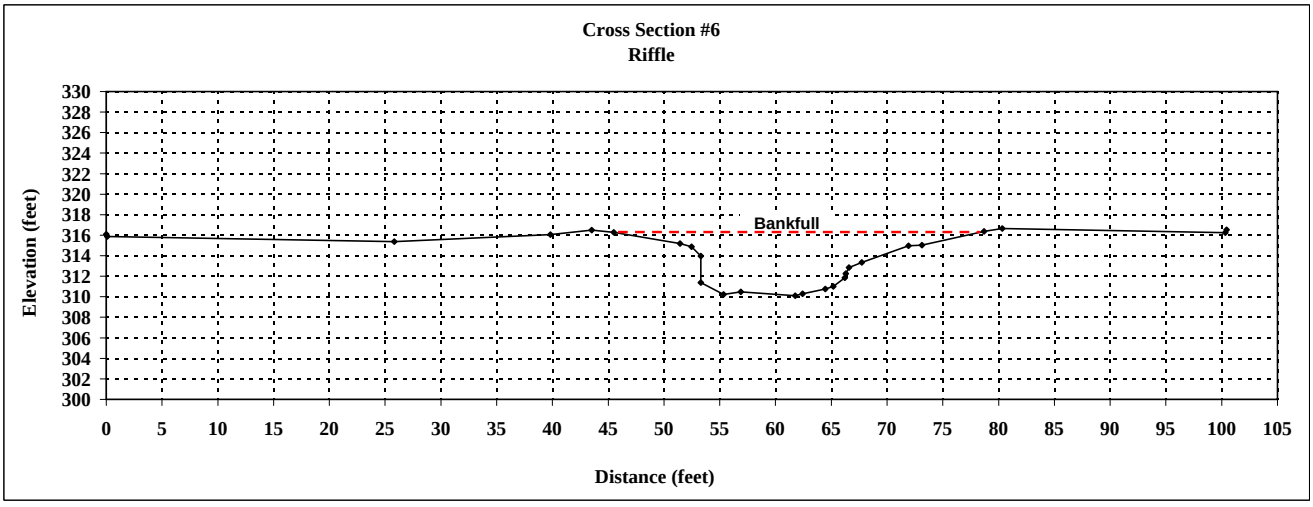
	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	0.6	0.0	0.56	0.0
	5.9	1.1	6.04	3.5
	1.0	1.4	1.07	1.3
	0.8	2.4	1.24	1.6
	0.0	4.9	2.58	0.0
	2.1	6.1	2.35	11.3
	1.5	5.9	1.55	9.1
	4.9	6.2	4.91	29.6
	0.7	6.1	0.69	4.1
	2.0	5.6	2.09	11.8
	0.7	5.3	0.75	3.9
	1.0	4.5	1.35	5.1
	0.1	4.1	0.40	0.3
	0.3	3.5	0.67	1.1
	1.1	3.0	1.24	3.6
	4.2	1.4	4.49	9.1
	1.2	1.3	1.21	1.6
	5.3	0.0	5.43	3.4
TOTALS	33.5		38.6	100.5

SUMMARY DATA (BANKFULL)

A(BKF)	100.5	W(FPA)	100+
W(BKF)	33.5	WP	38.6
Max d	6.24	Hydraulic Radius	2.60
Mean d	3.00	Wetted Perimeter=	WP
W/D	11.1	Area=	A
Bank Height	6.41	Width=	W
Entrenchment	3.0+	Depth=	D
Stream Type	C/E	Bankfull=	BKF
Area from Rural Regional Curve			98.3

Bankfull datum* = 316.33

*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION* (Feet)
0.00	330.80
9.48	329.27
11.94	329.82
12.34	329.34
12.83	329.06
15.16	328.84
19.23	328.62
20.36	328.54
20.77	328.19
21.08	328.17
21.98	327.54
23.12	326.93
23.36	327.22
23.94	326.69
24.62	326.36
25.53	326.47
26.71	326.30
27.73	326.34
30.73	326.60
31.84	327.06
31.91	327.64
34.96	329.08
35.68	329.25
37.84	329.66
45.87	330.50
50.21	330.89

NOTES

Bankfull/Top of Bank Hydraulic Geometry

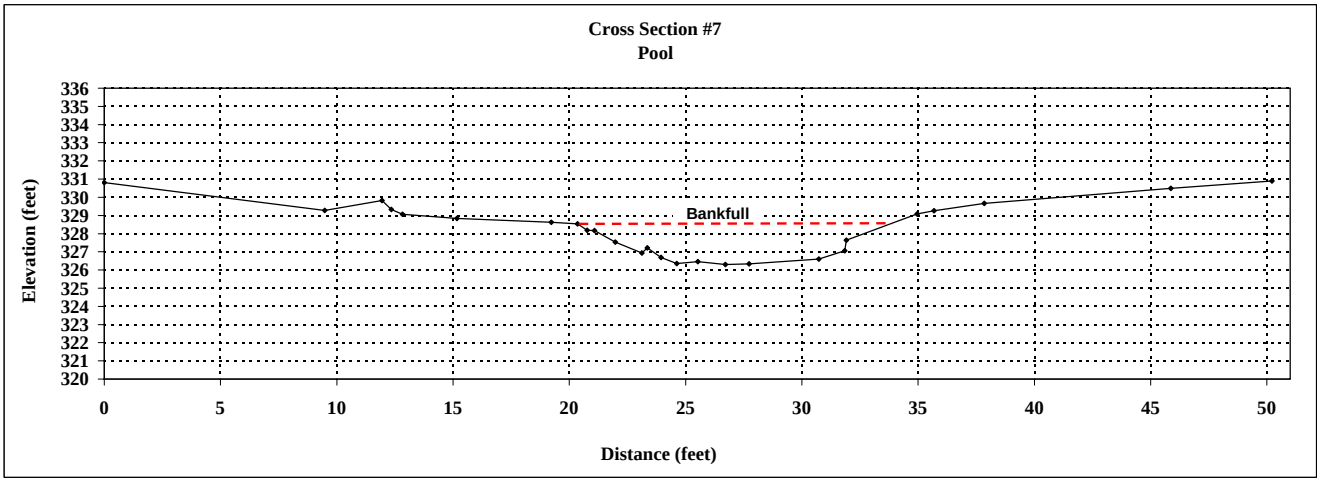
	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	0.4	0.3	0.50	0.1
	0.3	0.4	0.31	0.1
	0.9	1.0	1.10	0.6
	1.1	1.6	1.29	1.5
	0.2	1.3	0.38	0.3
	0.6	1.8	0.79	0.9
	0.7	2.2	0.76	1.4
	0.9	2.1	0.92	1.9
	1.2	2.2	1.19	2.5
	1.0	2.2	1.02	2.2
	3.0	1.9	3.01	6.1
	1.1	1.5	1.20	1.9
	0.1	0.9	0.58	0.1
	1.9	0.0	2.08	0.8
TOTALS	13.4		15.1	20.5

SUMMARY DATA

A(BKF)	20.5
W(BKF)	13.4
Max d	2.22
Mean d	1.53
Wet. P	15.1
Hyd. R	1.35

Bankfull datum* = 328.52

*Datum reset during Monitoring Year 2.



Field Crew:	IPJ and PDB
Stream Reach:	Horse Creek (WFCC)
Drainage Area:	7.9 mi^2
Date:	Oct-08
Monitoring Year	3

STATION (Feet)	ELEVATION* (Feet)
0.00	324.00
9.85	324.21
18.72	324.50
20.00	324.55
20.87	324.38
22.70	323.17
23.84	323.13
23.98	323.05
24.24	322.87
24.85	322.87
25.66	322.90
25.71	323.07
25.98	323.35
27.32	324.11
28.32	324.62
28.78	324.79
30.29	324.78
31.56	324.92
49.68	325.16

NOTES

Bankfull/Top of Bank Hydraulic Geometry

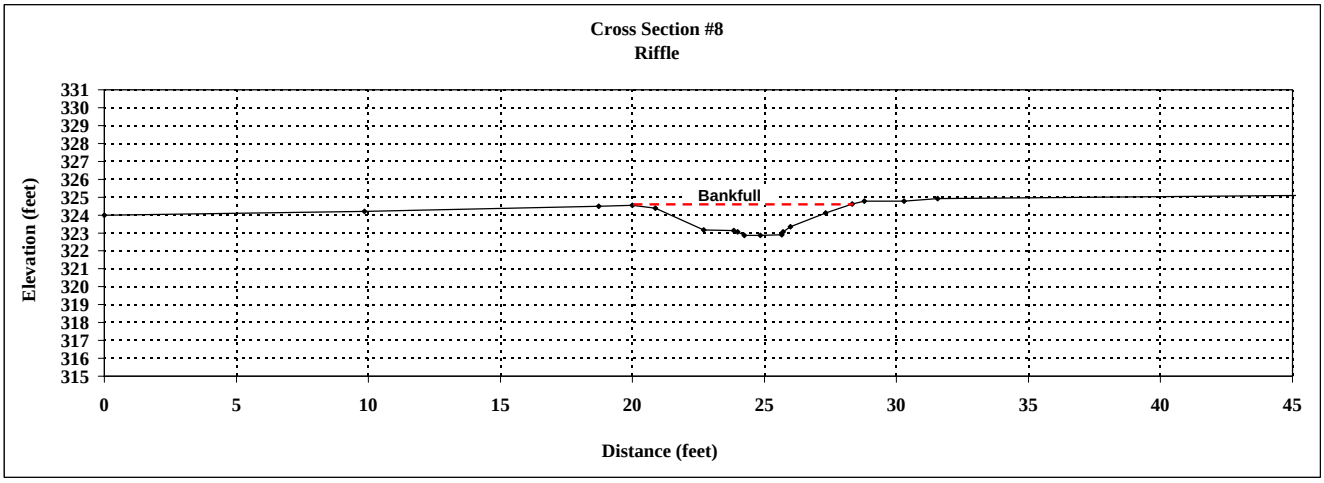
	Width (Feet)	Depth (Feet)	Perimeter (Feet)	Area (Sq. Ft.)
	0.0	0.0	0.00	0.0
	0.9	0.2	0.89	0.1
	1.8	1.4	2.19	1.5
	1.1	1.4	1.14	1.6
	0.1	1.5	0.16	0.2
	0.3	1.7	0.32	0.4
	0.6	1.7	0.61	1.0
	0.8	1.7	0.81	1.4
	0.1	1.5	0.17	0.1
	0.3	1.2	0.39	0.4
	1.3	0.5	1.54	1.1
	0.9	0.0	1.01	0.2
TOTALS	8.2		9.2	8.0

SUMMARY DATA (BANKFULL)

A(BKF)	8.0	W(FPA)	45+
W(BKF)	8.2	WP	9.2
Max d	1.70	Hydraulic Radius	0.86
Mean d	0.97	Wetted Perimeter=	WP
W/D	8.47	Area=	A
Bank Height	1.92	Width=	W
Entrenchment	5.5+	Depth=	D
Stream Type	E	Bankfull=	BKF
Area from Rural Regional Curve			98.3

Bankfull datum* = 324.57

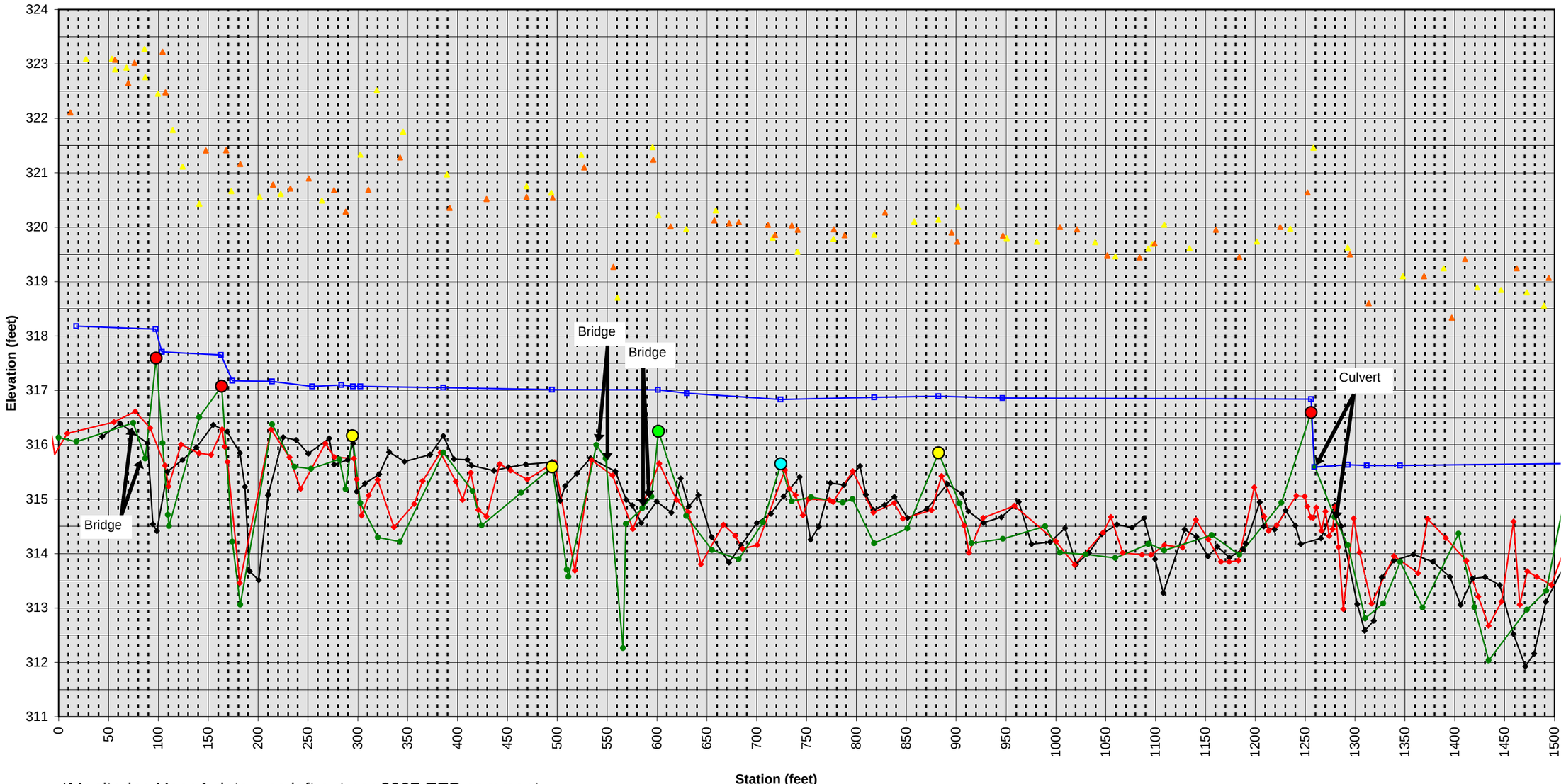
*Datum reset during Monitoring Year 2.



APPENDIX B5

STREAM LONGITUDINAL PROFILE

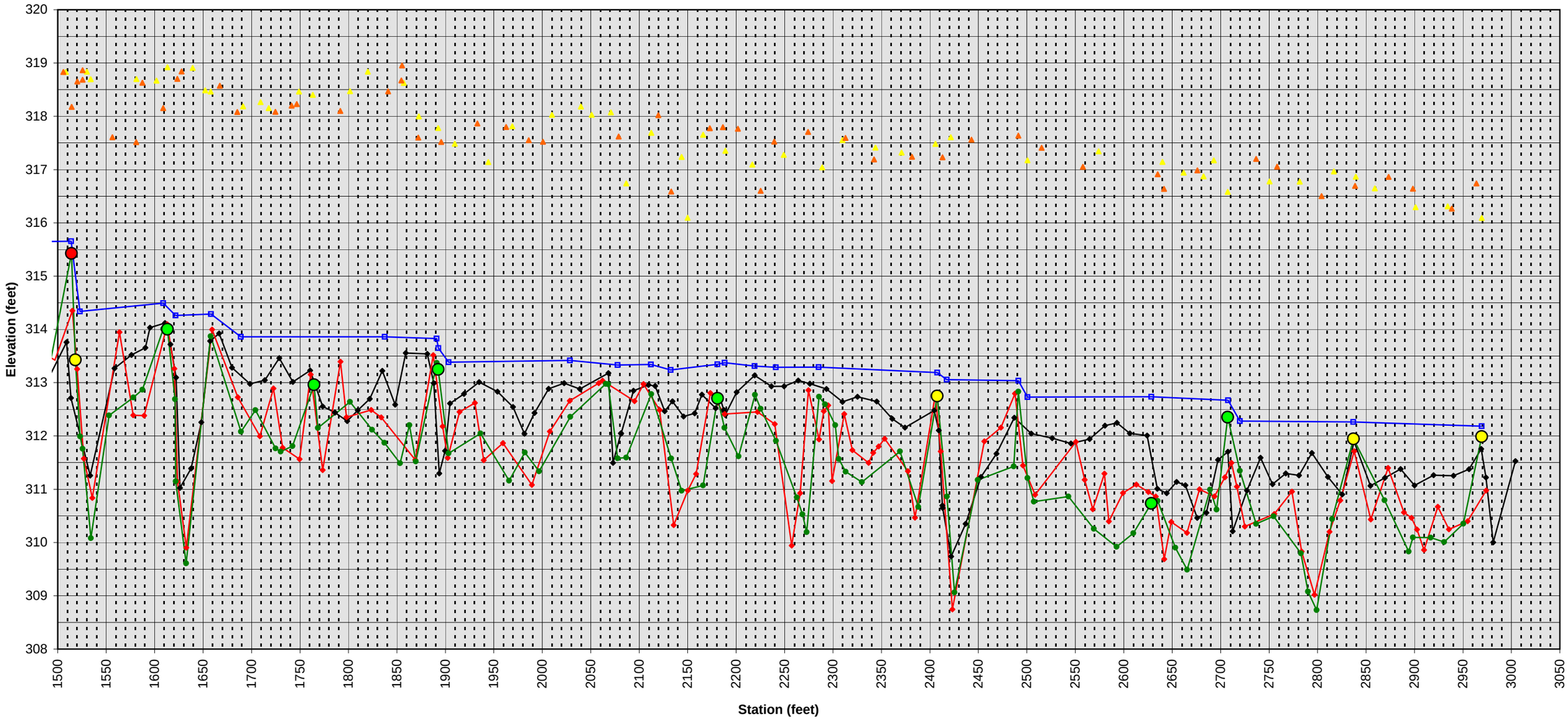
Longitudinal Profile Overlay (Years 0, 2, and 3)
Horse Creek Mainstem Page 1 of 2



*Monitoring Year 1 data was left out per 2007 EEP comment.

Thalweg Year 0 (6-27-2005)
Thalweg Year 2 (11-14-2007)
Thalweg Year 3 (10-30-2008)
Water Surface Year 3
Left Bankfull Year 3
Right Bankfull Year 3
Crossvane
Rock vane
J-hook
Beaver dam

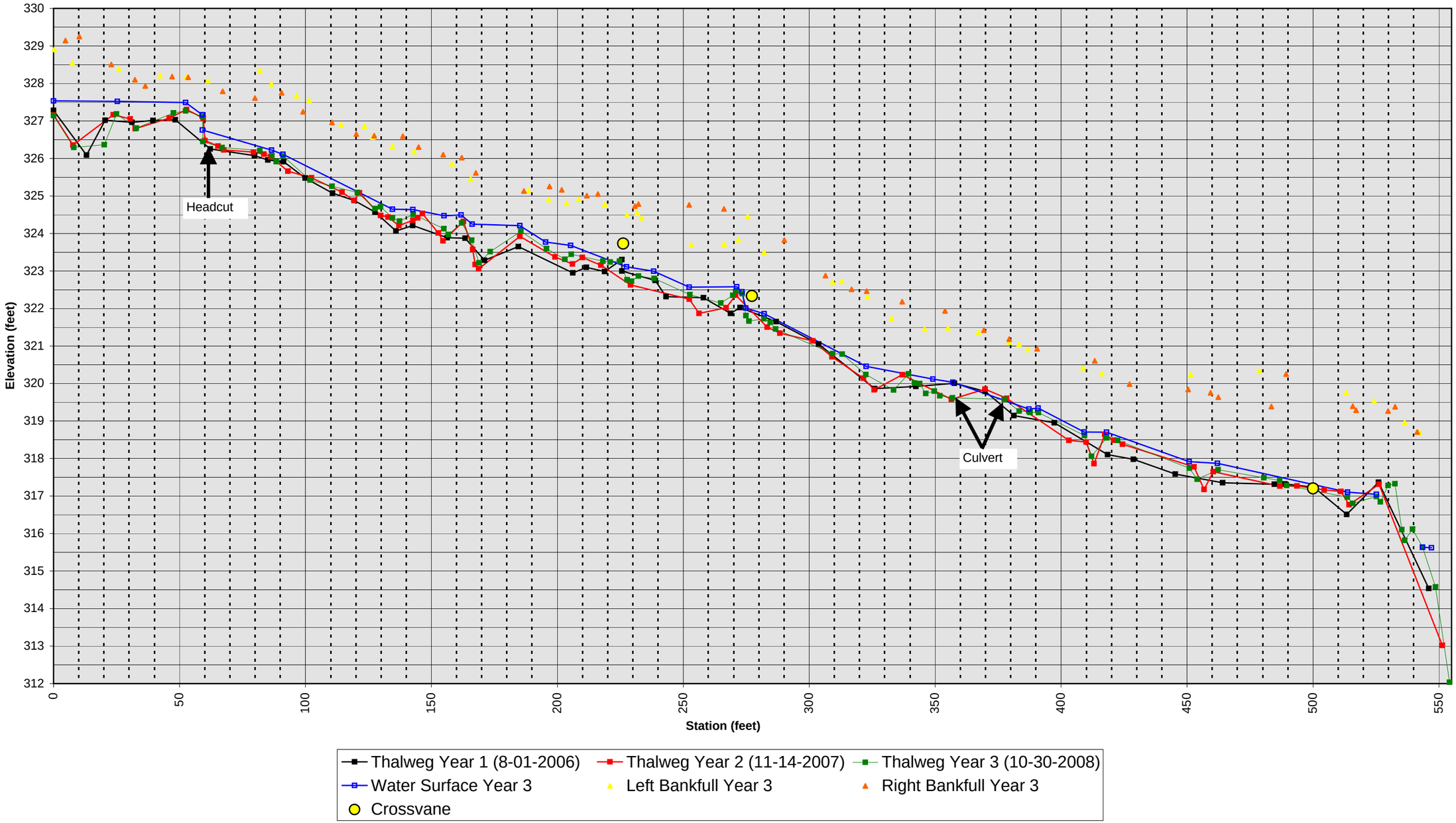
Longitudinal Profile Overlay (Years 0, 2, and 3)
Horse Creek Mainstem Page 2 of 2



*Monitoring Year 1 data was left out per 2007 EEP comment.

Thalweg Year 0 (6-27-2005)
Thalweg Year 2 (11-14-2007)
Thalweg Year 3 (10-30-2008)
Water Surface Year 3
Left Bankfull Year 3
Right Bankfull Year 3
Crossvane
J-hook
Beaver dam

Longitudinal Profile Overlay (Years 1 - 3)
UT to Horse Creek



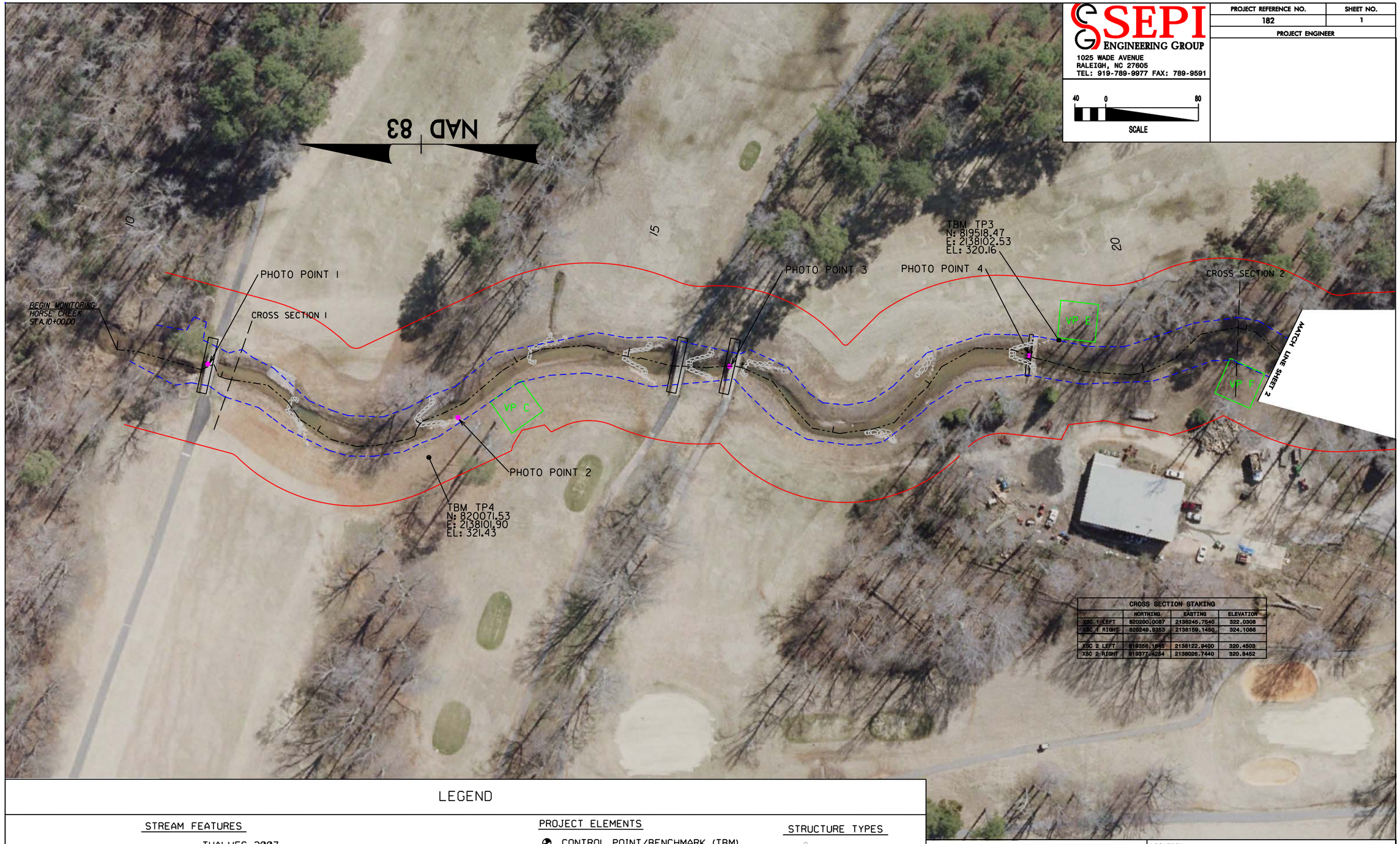
APPENDIX B6

STREAM PEBBLE COUNTS

At the request of EEP, pebble counts were not performed for Horse Creek or UT Horse Creek during Monitoring Year 3 because thse are sandbed streams.

APPENDIX C

PLAN VIEW SHEETS



CROSS SECTION STAKING			
	NORTHING	EASTING	ELEVATION
XSC 1 LEFT	820200.0087	2138245.7540	322.0308
XSC 1 RIGHT	820249.8353	2138159.1450	324.1086
XSC 2 LEFT	819356.1645	2138122.9400	320.4503
XSC 2 RIGHT	819377.4254	2138028.7440	320.8452

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

40 0 80
SCALE

PROJECT REFERENCE NO.	SHEET NO.
182	1
PROJECT ENGINEER	

LEGEND

STREAM FEATURES
- THALWEG 2007
- BANKFULL 2007

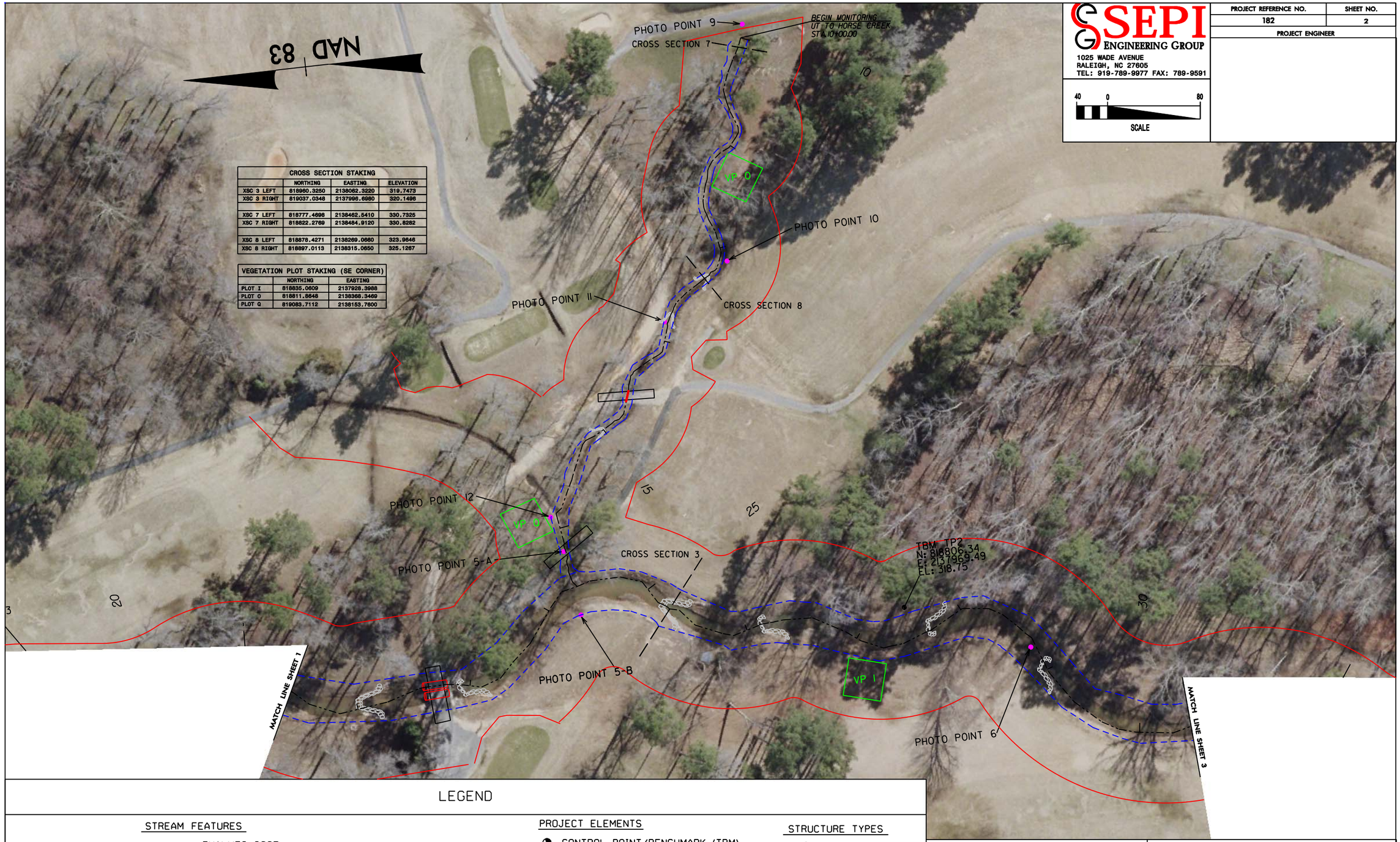
PROJECT ELEMENTS
- CONTROL POINT/BENCHMARK (TBM)
- PHOTO POINT
- VEGETATION PLOT WITH PHOTO CORNER (ARROW)
- CROSS-SECTIONS
- EASEMENT BOUNDARY
- CULVERT
- BRIDGE

STRUCTURE TYPES
- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

Ecosystem Enhancement Program

LOCATION:
HORSE CREEK
MONITORING PLAN VIEW
MONITORING YEAR 3

PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/04/09



CROSS SECTION STAKING			
	NORTHING	EASTING	ELEVATION
XSC 3 LEFT	818980.3250	2138062.3220	319.7473
XSC 3 RIGHT	819037.0348	2137966.6980	320.1496
XSC 7 LEFT	818777.4698	2138462.5410	330.7325
XSC 7 RIGHT	818822.2769	2138484.9120	330.8282
XSC 8 LEFT	818878.4271	2138269.0660	323.9646
XSC 8 RIGHT	818897.0113	2138315.0650	325.1267

VEGETATION PLOT STAKING (SE CORNER)		
	NORTHING	EASTING
PLOT I	818835.0609	2137928.3988
PLOT O	818811.8648	2138368.3469
PLOT Q	819083.7112	2138153.7600

LEGEND

STREAM FEATURES
- THALWEG 2007
- BANKFULL 2007

PROJECT ELEMENTS
- CONTROL POINT/BENCHMARK (TBM)
- PHOTO POINT
- VEGETATION PLOT WITH PHOTO CORNER (ARROW)
- CROSS-SECTIONS
- EASEMENT BOUNDARY
- CULVERT
- BRIDGE

STRUCTURE TYPES
- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

40 0 80
SCALE

PROJECT REFERENCE NO.	SHEET NO.
182	2
PROJECT ENGINEER	

Ecosystem Enhancement PROGRAM

LOCATION:
HORSE CREEK
MONITORING PLAN VIEW
MONITORING YEAR 3

PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/04/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	3
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83

30

35

MATCH LINE SHEET 2

CROSS SECTION 4

CREST GAUGE

PHOTO POINT 7

VP K

TBM TPI
N: 818305.79
E: 2137676.24
EL: 317.65

CROSS SECTION 5

VP L

PHOTO POINT 8

CROSS SECTION 6

END MONITORING
HORSE CREEK
STA.39+69.44

CROSS SECTION STAKING

	NORTHING	EASTING	ELEVATION
XSC 4 LEFT	818449.2500	2137813.8270	318.7794
XSC 4 RIGHT	818522.4458	2137742.6420	318.7754
XSC 5 LEFT	818067.7944	2137638.0080	317.1791
XSC 5 RIGHT	818116.3175	2137551.7400	317.9128
XSC 6 LEFT	817903.6403	2137472.8830	316.1166
XSC 6 RIGHT	817951.8580	2137384.5300	316.6470

LEGEND

STREAM FEATURES
- THALWEG 2007
- BANKFULL 2007

PROJECT ELEMENTS
- CONTROL POINT/BENCHMARK (TBM)
- PHOTO POINT
- VEGETATION PLOT WITH PHOTO CORNER (ARROW)
- CROSS-SECTIONS
- EASEMENT BOUNDARY
- CULVERT
- BRIDGE

STRUCTURE TYPES
- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

Ecosystem Enhancement PROGRAM

LOCATION: HORSE CREEK
MONITORING PLAN VIEW
MONITORING YEAR 3

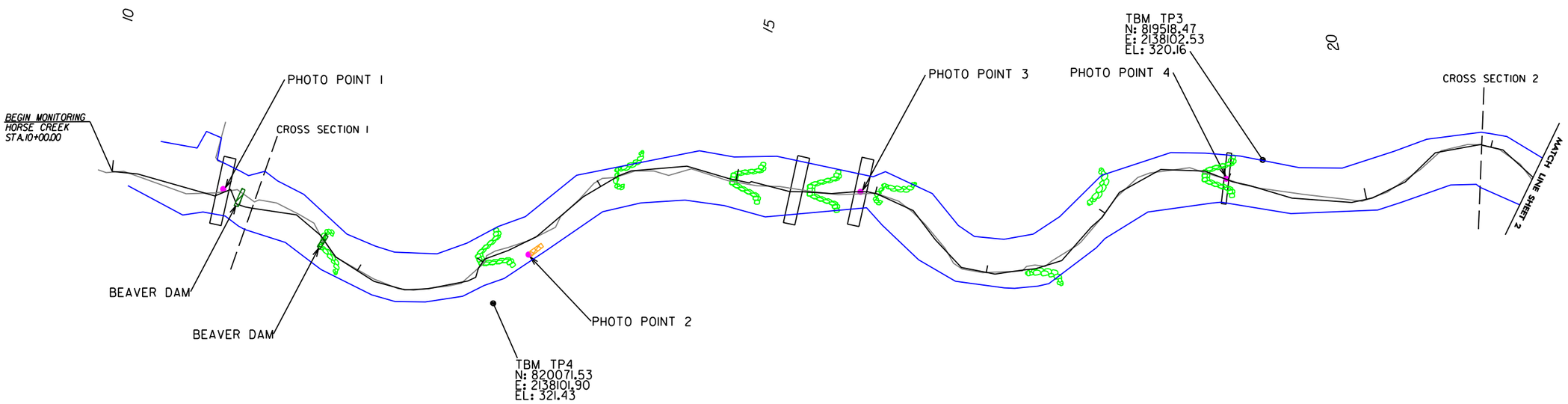
PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/04/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	1
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83



CROSS SECTION STAKING			
	NORTHING	EASTING	ELEVATION
XSC 1 LEFT	820200.0087	2138245.7540	322.0308
XSC 1 RIGHT	820249.8353	2138159.1450	324.1086
XSC 2 LEFT	819356.1645	2138122.9400	320.4503
XSC 2 RIGHT	819377.4254	2138026.7440	320.8452

LEGEND

- THALWEG 2007
- THALWEG 2008
- BANKFULL 2008
- CROSS-SECTIONS
- PHOTO POINT

- BANK EROSION
- SEVERE BANK EROSION
- AGGRADATION
- BAR FORMATION
- UNDERCUT BANK
- BEAVER DAM

STRUCTURE TYPES

COLOR CODE FOR STRUCTURES

- GOOD STRUCTURE
- STRUCTURE WITH POTENTIAL PROBLEM
- FAILING STRUCTURE

Ecosystem Enhancement PROGRAM

LOCATION:
HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
STREAM MONITORING - YEAR 3

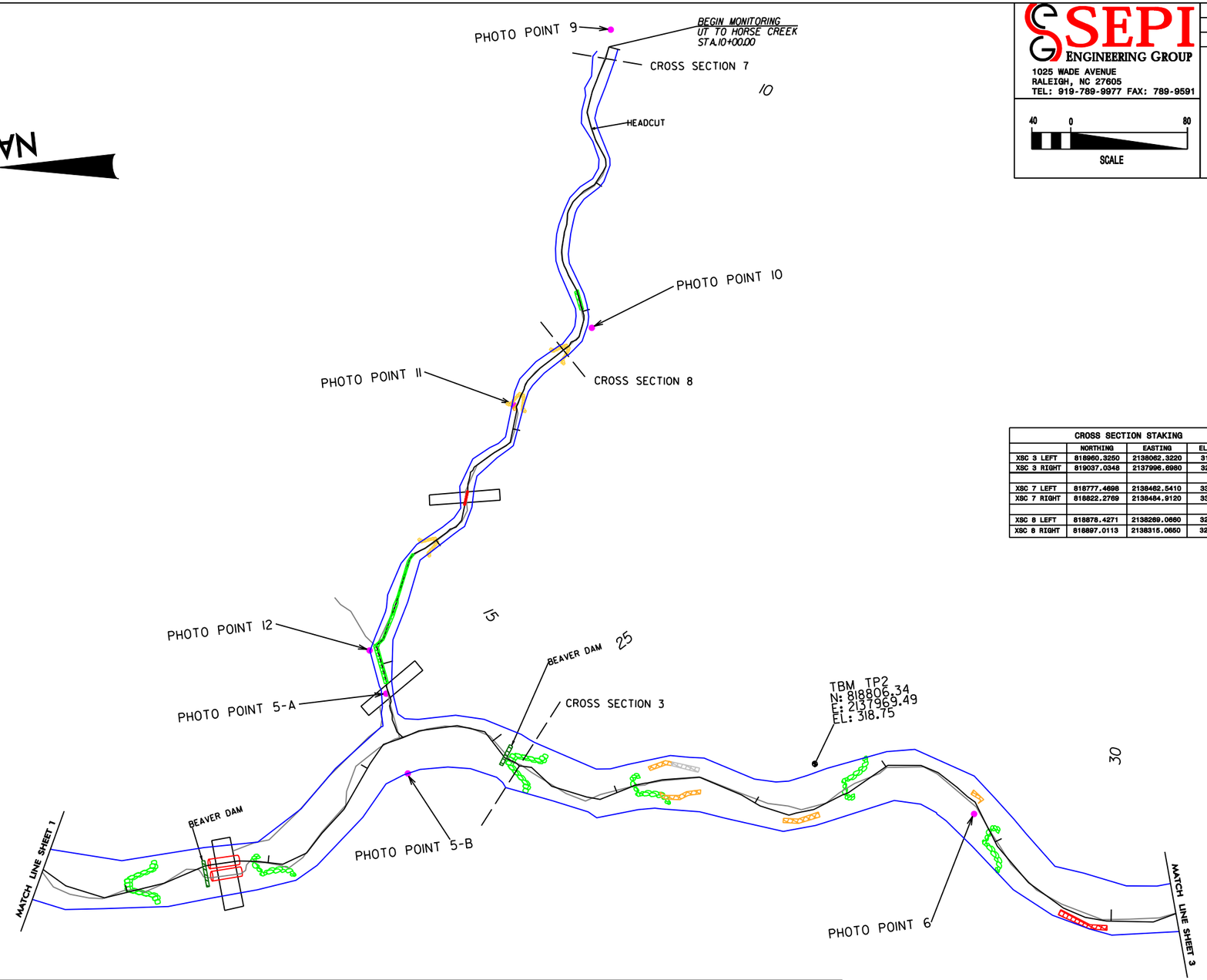
PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/10/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	2
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83



CROSS SECTION STAKING			
	NORTHING	EASTING	ELEVATION
XSC 3 LEFT	818960.3250	2138062.3220	319.7473
XSC 3 RIGHT	819037.0348	2137996.6980	320.1496
XSC 7 LEFT	818777.4698	2138462.5410	330.7325
XSC 7 RIGHT	818822.2769	2138484.9120	330.8282
XSC 8 LEFT	818878.4271	2138289.0660	323.9646
XSC 8 RIGHT	818897.0113	2138315.0650	325.1267

LEGEND

- THALWEG 2007
- THALWEG 2008
- BANKFULL 2008
- CROSS-SECTIONS
- PHOTO POINT

- BANK EROSION
- SEVERE BANK EROSION
- AGGRADATION
- BAR FORMATION
- UNDERCUT BANK
- BEAVER DAM

STRUCTURE TYPES

- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

COLOR CODE FOR STRUCTURES

- GOOD STRUCTURE
- STRUCTURE WITH POTENTIAL PROBLEM
- FAILING STRUCTURE

Ecosystem Enhancement PROGRAM

LOCATION:
HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
STREAM MONITORING - YEAR 3

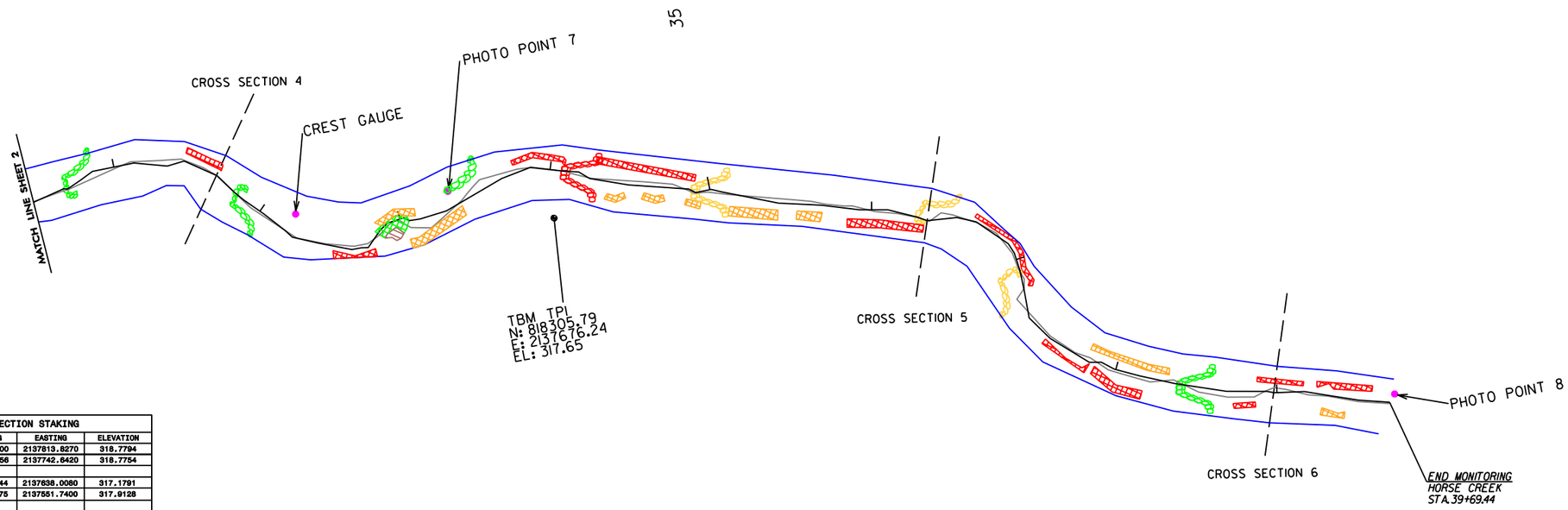
PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/10/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	3
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83



CROSS SECTION STAKING			
	NORTHING	EASTING	ELEVATION
XSC 4 LEFT	818449.2500	2137813.8270	318.7794
XSC 4 RIGHT	818522.4456	2137742.6420	318.7754
XSC 5 LEFT	818067.7944	2137638.0080	317.1791
XSC 5 RIGHT	818116.3175	2137551.7400	317.9128
XSC 6 LEFT	817903.6403	2137472.8830	316.1166
XSC 6 RIGHT	817951.8580	2137384.5300	316.6470

LEGEND

THALWEG 2007
THALWEG 2008
BANKFULL 2008
CROSS-SECTIONS
PHOTO POINT

BANK EROSION
SEVERE BANK EROSION
AGGRADATION
BAR FORMATION
UNDERCUT BANK
BEAVER DAM

STRUCTURE TYPES
ROCK CROSS VANE
J-HOOK VANE
ROOTWAD
ROCK VANE

COLOR CODE FOR STRUCTURES
GOOD STRUCTURE
STRUCTURE WITH POTENTIAL PROBLEM
FAILING STRUCTURE

Ecosystem Enhancement PROGRAM

LOCATION: HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
STREAM MONITORING - YEAR 3

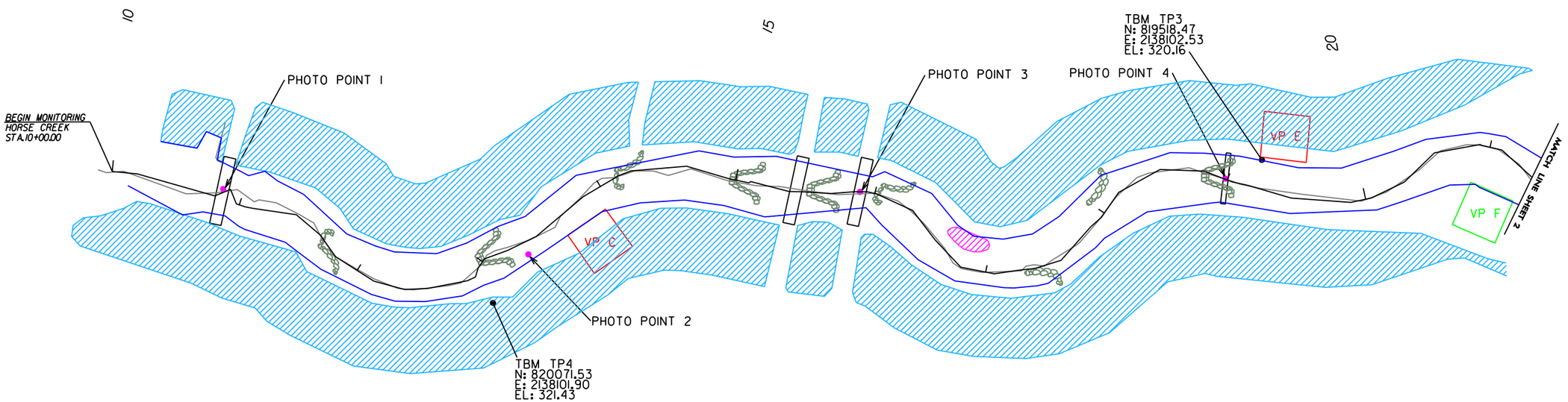
PROJ #:	COUNTY:
182	WAKE
PREPARED BY: IPJ	
CHECKED BY: PDB	DATE: 2/10/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	1
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83



VEGETATION PLOT STAKING (SE CORNER)		
	NORTHING	EASTING
PLOT C	819981.3041	2138152.7109
PLOT E	819479.2526	2138126.5801
PLOT F	819349.1988	2138041.6765

LEGEND

THALWEG 2007
THALWEG 2008
BANKFULL 2008
PHOTO POINT
VEGETATION PLOT
VEGETATION PLOT NOT MEETING SUCCESS REQUIREMENTS

STRUCTURE TYPES

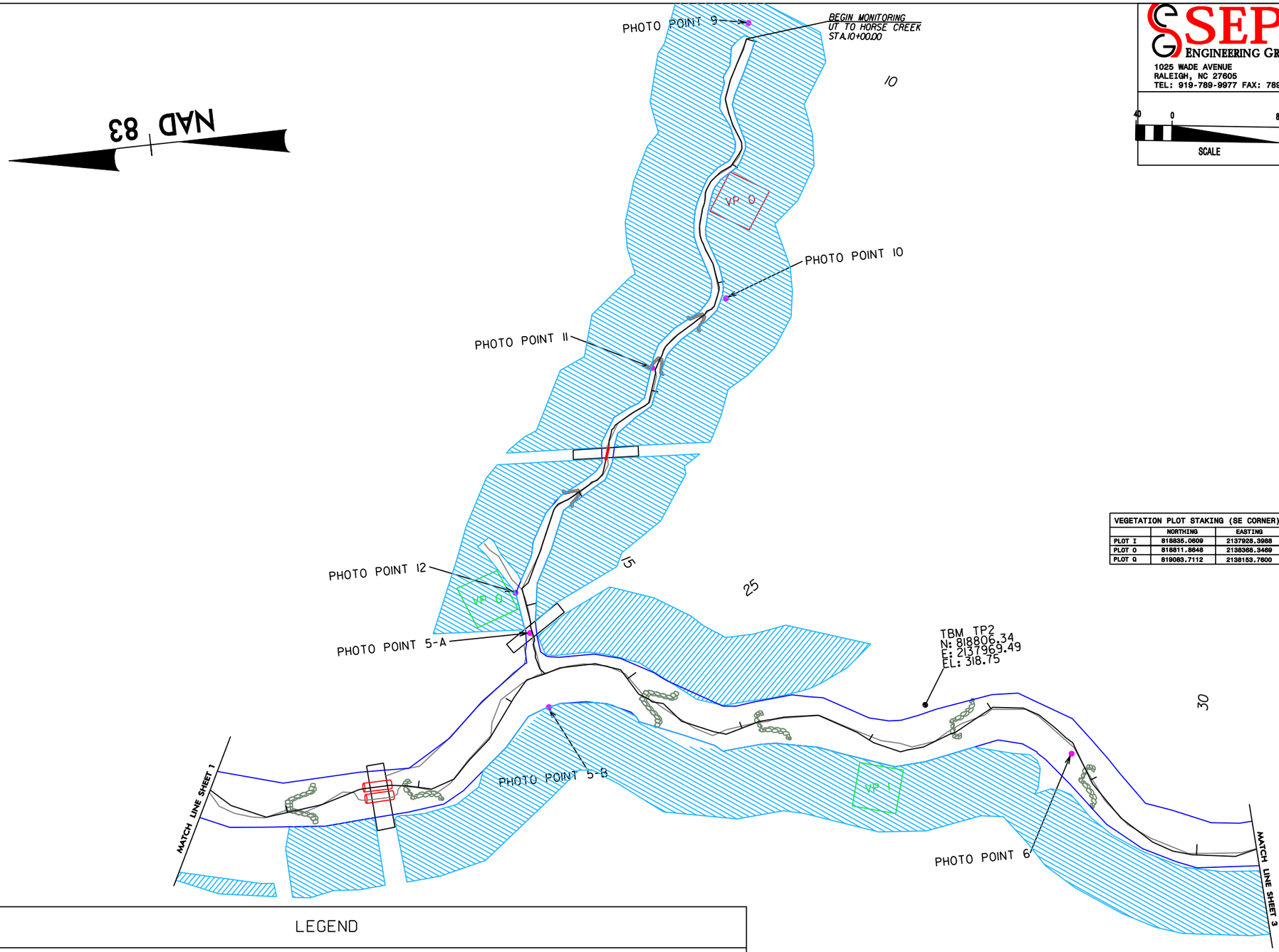
ROCK CROSS VANE
J-HOOK VANE
ROOTWAD
ROCK VANE

BARE BENCH/BANK
PAST MOWING/MAINTENANCE WITHIN EASEMENT
LIGUSTRUM SINENSE PRESENT

Ecosystem Enhancement PROGRAM

LOCATION:
HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
VEGETATION ASSESSMENT - YEAR 3

PROJ #: 182
COUNTY: WAKE
MONITORED BY: IPJ
CHECKED BY: PDB
DATE: 2/10/09



VEGETATION PLOT STAKING (SE CORNER)		
	NORTHING	EASTING
PLOT I	818835.0609	2137928.3988
PLOT O	818611.8648	2138388.3469
PLOT Q	819083.7112	2138153.7600

LEGEND

- THALWEG 2007
- THALWEG 2008
- BANKFULL 2008
- PHOTO POINT
- VEGETATION PLOT
- VEGETATION PLOT NOT MEETING SUCCESS REQUIREMENTS

STRUCTURE TYPES

- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

- BARE BENCH/BANK
- PAST MOWING/MAINTENANCE WITHIN EASEMENT
- *LIGUSTRUM SINENSE* PRESENT

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

SCALE: 40 0 80

PROJECT REFERENCE NO.	SHEET NO.
182	2
PROJECT ENGINEER	

Ecosystem Enhancement Program

LOCATION:
HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
VEGETATION ASSESSMENT - YEAR 3

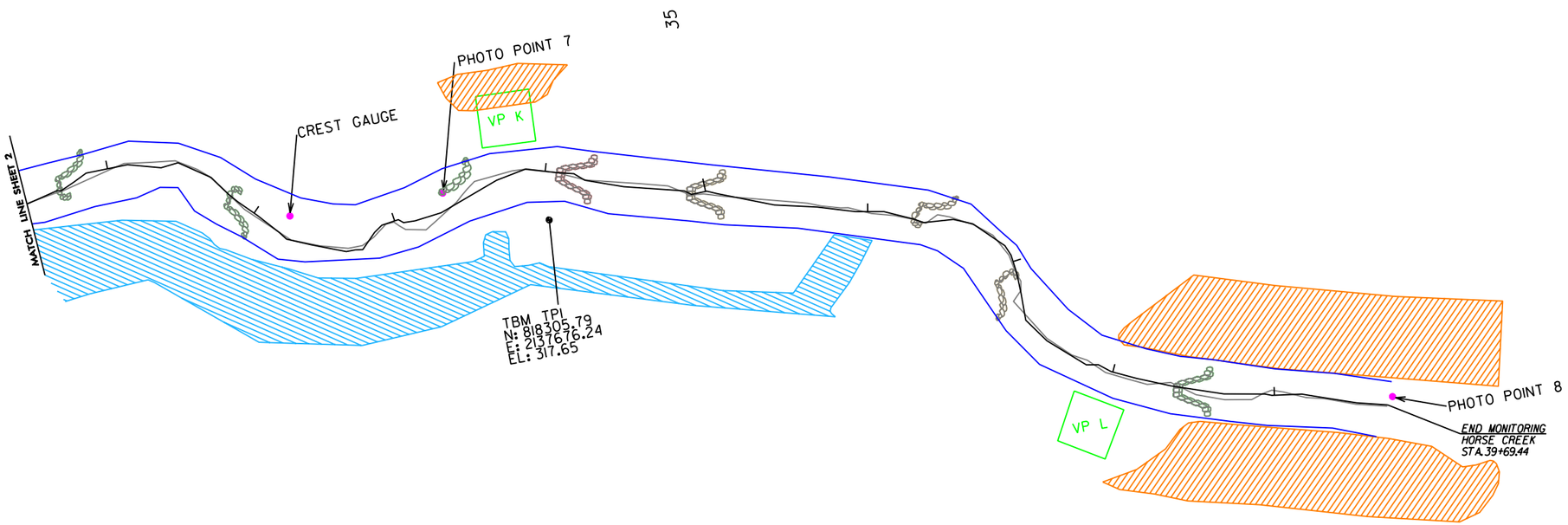
PROJ #: 182
COUNTY: WAKE
MONITORED BY: IPJ
CHECKED BY: PDB
DATE: 2/10/09

SEPI ENGINEERING GROUP
1025 WADE AVENUE
RALEIGH, NC 27605
TEL: 919-789-9977 FAX: 789-9591

PROJECT REFERENCE NO.	SHEET NO.
182	3
PROJECT ENGINEER	

40 0 80
SCALE

NAD 83



VEGETATION PLOT STAKING (SE CORNER)		
	NORTHING	EASTING
PLOT K	818288.7506	2137755.1659
PLOT L	818020.3080	2137442.3498

LEGEND

- THALWEG 2007
- THALWEG 2008
- BANKFULL 2008
- PHOTO POINT
- VEGETATION PLOT
- VEGETATION PLOT NOT MEETING SUCCESS REQUIREMENTS

STRUCTURE TYPES

- ROCK CROSS VANE
- J-HOOK VANE
- ROOTWAD
- ROCK VANE

- BARE BENCH/BANK
- PAST MOWING/MAINTENANCE WITHIN EASEMENT
- *LIGUSTRUM SINENSE* PRESENT

Ecosystem Enhancement PROGRAM

LOCATION:
HORSE CREEK
CURRENT CONDITIONS PLAN VIEW
VEGETATION ASSESSMENT - YEAR 3

PROJ #:	COUNTY:
182	WAKE
MONITORED BY: IPJ	
CHECKED BY: PDB	DATE: 2/10/09