

***ANNUAL MONITORING REPORT  
YEAR 3 (2010) ANNUAL MONITORING***

**BROWN MARSH SWAMP STREAM AND WETLAND  
RESTORATION SITE**

Robeson County, North Carolina

Hydrologic Unit 03040204037010 of the Lumber River Basin

Contract No. 16-D06038



Prepared for:



**NCDENR-Ecosystem Enhancement Program**

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## EXECUTIVE SUMMARY

The Brown Marsh Swamp Restoration Site (Site) is located one mile east of the North Carolina and South Carolina state line, and is approximately 15 miles southwest of the Town of Lumberton, in Robeson County. The Site is situated due east of the intersection of Cotton Valley Road and McCormick Road, approximately one mile south of Interstate 95. The Site is located within United States Geological Survey (USGS) Hydrologic Unit and Targeted Local Watershed 03040204037010 (North Carolina Division of Water Quality Subbasin 03-07-55) of the Lumber River Basin and will service the USGS 8-digit Cataloging Unit 03040204. The Site was identified to assist the North Carolina Ecosystem Enhancement Program in meeting its stream and wetland restoration goals.

Primary activities at the Site included 1) stream restoration, 2) wetland restoration, 3) soil scarification, and 4) plant community restoration. Project restoration efforts provided 5004 Stream Mitigation Units and 5.0 Nonriverine Wetland Mitigation Units.

Seventeen vegetation plots (10-10 meters by 10 meters and 7-20 meters by 5 meters in size) were established and permanently monumented. These plots were surveyed in August 2010 for the Year 3 (2010) monitoring season. Based on the number of stems counted, average densities were measured at 793 planted stems per acre surviving in Year 3 (2010). The dominant species identified at the Site were planted stems of silky dogwood (*Cornus amomum*), elm (*Ulmus* sp.), green ash (*Fraxinus pennsylvanica*), overcup oak (*Quercus lyrata*), cherrybark oak (*Quercus pagoda*), and swamp chestnut oak (*Quercus michauxii*), and natural recruits of red maple (*Acer rubrum*). No vegetation problem areas were noted during the Year 3 (2010) monitoring season.

Twenty cross-sections and longitudinal profiles within five 600-foot reaches were measured for the Year 3 (2010) monitoring season. As a whole, monitoring measurements indicate minimal changes in both the longitudinal profile and cross-sections as compared to as-built data. The channel geometry compares favorably with the emulated, stable E/C type stream reach as set forth in the detailed mitigation plan and as constructed. Current monitoring has demonstrated dimension, pattern, and profile were stable over the course of the monitoring period. No stream problem areas were noted during Year 3 (2010) monitoring.

Two onsite groundwater gauges and one reference groundwater gauge were maintained for the Year 3 (2010) monitoring season. Monitoring Gauge 2 was inundated/saturated within 12 inches of the surface for greater than 12.5 percent of the growing season while Gauge 1 was just shy of success criteria with inundation/saturation within 12 inches of the surface for 11.8 percent of the growing season. In addition, the reference gauge did not meet success criteria for the Year 3 (2010) monitoring season and rainfall was well-below normal for the month of April. No wetland problem areas were noted during Year 3 (2010) monitoring.

In summary, the Site achieved success criteria for vegetation, stream, and hydrology attributes in the Third Monitoring Year (2010).

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## 1.0 PROJECT BACKGROUND

### 1.1 Location and Setting

The Site is located one mile east of the North Carolina and South Carolina state line, and approximately 3.2 miles southeast of the town of Rowland (Figure 1). The center of the Site has a latitude and longitude of 034° 29' 31.85" N and 079° 16' 26.87" W. The Site is situated due east of the intersection of Cotton Valley Road (SR 2492) and McCormick Road (SR 2491), approximately one mile south of Interstate 95. The Site is located within United States Geological Survey (USGS) Hydrologic Unit and Targeted Local Watershed 03040204037010 (North Carolina Division of Water Quality [NCDWQ] Subbasin 03-07-55) of the Lumber River Basin and will service the USGS 8-digit Cataloging Unit 03040204 (USGS 1974, NCWRP 2003). The Site was identified to assist the North Carolina Ecosystem Enhancement Program (EEP) in meeting its stream and wetland restoration goals.

Directions to the Site from Raleigh, North Carolina, are as follows:

- Take Interstate 40 East for approximately 18 miles to Interstate Highway 95 (I-95) South
- Take I-95 South for approximately 80 miles to Exit 2, North Carolina Highway 130 (NC-130)
- Take a left/travel south on NC-130 for approximately 0.1 mile to Cotton Valley Road (SR 2492) and turn right
- Follow Cotton Valley Road for approximately 2 miles
- The project is south of Cotton Valley Road and east of McCormick Road (SR 2491)

### 1.2 Project Objectives

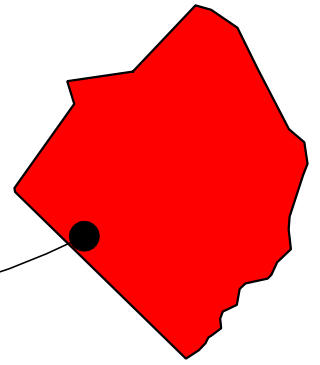
The primary components of the restoration project included 1) construction of a stable, riffle-pool stream channel; 2) enhancement of water quality functions within, upstream, and downstream of the Site; 3) creation of a natural vegetated buffer along restored stream channels; 4) restoration of jurisdictional nonriverine wetlands in the Site; 5) improvement of aquatic habitat and species diversity by enhancing stream bed variability; and 6) restoration of wildlife functions associated with a riparian corridor/stable stream.

### 1.3 Project Structure, Restoration Type, and Approach

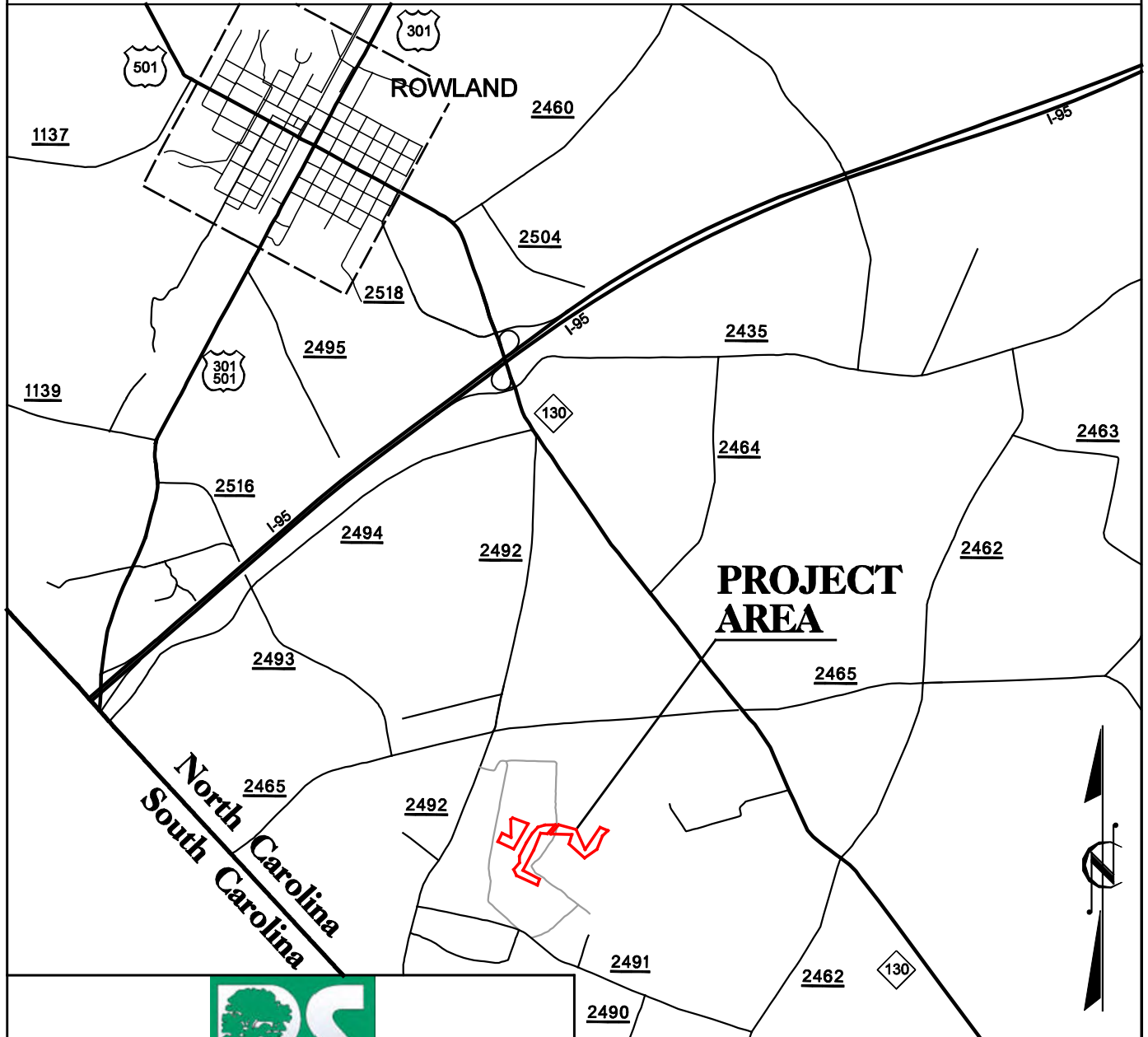
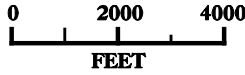
A 20.25-acre conservation easement has been placed on the Site to incorporate all restoration activities. The Site contains 5.0 acres of hydric soils, two first-order unnamed tributaries (UTs) to Contrary Swamp (Northern UT and Southern UT), associated floodplain, and upland slopes. The purpose of this project was to restore stable pattern, dimension, and profile to the UTs; restore hydrology to drained nonriverine wetlands; and revegetate streams, floodplains, wetlands, and upland slopes within the Site. The contributing watershed is characterized primarily by agricultural row crop production and pine plantation/forest land. Preproject Site conditions consisted of agricultural row crop production. Land use modifications including the removal of riparian vegetation, straightening and dredging of stream channels, and ditching of floodplain wetlands resulted in degraded water quality and unstable channel characteristics (stream entrenchment, erosion, and bank collapse).

The primary goals of this stream and wetland restoration project focused on improving water quality, decreasing floodwater levels, and restoring aquatic and riparian habitat. These goals were accomplished by:

# Robeson County North Carolina



## PROJECT AREA



## Vicinity Map

Brown Marsh Swamp  
Robeson County, North Carolina



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Date: 11/07/08

Figure: 1

- Reducing nonpoint sources of pollution associated with agricultural land uses by providing a forested buffer adjacent to streams to treat surface runoff.
- Reestablishing stream stability and the capacity to transport watershed flows and sediment loads by restoring stable dimension, pattern, and profile.
- Promoting floodwater attenuation by;
  - excavating a floodplain at a new bankfull elevation;
  - restoring a secondary, entrenched tributary thereby reducing floodwater velocities within smaller catchment basins;
  - increasing storage capacity for floodwaters within the Site limits; and
  - revegetating floodplains to increase frictional resistance on floodwaters.
- Improving aquatic habitat by enhancing stream bed variability, restoring a riffle-pool complex, and by incorporating grade control/habitat structures.
- Providing wildlife habitat including a forested riparian corridor within an area highly dissected by agricultural land uses.

Primary activities at the Site included 1) stream restoration, 2) wetland restoration, 3) soil scarification, and 4) plant community restoration. Table 1 describes the Site restoration structures and objectives, which have provided 5004 Stream Mitigation Units (SMUs) and 5.0 Nonriverine Wetland Mitigation Units (WMUs).

- Restored 5004 linear feet of two unnamed tributaries to Contrary Swamp (Northern UT and Southern UT) by constructing moderately sinuous, E-type channels on new location.
- Restored 5.0 acres of nonriverine wetland within the interstream flat filling ditches, removing elevated spoil, thereby reestablishing historic water table elevations.
- Reforested approximately 20.05 acres of floodplain, stream bank, upland slopes, and nonriverine wetlands with native forest species.

**Table 1. Site Restoration Structures and Objectives**

Restoration Segment/ Reach ID	Station Range	Restoration Type/Approach*	Existing Linear Footage/ Acreage	Designed Linear Footage/Acreage	SMU/WMUs
Northern UT	10+00 – 54+65	Restoration/PII	2700	4,465	4465
Southern UT	10+00 – 15+39	Restoration/PII	442	539	539
Nonriverine Wetlands	--	Restoration	5.0	5.0	5.0
<b>Mitigation Unit Summations</b>					
<b>Stream</b>	<b>Nonriverine Wetland</b>				
5004 SMUs	5.0 WMUs				

\*PII=Priority 2

#### 1.4 Project History and Background

Completed project activities, reporting history, completion dates, project contacts, and background information are summarized in Tables 2-4.



**Table 2. Project Activity and Reporting History**

<b>Activity or Report</b>	<b>Data Collection Completion</b>	<b>Actual Completion or Delivery</b>
Restoration Plan	November 2006	December 2006
Final Design (~90%)	NA	July 2007
Construction Completion	NA	November 2007
Site Planting	NA	January 2008
Mitigation Plan/As-builts	February 2008	April 2008
Year 1 Monitoring (2008)	November 2008	November 2008
Supplemental Planting	NA	Early 2009
Year 2 Monitoring (2009)	November 2009	November 2009
Year 3 Monitoring (2010)	November 2010	November 2010

**Table 3. Project Contacts Table**

<b>Full Delivery Provider</b>	Restoration Systems 1101 Haynes Street, Suite 211 Raleigh, North Carolina 27604 George Howard and John Preyer (919) 755-9490
<b>Designer and Monitoring Performer (Streams and Groundwater Hydrology)</b>	Ko & Associates, P.C. 1011 Schaub Drive, Suite 202 Raleigh, North Carolina 27606 Kevin Williams (919) 851-6066
<b>Construction Contractor</b>	Land Mechanics Designs, Inc. Lloyd Glover 126 Circle G Lane Willow Springs, North Carolina 27592 (919) 639-6132
<b>Planting Contractor</b>	Carolina Silvics 908 Indian Trail Road Edenton, North Carolina 27932 Dwight McKinney (252) 482-8491
<b>Monitoring Performer (Vegetation)</b>	Axiom Environmental, Inc. 20 Enterprise Street, Suite 7 Raleigh, North Carolina 27607 Grant Lewis (919) 215-1693

**Table 4. Project Background Table**

Project County	Robeson County, North Carolina
Drainage Area	Northern UT - 1.13 square miles Southern UT - 0.18 square mile
Drainage impervious cover estimate (%)	< 1
Stream Order	Second
Physiographic Region	Coastal Plain
Ecoregion	Southeastern Plains, Atlantic Southern Loam Plains
Rosgen Classification of As-built	E-/C-type
Dominant Soil Types	Trebloc, Nahunta, Exum, Faceville
Reference Site ID	Mill Creek, UT to Wildcat Branch, UT to Hog Swamp
USGS HUC	03040204
NCDWQ Subbasin	03-07-55
NCDWQ Classification	C Sw (Stream Index # 14-35-2)
Any portion of any project segment 303d listed?	No
Any portion of any project segment upstream of a 303d listed segment?	No
Reasons for 303d listing or stressor	Not Applicable
% of project easement fenced	0%

### 1.5 Monitoring Plan View

Monitoring activities for the Site, including relevant structures and utilities, project features, specific project structures, and monitoring features are detailed in the monitoring plan view in Appendix D. Site features including vegetation, stream dimension (cross-sections), stream profile and pattern, wetland hydrology, and photographic documentation were monitored in Year 3 (2010).

## 2.0 PROJECT CONDITION AND MONITORING RESULTS

### 2.1 Vegetation Assessment

Following Site construction, seventeen plots (10-10 meters by 10 meters and 7-20 meters by 5 meters in size) were established and monumented with metal fence posts at all plot corners and PVC at each plot origin. Sampling was conducted as outlined in the *CVS-EEP Protocol for Recording Vegetation, Version 4.0* (Lee et al. 2006) (<http://cvs.bio.unc.edu/methods.htm>); results are included in Appendix A. The taxonomic standard for vegetation used for this document was *Flora of the Carolinas, Virginia, Georgia, and Surrounding Areas* (Weakley 2007). The locations of vegetation monitoring plots were placed to accurately represent the entire Site and are depicted on the monitoring plan view in Appendix D.

#### 2.1.1 Vegetation Success Criteria

Success criteria have been established to verify that the vegetation component supports community elements necessary for forest development. Success criteria are dependent upon the density and growth of characteristic forest species. Additional success criteria are dependent upon density and growth of “Character Tree Species.” Character Tree Species include planted species, species identified through visual inventory of an approved reference (relatively undisturbed) forest community used to orient the Site design, and appropriate community descriptions from *Classification of the Natural Communities of North Carolina* (Schafale and Weakley 1990) including Coastal Plain Small Stream Swamp and

Nonriverine Wet Hardwood Forest. All canopy tree species planted and identified in the reference forest will be utilized to define “Character Tree Species” as termed in the success criteria. Table 5 below outlines planted and reference forest species.

**Table 5. Planted and Reference Forest Ecosystem**

<b>Planted and Reference Forest Ecosystem Character Tree Species</b>
Red maple ( <i>Acer rubrum</i> )
Ironwood ( <i>Carpinus caroliniana</i> )
Green ash ( <i>Fraxinus pennsylvanica</i> )
American holly ( <i>Ilex opaca</i> )
Sweetgum ( <i>Liquidambar styraciflua</i> )
Tulip poplar ( <i>Liriodendron tulipifera</i> )
Water tupelo ( <i>Nyssa biflora</i> )
Laurel oak ( <i>Quercus laurifolia</i> )
Swamp chestnut oak ( <i>Quercus michauxii</i> )
Water oak ( <i>Quercus nigra</i> )
American elm ( <i>Ulmus americana</i> )

Success criteria dictate that an average density of 320 stems per acre of Character Tree Species must be surviving in the first three monitoring years. Subsequently, 290 Character Tree Species per acre must be surviving in year 4 and 260 Character Tree Species per acre in year 5.

### 2.1.2 Vegetative Problem Areas

During Year 1 (2008) monitoring, vegetation sampling across the Site was above the required average density with 476 stems per acre of Character Tree Species surviving; however, five of the seventeen plots had low densities (plots 12 and 14-17). Approximately 5 acres of the Site with low densities of stem survival were replanted at a density of 680 stems per acre in early 2009 prior to Year 2 (2009) monitoring. These areas appear to be recovering well. No vegetation problem areas were noted during the Year 3 (2010) monitoring season.

## 2.2 Stream Assessment

Twenty permanent cross-sections within five 600-foot reaches were established after construction was completed. Measurements of each cross-section include points at all breaks in slope including top of bank, bankfull, and thalweg. Riffle cross-sections are classified using the Rosgen stream classification system. Longitudinal profile measurements of five 600-foot reaches include thalweg, water surface, and bankfull; with each measurement taken at the head of facets (i.e. riffle, run, pool, and glide) in addition to the maximum pool depth.

### 2.2.1 Stream Success Criteria

Success criteria for stream restoration will include 1) successful classification of the reach as a functioning stream system (Rosgen 1996) and 2) channel variables indicative of a stable stream system.

The channel configuration will be measured on an annual basis in order to track changes in channel geometry and profile. These data will be utilized to determine the success in restoring stream channel

stability. Specifically, the width-to-depth ratio should characterize an E-type or borderline E-/C-type channel, bank-height ratios indicative of a stable or moderately unstable channel, and minimal changes in cross-sectional area, channel width, and/or bank erosion along the monitoring reach. In addition, channel abandonment and/or shoot cutoffs must not occur and sinuosity values must remain relatively constant. The field indicator of bankfull will be described in each monitoring year and indicated on a representative channel cross-section figure. If the stream channel is down-cutting or the channel width is enlarging due to bank erosion, additional bank or slope stabilization methods will be employed.

Stream substrate is not expected to coarsen over time; therefore, pebble counts are not proposed as part of the stream success criteria.

Visual assessment of in-stream structures will be conducted to determine if failure has occurred. Failure of a structure may be indicated by collapse of the structure, undermining of the structure, abandonment of the channel around the structure, and/or stream flow beneath the structure.

### 2.2.2 Bankfull Events

Documented bankfull events are included in the table below. Three bankfull event were documented to date during the Year 3 (2010) monitoring period for a total of seven bankfull events.

**Table 6. Verification of Bankfull Events**

<b>Date of Occurrence</b>	<b>Method</b>	<b>Photo (if available)</b>
April 5, 2008	A total of 3.73 inches of rain fell on April 5, 2008 as recorded by a nearby rain station in Lumberton*	--
September 6, 2008	A total of 4.6 inches of rain fell on September 5-6, 2008 as recorded by a nearby rain station in Lumberton*	See below
March 1, 2009	A total of 2.0 inches of rain fell on February 28-March 1, 2009 as recorded by a nearby rain station in Lumberton*. In addition wrack was documented within the floodplain during a Site visit.	--
November 11, 2009	A total of 3.3 inches of rain fell on November 10-12, 2009 as recorded by a nearby rain station in Lumberton* resulting from Tropical Storm Ida	1-2
May 23, 2010	A total of 2.7 inches of rain fell on May 22-24, 2010 as recorded by a nearby rain station in Lumberton*.	--
July 27, 2010	A total of 2.9 inches of rain fell on July 27, 2010 as recorded by a nearby rain station in Lumberton*.	--
September 27, 2010	A 7.7-inch* rainfall event occurring between September 26-30, 2010 as recorded by a nearby rain station in Lumberton*.	--

\*Weather Underground 2010



**2.2.3 Stream Problem Areas**

No stream problem areas were documented within the Site during the Year 3 (2010) monitoring period.

**2.2.4 Categorical Stream Feature Visual Stability Assessment**

Each stream reach was visually inspected during the Year 3 (2010) monitoring period using eight feature categories and various metrics within each category. Assessment features included riffles, pools, thalweg, meanders, channel bed, structures, and root wads/boulders. Tables for semi-quantitative assessments of each reach are included in Appendix B (Tables B1-B5). The mean percentage of performance for features within each reach are summarized in the tables below.

**Table 7A. Categorical Stream Feature Visual Stability Assessment: Brown Marsh (Reach 1)**

Feature	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)	Year 4 (2011)	Year 5 (2012)
A. Riffles	100%	100%	100%		
B. Pools	100%	100%	100%		
C. Thalweg	100%	100%	100%		
D. Meanders	100%	100%	100%		
E. Bed General	100%	100%	100%		
F. Banks	100%	100%	100%		
G. Vanes / J. Hooks, Etc.	NA	NA	NA		
H. Wads and Boulders	NA	NA	NA		

**Table 7B. Categorical Stream Feature Visual Stability Assessment: Brown Marsh (Reach 2)**

Feature	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)	Year 4 (2011)	Year 5 (2012)
A. Riffles	100%	100%	100%		
B. Pools	100%	100%	100%		
C. Thalweg	100%	100%	100%		
D. Meanders	100%	100%	100%		
E. Bed General	100%	100%	100%		
F. Banks	100%	100%	100%		
G. Vanes / J. Hooks, Etc.	NA	NA	NA		
H. Wads and Boulders	NA	NA	NA		

**Table 7C. Categorical Stream Feature Visual Stability Assessment**

**Brown Marsh (Reach 3)**

<b>Feature</b>	<b>Year 1 (2008)</b>	<b>Year 2 (2009)</b>	<b>Year 3 (2010)</b>	<b>Year 4 (2011)</b>	<b>Year 5 (2012)</b>
A. Riffles	100%	100%	100%		
B. Pools	100%	100%	100%		
C. Thalweg	100%	100%	100%		
D. Meanders	100%	100%	100%		
E. Bed General	100%	100%	100%		
F. Banks	100%	100%	100%		
G. Vanes / J. Hooks, Etc.	NA	NA	NA		
H. Wads and Boulders	100%	100%	100%		

**Table 7D. Categorical Stream Feature Visual Stability Assessment**

**Brown Marsh (Reach 4)**

<b>Feature</b>	<b>Year 1 (2008)</b>	<b>Year 2 (2009)</b>	<b>Year 3 (2010)</b>	<b>Year 4 (2011)</b>	<b>Year 5 (2012)</b>
A. Riffles	100%	100%	100%		
B. Pools	100%	100%	100%		
C. Thalweg	100%	100%	100%		
D. Meanders	100%	100%	100%		
E. Bed General	100%	100%	100%		
F. Banks	100%	100%	100%		
G. Vanes / J. Hooks, Etc.	NA	NA	NA		
H. Wads and Boulders	100%	100%	100%		

**Table 7E. Categorical Stream Feature Visual Stability Assessment**

**Brown Marsh (Reach 5)**

<b>Feature</b>	<b>Year 1 (2008)</b>	<b>Year 2 (2009)</b>	<b>Year 3 (2010)</b>	<b>Year 4 (2011)</b>	<b>Year 5 (2012)</b>
A. Riffles	100%	100%	100%		
B. Pools	100%	100%	100%		
C. Thalweg	100%	100%	100%		
D. Meanders	100%	100%	100%		
E. Bed General	100%	100%	100%		
F. Banks	100%	100%	100%		
G. Vanes / J. Hooks, Etc.	NA	NA	NA		
H. Wads and Boulders	100%	100%	100%		

### **2.2.5 Quantitative Stream Measurements**

During the Year 3 (2010) monitoring period 20 cross-sections and longitudinal profiles within five 600-foot reaches were measured. Permanent cross-sections and longitudinal profiles are included in Appendix B; each is graphically depicted for as-built through Year 3 (2010) for analysis. The stream channel did not have flowing water during Year 3 (2010) stream measurements; therefore, water surface slopes could not be calculated. As a whole, monitoring measurements indicate minimal changes in both the longitudinal profile and cross-sections as compared to as-built data. The channel geometry compares favorably with the emulated, stable E/C type stream reach as set forth in the detailed mitigation plan and as constructed. Current monitoring has demonstrated dimension, pattern, and profile were stable over the course of the monitoring period. Tables for quantitative assessments are included below; these tables include data from previous years.

### **2.3 Wetland Assessment**

Two groundwater monitoring gauges and one reference groundwater gauge were maintained and monitored throughout the Year 3 (2010) growing season. Graphs of groundwater hydrology and precipitation from a nearby rain station (Weather Underground 2010) are included in Appendix C.

#### **2.3.1 Wetland Success Criteria**

Target hydrological characteristics include saturation or inundation for at least 12.5 percent within Trebloc soils (nonriverine wetlands) of the growing season, during average climatic conditions. This value is based on DRAINMOD simulations for 62 years of rainfall data in an old field stage. These areas are expected to support hydrophytic vegetation. If wetland parameters are marginal a jurisdictional determination will be performed for vegetation and soils in these areas (Environmental Laboratory 1987).

#### **2.3.2 Wetland Problem Areas**

No wetland problem areas were identified within the Site during Year 3 (2010) monitoring.

#### **2.3.3 Wetland Criteria Attainment**

Monitoring Gauge 2 was inundated/saturated within 12 inches of the surface for greater than 12.5 percent of the growing season while Gauge 1 was just shy of success criteria with inundation/saturation within 12 inches of the surface for 11.8 percent of the growing season. In addition, the reference gauge did not meet success criteria for the Year 3 (2010) monitoring season and rainfall was well-below normal for the month of April (Table 10 and Figure C1, Appendix C). Hydrographs containing groundwater and precipitation data for each gauge can be found in Appendix C in addition to a graph depicting annual rainfall at the Lumberton Airport versus 30-year historic rainfall data collected in Lumberton (Weatherunderground 2010, NOAA 2004). Groundwater data has been collected through October 1, 2010 and will continue to be collected for the remainder of the growing season (until November 14, 2010).

**Table 8A. Baseline Morphology and Hydraulic Summary  
Brown Marsh Swamp (Reach 1)**

Parameter	USGS Gage Data			Pre-Existing Condition			Project Reference Stream (Mill Cr)			Project Reference Stream (Wild Cat Br)			Design			As-built			
	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	
<b>Dimension</b>																			
BF Width (ft)	USGS gage data is unavailable for this project					5.6			11.3			8.2			7.5	6.2	6.3	6.3	
Floodprone Width (ft)						7.3			300			130			15	25	39	32	
BF Cross Sectional Area (ft <sup>2</sup> )						3			21			8.5			5.9	3.8	4.2	4	
BF Mean Depth (ft)						0.9			1.9			1			0.8	0.6	0.7	0.6	
BF Max Depth (ft)						1.2			2.6			1.6			1.6				1.1
Width/Depth Ratio						6			6			8			9.5	10	11	11	
Entrenchment Ratio						1.3			26			16			2	4	6	5	
Bank Height Ratio						===			===			===			1			1	
Wetted Perimeter(ft)						===			===			===			===			===	
Hydraulic radius (ft)						===			===			===			===			===	
<b>Pattern</b>																			
Channel Beltwidth (ft)					100	15	27		14	19		15	45		16	36	27		
Radius of Curvature (ft)					11.7	10	30		11	15		15	22.5				18		
Meander Wavelength (ft)					800	38	73		23	29		22.5	75		61	89	74		
Meander Width ratio					18	1.3	2.4		1.7	2.4		2	6		10	14	12		
<b>Profile</b>																			
Riffle length (ft)						===			===			===			===	13	33	23	
Riffle slope (ft/ft)						===			===			===			===	0.02%	2.36%	0.88%	
Pool length (ft)						===			===			===			===	12	22	16	
Pool spacing (ft)				4.7	54.1		11.4	61		14	17		18	46		26	55	40	
<b>Substrate</b>																			
d50 (mm)						===			===			===			===			===	
d84 (mm)						===			===			===			===			===	
<b>Additional Reach Parameters</b>																			
Valley Length (ft)						===			===			===			===			===	
Channel Length (ft)						===			===			===			===			599	
Sinuosity						1			1.2			1.2			1.2			1.2	
Water Surface Slope (ft/ft)						0.03%			0.03%			0.02%			0.03%			0.23%	
BF slope (ft/ft)						===			===			===			===			===	
Rosgen Classification						G5			E5			E5			E5			E5	



**Table 8B. Baseline Morphology and Hydraulic Summary  
Brown Marsh Swamp (Reaches 2, 3, 4, and 5)**

Parameter	USGS Gage Data			Pre-Existing Condition			Project Reference Stream (Mill Cr)			Project Reference Stream (Wild Cat Br)			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)	USGS gage data is unavailable for this project					10.7			11.3			8.2			11.5	10	15	12
Floodprone Width (ft)						21.7			300			130			35	35	50	39
BF Cross Sectional Area (ft2)						19.7			21			8.5			17.6	12	19	14
BF Mean Depth (ft)						1.9			1.9			1			1.5	1.2	1.3	1.2
BF Max Depth (ft)						2.9			2.6			1.6			1.5	2	2.3	2.2
Width/Depth Ratio						6			6			8			7.5	8.3	12.5	10.0
Entrenchment Ratio						2			26			16			3	2.9	4.2	3.3
Bank Height Ratio						===			===			===			1			1
Wetted Perimeter(ft)						===			===			===			===			===
Hydraulic radius (ft)						===			===			===			===			===
<b>Pattern</b>																		
Channel Beltwidth (ft)						600	15	27		14	19		23	69		23	87	62
Radius of Curvature (ft)	150	400					10	30		11	15		23	35				35
Meander Wavelength (ft)						1500	38	73		23	29		34	115		95	180	142
Meander Width ratio						56	1.3	2.4		1.7	2.4		2	6		7.9	15.0	11.8
<b>Profile</b>																		
Riffle length (ft)						===			===			===			===	45	75	59
Riffle slope (ft/ft)						===			===			===			===	0.03%	0.31%	0.21%
Pool length (ft)						===			===			===			===	19	37	28
Pool spacing (ft)	60	140					11.4	61		14	17		27	70		62	105	81
<b>Substrate</b>																		
d50 (mm)						===			===			===			===			===
d84 (mm)						===			===			===			===			===
<b>Additional Reach Parameters</b>																		
Valley Length (ft)						===			===			===			===			===
Channel Length (ft)						===			===			===			===			4465
Sinuosity						1			1.2			1.2			1.4			1.4
Water Surface Slope (ft/ft)						0.01%			0.03%			0.02%			0.01%			0.11%
BF slope (ft/ft)						===			===			===			===			===
Rosgen Classification						G5			E5			E5			E5			E5

**Table 9A. Morphology and Hydraulic Monitoring Summary**  
**Brown Marsh Swamp**  
**Reach 1 (Sta. 10+10 to 15+67)**

Parameter	Cross Section 17						Cross Section 18						Cross Section 19						Cross Section 20					
	Station 13+60 Riffle						Station 12+45 Pool						Station 10+72 Riffle						Station 10+52 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	8.8	7.8	9.8				7.0	8.2	8.8				6.7	7.2	7.2				6.2	6.9	7.8			
Floodprone Width (ft) (approx)	35.0						35.0						35.0						35.0					
BF Cross Sectional Area (ft <sup>2</sup> )	4.7	4.9	6.2				7.7	6.9	7.8				4.3	3.8	3.8				6.2	5.4	6.4			
BF Mean Depth (ft)	0.5	0.6	0.6				1.1	0.8	0.9				0.6	0.5	0.5				1.0	0.8	0.8			
BF Max Depth (ft)	1.3	1.3	1.2				2.1	1.6	1.6				1.1	1.0	0.9				1.9	1.5	1.5			
Width/Depth Ratio	16.2	12.6	15.5				NA	NA	NA				10.4	13.6	13.7				NA	NA	NA			
Entrenchment Ratio	3.4	4.5	3.6				NA	NA	NA				4.5	4.9	4.8				NA	NA	NA			
Bank Height Ratio	1.0	1.0	1.0				NA	NA	NA				1.0	1.0	1.0				NA	NA	NA			
Wetted Perimeter(ft)	9.3	8.3	10.2				8.3	8.9	9.4				7.1	7.6	7.5				7.4	7.6	8.4			
Hydraulic radius (ft)	0.5	0.6	0.6				0.9	0.8	0.8				0.6	0.5	0.5				0.8	0.7	0.8			
Substrate	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
d50 (mm)																								
d84 (mm)																								
Parameter	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Channel Beltwidth (ft)	16	36	27	16	36	27	16	36	27															
Radius of Curvature (ft)	0	0	18	0	0	18	0	0	18															
Meander Wavelength (ft)	61	74	89	61	74	89	61	74	89															
Meander Width ratio	1.7	2.1	2.5	1.7	2.1	2.5	1.7	2.1	2.5															
Profile	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Riffle length (ft)	7	36.7	19.7	5	35	20	9	23	14															
Riffle slope (ft/ft)	0.1%	2.4%	0.4%	NA*	NA*	NA*	NA*	NA*	NA*															
Pool length (ft)	3	17.3	4.1	7	27	20	17	44	26															
Pool spacing (ft)	26	55	40	26	55	40	26	55	40															
Additional Reach Parameters	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Valley Length (ft)	499			493			458																	
Channel Length (ft)	599			591			550																	
Sinuosity	1.2			1.2			1.2																	
Water Surface Slope (ft/ft)	0.18%			NA*			NA*																	
BF slope (ft/ft)	---			---			---																	
Rosgen Classification	C/E type			C/E type			C/E type																	
Number of Bankfull Events	1			1			3																	

NA\* No water in channel; therefore, slope calculations could not be evaluated.

**Table 9B. Morphology and Hydraulic Monitoring Summary**  
**Brown Marsh Swamp**  
**Reach 2 (Sta. 46+10 to 52+78)**

Parameter	Cross Section 13						Cross Section 14						Cross Section 15						Cross Section 16					
	Station 47+45 Pool						Station 47+48 Riffle						Station 50+75 Pool						Station 52+02 Riffle					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	12.9	12.5	13.0				10.9	10.9	10.9				10.9	11.4	11.0				10.8	12.0	11.9			
Floodprone Width (ft) (approx)	45.0						45.0						45.0						45.0					
BF Cross Sectional Area (ft <sup>2</sup> )	21.3	20.1	21.6				14.1	12.8	13.3				20.0	20.1	19.0				14.4	13.9	14.5			
BF Mean Depth (ft)	1.7	1.6	1.7				1.3	1.2	1.2				1.8	1.8	1.7				1.3	1.2	1.2			
BF Max Depth (ft)	3.1	3.0	3.0				2.1	2.3	2.2				3.3	3.4	2.7				2.3	2.4	2.3			
Width/Depth Ratio	NA	NA	NA				8.4	9.2	8.9				NA	NA	NA				8.1	10.4	9.7			
Entrenchment Ratio	NA	NA	NA				4.1	4.1	4.1				NA	NA	NA				4.2	3.8	3.8			
Bank Height Ratio	NA	NA	NA				1.0	1.0	1.0				NA	NA	NA				1.0	1.0	1.0			
Wetted Perimeter(ft)	14.8	14.1	14.4				12.0	11.9	11.8				13.1	13.4	12.6				12.0	13.2	12.8			
Hydraulic radius (ft)	1.4	1.4	1.5				1.2	1.1	1.1				1.5	1.5	1.5				1.2	1.1	1.1			
Substrate	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
d50 (mm)																								
d84 (mm)																								
Parameter	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Channel Beltwidth (ft)	23	87	62	23	87	62	23	87	62															
Radius of Curvature (ft)	0	0	35	0	0	35	0	0	35															
Meander Wavelength (ft)	95	180	142	95	180	142	95	180	142															
Meander Width ratio	2.1	4.0	3.2	2.1	4.0	3.2	2.1	4.0	3.2															
Profile	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Riffle length (ft)	53.6	85.8	68.3	26	68	57	25	41	29															
Riffle slope (ft/ft)	0.1%	0.3%	0.1%	NA*	NA*	NA*	NA*	NA*	NA*															
Pool length (ft)	2.6	5.4	3.4	13	51	21	36	79	47															
Pool spacing (ft)	62	105	81	62	105	81	62	105	81															
Additional Reach Parameters	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Valley Length (ft)	478			429			486																	
Channel Length (ft)	669			600			680																	
Sinuosity	1.4			1.4			1.4																	
Water Surface Slope (ft/ft)	0.10%			NA*			NA*																	
BF slope (ft/ft)	---			---			---																	
Rosgen Classification	E type			E type			E type																	
Number of Bankfull Events	1			1			3																	

NA\* No water in channel; therefore, slope calculations could not be evaluated.

**Table 9C. Morphology and Hydraulic Monitoring Summary**  
**Brown Marsh Swamp**  
**Reach 3 (Sta. 37+30 to 43+69)**

Parameter	Cross Section 9						Cross Section 10						Cross Section 11						Cross Section 12					
	Station 41+25 Riffle						Station 42+30 Pool						Station 43+75 Riffle						Station 45+05 Pool					
<b>Dimension</b>	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	12.3	11.6	11.7				14.6	11.7	11.8				12.6	10.4	11.6				12.0	9.3	10.8			
Floodprone Width (ft) (approx)	45.0						45.0						45.0						45.0					
BF Cross Sectional Area (ft <sup>2</sup> )	14.8	13.1	13.3				20.3	17.4	18.2				16.4	11.1	12.7				18.6	10.5	13.7			
BF Mean Depth (ft)	1.2	1.1	1.1				1.4	1.5	1.5				1.3	1.1	1.1				1.6	1.1	1.3			
BF Max Depth (ft)	2.3	2.1	2.1				3.6	2.8	2.7				2.5	2.1	2.1				2.9	2.1	2.2			
Width/Depth Ratio	10.2	10.2	10.4				NA	NA	NA				9.7	9.8	10.6				NA	NA	NA			
Entrenchment Ratio	3.7	3.9	3.8				NA	NA	NA				3.6	4.3	3.9				NA	NA	NA			
Bank Height Ratio	1.0	1.0	1.0				NA	NA	NA				1.0	1.0	1.0				NA	NA	NA			
Wetted Perimeter(ft)	13.2	12.4	12.5				16.6	13.1	13.1				13.7	11.2	12.4				13.6	10.3	11.8			
Hydraulic radius (ft)	1.1	1.1	1.1				1.2	1.3	1.4				1.2	1.0	1.0				1.4	1.0	1.2			
<b>Substrate</b>	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
d50 (mm)																								
d84 (mm)																								
<b>Parameter</b>	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
<b>Pattern</b>	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Channel Beltwidth (ft)	23	87	62	23	87	62	23	87	62															
Radius of Curvature (ft)	0	0	35	0	0	35	0	0	35															
Meander Wavelength (ft)	95	180	142	95	180	142	95	180	142															
Meander Width ratio	2.1	4.0	3.2	2.1	4.0	3.2	2.1	4.0	3.2															
<b>Profile</b>	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Riffle length (ft)	55.3	98.7	70.8	6	62	38	35	54	41															
Riffle slope (ft/ft)	0.03%	0.08%	0.03%	NA*	NA*	NA*	NA*	NA*	NA*															
Pool length (ft)	0.7	4.6	3.4	19	47	39	46	55	50															
Pool spacing (ft)	62	105	81	62	105	81	62	105	81															
<b>Additional Reach Parameters</b>	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Valley Length (ft)	456			429			457																	
Channel Length (ft)	639			600			640																	
Sinuosity	1.4			1.4			1.4																	
Water Surface Slope (ft/ft)	0.14%			NA*			NA*																	
BF slope (ft/ft)	---			---			---																	
Rosgen Classification	E type			E type			E type																	
Number of Bankfull Events	1			1			3																	

NA\* No water in channel; therefore, slope calculations could not be evaluated.

**Table 9D. Morphology and Hydraulic Monitoring Summary**  
**Brown Marsh Swamp**  
**Reach 4 (Sta. 20+16 to 26+22)**

Parameter	Cross Section 5						Cross Section 6						Cross Section 7						Cross Section 8					
	Station 20+55 Pool						Station 21+80 Riffle						Station 22+95 Pool						Station 25+80 Riffle					
<b>Dimension</b>	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	11.1	11.2	11.3				11.3	11.5	10.2				13.6	12.9	13.2				11.2	12.0	10.5			
Floodprone Width (ft) (approx)	45.0						45.0						45.0						45.0					
BF Cross Sectional Area (ft <sup>2</sup> )	19.0	15.1	15.7				13.9	13.2	12.2				21.8	18.9	20.2				11.2	12.3	12.2			
BF Mean Depth (ft)	1.7	1.4	1.4				1.2	1.1	1.2				1.6	1.5	1.5				1.0	1.0	1.2			
BF Max Depth (ft)	3.2	2.6	2.6				2.4	2.3	2.2				3.2	2.7	2.7				2.2	2.2	2.2			
Width/Depth Ratio	NA	NA	NA				9.1	10.1	8.5				NA	NA	NA				11.3	11.7	9.0			
Entrenchment Ratio	NA	NA	NA				4.0	3.9	4.4				NA	NA	NA				4.0	3.8	4.3			
Bank Height Ratio	NA	NA	NA				1.0	1.0	1.0				NA	NA	NA				1.0	1.0	1.0			
Wetted Perimeter(ft)	13.0	12.6	12.7				12.4	12.5	11.2				15.5	14.2	14.4				12.3	12.9	11.4			
Hydraulic radius (ft)	1.5	1.2	1.2				1.1	1.1	1.1				1.4	1.3	1.4				0.9	1.0	1.1			
<b>Substrate</b>	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
d50 (mm)																								
d84 (mm)																								
<b>Parameter</b>	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
<b>Pattern</b>	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Channel Beltwidth (ft)	23	87	62	23	87	62	23	87	62															
Radius of Curvature (ft)	0	0	35	0	0	35	0	0	35															
Meander Wavelength (ft)	95	180	142	95	180	142	95	180	142															
Meander Width ratio	2.1	4.0	3.2	2.1	4.0	3.2	2.1	4.0	3.2															
<b>Profile</b>	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Riffle length (ft)	54.7	130.6	73.5	11	59	30	24	55	36															
Riffle slope (ft/ft)	0.00%	0.27%	0.06%	NA*	NA*	NA*	NA*	NA*	NA*															
Pool length (ft)	2	16.7	3.7	14	63	33	24	69	42															
Pool spacing (ft)	62	105	81	62	105	81	62	105	81															
<b>Additional Reach Parameters</b>	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Valley Length (ft)	433			429			433																	
Channel Length (ft)	606			600			606																	
Sinuosity	1.4			1.4			1.4																	
Water Surface Slope (ft/ft)	0.05%			NA*			NA*																	
BF slope (ft/ft)	---			---			---																	
Rosgen Classification	E type			E type			E type																	
Number of Bankfull Events	1			1			3																	

NA\* No water in channel; therefore, slope calculations could not be evaluated.

**Table 9E. Morphology and Hydraulic Monitoring Summary**  
**Brown Marsh Swamp**  
**Reach 5 (Sta. 14+25 to 20+27)**

Parameter	Cross Section 1						Cross Section 2						Cross Section 3						Cross Section 4					
	Station 11+60 Riffle						Station 13+70 Pool						Station 14+90 Riffle						Station 17+40 Pool					
Dimension	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
BF Width (ft)	17.2	13.7	11.2				16.2	17.5	11.3				12.0	16.4	12.0				13.6	11.9	12.3			
Floodprone Width (ft) (approx)	45.0						45.0						45.0						45.0					
BF Cross Sectional Area (ft <sup>2</sup> )	21.0	13.5	11.1				22.2	20.9	13.3				13.6	15.4	13.9				19.1	15.4	17.5			
BF Mean Depth (ft)	1.2	1.0	1.0				1.4	1.2	1.2				1.1	0.9	1.2				1.4	1.3	1.4			
BF Max Depth (ft)	2.4	2.0	1.8				2.8	2.5	1.9				2.2	2.2	2.1				3.0	2.5	2.6			
Width/Depth Ratio	14.2	13.9	11.2				NA	NA	NA				10.6	17.6	10.3				NA	NA	NA			
Entrenchment Ratio	2.6	3.3	4.0				NA	NA	NA				3.7	2.7	3.8				NA	NA	NA			
Bank Height Ratio	1.0	1.0	1.0				NA	NA	NA				1.0	1.0	1.0				NA	NA	NA			
Wetted Perimeter(ft)	18.1	14.3	11.8				17.4	18.4	12.1				12.9	17.1	12.8				15.1	13.0	13.5			
Hydraulic radius (ft)	1.2	0.9	0.9				1.3	1.1	1.1				1.1	0.9	1.1				1.3	1.2	1.3			
Substrate	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+	MY1	MY2	MY3	MY4	MY5	MY+
d50 (mm)																								
d84 (mm)																								
Parameter	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Pattern	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Channel Beltwidth (ft)	23	87	62	23	87	62	23	87	62															
Radius of Curvature (ft)	0	0	35	0	0	35	0	0	35															
Meander Wavelength (ft)	95	180	142	95	180	142	95	180	142															
Meander Width ratio	2.1	4.0	3.2	2.1	4.0	3.2	2.1	4.0	3.2															
Profile	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med	Min	Max	Med						
Riffle length (ft)	47	81.5	70.5	29	63	41	21	60	32															
Riffle slope (ft/ft)	0.06%	0.09%	0.07%	NA*	NA*	NA*	NA*	NA*	NA*															
Pool length (ft)	1.4	15.8	4.5	22	61	52	32	76	48															
Pool spacing (ft)	62	105	81	62	105	81	62	105	81															
Additional Reach Parameters	MY-01 (2008)			MY-02 (2009)			MY-03 (2010)			MY-04 (2011)			MY-05 (2012)			MY+								
Valley Length (ft)	429			435			654																	
Channel Length (ft)	601			609			916																	
Sinuosity	1.4			1.4			1.4																	
Water Surface Slope (ft/ft)	0.07%			NA*			NA*																	
BF slope (ft/ft)	---			---			---																	
Rosgen Classification	C/E type			C/E type			E type																	
Number of Bankfull Events	1			1			3																	

**Table 10. Wetland Criteria Attainment for Year 3 (2010)**

Gauge ID	Hydrology Threshold Met?	Hydrophytic Vegetation Criteria Met?	Site Mean	Vegetation Plot ID	Vegetation Survival Threshold Met?	Site Mean
1	No	Yes	50 %	1	Yes	100 %
2	Yes	Yes		2	Yes	
				3	Yes	
				4	Yes	
				5	Yes	
				6	Yes	
				7	Yes	
				8	Yes	
				9	Yes	
				10	Yes	
				11	Yes	
				12	Yes	
				13	Yes	
				14	Yes	
				15	Yes	
				16	Yes	
				17	Yes	

### 3.0 CONCLUSIONS

The Site achieved the defined (or targeted) success criteria, with saturation (free water) within one foot of the soil surface for a minimum of 12.5 percent (30 consecutive days) of the growing season at monitoring Gauge 2 while Gauge 1 was just shy of success criteria with inundation/saturation within 12 inches of the surface for 11.8 percent of the growing season. In addition, the reference gauge did not meet success criteria for the Year 3 (2010) monitoring season and rainfall was well-below normal for the month of April. A summary of groundwater gauge data is included in Table 11. Vegetation plots across the Site were above the required 320 stems per acre with an average of 793 planted tree stems per acre in the Third Monitoring Year (Year 2010) (Table 12). In addition, each individual plot was above success criteria with planted stems alone with the exception of plot 12; however, when including natural recruits/Character Tree Species this plot was well-above required densities with 647 stems per acre.

**Table 11. Summary of Groundwater Gauge Results**

Gauge	Success Criteria Achieved/Max Consecutive Days During Growing Season (Percentage)				
	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)*	Year 4 (2011)	Year 5 (2012)
1	Yes/68 days (28 percent)	Yes/53 days (21.5 percent)	No/29 days (11.8 percent)		
2	Yes/35 days (23 percent)	Yes/55 days (22.4 percent)	Yes/35 days (14.2 percent)		
Ref 1	34 days (14 percent)	42 days (17.1 percent)	13 days (5.3 percent)		

\*Data was collected through October 1, 2010; data will continue to be collected for the remainder of the Year 3 (2010) growing season (through November 14, 2010).

**Table 12. Summary of Planted Vegetation Plot Results**

Plot	Planted Stems/Acre Counting Towards Success Criteria				
	Year 1 (2008)	Year 2 (2009)	Year 3 (2010)	Year 4 (2011)	Year 5 (2012)
1	526	809	850		
2	486	567	607		
3	445	526	526		
4	243	850	728		
5	971	1214	1214		
6	445	607	607		
7	405	850	1012		
8	809	1214	1335		
9	931	1052	1012		
10	1093	1012	971		
11	405	486	486		
12	40	162	202		
13	567	607	647		
14	162	647	890		
15	40	526	971		
16	202	445	526		
17	81	647	890		
<b>Average of All Plots (1-17)</b>	<b>476</b>	<b>705</b>	<b>793</b>		



#### 4.0 REFERENCES

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APPENDIX A  
VEGETATION DATA

1. Vegetation Survey Data Tables
2. Vegetation Monitoring Plot Photos

**Report Prepared By** Corri Faquin  
8/24/2010 10:27

**Date Prepared**

**database name** RestorationSystems-2010-A.mdb  
**database location** C:\Axiom\Business\CVS Database\2010  
**computer name** CORRI  
**file size** 55275520

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

**Metadata** Description of database file, the report worksheets, and a summary of project(s) and project data.  
**Proj, planted** Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.  
Each project is listed with its TOTAL stems per acre, for each year. This includes live stakes, all planted stems, and all natural/volunteer stems.  
**Proj, total stems**  
**Plots** List of plots surveyed with location and summary data (live stems, dead stems, missing, etc.).  
**Vigor** Frequency distribution of vigor classes for stems for all plots.  
**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.  
**Planted Stems by Plot and Spp** A matrix of the count of PLANTED living stems of each species for each plot; dead and missing stems are excluded.  
**ALL Stems by Plot and spp** A matrix of the 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** BrownMarsh  
**project Name** Brown Marsh Restoration Site  
**Description** Stream and Wetland Restoration Site in Robeson County  
**Sampled Plots** 17

Living planted stems, excluding live stakes, per acre: Negative (red) numbers indicate the project failed to reach requirements in a particular year.

Project Code	Project Name	River Basin	Year 3
BrownMarsh	Brown Marsh Restoration Site	Lumber	792.71

Total stems, including planted stems of all kinds (including live stakes) and natural/volunteer stems:

Project Code	Project Name	River Basin	Year 3
BrownMarsh	Brown Marsh Restoration Site	Lumber	1137.880808

### Plot Info

plot	Planted Living Stems	Planted Living Stems EXCLUDING Live Stakes	Dead/Missing Stems	Natural (Volunteer) Stems	Total Living Stems	Total Living Stems EXCLUDING Live Stakes	Planted Living Stems per ACRE	Planted Living Stems EXCLUDING Live Stakes PER ACRE	Natural (Volunteer) Stems PER ACRE	Total Living Stems PER ACRE	Total Living Stems EXCLUDING Live Stakes PER ACRE	# species
1	21	21	0	2	23	23	850	850	81	931	931	4
2	15	15	0	1	16	16	607	607	40	647	647	1
3	13	13	0	0	13	13	526	526	0	526	526	1
4	22	18	0	24	46	42	890	728	971	1862	1700	4
5	30	30	1	31	61	61	1214	1214	1255	2469	2469	5
6	16	15	0	0	16	15	647	607	0	647	607	4
7	25	25	1	11	36	36	1012	1012	445	1457	1457	5
8	33	33	1	0	33	33	1335	1335	0	1335	1335	10
9	25	25	4	10	35	35	1012	1012	405	1416	1416	5
10	24	24	2	2	26	26	971	971	81	1052	1052	2
11	12	12	0	2	14	14	486	486	81	567	567	3
12	5	5	0	11	16	16	202	202	445	647	647	2
13	16	16	2	25	41	41	647	647	1012	1659	1659	3
14	22	22	0	1	23	23	890	890	40	931	931	5
15	24	24	0	0	24	24	971	971	0	971	971	4
16	13	13	5	18	31	31	526	526	728	1255	1255	5
17	22	22	0	2	24	24	890	890	81	971	971	7

**Vigor**

<b>vigor</b>	<b>Count</b>	<b>Percent</b>
0	6	1.7
1	4	1.1
2	15	4.2
3	114	32.2
4	205	57.9
Missing	10	2.8

**Vigor by Species**

<b>Species</b>	<b>CommonName</b>	<b>4</b>	<b>3</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>Missing</b>	<b>Unknown</b>
Cephalanthus occidentalis	common buttonbush		1					
Cornus amomum	silky dogwood	34	52	7	1	1	3	
Diospyros virginiana	common persimmon		1					
Fraxinus pennsylvanica	green ash	45						
Nyssa aquatica	water tupelo	8	3		1	2		
Quercus falcata	southern red oak		1					
Quercus laurifolia	laurel oak		1				1	
Quercus lyrata	overcup oak	30	4				1	
Quercus michauxii	swamp chestnut oak	15	12			2	1	
Quercus nigra	water oak	7						
Quercus pagoda	cherrybark oak	21	7			1	2	
Quercus phellos	willow oak	2	3					
Salix nigra	black willow		3					
Sambucus canadensis	Common Elderberry		2					
Quercus	oak		2					
Fraxinus	ash	2						
Cephalanthus	buttonbush	2						
Ulmus	elm	36	22	8	2		2	
Ulmus americana	American elm	3						
<b>19</b>	<b>19</b>	<b>205</b>	<b>114</b>	<b>15</b>	<b>4</b>	<b>6</b>	<b>10</b>	

**Damage**

Damage	Count	Percent Of Stems
(no damage)	316	89.3
Unknown	16	4.5
Insects	13	3.7
Deer	4	1.1
Human Trampled	3	0.8
(other damage)	2	0.6

**Damage by Species**

Species	CommonName	Count of Damage Categories	(no damage)	Deer	Human Trampled	Insects	Unknown	Other
Cephalanthus	buttonbush	0	2					
Cephalanthus occidentalis	common buttonbush	0	1					
Cornus amomum	silky dogwood	11	87	3	1		7	
Diospyros virginiana	common persimmon	0	1					
Fraxinus	ash	0	2					
Fraxinus pennsylvanica	green ash	0	45					
Nyssa aquatica	water tupelo	3	11	1	1	1		
Quercus	oak	0	2					
Quercus falcata	southern red oak	0	1					
Quercus laurifolia	laurel oak	0	2					
Quercus lyrata	overcup oak	1	34			1		
Quercus michauxii	swamp chestnut oak	6	24		1	3		2
Quercus nigra	water oak	0	7					
Quercus pagoda	cherrybark oak	4	27			4		
Quercus phellos	willow oak	0	5					
Salix nigra	black willow	0	3					
Sambucus canadensis	Common Elderberry	0	2					
Ulmus	elm	12	58			3	9	

**Damage by Plot**

<b>plot</b>	<b>Count of Damage Categories</b>	<b>(no damage)</b>	<b>Deer</b>	<b>Human Trampled</b>	<b>Insects</b>	<b>Unknown</b>	<b>Other</b>
1	0	21					
2	1	14	1				
3	1	12				1	
4	4	18			2	2	
5	4	27		1	3		
6	1	15			1		
7	7	19	1		4		2
8	0	34					
9	1	28		1			
10	13	13	1	1		11	
11	2	10				2	
12	0	5					
13	0	18					
14	2	20	1		1		
15	0	24					
16	0	18					
17	2	20			2		
<b>17</b>	<b>38</b>	<b>316</b>	<b>4</b>	<b>3</b>	<b>13</b>	<b>16</b>	<b>2</b>

**Planted Stems by Plot and Species**

Species	CommonName	Total Stems	# plots	avg# stems	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Cephalanthus	buttonbush	2	2	1				1		1											
Cephalanthus occidentalis	common buttonbush	1	1	1											1						
Cornus amomum	silky dogwood	94	10	9.4		15	13	12		9	4	5		14	9		12				1
Diospyros virginiana	common persimmon	1	1	1													1				
Fraxinus	ash	2	1	2					2												
Fraxinus pennsylvanica	green ash	45	5	9	14													13	6	1	11
Nyssa aquatica	water tupelo	12	5	2.4					3									2	4	2	1
Quercus	oak	2	2	1								1				1					
Quercus falcata	southern red oak	1	1	1								1									
Quercus laurifolia	laurel oak	1	1	1								1									
Quercus lyrata	overcup oak	34	7	4.86							7	1	1					3	13	7	2
Quercus michauxii	swamp chestnut oak	27	7	3.86	1				2	2	9	2	9		2						
Quercus nigra	water oak	7	4	1.75							3	2	1								1
Quercus pagoda	cherrybark oak	28	10	2.8	2			7	2	4			1			4		3	1	2	2
Quercus phellos	willow oak	5	3	1.67								2						1			2
Salix nigra	black willow	3	1	3													3				
Sambucus canadensis	Common Elderberry	2	1	2								2									
Ulmus	elm	68	7	9.71	4			2	21		2	16	13	10							
Ulmus americana	American elm	3	1	3																	3
<b>19</b>	<b>19</b>	<b>338</b>	<b>19</b>		<b>21</b>	<b>15</b>	<b>13</b>	<b>22</b>	<b>30</b>	<b>16</b>	<b>25</b>	<b>33</b>	<b>25</b>	<b>24</b>	<b>12</b>	<b>5</b>	<b>16</b>	<b>22</b>	<b>24</b>	<b>13</b>	<b>22</b>



**Planted and Natural Recruit Stems by Plot and Species**

Species	Common Name	Total Stems	# plots	avg# stems	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Acer rubrum	red maple	31	5	6.2												4	21	1		4	1
Baccharis halimifolia	eastern baccharis	67	5	13.4				23	31		9		3							1	
Cephalanthus	buttonbush	2	2	1				1		1											
Cephalanthus occidentalis	common buttonbush	1	1	1											1						
Cornus amomum	silky dogwood	95	10	9.5		15	13	12		9	4	5		15	9		12				1
Diospyros virginiana	common persimmon	12	2	6													1				11
Fraxinus	ash	2	1	2					2												
Fraxinus pennsylvanica	green ash	45	5	9	14													13	6	1	11
Liquidambar styraciflua	sweetgum	13	5	2.6									3		1	7				1	1
Nyssa aquatica	water tupelo	14	6	2.33					3		1							2	4	3	1
Pinus	pine	1	1	1				1													
Pinus taeda	loblolly pine	12	6	2	2	1					2		4	1			2				
Quercus	oak	2	2	1								1				1					
Quercus falcata	southern red oak	1	1	1								1									
Quercus laurifolia	laurel oak	1	1	1								1									
Quercus lyrata	overcup oak	34	7	4.86							7	1	1					3	13	7	2
Quercus michauxii	swamp chestnut oak	29	7	4.14	1				2	2	9	2	11		2						
Quercus nigra	water oak	7	4	1.75							3	2	1							1	
Quercus pagoda	cherrybark oak	29	10	2.9	2			7	2	4			1			4		3	1	3	2
Quercus phellos	willow oak	5	3	1.67								2						1			2
Salix nigra	black willow	8	4	2										1	1		5			1	
Sambucus canadensis	Common Elderberry	2	1	2								2									
Ulmus	elm	68	7	9.71	4			2	21		2	16	13	10							

Brown Marsh Swamp Restoration Site  
Year 3 (2010) Annual Monitoring  
Vegetation Plot Photos  
Taken August 2010

Plot 1



Plot 2



Plot 3



Plot 4



Plot 5



Plot 6



Brown Marsh Swamp Restoration Site  
Year 3 (2010) Annual Monitoring  
Vegetation Plot Photos  
Taken August 2010  
(continued)



Brown Marsh Swamp Restoration Site  
Year 3 (2010) Annual Monitoring  
Vegetation Plot Photos  
Taken August 2010  
(continued)



## APPENDIX B

### GEOMORPHOLOGIC DATA

1. Tables B1-B5. Qualitative Visual Stability Assessment
2. Cross-section Plots and Tables
3. Longitudinal Profile Plots

**Table B1. Visual Morphological Stability Assessment  
Brown Marsh Reach 1 (557 linear feet)**

Feature Category	Metric (per As-built and reference baselines)	(# Stable Number Performing as Intended)	Total number	Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
<b>A. Riffles</b>	1. Present	12	12	NA	100%	100%
	2. Armor stable (e.g. no displacement)?	12	12	NA	100%	
	3. Facet grade appears stable?	12	12	NA	100%	
	4. Minimal evidence of embedding / fining?	12	12	NA	100%	
	5. Length appropriate?	12	12	NA	100%	
<b>B. Pools</b>	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	12	12	NA	100%	100%
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	12	12	NA	100%	
	3. Length appropriate?	12	12	NA	100%	
<b>C. Thalweg</b>	1. Upstream of meander bend (run/inflection) centering?	12	12	NA	100%	100%
	2. Downstream of meander (glide/inflection) centering?	12	12	NA	100%	
<b>D. Meanders</b>	1. Outer bend in state of limited/controlled erosion?	12	12	NA	100%	100%
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	0	100%	
	3. Apparent Rc within spec?	12	12	NA	100%	
	4. Sufficient floodplain access and relief?	12	12	NA	100%	
<b>E. Bed General</b>	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100%	100%
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	100%	
<b>F. Bank</b>	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100%	100%
<b>G. Vanes</b>	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	
	4. Free of piping or other structural failures?	NA	NA	NA	NA	
<b>H. Wads / Boulders</b>	1. Free of scour?	NA	NA	NA	NA	NA
	2. Footing stable?	NA	NA	NA	NA	

**Table B2. Visual Morphological Stability Assessment  
Brown Marsh Reach 2 (668 linear feet)**

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total number	Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
<b>A. Riffles</b>	1. Present	10	10	NA	100%	100%
	2. Armor stable (e.g. no displacement)?	10	10	NA	100%	
	3. Facet grade appears stable?	10	10	NA	100%	
	4. Minimal evidence of embedding / fining?	10	10	NA	100%	
	5. Length appropriate?	10	10	NA	100%	
<b>B. Pools</b>	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	10	10	NA	100%	100%
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	10	10	NA	100%	
	3. Length appropriate?	10	10	NA	100%	
<b>C. Thalweg</b>	1. Upstream of meander bend (run/inflection) centering?	10	10	NA	100%	100%
	2. Downstream of meander (glide/inflection) centering?	10	10	NA	100%	
<b>D. Meanders</b>	1. Outer bend in state of limited/controlled erosion?	10	10	NA	100%	100%
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	0	100%	
	3. Apparent Rc within spec?	10	10	NA	100%	
	4. Sufficient floodplain access and relief?	10	10	NA	100%	
<b>E. Bed General</b>	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100%	100%
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	100%	
<b>F. Bank</b>	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100%	100%
<b>G. Vanes</b>	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	
	4. Free of piping or other structural failures?	NA	NA	NA	NA	
<b>H. Wads / Boulders</b>	1. Free of scour?	NA	NA	NA	NA	NA
	2. Footing stable?	NA	NA	NA	NA	

**Table B3. Visual Morphological Stability Assessment  
Brown Marsh Reach 3 (639 linear feet)**

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total number	Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
<b>A. Riffles</b>	1. Present	8	8	NA	100%	100%
	2. Armor stable (e.g. no displacement)?	8	8	NA	100%	
	3. Facet grade appears stable?	8	8	NA	100%	
	4. Minimal evidence of embedding / fining?	8	8	NA	100%	
	5. Length appropriate?	8	8	NA	100%	
<b>B. Pools</b>	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	8	8	NA	100%	100%
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	8	8	NA	100%	
	3. Length appropriate?	8	8	NA	100%	
<b>C. Thalweg</b>	1. Upstream of meander bend (run/inflection) centering?	8	8	NA	100%	100%
	2. Downstream of meander (glide/inflection) centering?	8	8	NA	100%	
<b>D. Meanders</b>	1. Outer bend in state of limited/controlled erosion?	8	8	NA	100%	100%
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	0	100%	
	3. Apparent Rc within spec?	8	8	NA	100%	
	4. Sufficient floodplain access and relief?	8	8	NA	100%	
<b>E. Bed General</b>	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100%	100%
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	100%	
<b>F. Bank</b>	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100%	100%
<b>G. Vanes</b>	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	
	4. Free of piping or other structural failures?	NA	NA	NA	NA	
<b>H. Wads / Boulders</b>	1. Free of scour?	2	2	NA	100%	100%
	2. Footing stable?	2	2	NA	100%	



**Table B4. Visual Morphological Stability Assessment  
Brown Marsh Reach 4 (606 linear feet)**

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total number	Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
<b>A. Riffles</b>	1. Present	7	7	NA	100%	100%
	2. Armor stable (e.g. no displacement)?	7	7	NA	100%	
	3. Facet grade appears stable?	7	7	NA	100%	
	4. Minimal evidence of embedding / fining?	7	7	NA	100%	
	5. Length appropriate?	7	7	NA	100%	
<b>B. Pools</b>	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	7	7	NA	100%	100%
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	7	7	NA	100%	
	3. Length appropriate?	7	7	NA	100%	
<b>C. Thalweg</b>	1. Upstream of meander bend (run/inflection) centering?	7	7	NA	100%	100%
	2. Downstream of meander (glide/inflection) centering?	7	7	NA	100%	
<b>D. Meanders</b>	1. Outer bend in state of limited/controlled erosion?	7	7	NA	100%	100%
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	0	100%	
	3. Apparent Rc within spec?	7	7	NA	100%	
	4. Sufficient floodplain access and relief?	7	7	NA	100%	
<b>E. Bed General</b>	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100%	100%
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	100%	
<b>F. Bank</b>	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100%	100%
<b>G. Vanes</b>	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	
	4. Free of piping or other structural failures?	NA	NA	NA	NA	
<b>H. Wads / Boulders</b>	1. Free of scour?	1	1	NA	100%	100%
	2. Footing stable?	1	1	NA	100%	

**Table B5. Visual Morphological Stability Assessment  
Brown Marsh Reach 5 (602 linear feet)**

Feature Category	Metric (per As-built and reference baselines)	(# Stable) Number Performing as Intended	Total number	Number / feet in unstable state	% Perform in Stable Condition	Feature Perform. Mean or Total
<b>A. Riffles</b>	1. Present	12	12	NA	100%	100%
	2. Armor stable (e.g. no displacement)?	12	12	NA	100%	
	3. Facet grade appears stable?	12	12	NA	100%	
	4. Minimal evidence of embedding / fining?	12	12	NA	100%	
	5. Length appropriate?	12	12	NA	100%	
<b>B. Pools</b>	1. Present? (e.g. not subject to severe aggrad. Or migrat.?)	12	12	NA	100%	100%
	2. Sufficiently deep (Max Pool D:Mean Bkf>1.6?)	12	12	NA	100%	
	3. Length appropriate?	12	12	NA	100%	
<b>C. Thalweg</b>	1. Upstream of meander bend (run/inflection) centering?	12	12	NA	100%	100%
	2. Downstream of meander (glide/inflection) centering?	12	12	NA	100%	
<b>D. Meanders</b>	1. Outer bend in state of limited/controlled erosion?	12	12	NA	100%	100%
	2. Of those eroding, # w/concomitant point bar formation?	NA	NA	0	100%	
	3. Apparent Rc within spec?	12	12	NA	100%	
	4. Sufficient floodplain access and relief?	12	12	NA	100%	
<b>E. Bed General</b>	1. General channel bed aggradation areas (bar formation)	NA	NA	0	100%	100%
	2. Channel bed degradation – areas of increasing down-cutting or head cutting?	NA	NA	0	100%	
<b>F. Bank</b>	1. Actively eroding, wasting, or slumping bank	NA	NA	0	100%	100%
<b>G. Vanes</b>	1. Free of back or arm scour?	NA	NA	NA	NA	NA
	2. Height appropriate?	NA	NA	NA	NA	
	3. Angle and geometry appear appropriate?	NA	NA	NA	NA	
	4. Free of piping or other structural failures?	NA	NA	NA	NA	
<b>H. Wads / Boulders</b>	1. Free of scour?	1	1	NA	100%	100%
	2. Footing stable?	1	1	NA	100%	

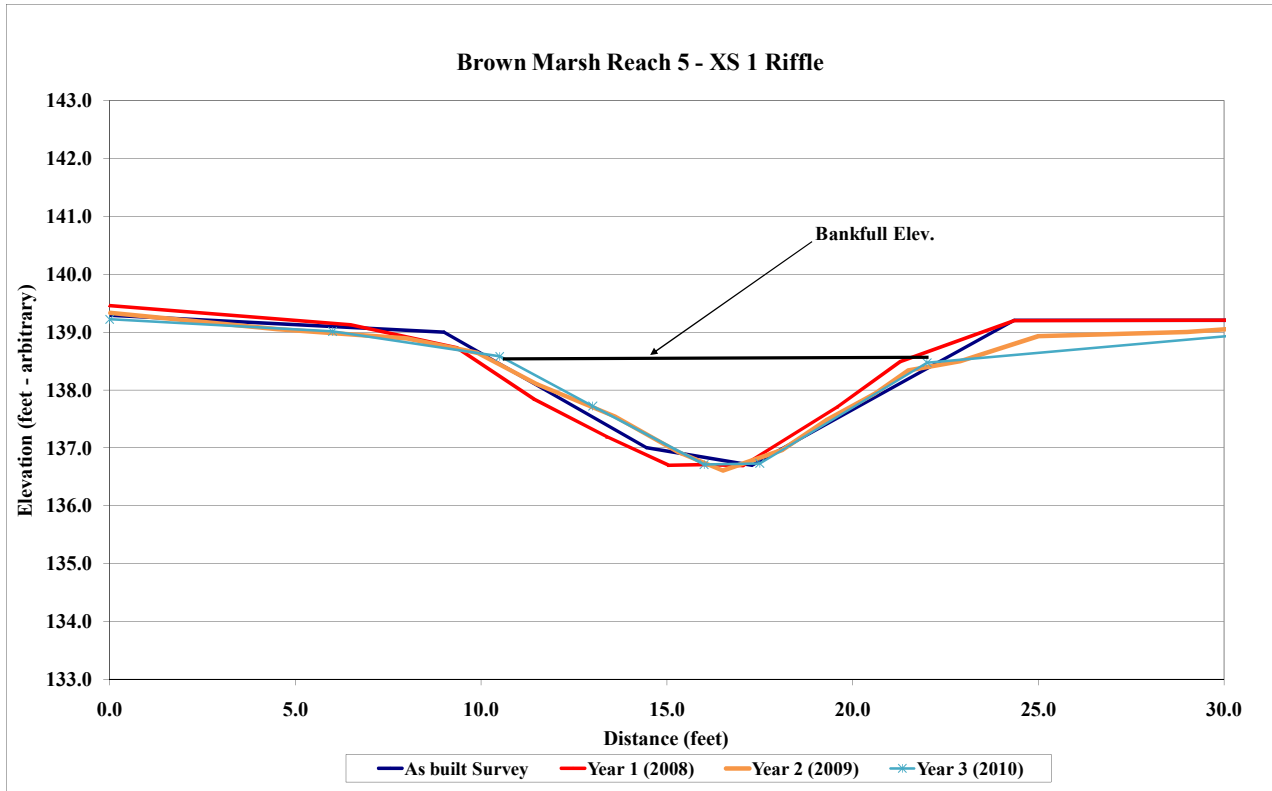
Project Name	Brown Marsh
Cross Section	Reach 5 - XS 1
Feature	Riffle
Date	10/1/10
Crew	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-7.7	141.1	0.0	139.5	0.0	139.3	0.0	139.2
-0.4	139.3	6.5	139.1	4.5	139.1	6.0	139.0
9.0	139.0	9.3	138.7	8.0	138.9	10.5	138.6
14.5	137.0	11.4	137.8	9.9	138.6	13.0	137.7
17.3	136.7	13.4	137.2	11.5	138.1	16.0	136.7
24.3	139.2	15.0	136.7	13.6	137.5	17.5	136.7
31.8	139.2	16.0	136.7	15.3	136.9	22.0	138.5
38.9	141.7	17.0	136.7	16.5	136.6	32.5	139.1
		19.6	137.7	18.1	137.0		
		21.3	138.5	19.3	137.5		
		24.3	139.2	20.6	137.9		
		32.0	139.2	21.5	138.3		
				22.9	138.5		
				25.0	138.9		
				29.0	139.0		
				32.5	139.2		



Photo of Cross-Section R5-1 - Looking Downstream @ STA 11+60

	2008	2009	2010	2011	2012
Area	21.0	13.5	11.1		
Width	17.2	13.7	11.2		
Mean Depth	1.2	1.0	1.0		
Max Depth	2.4	2.0	1.8		
W/D	14.2	13.9	11.2		



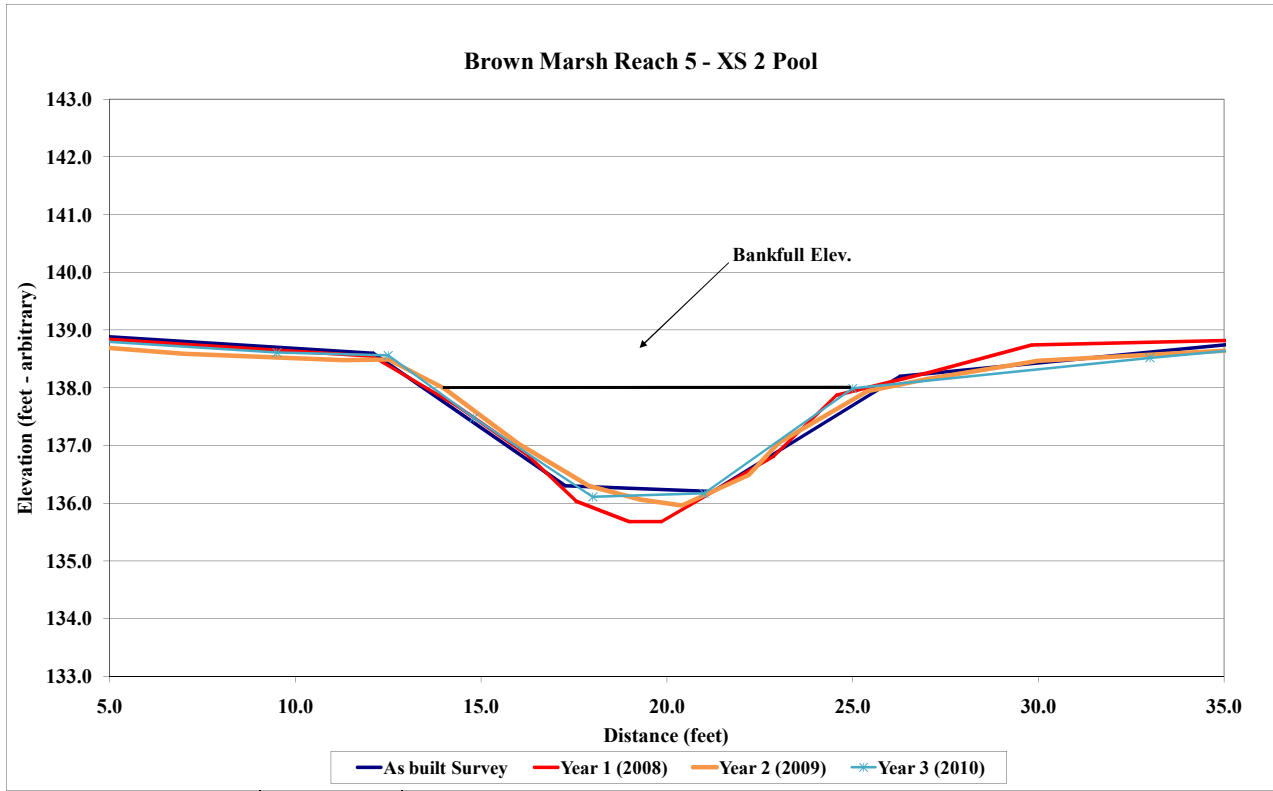
**Project Name** Brown Marsh  
**Cross Section** Reach 5 - XS 2  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-5.8	140.8	0.0	139.1	0.0	138.9	0.0	139.0
-0.5	139.1	7.1	138.7	7.0	138.6	9.5	138.6
12.1	138.6	12.1	138.5	11.3	138.5	12.5	138.6
17.3	136.3	14.3	137.7	12.5	138.5	14.8	137.5
21.2	136.2	16.2	136.9	14.0	138.0	18.0	136.1
26.3	138.2	17.6	136.0	16.0	137.0	21.0	136.2
37.5	138.9	19.0	135.7	17.9	136.3	25.0	138.0
44.8	140.7	19.9	135.7	19.3	136.1	33.0	138.5
		22.9	136.8	20.4	136.0	38.0	138.8
		24.6	137.9	22.2	136.5		
		27.2	138.3	23.0	137.0		
		29.8	138.7	25.4	137.9		
		37.3	138.9	27.0	138.2		
				30.0	138.5		
				38.1	138.8		



Photo of Cross-Section R5-2 - Looking Downstream @ STA 13+70

	2008	2009	2010	2011	2012
Area	22.2	20.9	13.3		
Width	16.2	17.5	11.3		
Mean Depth	1.4	1.2	1.2		
Max Depth	2.8	2.5	1.9		
W/D	NA	NA	NA		



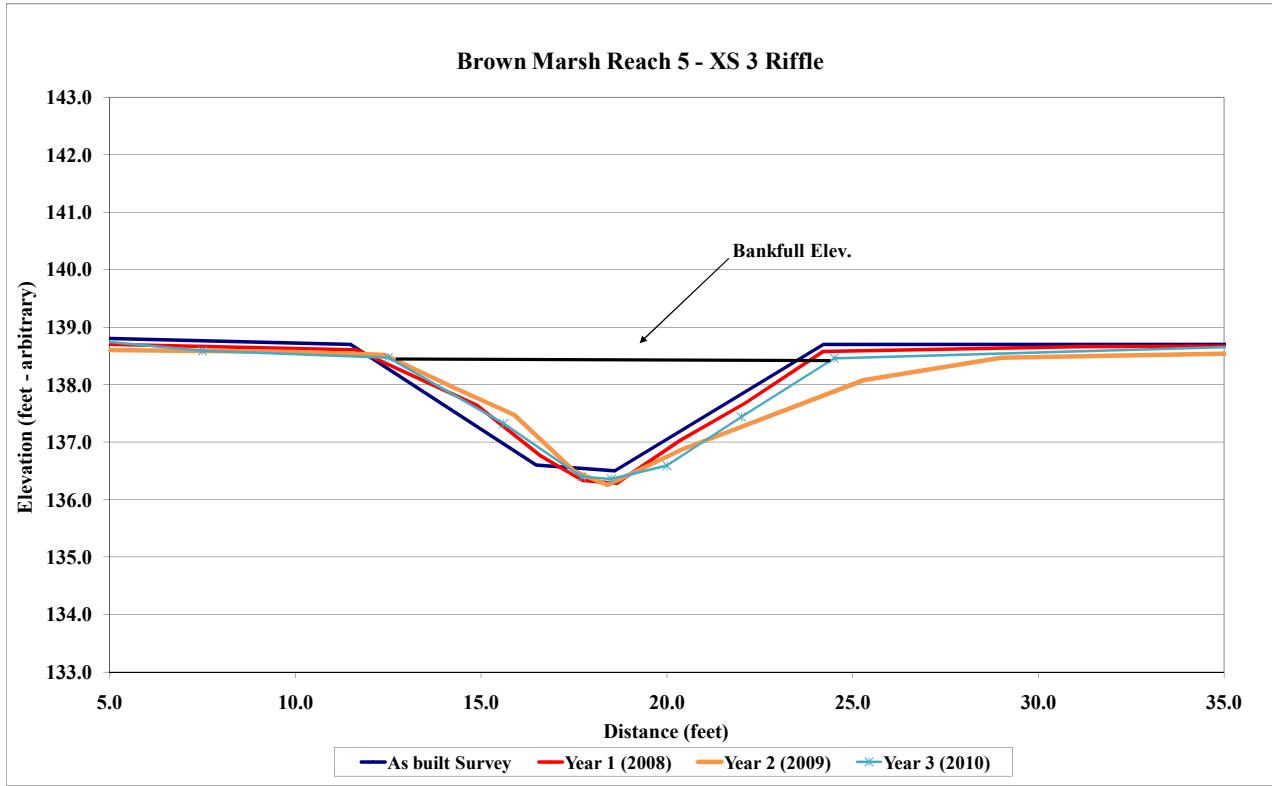
**Project Name** Brown Marsh  
**Cross Section** Reach 5 - XS 3  
**Feature** Riffle  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-7.5	140.8	0.0	139.0	0.0	139.0	0.0	139.0
-1.0	138.9	3.6	138.7	5.0	138.6	7.5	138.6
11.5	138.7	11.6	138.6	10.0	138.6	12.5	138.5
16.5	136.6	14.9	137.6	12.4	138.5	15.6	137.3
18.6	136.5	16.6	136.8	14.2	138.0	17.7	136.4
24.2	138.7	17.7	136.3	15.9	137.5	18.5	136.4
35.8	138.7	18.6	136.3	17.5	136.5	20.0	136.6
42.9	140.8	20.4	137.0	18.4	136.3	22.0	137.4
		22.1	137.7	20.4	136.9	24.5	138.5
		24.2	138.6	25.3	138.1	36.5	138.7
		31.1	138.7	29.0	138.5		
		35.5	138.7	36.1	138.6		



Photo of Cross-Section R5-3 - Looking Downstream @ STA 14+90

	2008	2009	2010	2011	2012
Area	13.6	15.4	13.9		
Width	12.0	16.4	12.0		
Mean Depth	1.1	0.9	1.2		
Max Depth	2.2	2.2	2.1		
W/D	10.6	17.6	10.3		



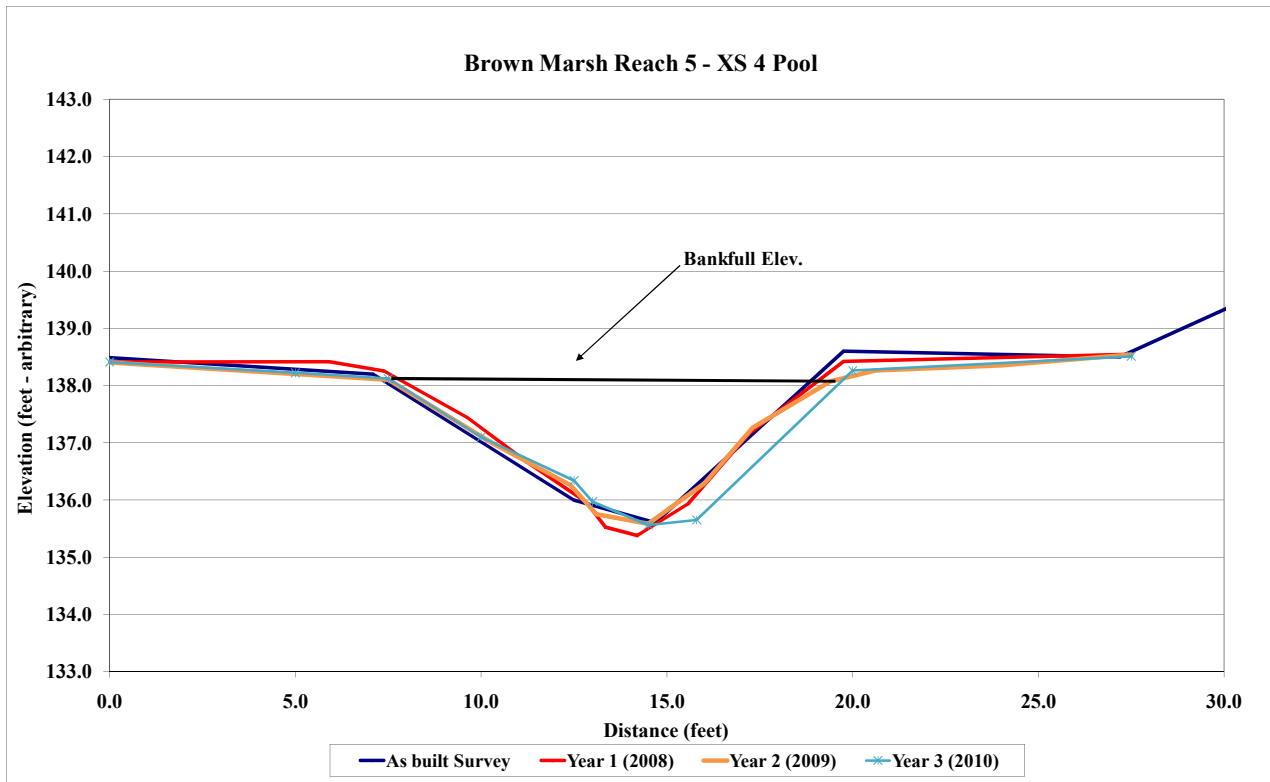
**Project Name** Brown Marsh  
**Cross Section** Reach 5 - XS 4  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-7.4	140.2	0.0	138.4	0.0	138.4	0.0	138.4
-0.3	138.5	5.9	138.4	5.0	138.2	5.0	138.2
7.1	138.2	7.4	138.3	7.5	138.1	7.5	138.1
12.5	136.0	9.6	137.4	10.3	137.0	10.0	137.1
14.7	135.6	11.2	136.7	12.4	136.3	12.5	136.3
19.8	138.6	12.8	136.0	13.1	135.8	13.0	136.0
27.2	138.5	13.3	135.5	14.5	135.6	14.5	135.6
33.7	140.4	14.2	135.4	16.0	136.3	15.8	135.7
		15.6	135.9	17.3	137.3	20.0	138.3
		17.2	137.2	19.4	138.1	27.5	138.5
		19.8	138.4	20.6	138.3		
		27.4	138.5	24.0	138.4		
				27.5	138.5		



Photo of Cross-Section R5-4 - Looking Downstream @ STA 17+40

	2008	2009	2010	2011	2012
Area	19.1	15.4	17.5		
Width	13.6	11.9	12.3		
Mean Depth	1.4	1.3	1.4		
Max Depth	3.0	2.5	2.6		
W/D	NA	NA	NA		



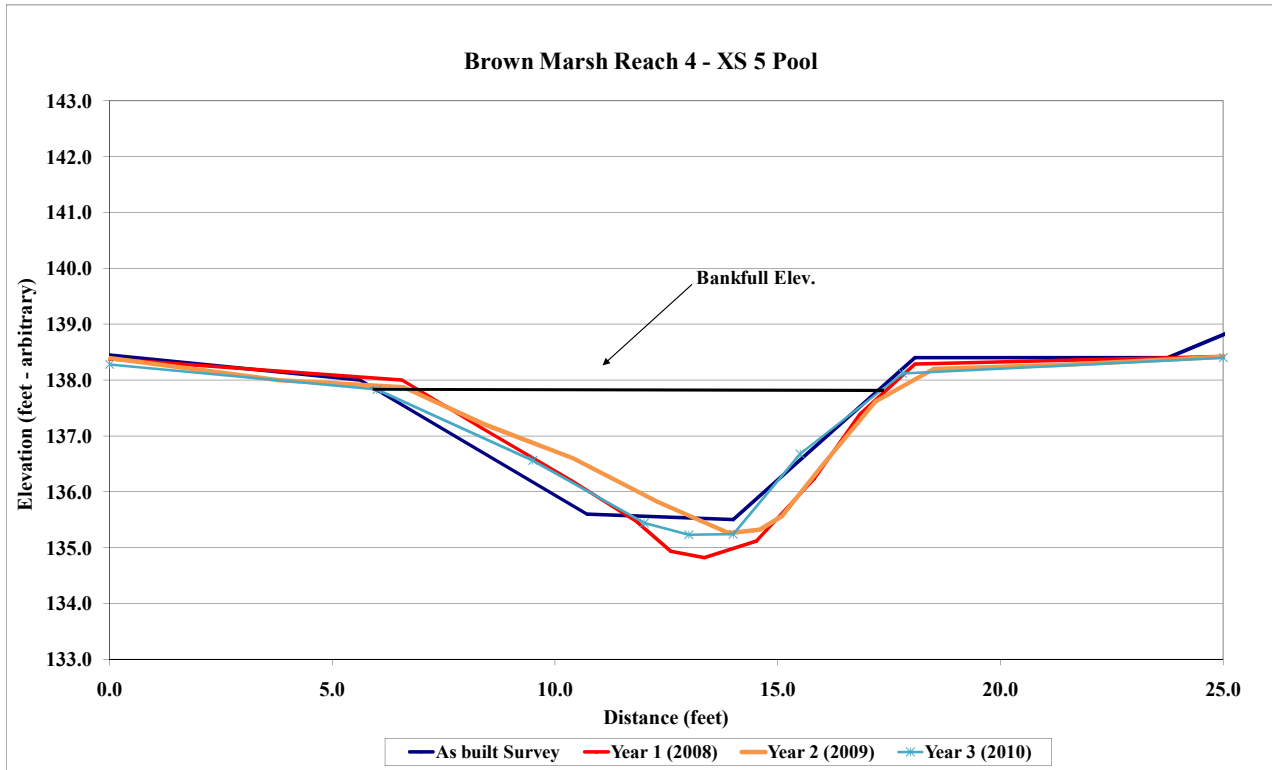
**Project Name** Brown Marsh  
**Cross Section** Reach 4 - XS 5  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-7.5	140.4	0.0	138.4	25.4	138.4	0.0	138.3
-0.6	138.5	6.6	138.0	21.4	138.3	6.0	137.8
5.6	138.0	8.4	137.1	18.5	138.2	9.5	136.6
10.7	135.6	10.4	136.2	17.2	137.6	12.0	135.4
14.0	135.5	11.8	135.5	16.0	136.5	13.0	135.2
18.1	138.4	12.6	134.9	15.1	135.6	14.0	135.2
23.8	138.4	13.4	134.8	14.6	135.3	15.5	136.7
31.3	140.9	14.5	135.1	13.9	135.3	17.8	138.1
		15.8	136.2	12.3	135.8	25.0	138.4
		16.8	137.4	10.4	136.6		
		18.1	138.3	8.4	137.2		
		25.0	138.4	6.6	137.9		
				3.8	138.0		
				0.0	138.4		



Photo of Cross-Section R4-X5 - Looking Downstream @ STA 20+55

	2008	2009	2010	2011	2012
Area	19.0	15.1	15.7		
Width	11.1	11.2	11.3		
Mean Depth	1.7	1.4	1.4		
Max Depth	3.2	2.6	2.6		
W/D	NA	NA	NA		



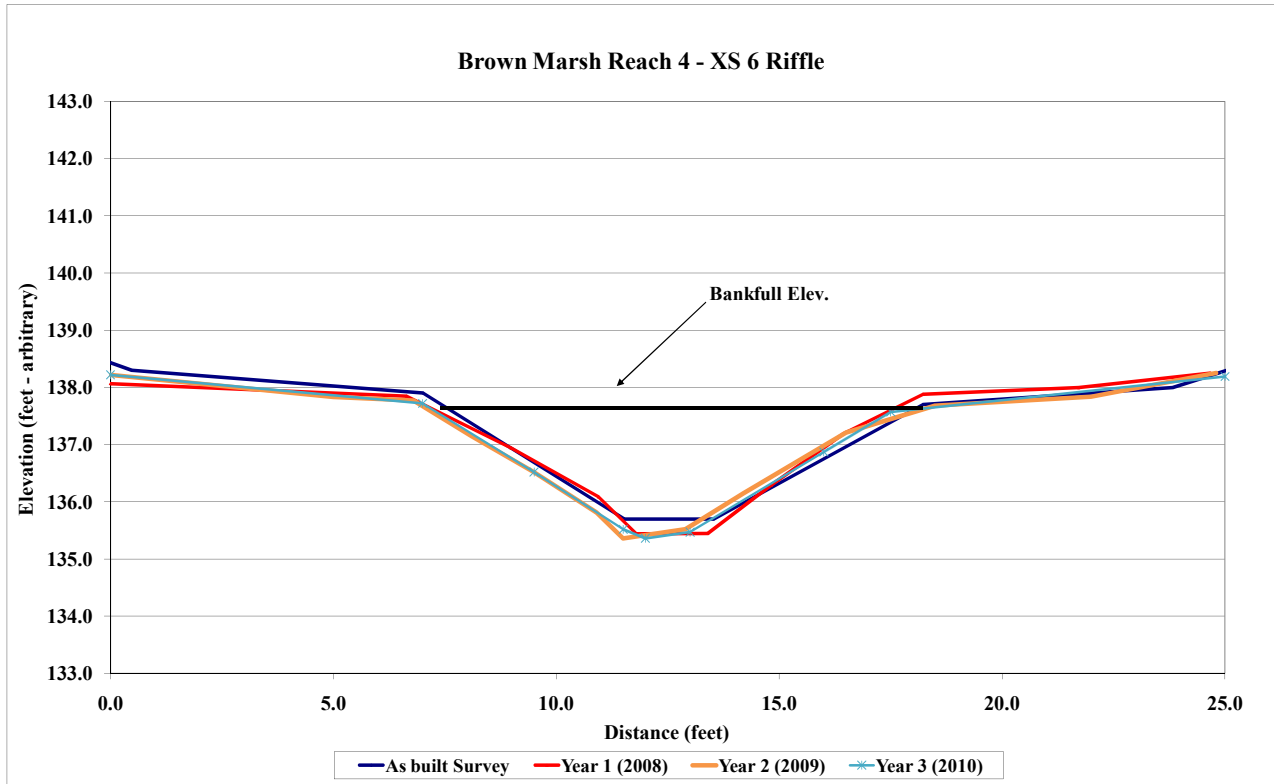
**Project Name** Brown Marsh  
**Cross Section** Reach 4 - XS 6  
**Feature** Riffle  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-8.5	140.8	0.0	138.1	0.0	138.2	0.0	138.2
0.5	138.3	6.6	137.8	5.0	137.8	7.0	137.7
7.0	137.9	9.0	136.9	6.8	137.8	9.5	136.5
11.5	135.7	10.9	136.1	8.1	137.2	11.5	135.5
13.5	135.7	11.8	135.4	9.5	136.5	12.0	135.4
18.2	137.7	13.4	135.4	10.9	135.8	13.0	135.5
23.8	138.0	14.8	136.3	11.5	135.4	16.0	136.9
33.9	140.5	16.5	137.2	12.9	135.5	17.5	137.6
		18.2	137.9	14.2	136.2	25.0	138.2
		21.7	138.0	16.5	137.2		
		24.7	138.2	18.5	137.7		
				22.0	137.8		
				24.8	138.3		



Photo of Cross-Section R4-6 - Looking Downstream @ STA 21+80

	2008	2009	2010	2011	2012
Area	13.9	13.2	12.2		
Width	11.3	11.5	10.2		
Mean Depth	1.2	1.1	1.2		
Max Depth	2.4	2.3	2.2		
W/D	9.1	10.1	8.5		





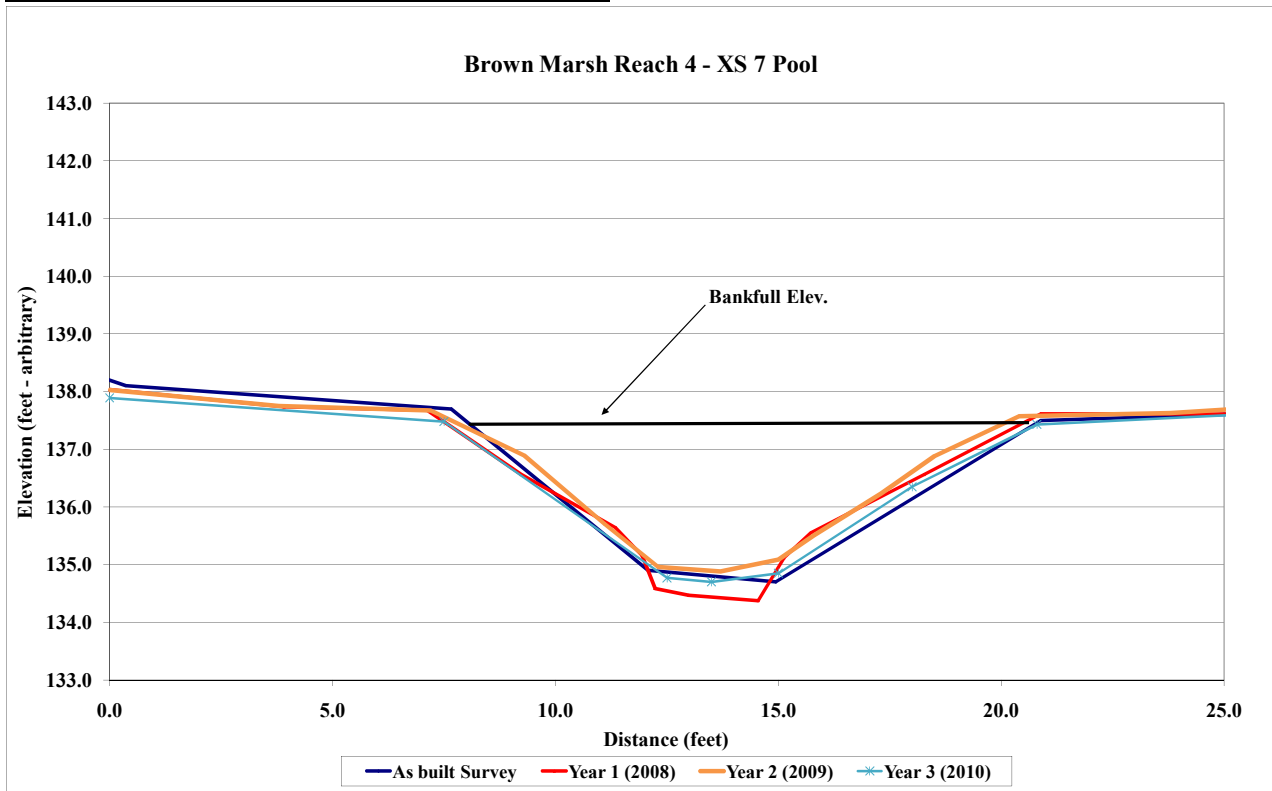
**Project Name** Brown Marsh  
**Cross Section** Reach 4 - XS 7  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-9.5	140.7	0.0	138.0	28.8	137.9	0.0	137.9
0.4	138.1	3.9	137.7	23.8	137.6	7.5	137.5
7.7	137.7	7.1	137.7	20.4	137.6	12.5	134.8
12.1	134.9	9.2	136.6	18.5	136.9	13.5	134.7
14.9	134.7	11.4	135.6	17.3	136.2	15.0	134.9
20.9	137.5	11.9	135.2	15.8	135.5	18.0	136.4
28.7	137.7	12.2	134.6	15.0	135.1	20.8	137.4
38.8	140.4	13.0	134.5	13.7	134.9	29.0	137.7
		14.5	134.4	12.3	135.0		
		15.1	135.1	11.1	135.7		
		15.7	135.6	9.3	136.9		
		18.3	136.6	7.2	137.7		
		20.9	137.6	3.8	137.8		
		28.2	137.6	0.0	138.0		



Photo of Cross-Section R4-7 - Looking Downstream @ STA 22+95

	2008	2009	2010	2011	2012
Area	21.8	18.9	20.2		
Width	13.6	12.9	13.2		
Mean Depth	1.6	1.5	1.5		
Max Depth	3.2	2.7	2.7		
W/D	NA	NA	NA		



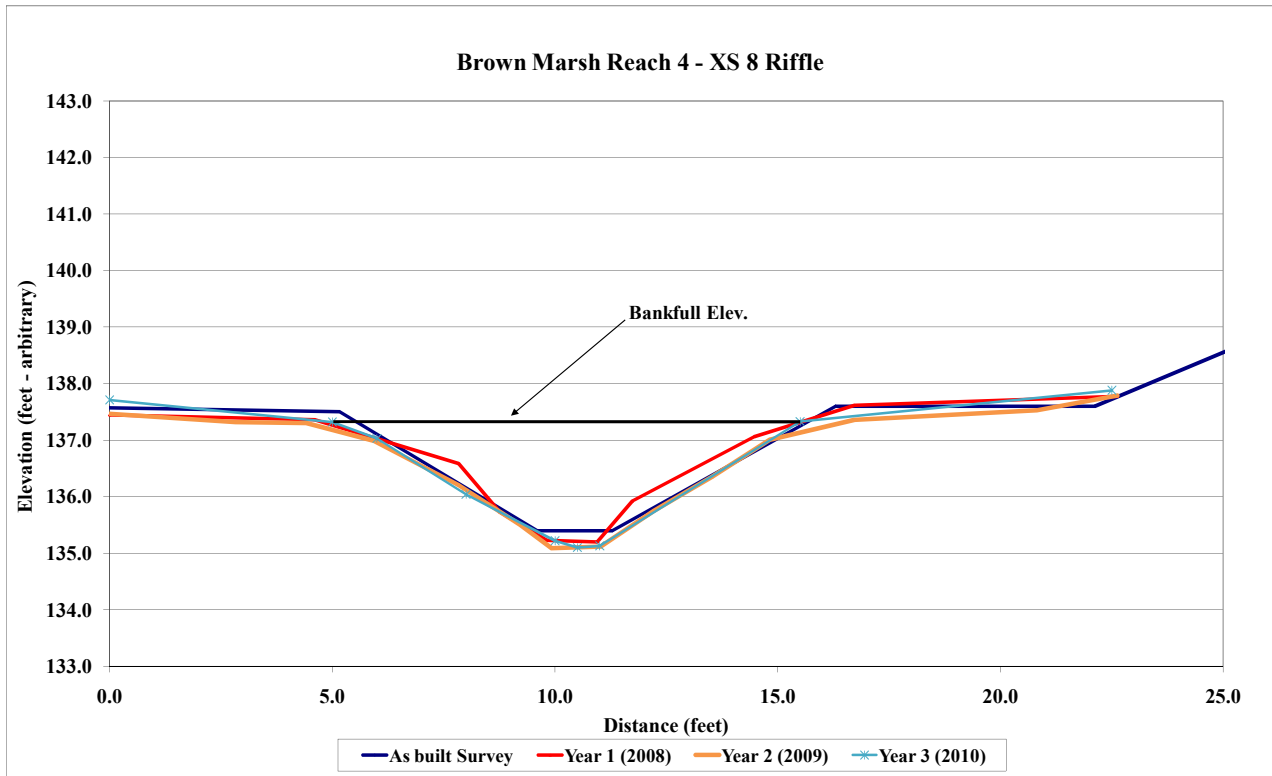
<b>Project Name</b>	Brown Marsh
<b>Cross Section</b>	Reach 4 - XS 8
<b>Feature</b>	Riffle
<b>Date</b>	10/1/10
<b>Crew</b>	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-11.0	140.3	0.0	137.4	-2.2	137.6	0.0	137.7
-2.1	137.6	4.6	137.4	2.8	137.3	5.0	137.3
5.2	137.5	7.8	136.6	4.4	137.3	6.0	137.0
9.6	135.4	8.8	135.7	5.9	137.0	8.0	136.0
11.3	135.4	9.8	135.2	7.8	136.2	10.0	135.2
16.3	137.6	10.9	135.2	9.2	135.5	10.5	135.1
22.1	137.6	11.7	135.9	9.9	135.1	11.0	135.1
30.9	140.5	14.5	137.1	11.0	135.1	15.5	137.3
		16.7	137.6	12.2	135.8	22.5	137.9
		22.6	137.8	13.5	136.4		
				14.8	137.0		
				16.7	137.4		
				20.8	137.5		
				22.6	137.8		



Photo of Cross-Section R4-8 - Looking Downstream @ STA 25+80

	2008	2009	2010	2011	2012
Area	11.2	12.3	12.2		
Width	11.2	12.0	10.5		
Mean Depth	1.0	1.0	1.2		
Max Depth	2.2	2.2	2.2		
W/D	11.3	11.7	9.0		



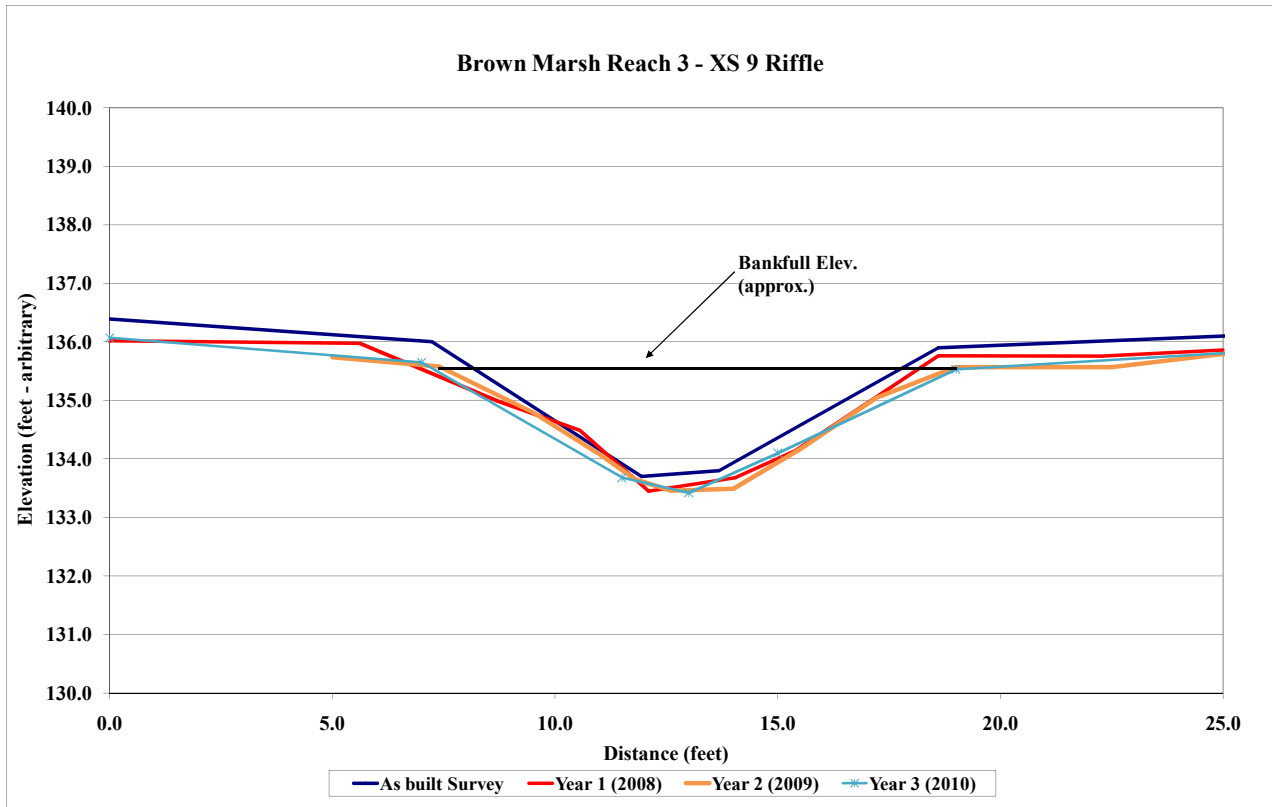
**Project Name** Brown Marsh  
**Cross Section** Reach 3 - XS 9  
**Feature** Riffle  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-9.1	139.3	0.0	136.0	5.0	135.7	0.0	136.1
-0.2	136.4	5.6	136.0	7.4	135.6	7.0	135.7
7.2	136.0	8.7	135.0	9.5	134.8	11.5	133.7
11.9	133.7	10.6	134.5	11.0	134.1	13.0	133.4
13.7	133.8	12.1	133.5	11.8	133.7	15.0	134.1
18.6	135.9	14.0	133.7	12.6	133.5	19.0	135.5
25.1	136.1	15.4	134.1	14.0	133.5	25.5	135.8
36.5	139.7	18.6	135.8	15.5	134.2		
		22.3	135.8	17.2	135.0		
		25.0	135.9	19.0	135.6		
				22.5	135.6		
				25.7	135.9		



Photo of Cross-Section R3-9 - Looking Downstream @ STA 41+25

	2008	2009	2010	2011	2012
Area	14.8	13.1	13.3		
Width	12.3	11.6	11.7		
Mean Depth	1.2	1.1	1.1		
Max Depth	2.3	2.1	2.1		
W/D	10.2	10.2	10.4		



**Project Name** Brown Marsh  
**Cross Section** Reach 3 - XS 10  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

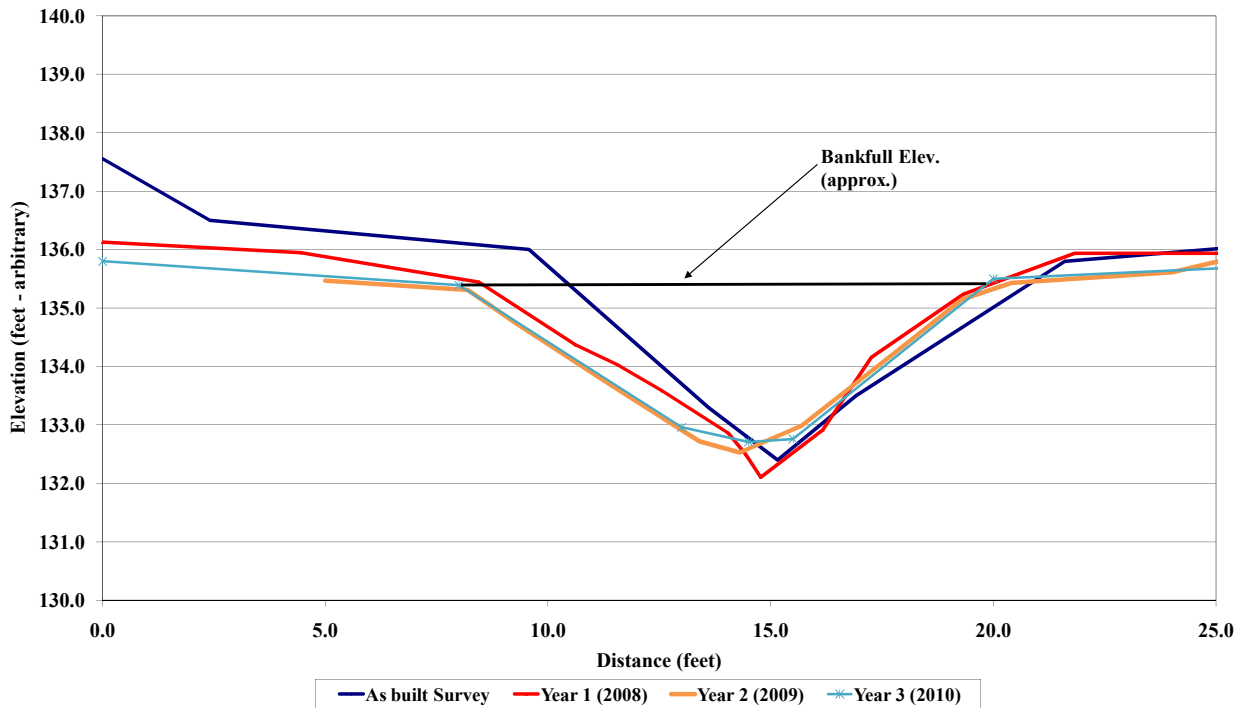
2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-4.0	139.3	0.0	136.1	5.0	135.5	0.0	135.8
2.4	136.5	4.5	135.9	8.2	135.3	8.0	135.4
9.6	136.0	8.5	135.4	9.3	134.7	13.0	133.0
13.6	133.3	10.6	134.4	11.4	133.7	14.5	132.7
15.2	132.4	11.6	134.0	13.4	132.7	15.5	132.8
16.9	133.5	12.6	133.6	14.3	132.5	20.0	135.5
21.6	135.8	14.0	132.9	15.7	133.0	27.0	135.8
29.5	136.3	14.4	132.5	17.9	134.3		
37.7	139.0	14.8	132.1	19.3	135.2		
		16.2	132.9	20.4	135.4		
		17.3	134.2	24.0	135.6		
		19.3	135.2	26.9	136.1		
		21.8	135.9				
		25.1	135.9				
		26.7	136.4				



Photo of Cross-Section R3-10 - Looking Downstream @ STA 42+30

	2008	2009	2010	2011	2012
Area	20.3	17.4	18.2		
Width	14.6	11.7	11.8		
Mean Depth	1.4	1.5	1.5		
Max Depth	3.6	2.8	2.7		
W/D	NA	NA	NA		

### Brown Marsh Reach 3 - XS 10 Pool



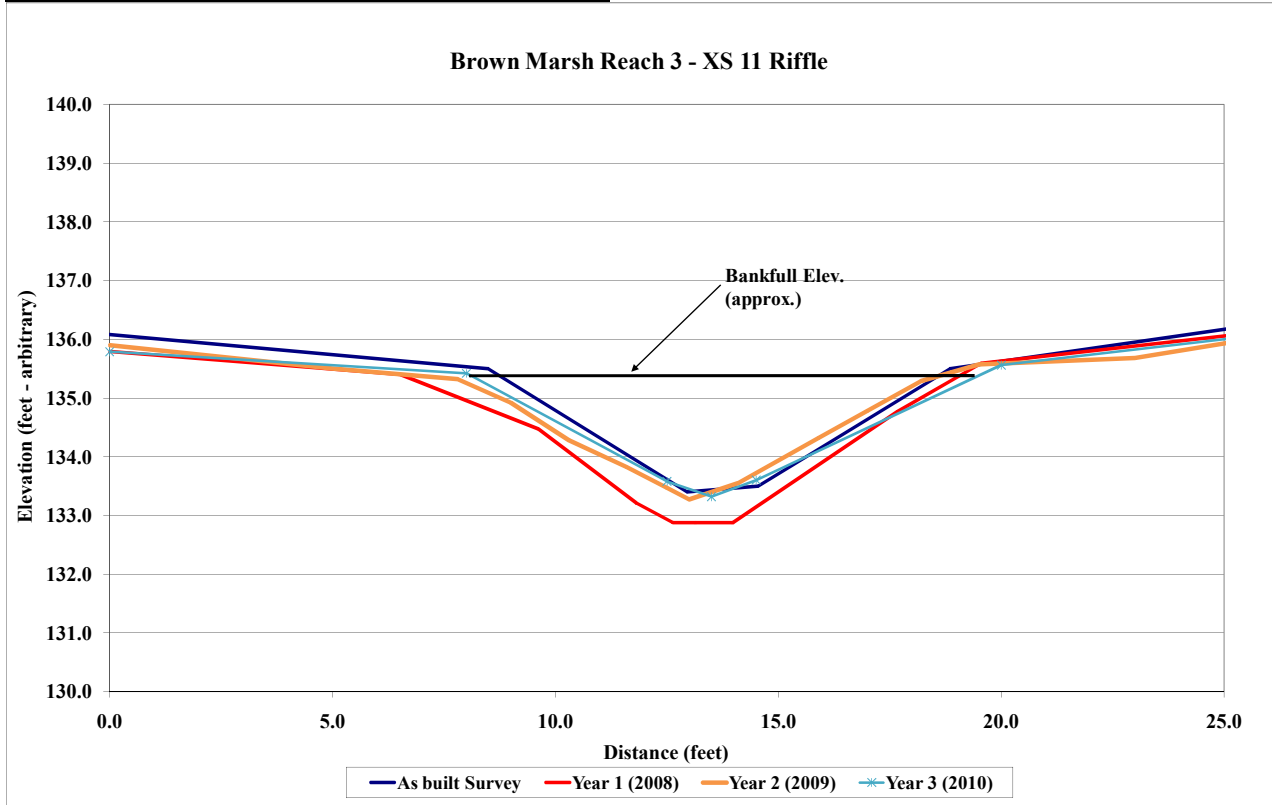
**Project Name** Brown Marsh  
**Cross Section** Reach 3 - XS 11  
**Feature** Riffle  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-8.7	139.0	0.0	135.8	0.0	135.9	0.0	135.8
-0.3	136.1	6.5	135.4	5.0	135.5	8.0	135.4
8.5	135.5	9.6	134.5	7.8	135.3	12.5	133.6
13.0	133.4	11.8	133.2	9.0	134.9	13.5	133.3
14.5	133.5	12.6	132.9	10.3	134.3	14.5	133.6
18.9	135.5	13.1	132.9	11.6	133.8	20.0	135.6
27.1	136.4	14.0	132.9	12.5	133.5	27.0	136.2
33.7	138.8	17.7	134.8	13.0	133.3		
		19.5	135.6	14.1	133.6		
		27.1	136.2	15.9	134.3		
				17.0	134.8		
				18.2	135.3		
				19.5	135.6		
				23.0	135.7		
				27.0	136.2		



Photo of Cross-Section R3-11 - Looking Downstream @ STA 43+75

	2008	2009	2010	2011	2012
Area	16.4	11.1	12.7		
Width	12.6	10.4	11.6		
Mean Depth	1.3	1.1	1.1		
Max Depth	2.5	2.1	2.1		
W/D	9.7	9.8	10.6		



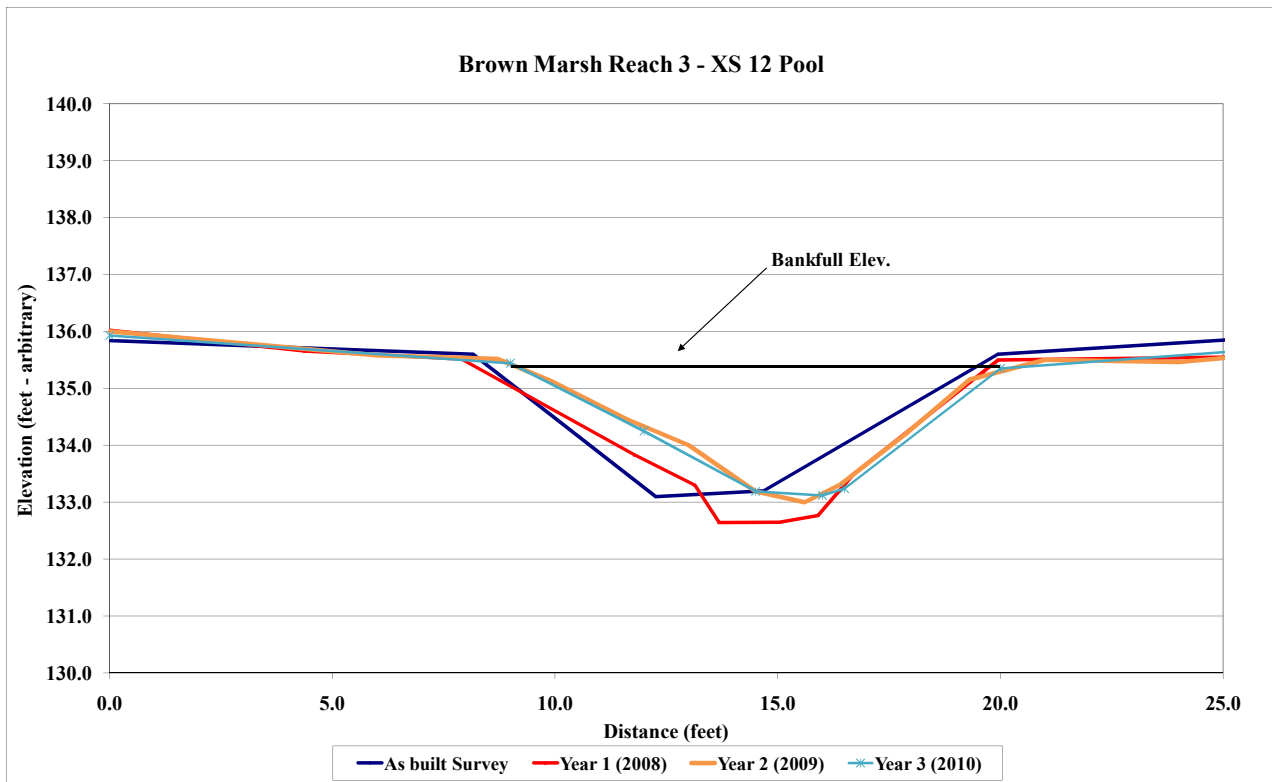
**Project Name** Brown Marsh  
**Cross Section** Reach 3 - XS 12  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-8.8	138.1	0.0	136.0	0.0	136.0	0.0	135.9
-8.7	138.1	4.4	135.7	6.0	135.6	9.0	135.4
-2.0	135.9	7.9	135.5	8.7	135.5	12.0	134.3
8.2	135.6	11.8	133.8	9.9	135.1	14.5	133.2
12.3	133.1	13.1	133.3	11.6	134.5	16.0	133.1
14.7	133.2	13.7	132.6	13.0	134.0	16.5	133.2
19.9	135.6	15.0	132.6	14.5	133.2	20.0	135.4
28.1	136.0	15.9	132.8	15.6	133.0	30.5	136.0
35.5	138.6	16.7	133.5	16.4	133.3		
		19.9	135.5	17.9	134.2		
		25.6	135.6	19.3	135.2		
		30.0	135.7	21.0	135.5		
				24.0	135.5		
				30.4	135.9		



Photo of Cross-Section R3-12 - Looking Downstream @ STA 45+05

	2008	2009	2010	2011	2012
Area	18.6	10.5	13.7		
Width	12.0	9.3	10.8		
Mean Depth	1.6	1.1	1.3		
Max Depth	2.9	2.1	2.2		
W/D	NA	NA	NA		



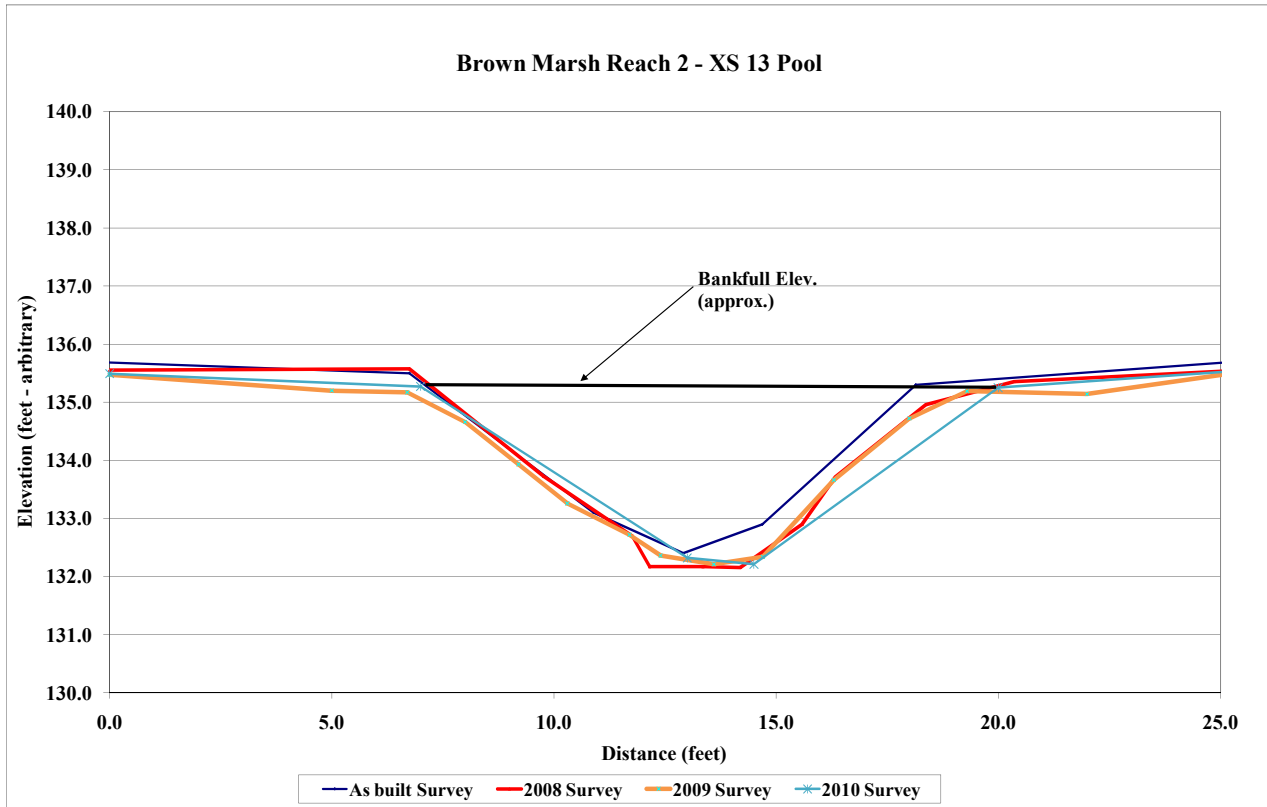
**Project Name** Brown Marsh  
**Cross Section** Reach 2 - XS 13  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-10.5	138.7	0.0	135.6	0.0	135.5	0.0	135.5
-0.7	135.7	6.7	135.6	5.0	135.2	7.0	135.3
6.7	135.5	9.8	133.7	6.7	135.2	13.0	132.3
10.9	133.1	11.8	132.7	8.0	134.7	14.5	132.2
12.9	132.4	12.2	132.2	9.2	133.9	20.0	135.3
14.7	132.9	13.4	132.2	10.3	133.3	26.0	135.6
18.1	135.3	14.2	132.2	11.7	132.7		
25.4	135.7	15.6	132.9	12.4	132.4		
33.2	138.5	16.3	133.7	13.6	132.2		
		18.4	135.0	14.7	132.3		
		20.4	135.4	16.3	133.7		
		26.1	135.6	18.0	134.7		
				19.3	135.2		
				22.0	135.1		
				26.0	135.6		



Photo of Cross-Section R2-13 - Looking Downstream @ STA 47+45

	2008	2009	2010	2011	2012
Area	21.3	20.1	21.6		
Width	12.9	12.5	13.0		
Mean Depth	1.7	1.6	1.7		
Max Depth	3.1	3.0	3.0		
W/D	NA	NA	NA		

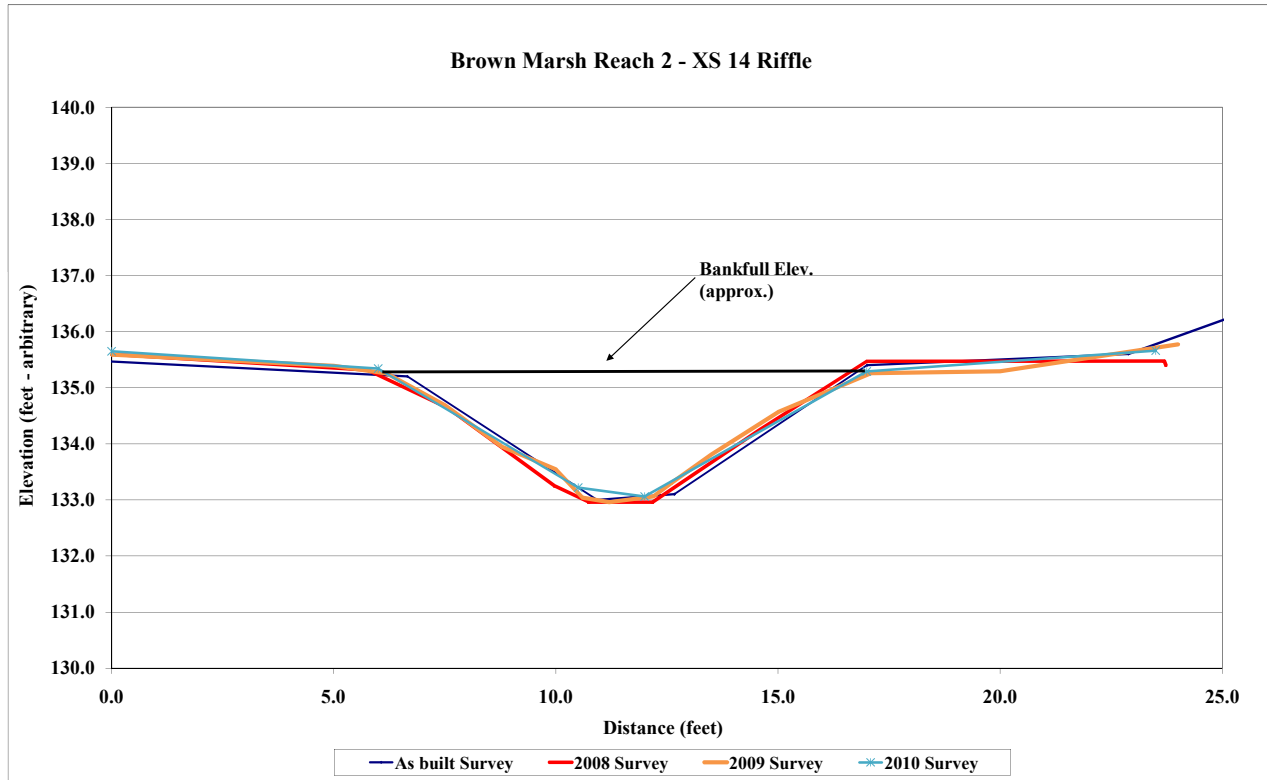


<b>Project Name</b>	Brown Marsh							
<b>Cross Section</b>	Reach 2 - XS 14							
<b>Feature</b>	Riffle							
<b>Date</b>	10/1/10							
<b>Crew</b>	Corbin, Smith							
	<b>2008</b>		<b>2008</b>		<b>2009</b>		<b>2010</b>	
	<b>As-built Survey</b>		<b>YR 1 Survey</b>		<b>YR 2 Survey</b>		<b>YR 3 Survey</b>	
<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>	
-9.2	138.5	0.0	135.6	0.0	135.6	0.0	135.7	
-0.8	135.5	5.7	135.3	5.0	135.4	6.0	135.3	
6.7	135.2	7.6	134.6	6.2	135.3	10.5	133.2	
10.9	133.0	10.0	133.2	7.5	134.7	12.0	133.1	
12.7	133.1	10.7	133.0	8.8	133.9	17.0	135.3	
17.0	135.4	12.2	133.0	10.0	133.5	23.5	135.7	
22.9	135.6	14.6	134.3	10.6	133.0			
34.8	139.0	17.0	135.5	11.2	133.0			
		23.7	135.5	12.2	133.1			
		23.7	135.4	12.6	133.3			
				13.5	133.8			
				15.0	134.6			
				17.1	135.3			
				20.0	135.3			
				24.0	135.8			



Photo of Cross-Section R2-14 - Looking Downstream @ STA 47+48

	2008	2009	2010	2011	2012
Area	14.1	12.8	13.3		
Width	10.9	10.9	10.9		
Mean Depth	1.3	1.2	1.2		
Max Depth	2.1	2.3	2.2		
W/D	8.4	9.2	8.9		





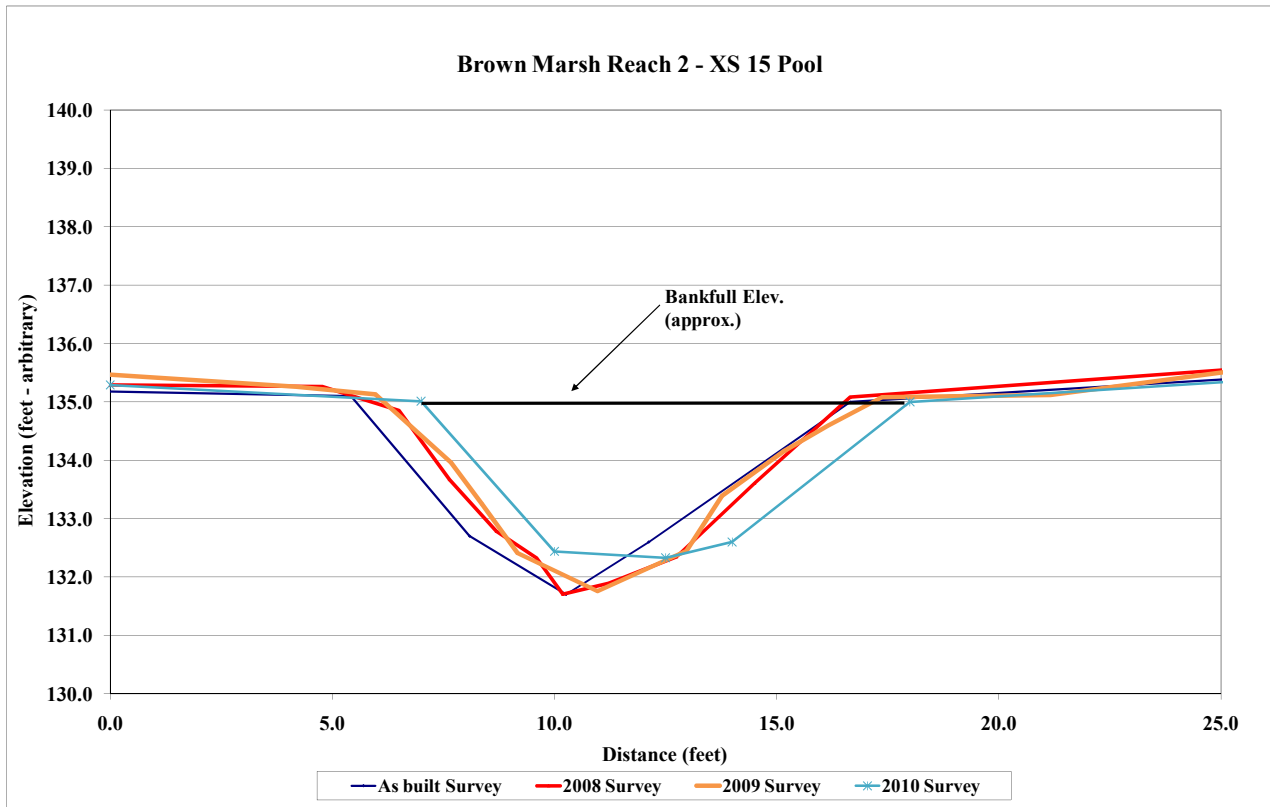
**Project Name** Brown Marsh  
**Cross Section** Reach 2 - XS 15  
**Feature** Pool  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-13.6	139.2	0.0	135.3	-0.8	135.5	0.0	135.3
-1.4	135.2	4.8	135.3	4.2	135.3	7.0	135.0
5.4	135.1	6.5	134.9	6.0	135.1	10.0	132.4
8.1	132.7	7.6	133.7	7.7	134.0	12.5	132.3
10.3	131.7	8.7	132.8	8.4	133.3	14.0	132.6
12.1	132.6	9.6	132.3	9.2	132.4	18.0	135.0
16.7	135.0	10.2	131.7	11.0	131.8	26.5	135.4
25.4	135.4	11.2	131.9	13.0	132.5		
33.7	138.8	12.8	132.3	13.8	133.4		
		14.5	133.6	15.2	134.2		
		16.7	135.1	16.2	134.6		
		25.9	135.6	17.4	135.1		
				21.2	135.1		
				25.9	135.6		



Photo of Cross-Section R2-15 - Looking Downstream @ STA 50+75

	2008	2009	2010	2011	2012
Area	20.0	20.1	19.0		
Width	10.9	11.4	11.0		
Mean Depth	1.8	1.8	1.7		
Max Depth	3.3	3.4	2.7		
W/D	NA	NA	NA		

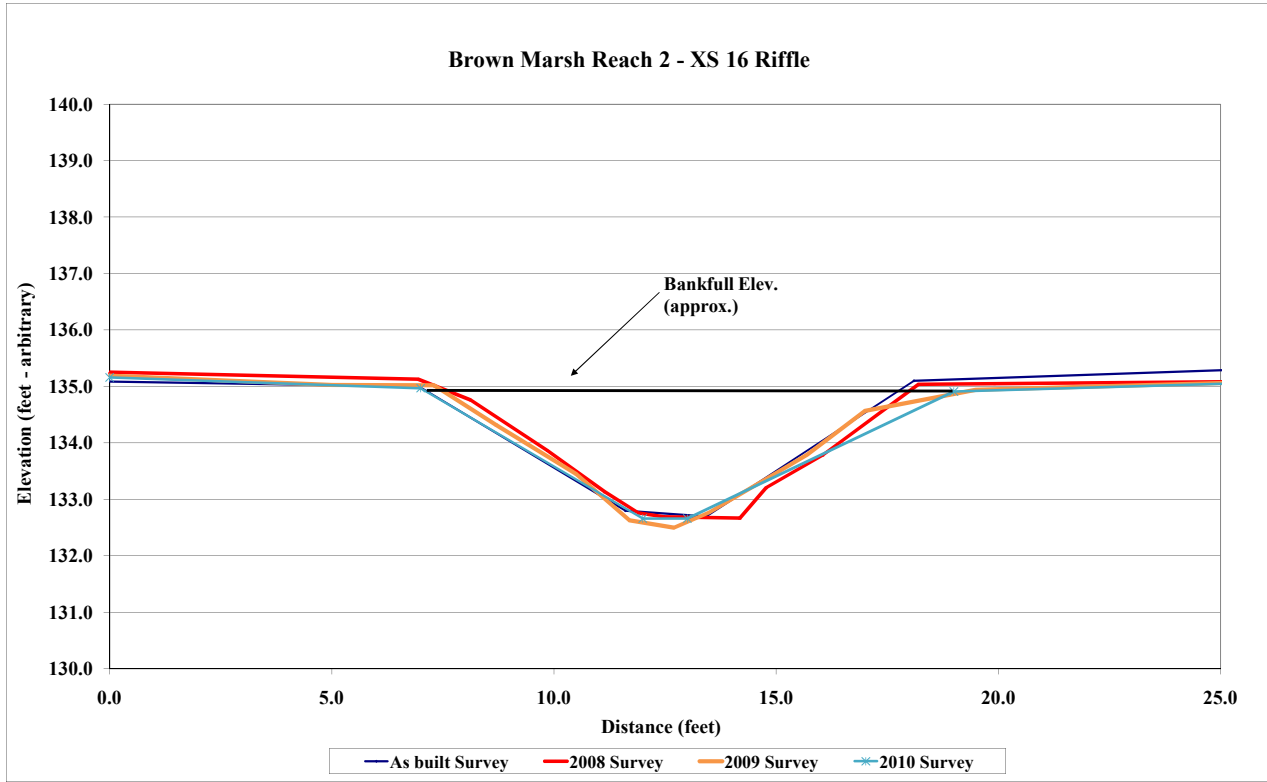


<b>Project Name</b>	Brown Marsh							
<b>Cross Section</b>	Reach 2 - XS 16							
<b>Feature</b>	Riffle							
<b>Date</b>	10/1/10							
<b>Crew</b>	Corbin, Smith							
	<b>2008</b>		<b>2008</b>		<b>2009</b>		<b>2010</b>	
	<b>As-built Survey</b>		<b>YR 1 Survey</b>		<b>YR 2 Survey</b>		<b>YR 3 Survey</b>	
	<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>	<b>Station</b>	<b>Elevation</b>
	-12.3	138.4	0.0	135.3	0.0	135.2	0.0	135.2
	-1.1	135.1	6.9	135.1	5.0	135.0	7.0	135.0
	7.0	135.0	8.1	134.8	7.3	135.0	12.0	132.7
	11.6	132.8	9.9	133.9	8.7	134.3	13.0	132.7
	13.4	132.7	11.1	133.1	10.5	133.5	19.0	134.9
	18.1	135.1	11.9	132.8	11.7	132.6	26.0	135.1
	25.4	135.3	12.5	132.7	12.7	132.5		
	34.6	139.0	14.2	132.7	13.5	132.8		
			14.8	133.2	15.7	133.8		
			16.1	133.8	17.0	134.6		
			18.2	135.0	19.5	134.9		
			19.9	135.1	26.3	135.1		
			26.8	135.1				



Photo of Cross-Section R2-16 - Looking Downstream @ STA 52+02

	2008	2009	2010	2011	2012
Area	14.4	13.9	14.5		
Width	10.8	12.0	11.9		
Mean Depth	1.3	1.2	1.2		
Max Depth	2.3	2.4	2.3		
W/D	8.1	10.4	9.7		



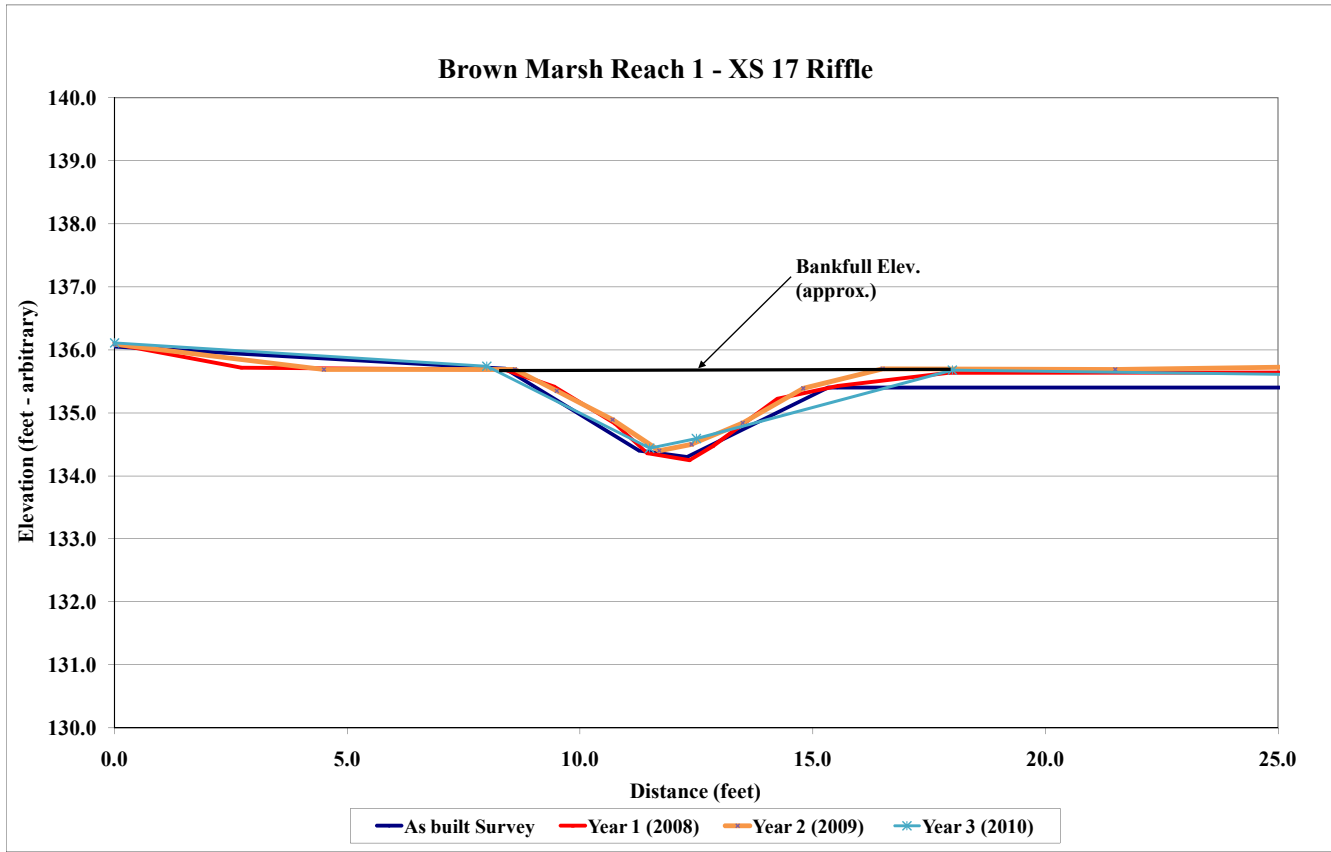
**Project Name** Brown Marsh  
**Cross Section** Reach 1 - XS 17  
**Feature** Riffle  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-6.9	138.2	26.1	135.6	26.5	135.7	26.0	135.6
-1.2	136.1	17.9	135.6	21.5	135.7	18.0	135.7
8.4	135.7	15.5	135.4	16.5	135.7	12.5	134.6
11.3	134.4	14.2	135.2	14.8	135.4	11.5	134.4
12.3	134.3	12.9	134.5	13.5	134.8	8.0	135.7
15.3	135.4	12.4	134.3	12.4	134.5	0.0	136.1
15.5	135.4	11.4	134.4	11.7	134.4		
31.9	135.4	10.7	134.8	10.7	134.9		
40.5	137.2	9.5	135.4	9.5	135.4		
		8.4	135.7	8.6	135.7		
		2.7	135.7	4.5	135.7		
		0.0	136.1	0.0	136.1		



Photo of Cross-Section R1-17 - Looking Downstream @ STA 13+60

	2008	2009	2010	2011	2012
Area	4.7	4.9	6.2		
Width	8.8	7.8	9.8		
Mean Depth	0.5	0.6	0.6		
Max Depth	1.3	1.3	1.2		
W/D	16.2	12.6	15.5		



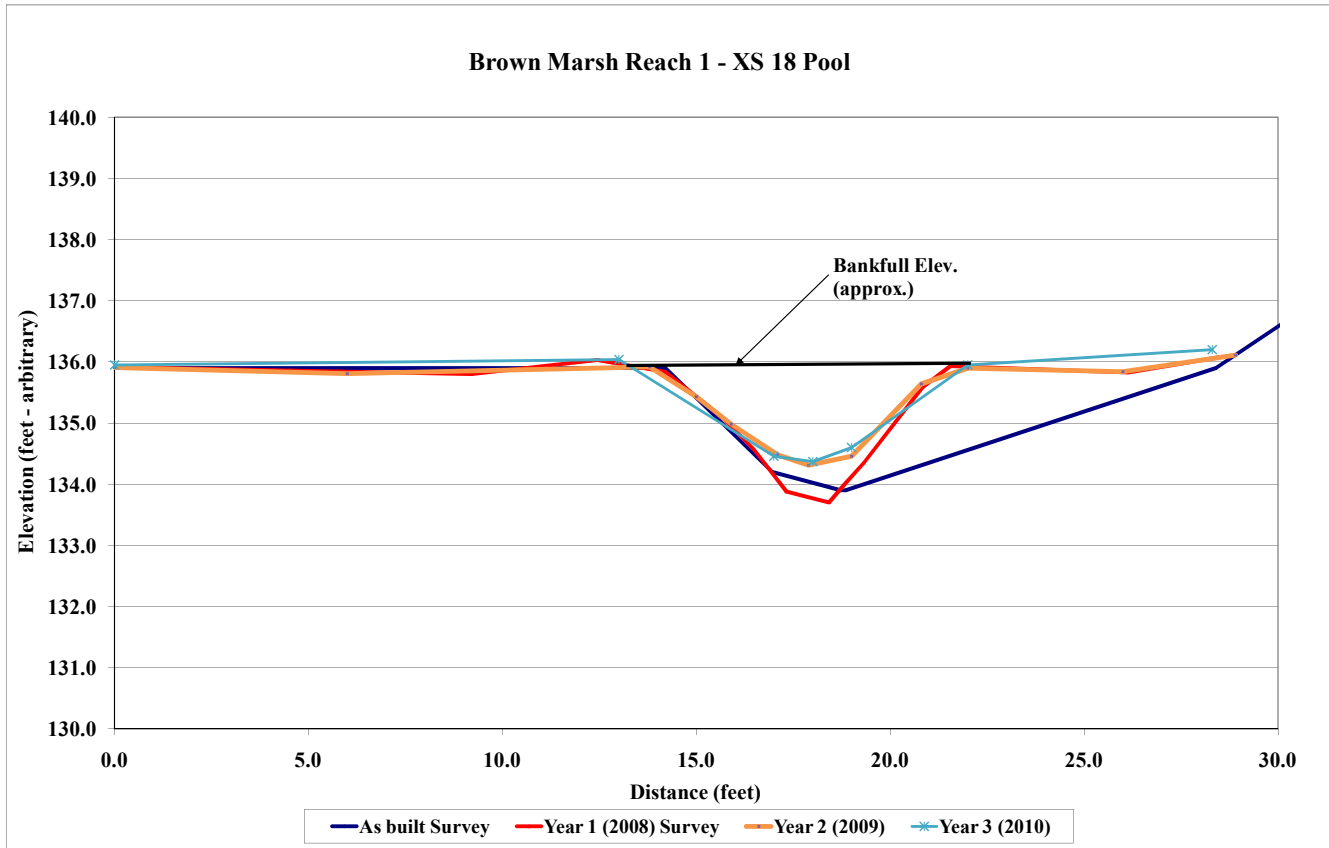
<b>Project Name</b>	Brown Marsh
<b>Cross Section</b>	Reach 1 - XS 18
<b>Feature</b>	Pool
<b>Date</b>	10/1/10
<b>Crew</b>	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-6.7	135.9	0.0	135.9	0.0	135.9	0.0	136.0
14.2	135.9	9.2	135.8	6.0	135.8	13.0	136.0
17.0	134.2	12.4	136.0	13.8	135.9	17.0	134.5
18.7	133.9	14.2	135.8	15.0	135.4	18.0	134.4
18.8	133.9	15.7	135.1	15.9	135.0	19.0	134.6
28.4	135.9	16.5	134.6	17.1	134.5	22.0	136.0
34.3	138.4	17.3	133.9	17.9	134.3	28.3	136.2
		18.4	133.7	19.0	134.5		
		18.8	134.0	20.8	135.6		
		19.3	134.4	22.0	135.9		
		20.8	135.6	26.0	135.8		
		21.6	135.9	28.9	136.1		
		26.1	135.8				
		28.5	136.1				



Photo of Cross-Section R1-18 - Looking Downstream @ STA 12+45

	2008	2009	2010	2011	2012
Area	7.7	6.9	7.8		
Width	7.0	8.2	8.8		
Mean Depth	1.1	0.8	0.9		
Max Depth	2.1	1.6	1.6		
W/D	NA	NA	NA		



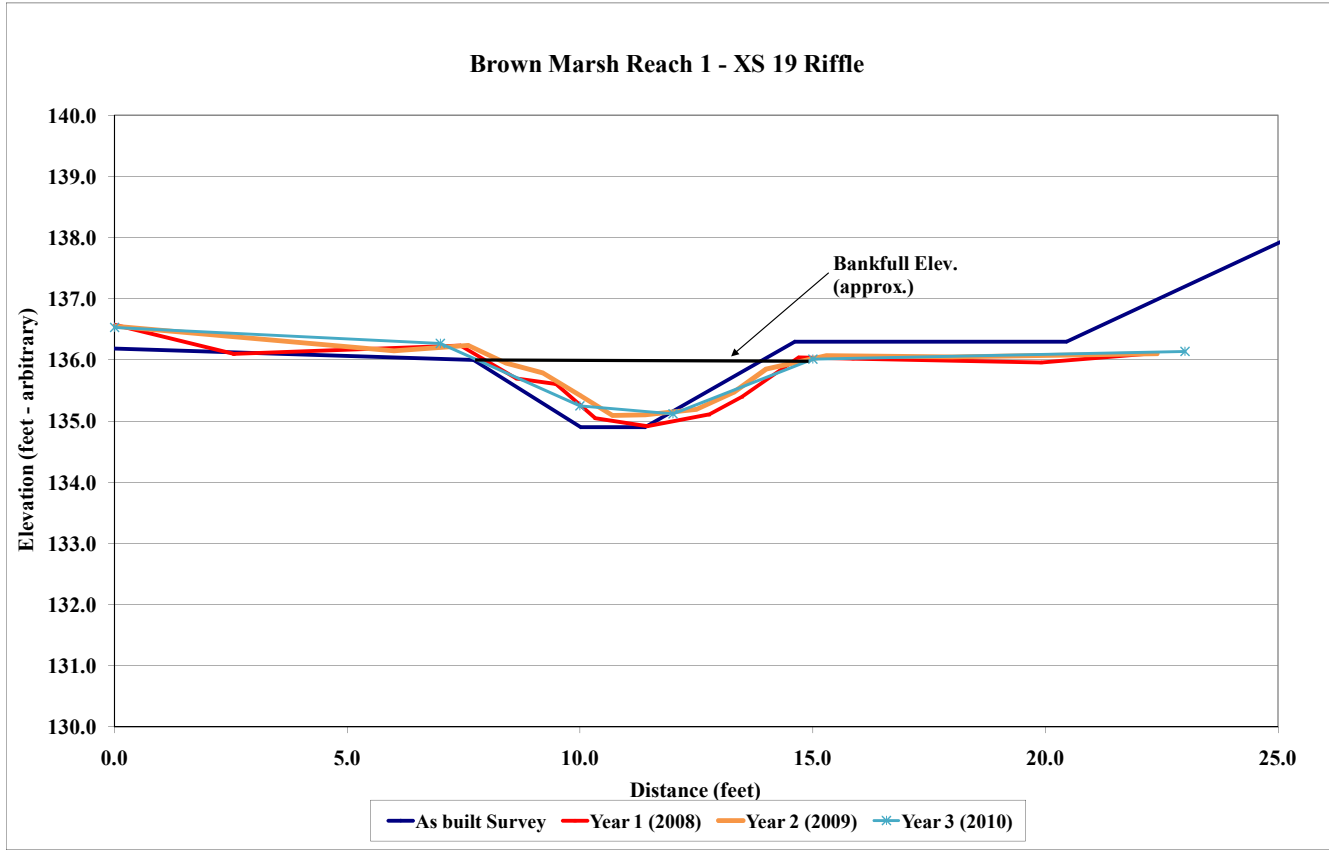
<b>Project Name</b>	Brown Marsh
<b>Cross Section</b>	Reach 1 - XS 19
<b>Feature</b>	Riffle
<b>Date</b>	10/1/10
<b>Crew</b>	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-4.6	137.9	0.0	136.6	0.0	136.6	0.0	136.5
-0.5	136.2	2.6	136.1	6.0	136.2	7.0	136.3
7.7	136.0	7.4	136.2	7.6	136.2	10.0	135.3
10.0	134.9	8.6	135.7	8.4	136.0	12.0	135.1
11.4	134.9	9.5	135.6	9.2	135.8	15.0	136.0
14.6	136.3	10.3	135.0	10.0	135.4	23.0	136.1
20.5	136.3	11.4	134.9	10.7	135.1		
29.8	139.6	12.8	135.1	11.4	135.1		
		13.5	135.4	12.5	135.2		
		14.7	136.0	13.3	135.5		
		15.9	136.0	14.0	135.9		
		19.9	136.0	15.3	136.1		
		22.3	136.1	18.0	136.1		
				22.4	136.1		



Photo of Cross-Section R1-19 - Looking Downstream @ STA 10+72

	2008	2009	2010	2011	2012
Area	4.3	3.8	3.8		
Width	6.7	7.2	7.2		
Mean Depth	0.6	0.5	0.5		
Max Depth	1.1	1.0	0.9		
W/D	10.4	13.6	13.7		



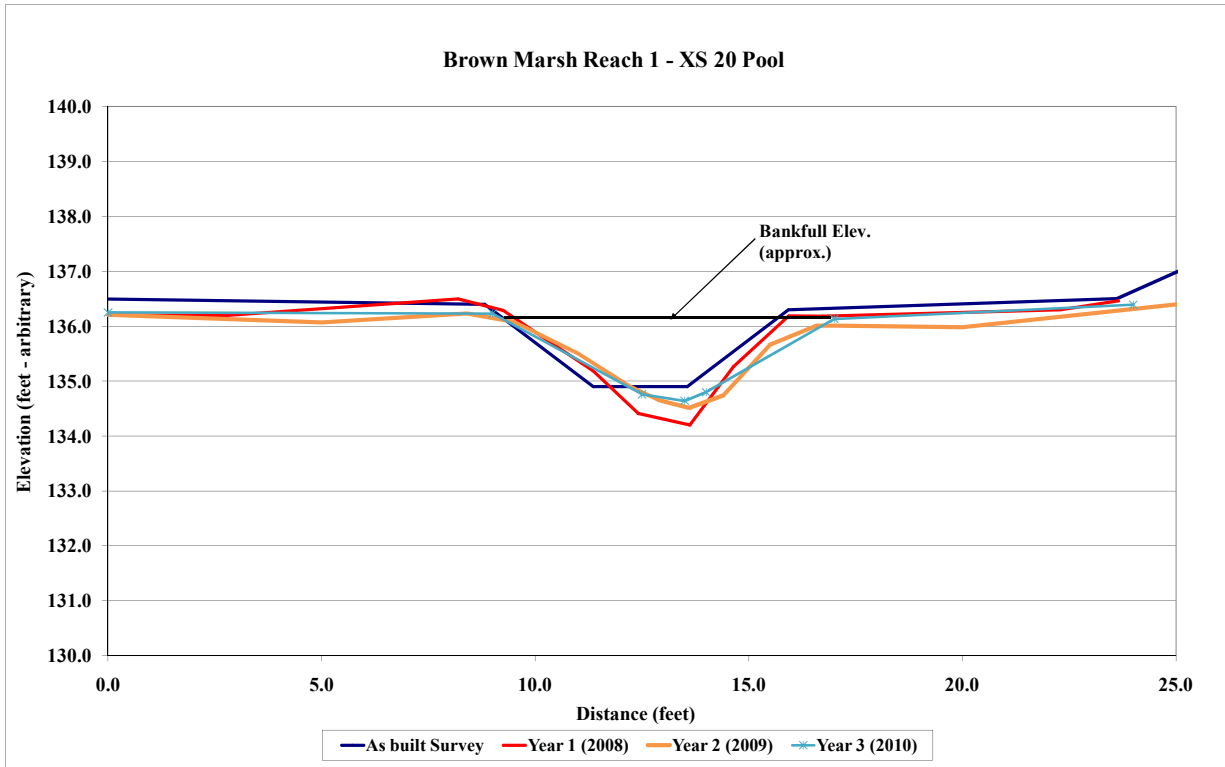
Project Name Brown Marsh  
 Cross Section Reach 1 - XS 20  
 Feature Pool  
 Date 10/1/10  
 Crew Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey		2009 YR 2 Survey		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
-8.5	139.2	0.0	136.2	0.0	136.2	0.0	136.3
-0.7	136.5	2.7	136.2	5.0	136.1	9.0	136.2
8.8	136.4	8.2	136.5	8.4	136.2	12.5	134.8
11.4	134.9	9.3	136.3	9.5	136.1	13.5	134.6
13.6	134.9	10.0	135.9	11.0	135.5	14.0	134.8
15.9	136.3	11.4	135.2	12.2	134.9	17.0	136.1
23.6	136.5	12.4	134.4	12.9	134.7	24.0	136.4
28.5	138.2	13.6	134.2	13.6	134.5		
		14.6	135.3	14.4	134.7		
		15.9	136.2	15.5	135.7		
		16.7	136.2	16.6	136.0		
		22.3	136.3	17.0	136.0		
		23.7	136.5	20.0	136.0		
				25.4	136.4		



Photo of Cross-Section RI-20 - Looking Downstream @ STA 10+52

	2008	2009	2010	2011	2012
Area	6.2	5.4	6.4		
Width	6.2	6.9	7.8		
Mean Depth	1.0	0.8	0.8		
Max Depth	1.9	1.5	1.5		
W/D	NA	NA	9.5		

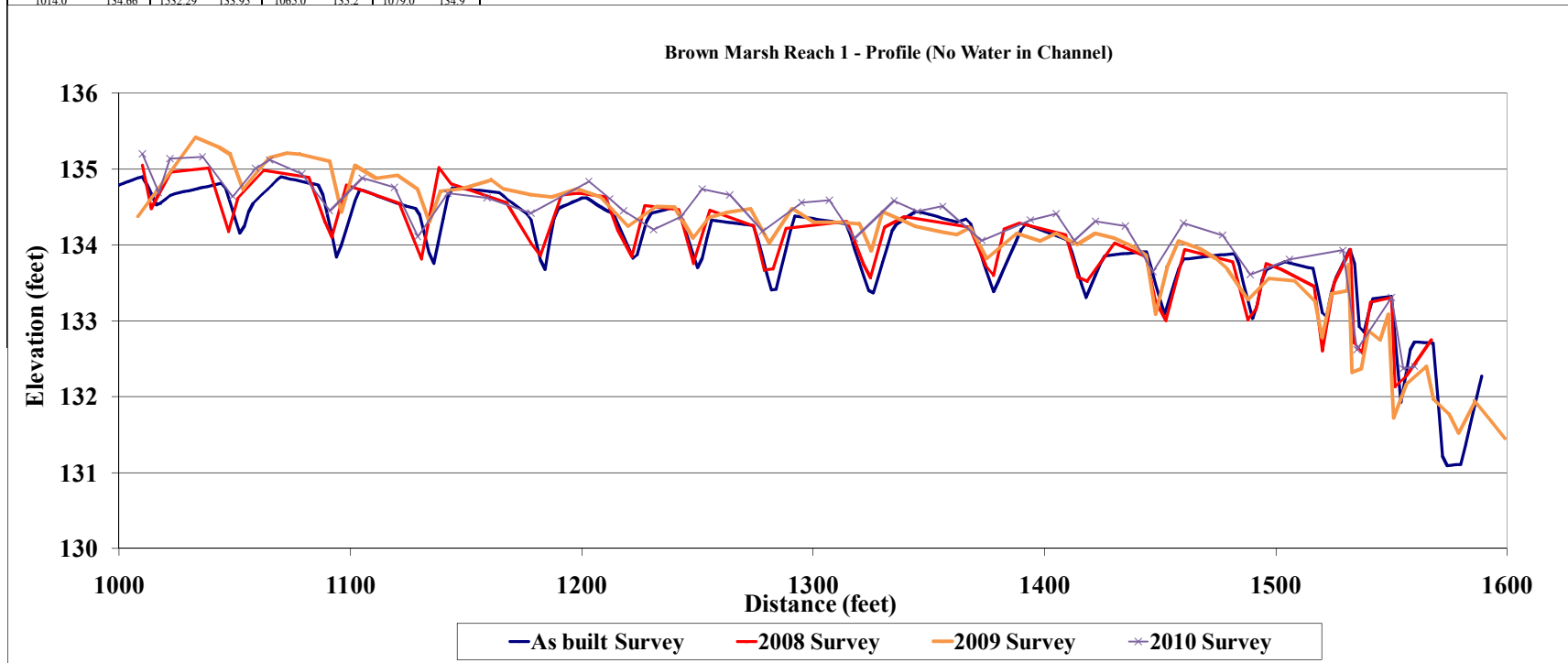


Project Name	Brown Marsh
Cross Section	Reach 1
Feature	Profile
Date	10/1/10
Crew	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey Bed		2009 YR 2 Survey Bed		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
1000.0	134.79	1567.25	132.75	1008.0	134.4	1010.0	135.2
1002.0	134.81	1556.23	132.27	1023.0	135.0	1017.0	134.7
1004.0	134.84	1551.45	132.14	1033.0	135.4	1022.0	135.1
1006.0	134.86	1549.89	133.31	1043.0	135.3	1036.0	135.2
1008.0	134.88	1541.01	133.25	1048.0	135.2	1049.0	134.6
1010.0	134.90	1537.42	132.58	1053.5	134.7	1059.0	135.0
1012.0	134.79	1533.68	132.72	1060.0	135.0	1065.0	135.1
1014.0	134.66	1532.29	133.95	1065.0	135.2	1079.0	134.9

	2008	2009	2010	2011	2012
Ave Slope	0.0018	NA*	NA*		
Riffle Length	19.7	20.0	14.0		
Riffle Slope	0.0039	NA*	NA*		
Pool Length	4.1	20.0	26.0		
Pool Slope	0.0000	NA*	NA*		

\* No water in channel.

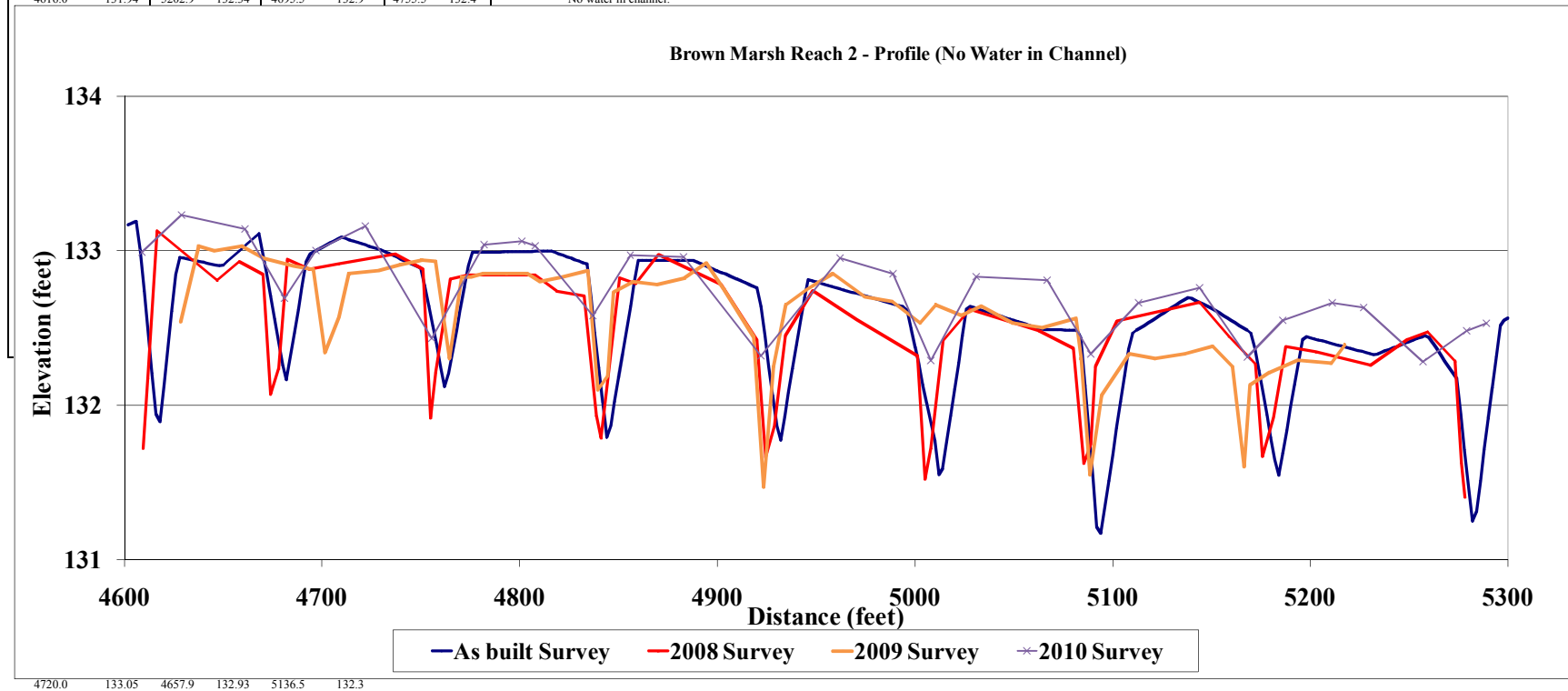


Project Name	Brown Marsh
Cross Section	Reach 2
Feature	Profile
Date	10/1/10
Crew	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey Bed		2009 YR 2 Survey Bed		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
4602.0	133.17	5278.2	131.40	4628.5	132.5	4609.0	133.0
4604.0	133.18	5276.4	131.63	4637.5	133.0	4629.0	133.2
4606.0	133.19	5273.3	132.29	4645.5	133.0	4661.0	133.1
4608.0	133.00	5259.4	132.47	4659.5	133.0	4681.0	132.7
4610.0	132.74	5249.1	132.43	4670.5	133.0	4697.0	133.0
4614.0	132.21	5230.4	132.26	4685.5	132.9	4722.0	133.2
4616.0	131.94	5202.9	132.34	4695.5	132.9	4755.5	132.4

	2008	2009	2010	2011	2012
Ave Slope	0.0010	NA*	NA*		
Riffle Length	68.3	57.0	29.0		
Riffle Slope	0.0012	NA*	NA*		
Pool Length	3.7	21.0	47.0		
Pool Slope	0.0000	NA*	NA*		

\* No water in channel.



4720.0 133.05 4657.9 132.93 5136.5 132.3

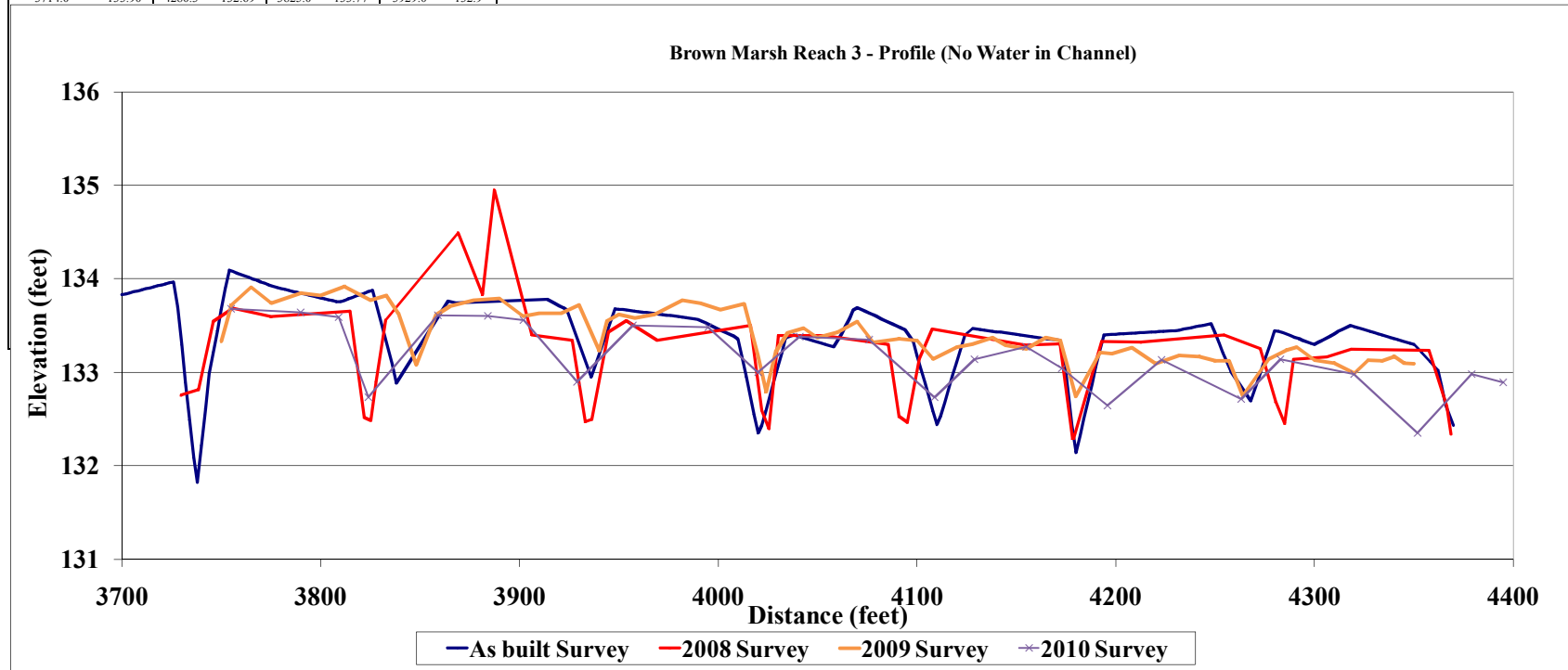


Project Name	Brown Marsh
Cross Section	Reach 3
Feature	Profile
Date	10/1/10
Crew	Corbin, Smith

2008		2008		2009		2010	
As-built Survey		YR 1 Survey Bed		YR 2 Survey Bed		YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
3700.0	133.83	4368.8	132.34	3750.0	133.33	3755.0	133.7
3702.0	133.84	4366.6	132.63	3755.0	133.72	3790.0	133.6
3704.0	133.85	4357.6	133.24	3765.0	133.91	3809.0	133.6
3706.0	133.86	4318.4	133.25	3775.0	133.74	3824.0	132.7
3708.0	133.87	4306.1	133.17	3790.0	133.85	3859.0	133.6
3710.0	133.88	4289.4	133.14	3800.0	133.82	3884.0	133.6
3712.0	133.89	4285.0	132.45	3812.0	133.92	3902.0	133.6
3714.0	133.90	4280.3	132.69	3825.0	133.77	3929.0	132.9

	2008	2009	2010	2011	2012
Ave Slope	0.0014	NA*	NA*		
Riffle Length	70.8	37.5	41.0		
Riffle Slope	0.0003	NA*	NA*		
Pool Length	3.4	39.0	50.0		
Pool Slope	0.0038	NA*	NA*		

\* No water in channel.

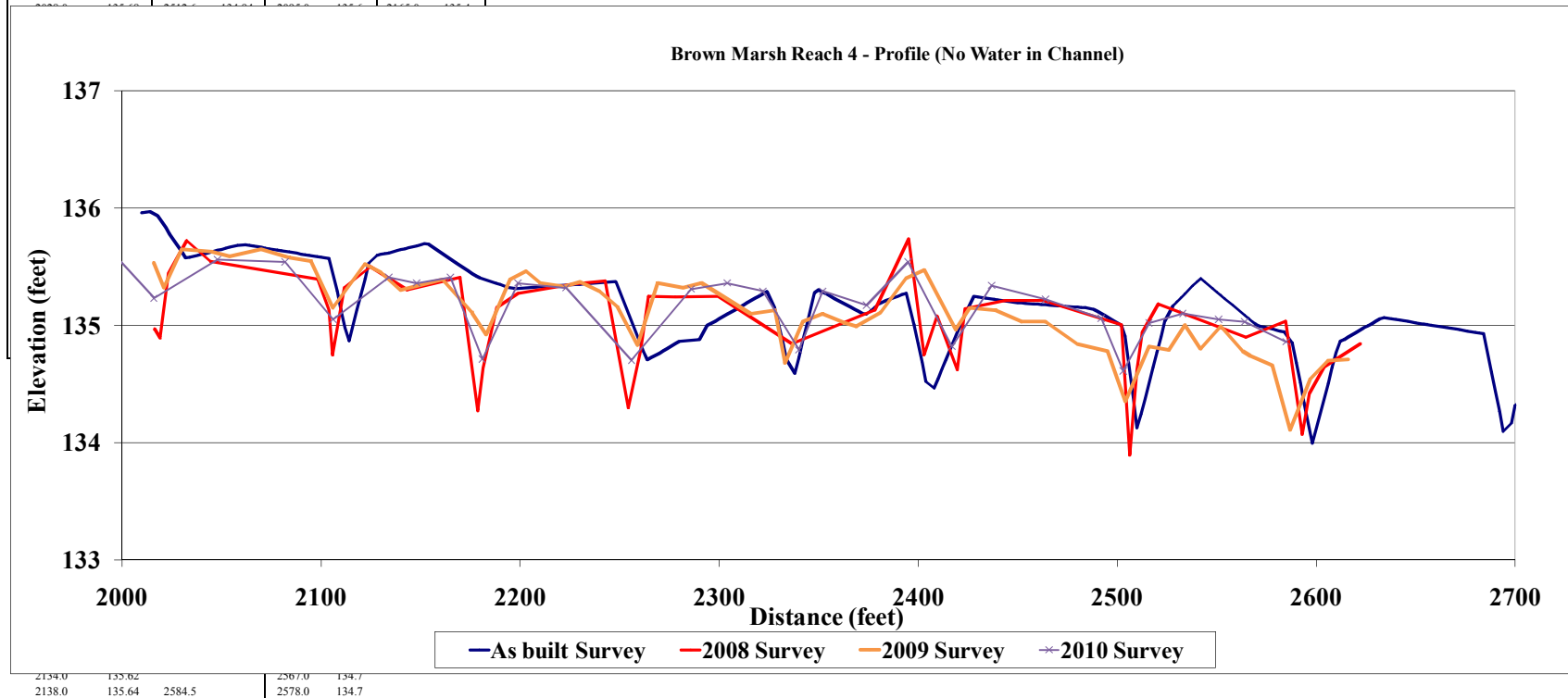


3806.0	133.76	4220.0	133.09
3808.0	133.75	4232.0	133.18

Project Name	Brown Marsh
Cross Section	Reach 4
Feature	Profile
Date	10/1/10
Crew	Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey Bed		2009 YR 2 Survey Bed		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
2010.0	135.96	2622.3	134.84	2016.0	135.5	1979.0	135.9
2012.0	135.96	2603.8	134.65	2021.0	135.3	2016.0	135.2
2014.0	135.97	2596.5	134.42	2030.0	135.7	2048.0	135.6
2018.0	135.93	2592.9	134.07	2045.0	135.6	2082.0	135.5
2020.0	135.88	2584.5	135.04	2054.0	135.6	2106.0	135.1
2022.0	135.83	2564.7	134.90	2070.0	135.7	2134.0	135.4
2024.0	135.78	2520.6	135.18	2084.0	135.6	2148.0	135.4

	2008	2009	2010	2011	2012
Ave Slope	0.0005	NA*	NA*		
Riffle Length	73.5	30.0	36.0		
Riffle Slope	0.0006	NA*	NA*		
Pool Length	3.7	33.0	42.0		
Pool Slope	0.0064	NA*	NA*		

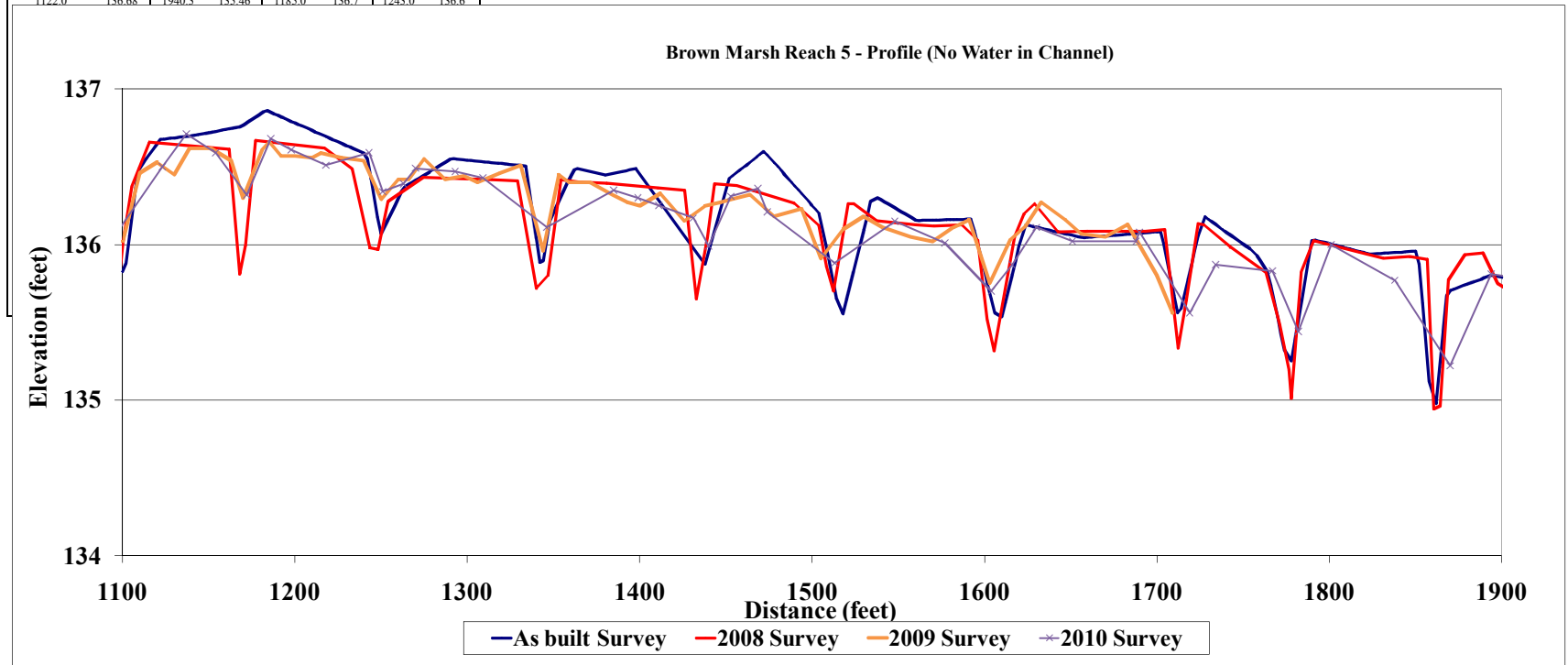


**Project Name** Brown Marsh  
**Cross Section** Reach 5  
**Feature** Profile  
**Date** 10/1/10  
**Crew** Corbin, Smith

2008 As-built Survey		2008 YR 1 Survey Bed		2009 YR 2 Survey Bed		2010 YR 3 Survey	
Station	Elevation	Station	Elevation	Station	Elevation	Station	Elevation
1100.0	135.83	2027.0	134.65	1100.0	136.0	1078.0	136.5
1102.0	135.88	2024.7	135.05	1110.0	136.5	1095.5	136.1
1104.0	136.06	2020.5	135.76	1120.0	136.5	1123.0	136.5
1108.0	136.41	2005.3	135.80	1130.0	136.5	1137.0	136.7
1110.0	136.49	1993.6	135.80	1139.0	136.6	1154.0	136.6
1112.0	136.52	1955.3	135.62	1151.0	136.6	1172.0	136.3
1114.0	136.55	1950.0	135.28	1163.0	136.5	1186.0	136.7
1118.0	136.61	1947.5	135.12	1170.0	136.3	1198.0	136.6
1120.0	136.65	1943.5	134.74	1181.0	136.6	1218.0	136.5
1122.0	136.68	1940.3	135.46	1185.0	136.7	1243.0	136.6

	2008	2009	2010	2011	2012
Ave Slope	0.0007	NA*	NA*		
Riffle Length	70.5	41.0	32.0		
Riffle Slope	0.0007	NA*	NA*		
Pool Length	45.0	52.0	48.0		
Pool Slope	0.0000	NA*	NA*		

\* No water in channel.



1230.0    136.64    1432.9    135.65    1656.0    136.1

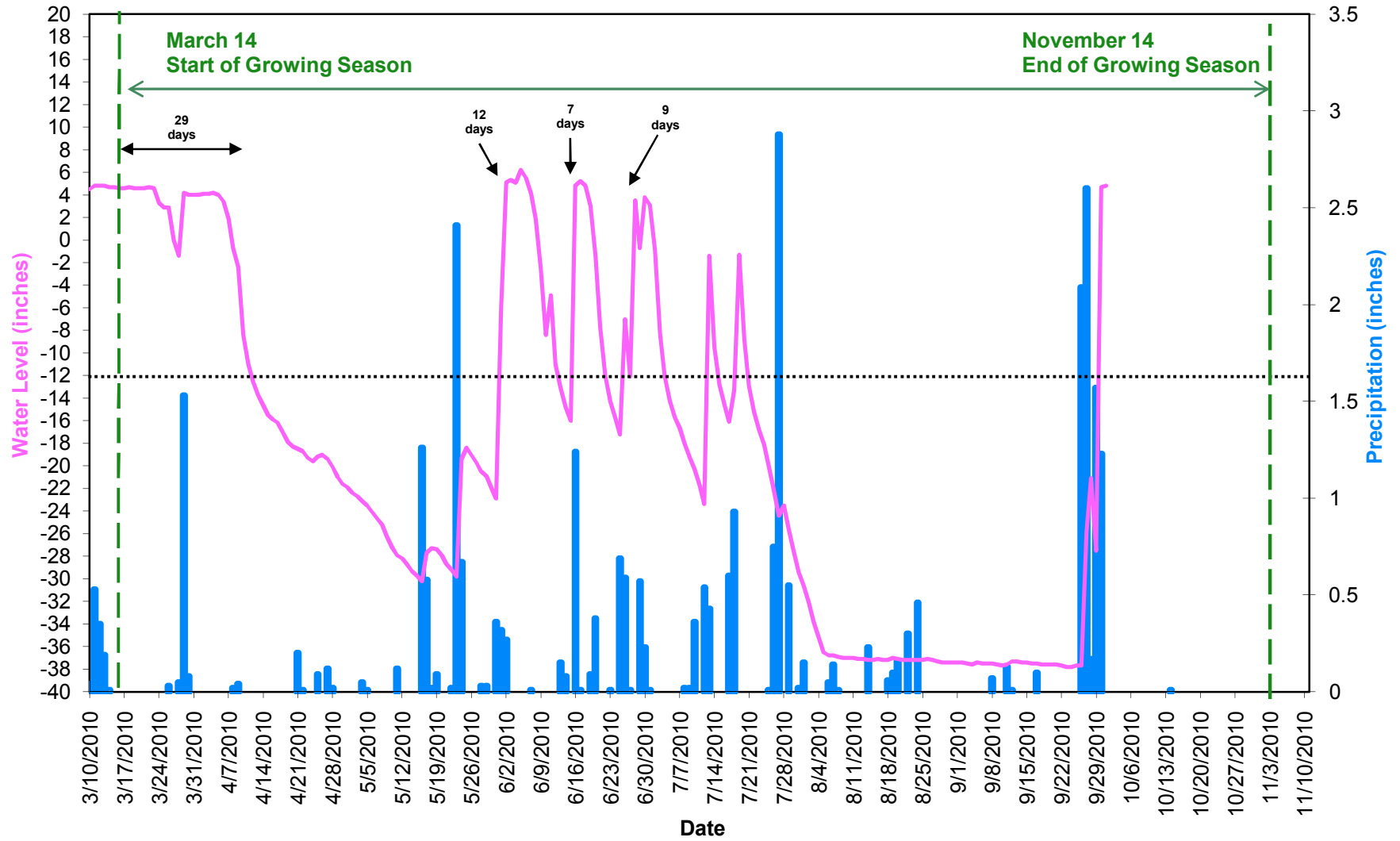
APPENDIX C

HYDROLOGY DATA

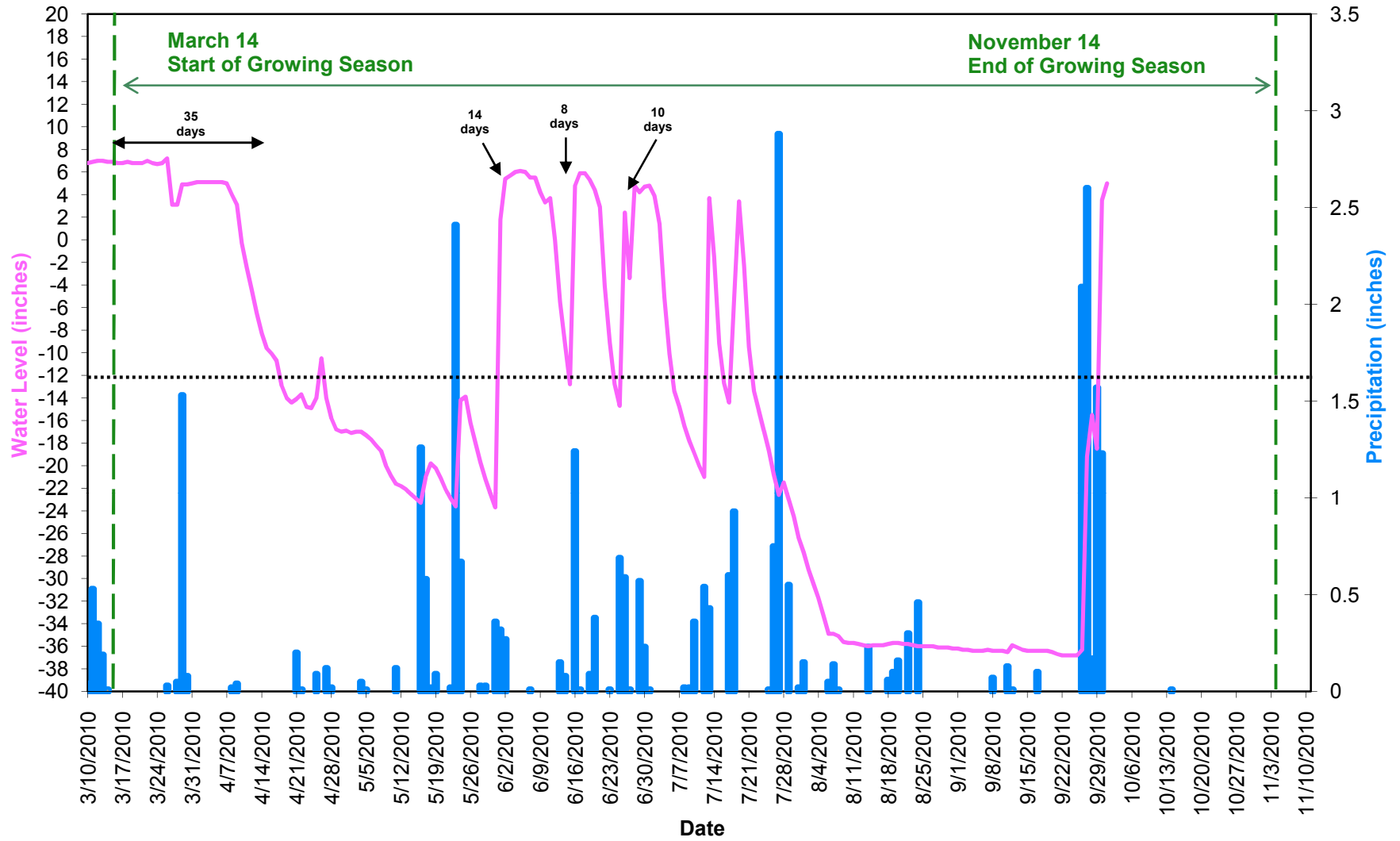
2010 Groundwater Gauge Graphs

Figure C1. Annual Climactic Data vs. 30-year Historic Data

**Brown Marsh Swamp Ground Water Gauge 1  
Year 3 (2010 Data)**



### Brown Marsh Swamp Ground Water Gauge 2 Year 3 (2010 Data)



### Brown Marsh Swamp Ground Water Reference Gauge Year 3 (2010 Data)

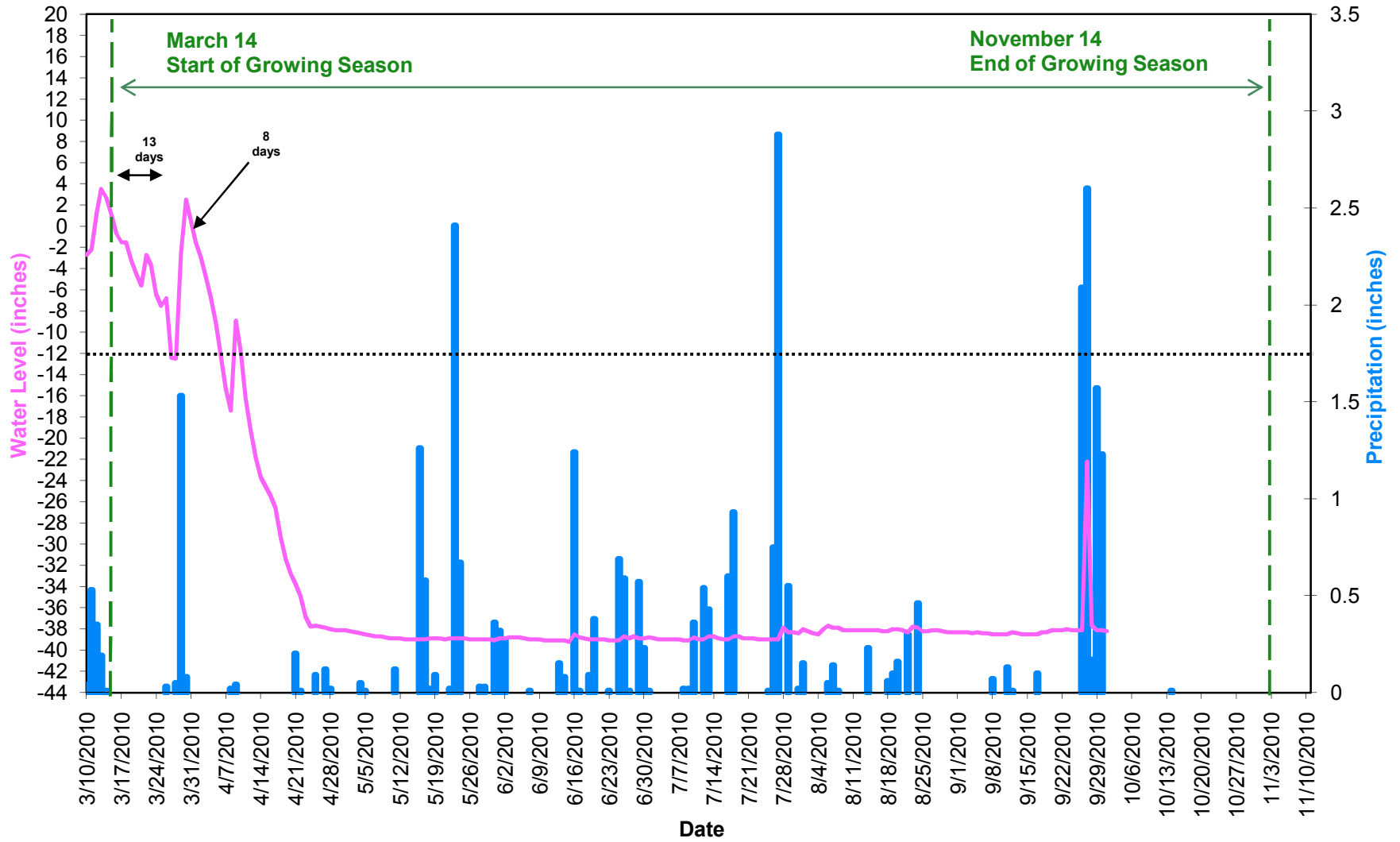
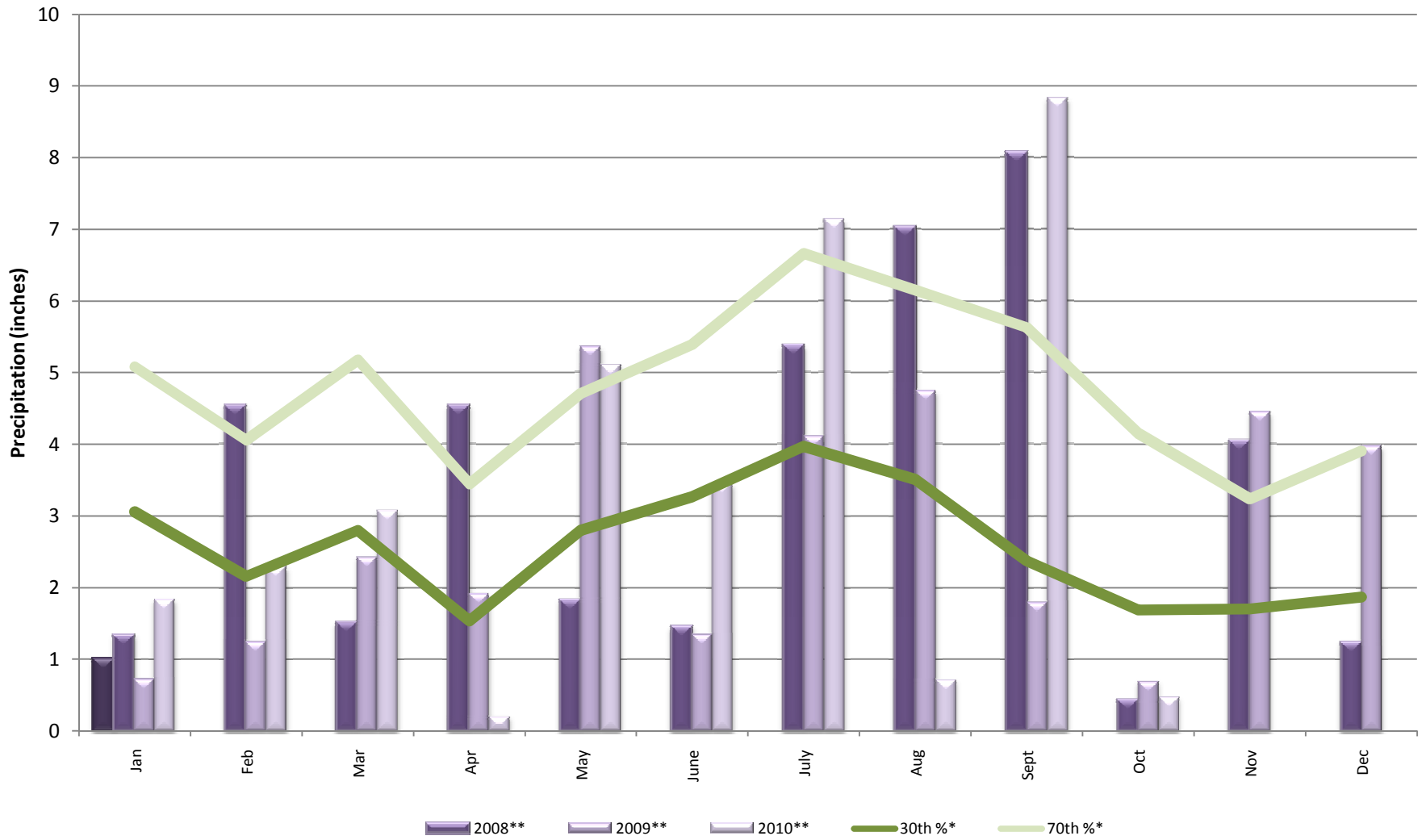


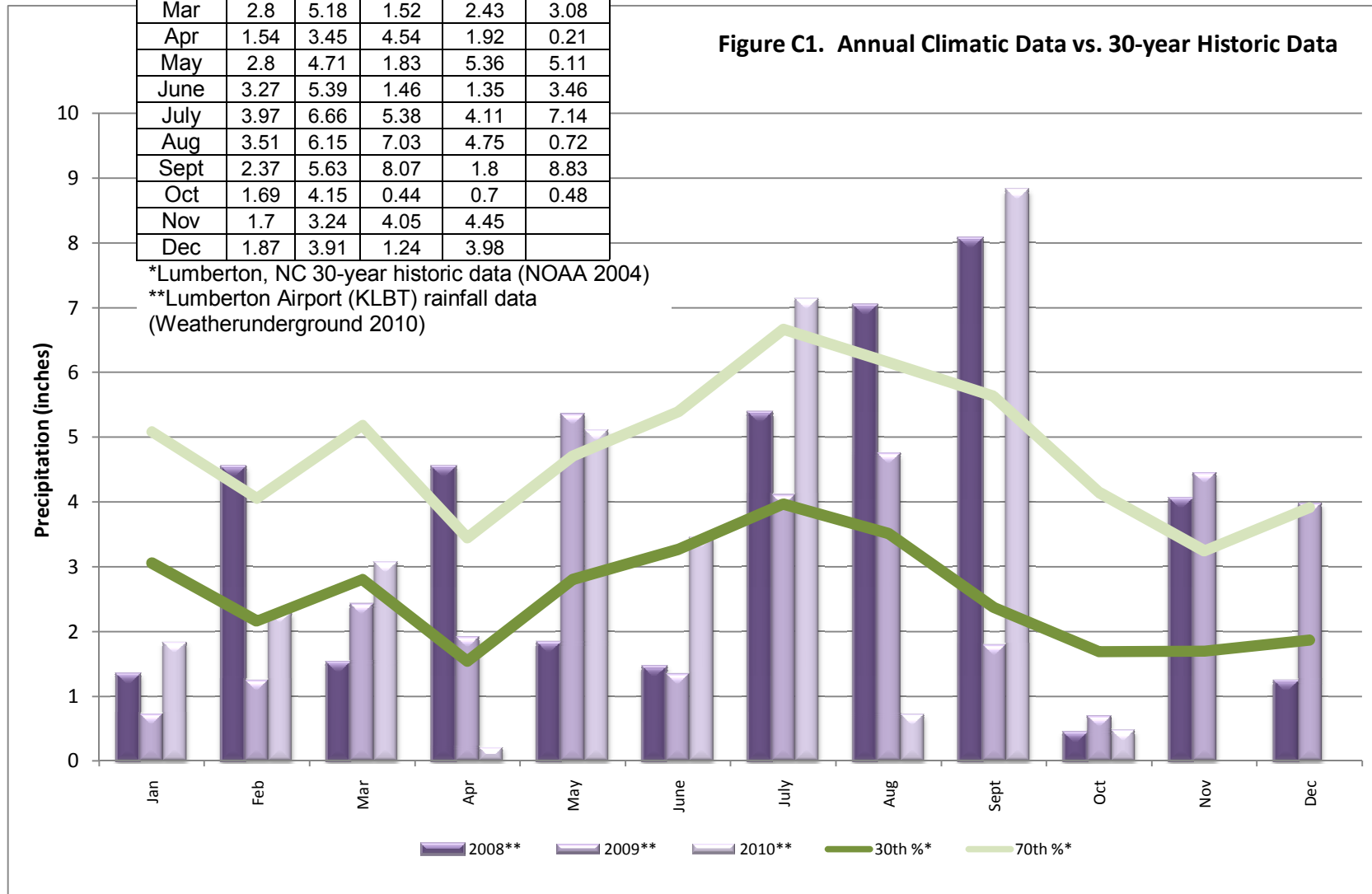
Figure C1. Annual Climatic Data vs. 30-year Historic Data





Month	30th %*	70th %*	2008**	2009**	2010**
Jan	3.06	5.08	1.34	0.73	1.84
Feb	2.16	4.06	4.54	1.25	2.3
Mar	2.8	5.18	1.52	2.43	3.08
Apr	1.54	3.45	4.54	1.92	0.21
May	2.8	4.71	1.83	5.36	5.11
June	3.27	5.39	1.46	1.35	3.46
July	3.97	6.66	5.38	4.11	7.14
Aug	3.51	6.15	7.03	4.75	0.72
Sept	2.37	5.63	8.07	1.8	8.83
Oct	1.69	4.15	0.44	0.7	0.48
Nov	1.7	3.24	4.05	4.45	
Dec	1.87	3.91	1.24	3.98	

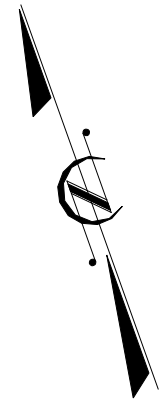
Figure C1. Annual Climatic Data vs. 30-year Historic Data



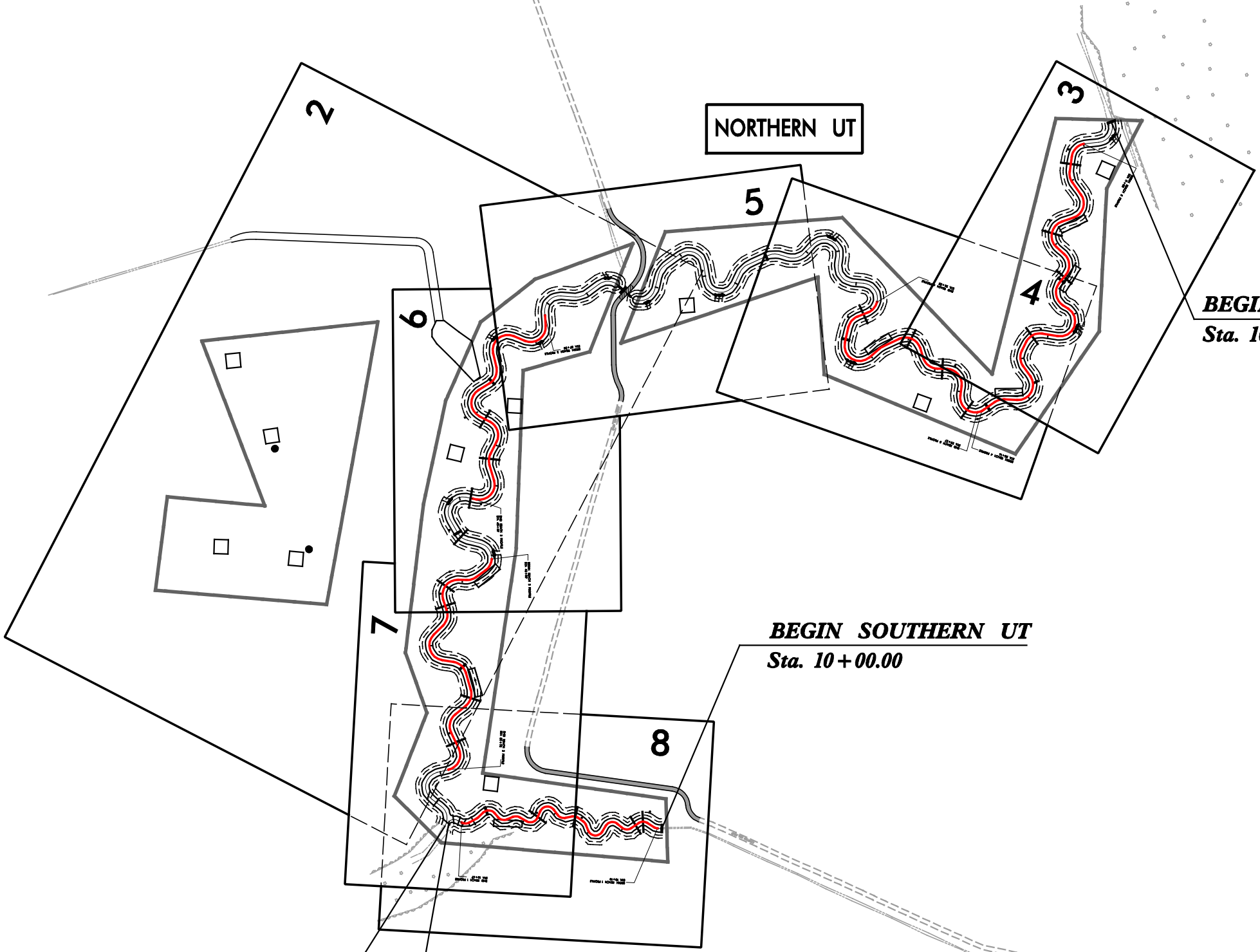
APPENDIX D  
MONITORING PLAN VIEWS

NOT TO SCALE

**OVERVIEW MAP**



SR 2492  
 COTTON VALLEY ROAD



**NORTHERN UT**

**SOUTHERN UT**

**BEGIN NORTHERN UT**  
 Sta. 10+00.00

**BEGIN SOUTHERN UT**  
 Sta. 10+00.00

**END NORTHERN UT**  
 Sta. 54+65.34

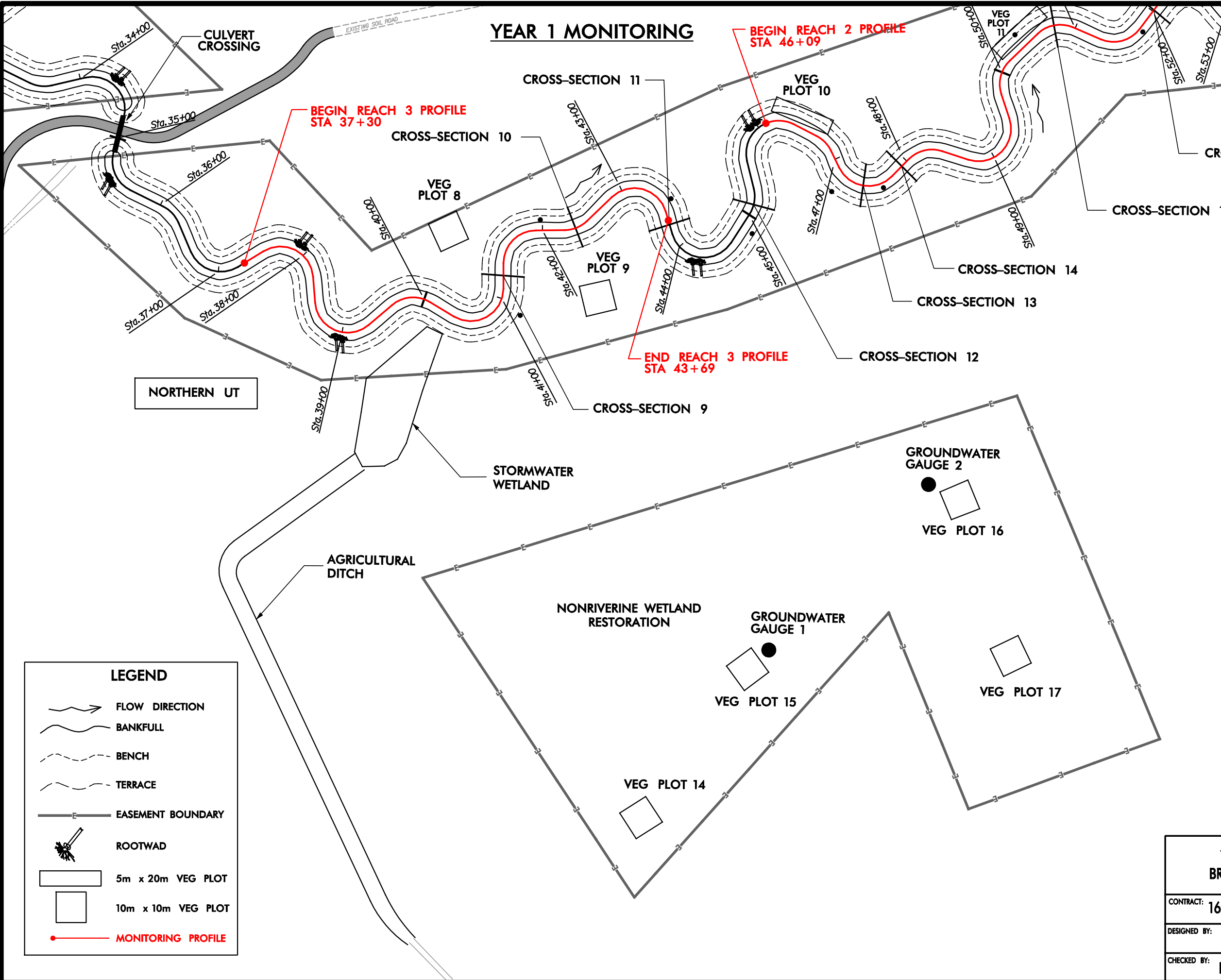
**END SOUTHERN UT**  
 Sta. 15+98.83

TO SR 2491

<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
CHECKED BY: RKW	SHEET 1 OF 8

8/17/99  
 I:\5\2008  
 Monitoring\Year\_1\_2008\BMS\_monitoring\_psh.i.dgn

**YEAR 1 MONITORING**



**LEGEND**

- FLOW DIRECTION
- BANKFULL
- BENCH
- TERRACE
- EASEMENT BOUNDARY
- ROOTWAD
- 5m x 20m VEG PLOT
- 10m x 10m VEG PLOT
- MONITORING PROFILE

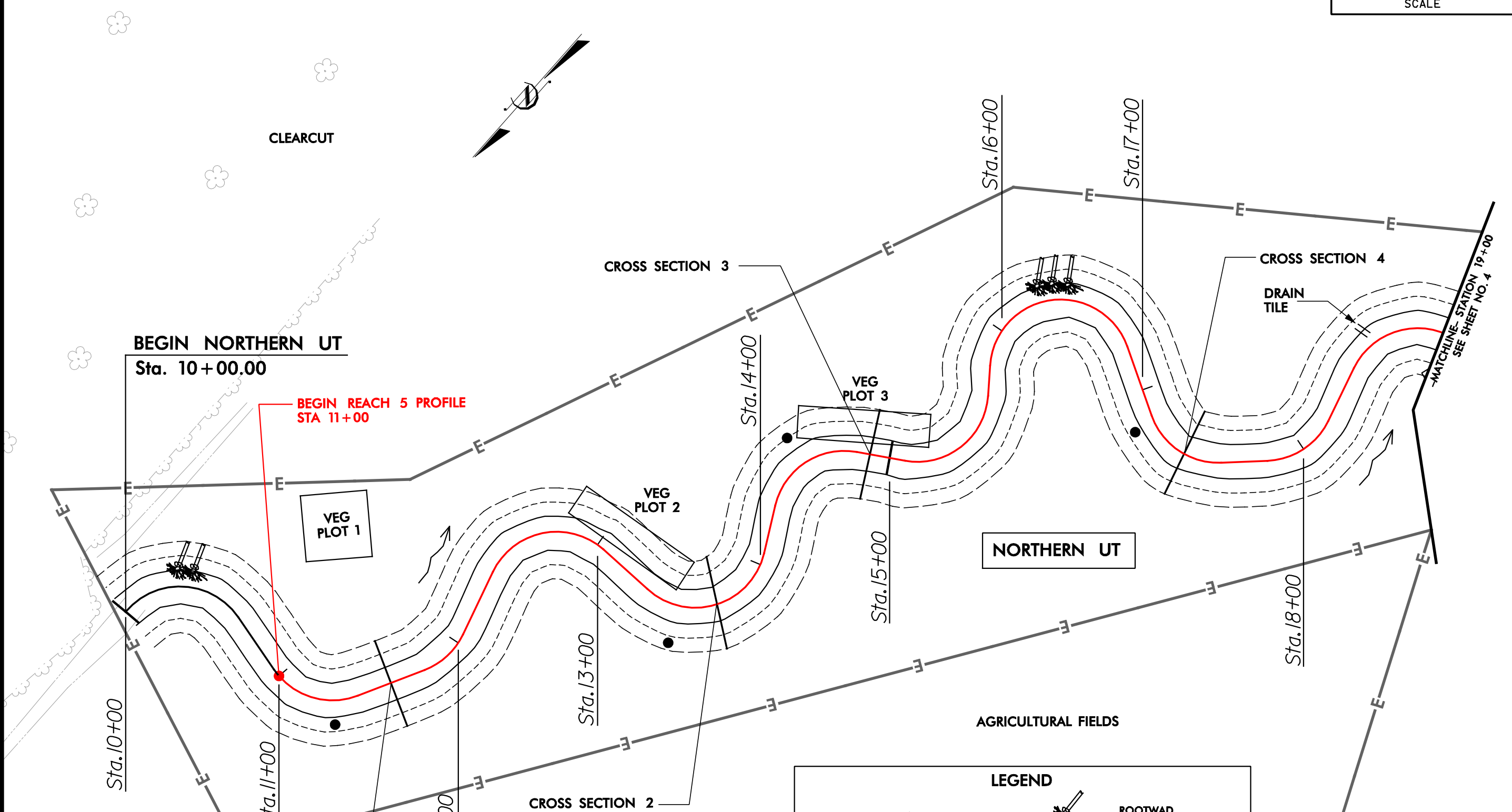
<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
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 Monitoring\Year\_1\_2008\BMS\_monitoring\_psh\_2.dgn  
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# YEAR 1 MONITORING

**KO & ASSOCIATES, P.C.**  
 Consulting Engineers  
 821 KINGDOM WAY, SUITE 100 RALEIGH, N.C. 27607  
 (919) 881-6966

25 0 50  
 SCALE



**LEGEND**

	FLOW DIRECTION		ROOTWAD
	BANKFULL		5m x 20m VEG PLOT
	BENCH		10m x 10m VEG PLOT
	TERRACE		PERMANENT PHOTO LOCATION
	EASEMENT BOUNDARY		MONITORING PROFILE

**YEAR 1 MONITORING  
 BROWN MARSH SWAMP**

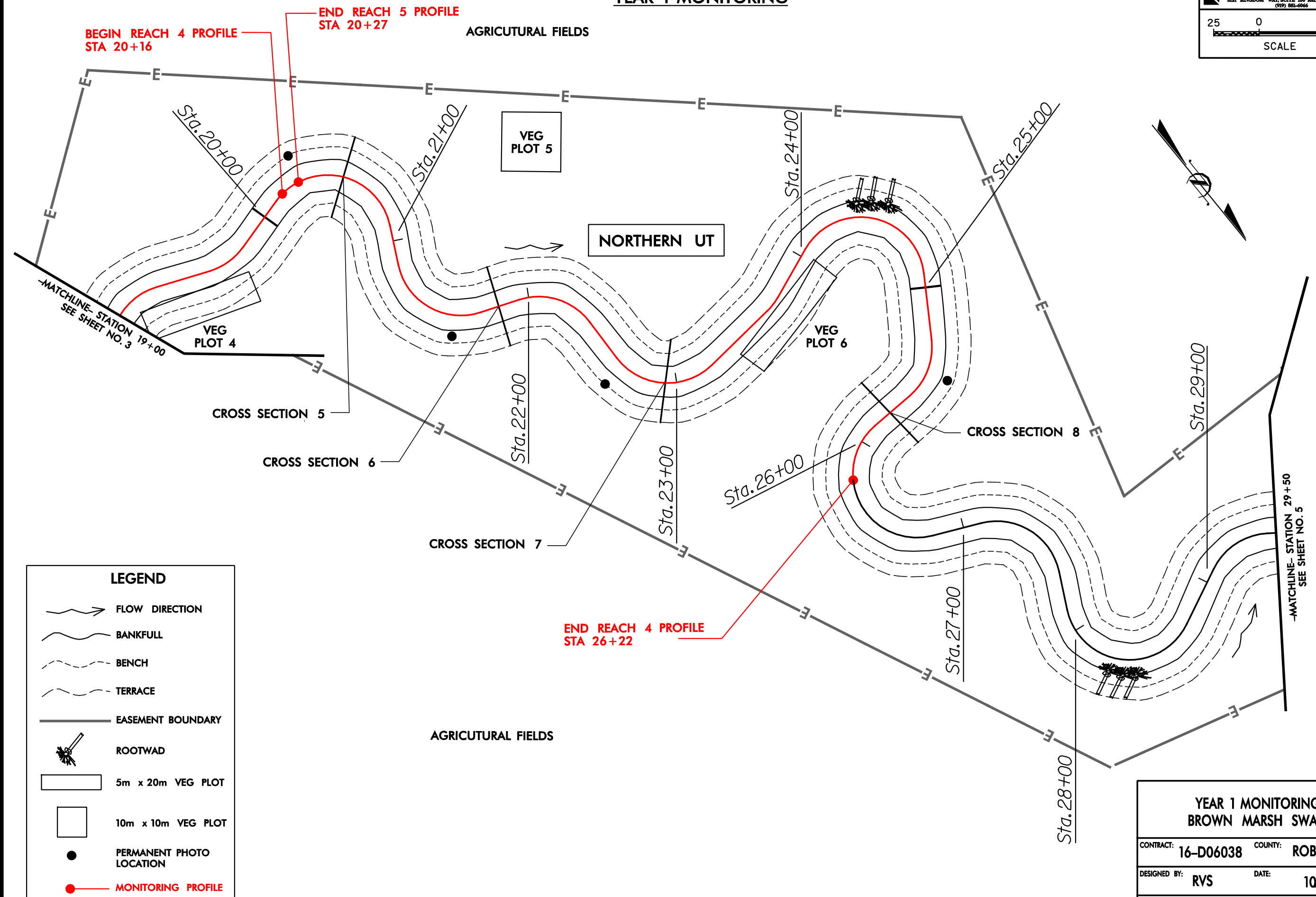
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DESIGNED BY: RVS	DATE: 1008
CHECKED BY: RKW	SHEET 3 OF 8

8/17/99  
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 Consulting Engineers  
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 (919) 881-6966

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**LEGEND**

- FLOW DIRECTION
- BANKFULL
- BENCH
- TERRACE
- EASEMENT BOUNDARY
- ROOTWAD
- 5m x 20m VEG PLOT
- 10m x 10m VEG PLOT
- PERMANENT PHOTO LOCATION
- MONITORING PROFILE

<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
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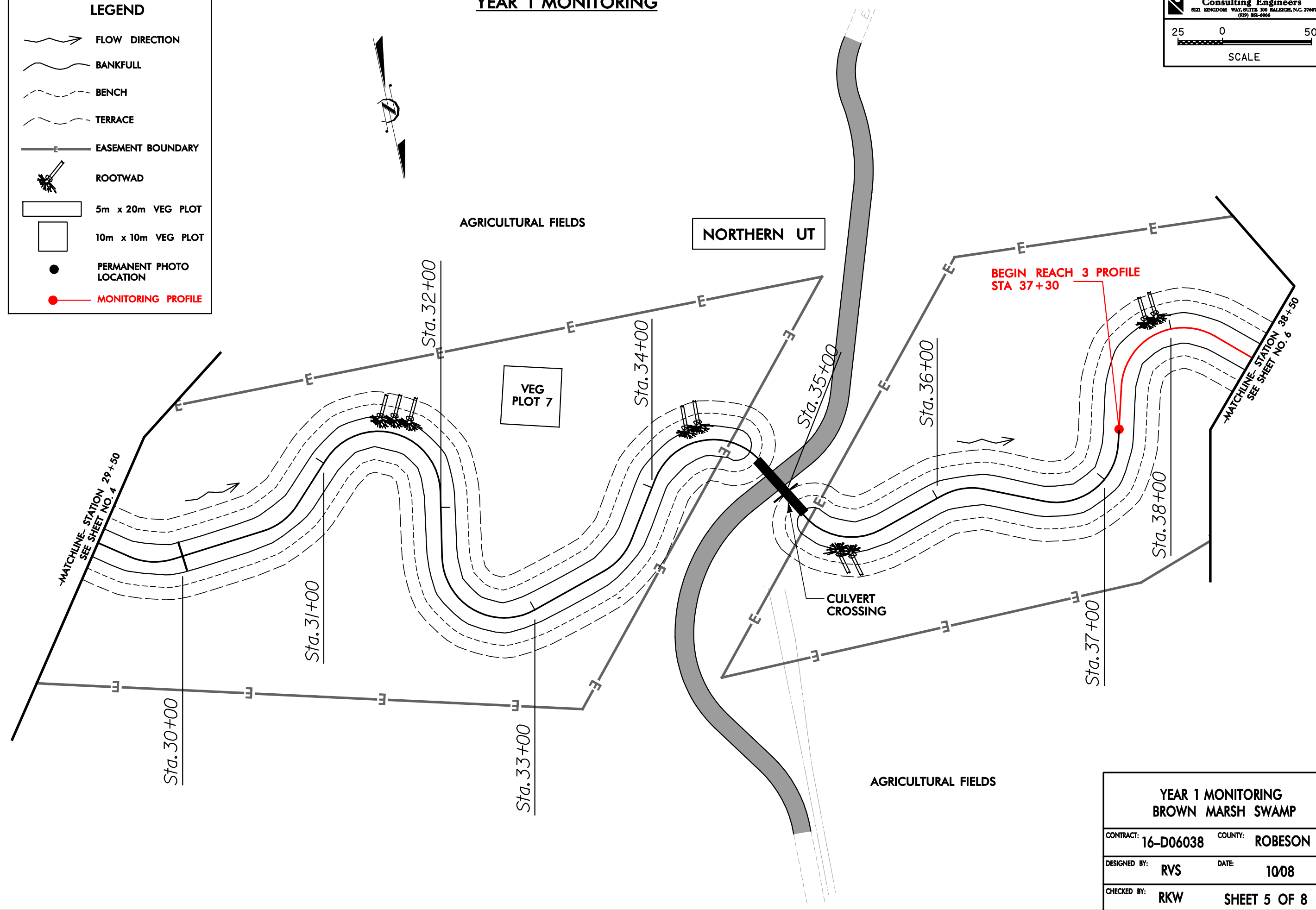
**KO & ASSOCIATES, P.C.**  
 Consulting Engineers  
 8121 KINGDOM WAY, SUITE 100 RALEIGH, N.C. 27607  
 (919) 881-6666

SCALE

# YEAR 1 MONITORING

**LEGEND**

- FLOW DIRECTION
- BANKFULL
- BENCH
- TERRACE
- EASEMENT BOUNDARY
- ROOTWAD
- 5m x 20m VEG PLOT
- 10m x 10m VEG PLOT
- PERMANENT PHOTO LOCATION
- MONITORING PROFILE



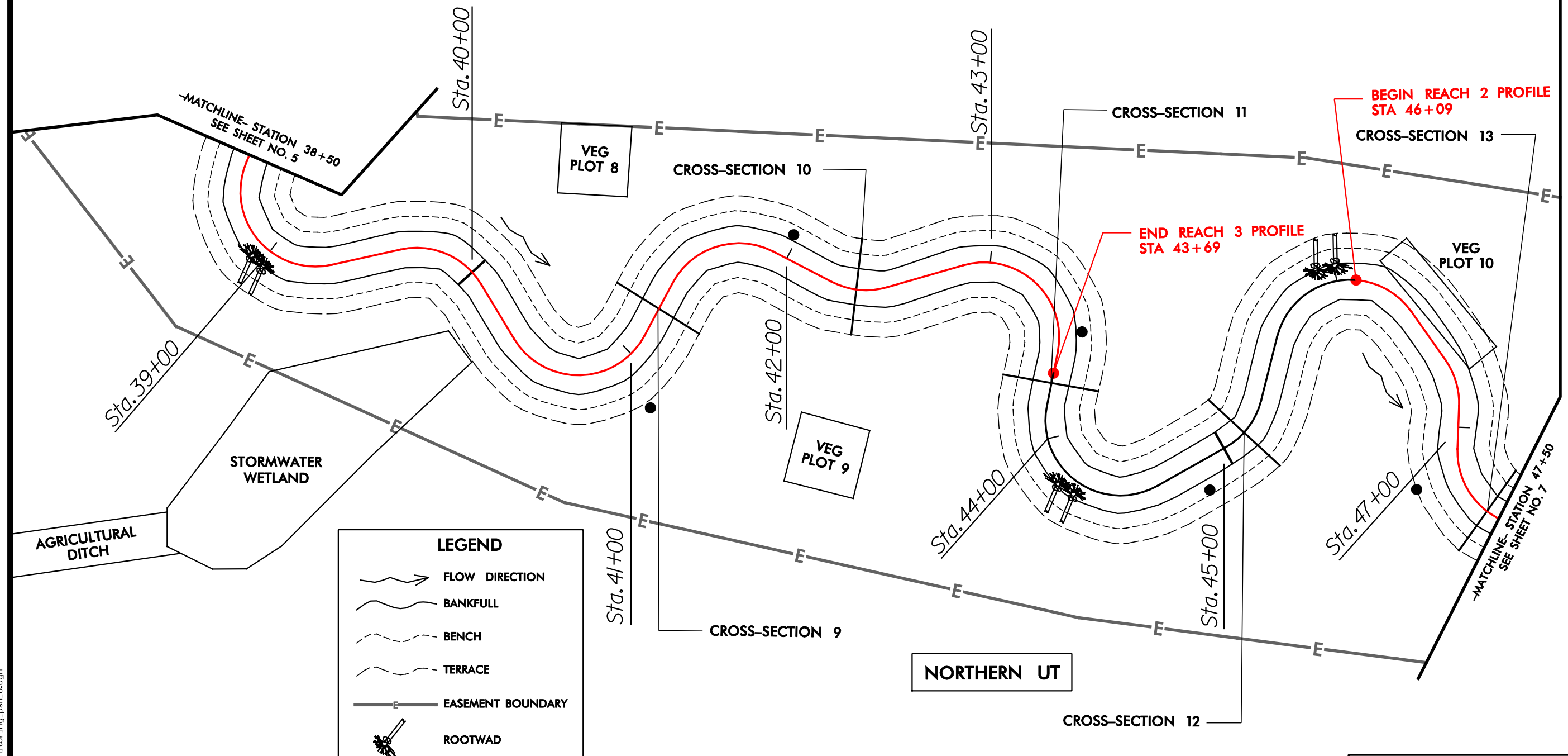
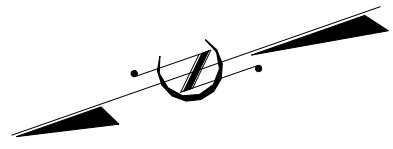
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Monitoring\Veget\_1\_2008\BMS\_monitoring\_pah\_5.dgn

<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
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 SCALE



**LEGEND**

- FLOW DIRECTION
- BANKFULL
- BENCH
- TERRACE
- EASEMENT BOUNDARY
- ROOTWAD
- 5m x 20m VEG PLOT
- 10m x 10m VEG PLOT
- PERMANENT PHOTO LOCATION
- MONITORING PROFILE

<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
CHECKED BY: RKW	SHEET 6 OF 8

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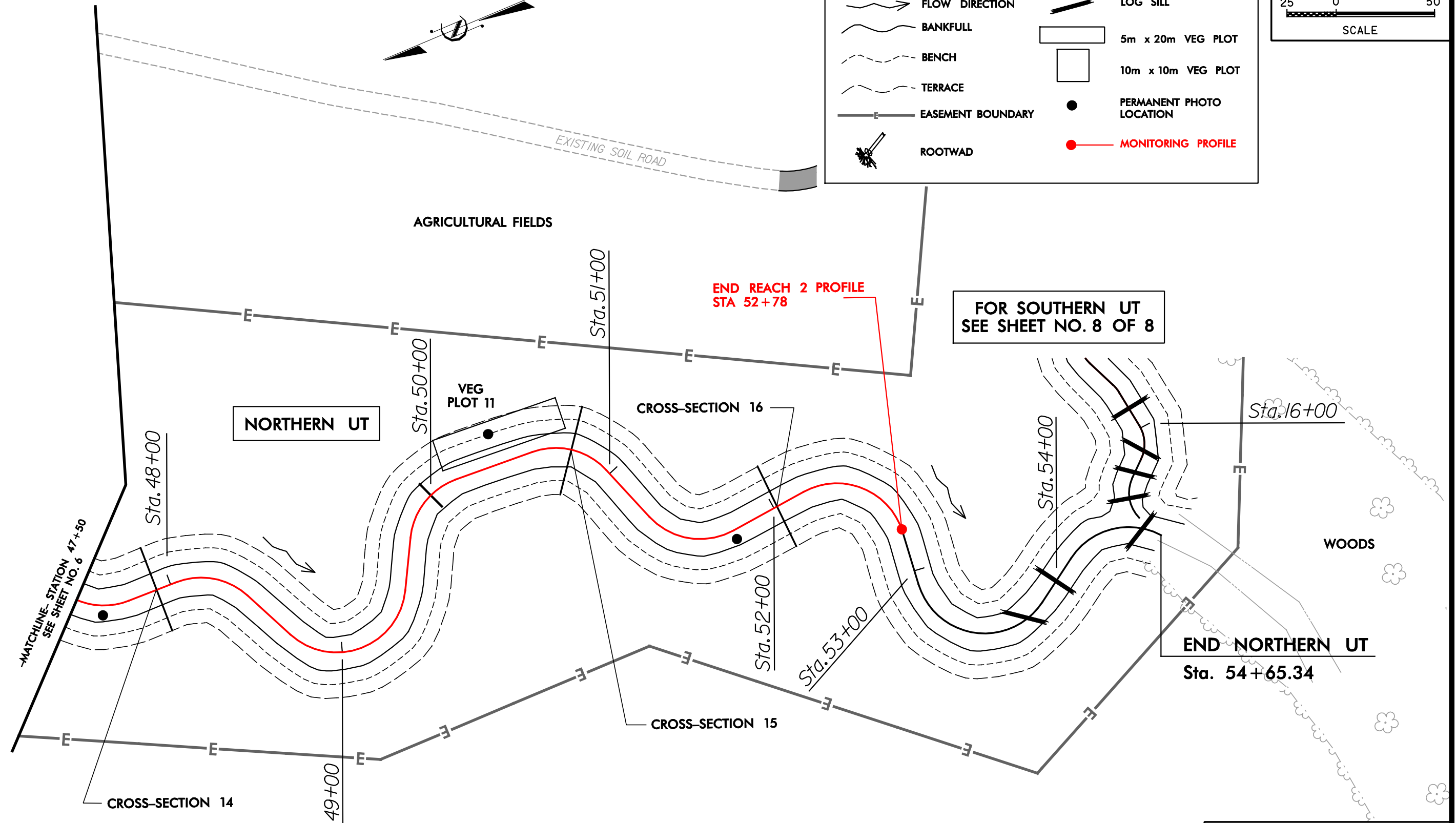
# YEAR 1 MONITORING

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 Consulting Engineers  
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 SCALE

**LEGEND**

- FLOW DIRECTION
- ~ BANKFULL
- - - BENCH
- - - TERRACE
- E- EASEMENT BOUNDARY
- ⚡ ROOTWAD
- ▬ LOG SILL
- 5m x 20m VEG PLOT
- 10m x 10m VEG PLOT
- PERMANENT PHOTO LOCATION
- MONITORING PROFILE



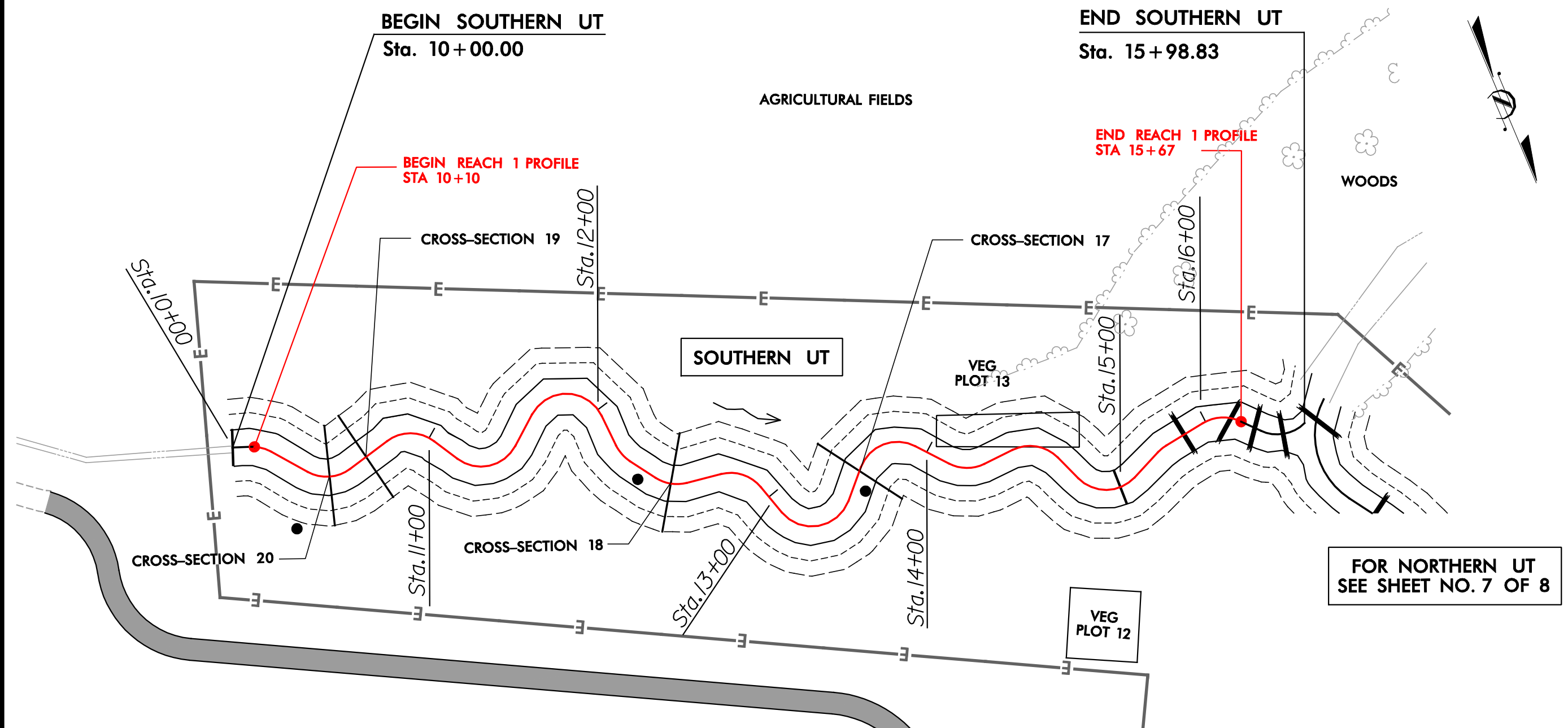
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CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
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8/17/99  
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# YEAR 1 MONITORING

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 SCALE



FOR NORTHERN UT  
 SEE SHEET NO. 7 OF 8

**LEGEND**

FLOW DIRECTION	LOG SILL
BANKFULL	5m x 20m VEG PLOT
BENCH	10m x 10m VEG PLOT
TERRACE	PERMANENT PHOTO LOCATION
EASEMENT BOUNDARY	MONITORING PROFILE
ROOTWAD	

<b>YEAR 1 MONITORING BROWN MARSH SWAMP</b>	
CONTRACT: 16-D06038	COUNTY: ROBESON
DESIGNED BY: RVS	DATE: 1008
CHECKED BY: RKW	SHEET 8 OF 8

8/17/99  
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