Key Branch Stream and Wetland Restoration Site
Year-8 Annual Monitoring Report (2011)

Anson County, North Carolina
WBS Element 34398.4.1
TIP No. R-2239WM
NCEEP Project 206

Submitted to:

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Ecosystem Enhancement Program
Raleigh, North Carolina

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SUMMARY

The Key Branch Stream and Wetland Restoration Site (hereafter referred to as the "Site") is located in Anson County and was constructed and planted in the fall of 2003. The 118-acre Site covers approximately 6,200 linear feet of restored stream channel and 108.9 acres of wetland restoration. Approximately 47,800 bottomland hardwood trees were planted on 70.2 acres of the Site. To be successful, the Site wetlands must meet success criteria for both hydrology and vegetation for five consecutive years or until approved by the regulatory agency. Additionally, the restored stream must show vertical and horizontal stability with respect to as-built conditions based upon the established success criteria.

Thirteen groundwater gauges were monitored in 2011, of which ten met the success criteria for jurisdictional hydrology (saturation within 12 inches of the surface for greater than 12.5 percent of the growing season). The three additional gauges did not meet success criteria. Two of the three gauges maintained saturation for approximately 9 percent of the growing season with the third approximating 6 percent. The Site experienced below average rainfall for the 2011 growing season.

Four vegetation plots established under North Carolina Department of Transportation (NCDOT) protocol, and four riparian vegetation plots established following replanting in 2005 were monitored to measure woody stem density. In the current monitoring year, plots representing the stream restoration buffer (riparian vegetation plots) had an average tree density of 283 trees per acre and plots representing the wetland restoration area (wetland vegetation plots) had an average tree density of 750 trees per acre.

Success criteria for the restored stream reach has been established to confirm that no significant changes have occurred to the dimension, pattern, profile, and bed material over the monitoring period. Location surveys of the constructed features were conducted to verify the performance of the stream. A survey was performed using a total station to describe the stream longitudinal profile and 12 permanent stream cross-sections. Overall, the stream channel bed form and banks are stable and have not changed significantly compared to as-built conditions.

Although the reach meets the criteria for success, beaver are abundant in the area and have persistently recolonized the Site after prior removal efforts. The beaver are active with dams above and below the Site as well as within the Site boundaries at the upper end. They were removed most recently in late 2010 and re-established dams in 2011. As per the North Carolina Ecosystem Enhancement Program another removal effort has been contracted with monthly monitoring scheduled for the Site until closeout. The beavers' presence has altered the function of the stream. Instead of a flowing stream, parts of the site are characterized as a lentic system. The stream has experienced limited flow in the summer months promoting vegetation growth in the channel. This condition has been caused by a combination of factors including multiple dry summers, beaver dams above the Site, and the low slope of the stream channel.

1.0 INTRODUCTION

1.1. Project Description

The Site encompasses 118 acres and is located in Anson County between Lower White Store Road (SR 1252) to the west and Mineral Springs Church Road (SR 1240) to the east (Figure 1).

1.2. Purpose

In order to demonstrate successful mitigation, the Site must be monitored for a minimum of five years or until approved for close-out by the regulatory agencies. Success criteria are based on federal and state guidelines for stream and wetland mitigation (USACE 2003). Criteria for wetland hydrologic conditions, restored stream channel stability, and vegetation survival are included in this document. The following report describes the monitoring results for groundwater hydrology, stream channel stability, and planted vegetation during the 2011 growing season at the Key Branch Restoration Site.

1.3. Project History

Fall 2003	Construction
November 2003	Site Planted
March-November 2004	Hydrologic Monitoring (Year 1)
July 2004	Stream and Vegetation Monitoring (Year 1)
February 2005	Site Replanted
March-November 2005	Hydrologic Monitoring (Year 2)
August 2005	Stream and Vegetation Monitoring (Year 2)
March-November 2006	Hydrologic Monitoring (Year 3)
September 2006	Stream and Vegetation Monitoring (Year 3)
March-November 2007	Hydrologic Monitoring (Year 4)
September 2007	Vegetation Monitoring (Year 4)
March - November 2008	Hydrologic Monitoring (Year 5)
October 2008	Vegetation Monitoring (Year 5)
March - November 2009	Hydrologic Monitoring (Year 6)
August 2009	Vegetation Monitoring (Year 6)
March – November 2010	Hydrologic Monitoring (Year 7)
September 2010	Stream and Vegetation Monitoring (Year 7)
March - November 2011	Hydrologic Monitoring (Year 8)
September 2011	Vegetation Monitoring (Year 8)
November 2011	Stream Monitoring (Year 8)

2.0 HYDROLOGY

2.1 Success Criteria

In accordance with federal and state guidelines for wetland mitigation, the success criteria for hydrology requires that these areas be inundated or saturated (within 12 inches of the surface) by surface or groundwater consecutively for at least 12.5 percent of the growing season. Areas meeting hydrology for less than 5 percent of the growing season are classified as non-wetlands. Areas meeting hydrology between 5 percent and 12.5 percent of the growing season can be classified as wetlands depending upon such factors as the presence of wetland vegetation and hydric soils. If wetland parameters are marginal as indicated by vegetation and hydrological monitoring, consultation with EEP personnel and regulatory agencies will be undertaken to determine the extent of wetland restoration in these areas. A jurisdictional determination will be performed in early 2012 to determine the extent of wetland areas at the Site.

The growing season in Anson County begins March 11 and ends November 23 (258 days). These dates correspond to a 50 percent probability that air temperatures will not drop below 28°F or lower after March 22 and before November 15. Minimum wetland hydrology is required for at least 12.5 percent of this growing season; for Anson County, 12.5 percent of the growing season equals 30 consecutive days.

2.2 Hydrologic Description

On-site hydrologic monitoring was initially facilitated by fourteen, continuously recording groundwater gauges located throughout the wetland restoration area (Figure 2). One of the gauges could not be located in 2009, reducing the number to 13. During the 2011 monitoring season, groundwater data was collected monthly from all monitoring gauges.

2.3 Results of Hydrologic Monitoring

2.3.1 Site Data

The maximum number of consecutive days that groundwater was within 12 inches of the surface was determined for each groundwater gauge. This number was converted into a percentage of the 258-day growing season. The results are summarized in Table 1 and indicate that all gauges exhibited saturation for at least 6.2 percent of the growing season. The average saturation period for all gauges was 60.1 days (23.3%) ranging from 16 to 107 days (6.2 and 41.4%). Ten of the thirteen gauges met success criteria by maintaining saturation for more than 30 days. The remaining three gauges maintain saturation for 5 to 12.5 percent of the growing season.

Appendix B contains hydrographs of the daily water depth recorded for each groundwater gauge. In general, groundwater levels show a typical pattern of flooding or

high water table during the winter to early spring, followed by a summer and early fall drawdown period, punctuated by peaks of associated precipitation events.

Table 1. Key Branch Hydrologic Monitoring Results

Monitoring Gauge	<5%	5-12.5%	>12.5%	Actual %	Success Dates	Number of Days Gauges met Success Criteria
KBMG1			✓	39.1	March 11 – June 19	101
KBMG2			✓	23.2	March 11 – May 9	60
KBMG3			✓	23.2	March 11 – May 9	60
KBMG5			✓	17.8	March 11 – April 25	46
KBMG6			✓	41.4	March 11 – June 25	107
KBMG7			✓	39.1	March 11 – June 19	101
KBMG8			✓	19.3	March 11 – April 29	50
KBMG9			✓	15.9	March 11 – April 20	41
KBMG10		✓		9.3	March 27 – April 19	24
KBMG11		✓		8.9	March 17 – April 18	23
KBMG12			✓	40.7	March 11 – June 23	105
KBMG13		✓		6.2	March 30 – April 14	16
KBMG14			✓	18.2	July 17 – August 30	47

2.3.2 Climatic Data

Figure 3 shows a comparison of 2011 monthly rainfall to the historic range of normal precipitation for Wadesboro, NC (State Climate Office of NC, CRONOS Database). The historic range of normal precipitation is determined from rainfall data collected between 1948 and 2011. Figure 3 depicts the range of normal rainfall between the 30 percent and 70 percent of all observations compared to the actual 2011 monthly rainfall amounts.

Monthly rainfall amounts were below the 30th percentile during five months of the growing season. The months of July, September and October received average rainfall, while May received above average rainfall. The total rainfall of 25.36 inches for the year

through November is below the historic average of 41.52 inches for the same time period.

3.0 STREAM ASSESSMENT

3.1. Stream Monitoring Requirements

The Site stream monitoring plan requires an assessment of geomorphologic parameters in keeping with the U.S. Army Corps of Engineers (USACE) "Stream Mitigation Guidelines", dated April 2003. The monitoring plan includes the protocol and provisions for providing photographs and channel stability analysis on a yearly basis. Global Positioning System (GPS) equipment was used along with metal detectors to locate existing cross section pins. Twelve permanent cross-sections were located and surveyed. A 3,000 foot longitudinal profile of the restored channel was surveyed beginning near station 13+00 (Figure 2 A-B). Bank stability and overall condition of the stream was assessed during the cross-section and longitudinal profile surveys. Lateral photographs were collected at each cross-section (Appendix D). A stream monitoring gauge located in the channel provides stream flow elevation data to verify bankfull events.

3.2. Post Construction Conditions

The project involved the construction of approximately 6,200 linear feet of channel using a Priority 1 restoration approach. Engineered structures included j-hook vanes, log vanes, rock cross vanes, rootwad revetments, step pools, and additional bank sloping. A step pool was installed at the beginning and end of the reach to maintain grade. A rootwad complex was installed in the apex of numerous bends with cover logs for habitat. Cross vanes, log vanes, and j-hook vanes were installed throughout the reach to direct higher flow velocities into the center of the channel. Throughout the entire reach the inner berm was maintained, enhanced, or created as channel modifications were made.

3.3 Results of Stream Monitoring

The mitigation plan stipulated the placement of a permanent monitoring cross-section every 20 bankfull widths. A total of twelve cross sections were surveyed. Three cross-sections were identified as riffles, cross sections 5, 10, and 12. For this report, only cross sections containing riffles were used in the comparison of channel morphology presented below in Table 5. Data shown in Table 6 includes all cross sections surveyed along the reach. Overall, the stream survey data indicates a stable channel with very little lateral or vertical movement. The stream gauge registered seven bankfull events during the 2011 monitoring year (March 28, April 1, April 6, April 10, May 12, May 15 and May 28), further demonstrating stream stability. Bankfull Events for the eight year monitoring period are presented in Table 2.

Table 2. Bankfull Events

Year	Evaluation Method	Number of Events	Monitoring Firm
2004	USGS Goose Creek Gauging Station	3	NCDOT
2005	N/A	N/A	NCDOT
2006	Stream Gauge 1	2	The Louis Berger Group
2007	Stream Gauge 1 and 2	N/A	The Louis Berger Group
2008	N/A	N/A	Atkins
2009	N/A	N/A	Atkins
2010	Stream Gauge 1	3	Atkins
2011	Stream Gauge 1	7	Atkins

Although the restored reach met criteria for success, beaver are abundant in the area and have persistently recolonized the Site after prior removal efforts. Beaver are active with dams above and below the Site as well as within the Site boundaries at the upper end (Figure 2, Appendix A). They were removed most recently in late 2010 and re-established dams in 2011. As per the North Carolina Ecosystem Enhancement Program another removal effort has been contracted with monthly monitoring scheduled for the Site until close out. The beavers' presence has altered the function of the stream. Instead of a flowing stream, parts of the site are characterized as a lentic system. The stream has experienced limited flow in the summer months promoting vegetative growth in the channel. This condition has been caused by a combination of factors including multiple dry summers, beaver dams above the Site, and the low slope of the stream channel.

Table 3. Baseline Stream Data Summary
Key Branch Stream and Wetland Restoration Site - EEP Project 206

Parameter	Gauge	Regional Curve			Pre-Existing Condition						Reference Reach(es) Data						Design			Monitoring Baseline					
Dimension and Substrate - Riffle Only		LL	UL	Eq.	Min	Mean	Med	Max	SD[5]	n	Min	Mean	Med	Max	SD[5]	n	Min	Med	Max	Min	Mean	Med	Max	SD[5]	n
Bankfull Width (ft)											27		35				22	25							
Floodprone Width (ft)											>200		>200				>150	>150							
Bankfull Mean Depth (ft)											1.01		1.16				0.65	0.93							
Bankfull Max Depth (ft)											1.75		2.17				1.15	1.74							
Bankfull Cross Sectional Area (ft^2)											35		37				17	21							
Width/Depth Ratio											27		34				27	34							
Entrenchment Ratio											>7		>7				>7	>7							
Bank Height Ratio																									
Profile																									
Riffle Length (ft)																									
Riffle Slope (ft/ft)																									
Pool Length (ft)																									
Pool Max depth (ft)																									
Pool Spacing (ft)																									
Pattern																									
Channel Beltwidth (ft)																	160		180						
Radius of Curvature (ft)											50.0		72.8				35		60						
Rc:Bankfull width (ft/ft)																									
Meander Wavelength (ft)											370		465				265		378						
Meander Width Ratio											6.3		8.1				6.3		8.1						

Transport parameters																									
Reach Shear Stress (competency) lb/f^2																									
Max part size (mm) mobilized at bankfull																									
Stream Power (transport capacity) W/m^2																									
Additional Reach Parameters																									
Rosgen Classification											C6						C6								
Bankfull Velocity (fps)																									
Bankfull Discharge (cfs)																									
Valley length (ft)											1590						4149								
Channel Thalweg length (ft)											1065						6182								
Sinuosity (ft)											1.49						1.49								
Water Surface Slope (Channel) (ft/ft)											0.19						0.005								
BF slope (ft/ft)																									
Bankfull Floodplain Area (acres)											115+						115+								
% of Reach with Eroding Banks																									
Channel Stability or Habitat Metric																									
Biological or Other																									

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Table 4. Morphology and Hydraulic Monitoring Summary

Key Branch Stream and Wetland Restoration Site - EEP Project 206

	Cross Section 1 (Glide)							Cross Section 2 (Run)							Cross Section 3 (Pool)							Cross Section 4 (Pool)							Cross Section 5 (Riffle)						
Based on fixed baseline bankfull elevation[1]	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+
Record elevation (datum) used																																			
Bankfull Width (ft)	18.6	18.4	19	19.7	15.4			20.2	23.8	26.1	24	22.3			18.1	28.3	29	21.8	24.4			17.3	21.3	19.5	20	22.1			20.9	22.9	22	22.5	24		
Floodprone Width (ft)	>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100		
Bankfull Mean Depth (ft)	0.7	0.9	1	0.9	0.7			1.1	1.5	1.3	1.3	1.1			1	1.2	1.2	1.3	1.2			1.2	1.1	1.2	1.3	1.3			1	1	1.1	1.1	0.9		
Bankfull Max Depth (ft)	1.5	1.6	2	1.9	1.2			2	2.6	2.6	2.3	1.7			1.9	2.5	2.9	2.3	2.5			2.2	2.1	2.1	2.4	2.3			1.8	2.8	2.1	1.9	1.7		
Bankfull Cross Sectional Area (ft^2)	13	16.2	19.5	16.9	11.1			22.2	35.2	34.2	31.4	24.9			18.1	33.4	35.1	28.1	30.4			20.8	24.2	23	26	29.3			20.9	23.3	25.2	24.1	20.9		
Bankfull Width/Depth Ratio	26.6	20.9	19	21.9	21.4			18.4	16.1	20	18.5	19.9			18.1	24	24.2	16.8	19.6			14.4	18.7	16.3	15.4	16.7			20.9	22.5	20	20.5	27.6		
Bankfull Entrenchment Ratio	>5	>5	>5	5.1	6.5			>5	>5	>5	4.2	4.5			>5	>5	>5	4.6	4.1			>5	>5	>5	5	4.5			>5	>5	>5	4.4	4.2		
Bankfull Bank Height Ratio	1	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1		
Cross Sectional Area between end pins (ft^2)																																			
d50 (mm)	Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt		

	Cross Section 6 (Glide)							Cross Section 7 (Run)							Cross Section 8 (Pool)							Cross Section 9 (Glide)							Cross Section 10 (Riffle)						
Based on fixed baseline bankfull elevation[1]	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+
Record elevation (datum) used																																			
Bankfull Width (ft)	19.7	21	21	25.1	19.9			22.9	19.9	20.7	30	17.9			21.9	19.9	19	21.2	26.3			20	19.9	20	22.8	23.4			21.1	20	27	22.2	24.8		
Floodprone Width (ft)	>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100			>100	>100	>100	>100	>100		
Bankfull Mean Depth (ft)	1.1	1.1	1.1	0.9	0.9			1.1	1.2	1.2	0.8	1			1.2	1.2	1.3	1.1	1.3			1.3	1.2	1.2	1	0.9			0.9	1	0.9	0.8	0.7		
Bankfull Max Depth (ft)	2	2.1	2	1.9	1.6			2	1.8	1.9	1.7	1.5			2.3	2.3	2.5	2	2.4			2.2	2	2	1.9	1.8			1.6	1.7	1.8	1.4	1.2		
Bankfull Cross Sectional Area (ft^2)	21.7	23.8	23.3	23.7	18.4			25.2	23.6	25	22.8	17.6			25.9	24.1	25.5	22.8	34.3			26	23.8	23.7	23.1	20.1			19	20.5	24.3	17.1	17.3		
Bankfull Width/Depth Ratio	17.9	18.5	19.1	27.9	21.5			20.8	16.8	17.3	37.5	17.9			18.5	16.4	14.6	19.3	20.2			15.4	16.6	16.7	22.8	27.3			23.4	19.5	30.1	27.8	35.6		
Bankfull Entrenchment Ratio	>5	>5	>5	4	5			>5	>5	>5	3.3	4.4			>5	>5	>5	4.7	3.8			>5	>5	>5	4.4	4.3			>5	>5	>5	4.5	4		
Bankfull Bank Height Ratio	1	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1			1	1	1	1	1		
Cross Sectional Area between end pins (ft^2)																																			
d50 (mm)	Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt		

	Cross Section 11 (Run)							Cross Section 12 (Riffle)						
Based on fixed baseline bankfull elevation[1]	MY1	MY2	MY3	MY7	MY8	MY+	MY+	MY1	MY2	MY3	MY7	MY8	MY+	MY+
Record elevation (datum) used														
Bankfull Width (ft)	27.6	26	31	21.5	26.2			26.9	22.9	21.2	21.5	19.4		
Floodprone Width (ft)	>100	>100	>100	>100	>100			>100	>100	>100	>100	>100		
Bankfull Mean Depth (ft)	1.1	1.2	1	0.9	1.1			1	0.9	0.9	0.8	0.8		
Bankfull Max Depth (ft)	2.2	2.4	2.3	1.5	1.6			2.1	1.9	2	1.6	1.5		
Bankfull Cross Sectional Area (ft^2)	30.4	31.9	31.4	18.6	28.4			26.9	20.5	20	18.2	15.6		
Bankfull Width/Depth Ratio	25.1	21.2	30.6	23.9	24.2			26.9	25.6	23.5	26.9	24.1		
Bankfull Entrenchment Ratio	>5	>5	>5	4.7	3.8			>5	>5	>5	4.7	5.2		
Bankfull Bank Height Ratio	1	1	1	1	1			1	1	1	1	1		
Cross Sectional Area between end pins (ft^2)														
d50 (mm)	Silt	Silt	Silt	Silt	Silt			Silt	Silt	Silt	Silt	Silt		

[1] It is uncertain if the monitoring datum has been consistent over the monitoring history, which may influence calculated values.
MY1, MY2, MY3 data from a prior performer is not available.

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Table 5. Visual Stream Morphology Stability Assessment

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			NA	6182*	0%			
		2. Degradation - Evidence of downcutting			NA	NA	NA			
	2. Riffle Condition	1. Texture/Substrate - Riffle maintains coarser substrate	0	49			0%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	52	52			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	52	52			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	52	52			100%			
		2. Thalweg centering at downstream of meander (Glide)	49	49			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	NA
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	NA
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	NA
				Totals	0	0	100%	0	0	NA
3. Engineered Structures**	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	46	46			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	46	46			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	46	46			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	46	46			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	46	46			100%			

* Aggradation of channel due to numerous due to reduced flow from beaver dams

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Table 6. Monitoring Data - Stream Reach Data Summary
Key Branch Stream and Wetland Restoration Site - EEP Project 206

Parameter	MY-1						MY-2						MY-3						MY- 7						MY- 8					
Dimension and Substrate - Riffle only	Min	Mean	Med	Max	SD[4]	n	Min	Mean	Med	Max	SD[4]	n	Min	Mean	Med	Max	SD[4]	n	Min	Mean	Med	Max	SD[4]	n	Min	Mean	Med	Max	SD[4]	n
Bankfull Width (ft)																			23	21.9	23.4	22.1			15.4	23.3	24.2	28.8		
Floodprone Width (ft)																			>100	>100	>100	>100			>100	>100	>100	>100		
Bankfull Mean Depth (ft)																			0.97	0.97	0.97	0.9			0.7	1	1	1.3		
Bankfull Max Depth (ft)																			1.83	2.13	1.97	1.63			1.2	1.8	1.7	2.5		
Bankfull Cross Sectional Area (ft^2)																			22.3	21.4	23.2	19.8			11.1	23.3	22.6	33.8		
Width/Depth Ratio																			23.7	22.5	24.5	25.1			16.7	24.2	23	35.6		
Entrenchment Ratio																			>5	>5	>5	4.53			3.5	4.4	4.1	>5		
Bank Height Ratio																			1	1	1	1			1	1	1	1		
Profile																														
Riffle Length (ft)							11		61	120			40		65	135			9.06	47.9	46.4	101.6	24.5	27	8.4	51.6	47.4	106	24.6	27
Riffle Slope (ft/ft)							0		0.006	0.037			0.001		0.004	0.011			0.000	0.000	0.001	0.012	0.005	27	0.000	0.004	0.003	0.012	0.003	27
Pool Length (ft)							22		46	70			28		75	178			17.2	31.7	29.7	51.2	9.09	26	12.2	31.8	28.6	51.5	11.1	26
Pool Max depth (ft)																														
Pool Spacing (ft)							39		113	252			32		111	246			25.6	75.8	76.8	135	29	26	27.6	77.7	73.8	128	28.1	26
Pattern																														
Channel Beltwidth (ft)							91		118	144			91		118	144			6.9	56.9	57	129	35.3		21.4	68.1	60.5	125	27.2	
Radius of Curvature (ft)							12		26	37			12		26	37			18	39.7	40	73	14.4		18.8	41.7	36.9	86.7	16.1	
Rc:Bankfull width (ft/ft)																														
Meander Wavelength (ft)							179		189	215			179		189	215			58	139	139	207	42.3		64.6	161	174	223	37.2	
Meander Width Ratio							NA		5.3	NA			NA		5.3	NA			0.3	2.6	2.6	5.8			1.39	2.92	2.5	4.33		

Additional Reach Parameters																														
Rosgen Classification	C6						C6						C6						C6						C6					
Channel Thalweg length (ft)							3023						3023						3023						3023					
Sinuosity (ft)							1.5						1.5						1.5						1.5					
Water Surface Slope (Channel) (ft/ft)							0.00041						0.00055						NA (dry channel)						0.00029					
BF slope (ft/ft)							0.000245						0.00049						0.00057						0.00065					
Ri% / Ru% / P% / G% / S%																														
SC% / Sa% / G% / C% / B% / Be%																														
d16 / d35 / d50 / d84 / d95 /																														
% of Reach with Eroding Banks																														
Channel Stability or Habitat Metric																														
Biological or Other																														

Shaded cells indicate data not available.

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4.0 VEGETATION ASSESSMENT

4.1. Success Criteria

According to the Stream Mitigation Guidelines, the success criteria for vegetation require that at least 320 planted stems per acre must be surviving after the third growing season. The required survival criterion will decrease by 10 percent per year after the third year of vegetation monitoring for two years (i.e., for an expected 288 stems per acre for Year 4, 260 stems per acre for Years 5 and beyond). NCDOT Stem Counting Protocol was used as the standard sampling methodology.

4.2. Description of Species

Based on the mitigation plan, the wetland restoration area and the riparian restoration area were to be planted with the following species:

Wetland Vegetation
*Quercus pagoda (*Cherrybark Oak)
Quercus phellos (Willow Oak)
Quercus michauxii (Swamp Chestnut Oak)
Quercus lyrata (Overcup Oak)
Quercus nigra (Water Oak)
*Ulmus americana (*American Elm)
Fraxinus pennsylvanica (Green Ash)
Betula nigra (River Birch)

Riparian Vegetation
Betula nigra (River Birch)
*Salix nigra (*Black Willow)
*Cephalanthus occidentalis (*Buttonbush)
*Cornus amomum (*Silky dogwood)

4.3. Results of Vegetation Monitoring

Eight vegetation monitoring (10 x 10 m^2) plots were established to monitor planted vegetation within the Site. Vegetation monitoring plots were separated into 4 riparian vegetation plots and 4 wetland vegetation plots. During Year 8 monitoring, the Site exceeded the vegetation success criteria with an average stem density of 283 stems per acre for riparian plots (Table 6), and an average stem density of 750 stems per acre for wetland plots (Table 7). Two riparian plots did not meet success criteria but did show improvement throughout the overall monitoring period (Tables 8 and 9). Herbaceous vegetation at the Site was found to be dense and healthy. (Photographs from the vegetation plots are provided in Appendix C). Each plot exhibited good diversity and

included between 5 and 9 species with 15 total species observed across all plots. Many of the trees exhibited heights in excess of 8-10 feet.

Table 7. Results of Riparian Vegetation Plots Monitoring

Riparian Plots	Betula nigra	Cephalanthus occidentalis	Franxinus pennsylvanica	Quercus laurifolia	Quercus lyrata	Quericus michauxii	Quercus nigra	Quercus pagoda	Salix nigra	Ulmus alata	Total Stems	Density (Trees/acre)
R1	7	0	11	2	6	0	2	1	13	0	42	420
R5	5	1	0	0	6	1	4	0	0	0	17	170
R6	5	0	4	0	5	2	3	0	0	0	19	190
R10	1	0	11	2	11	8	0	0	0	2	35	350
TOTAL	18	1	26	4	28	11	9	1	13	2	113	1130
Average Tree Density: 283												

Table 8. Results of Wetland Vegetation Plots Monitoring

Wetland Plots	Acer negundo	Acer rubrum	Betula nigra	Diospyros virginiana	Fraxinus pennsylvanica	Liquidambar styraciflua	Quercus laurifolia	Quercus lyrata	Quercus michauxii	Quercus nigra	Sambucus canadensis	Ulmus alata	Total Stems	Density (trees/acre)
D2	0	0	2	0	6	0	3	17	2	8	2	0	40	702
D3	0	0	3	0	44	0	7	9	0	0	0	4	67	1175
D5	0	2	5	2	13	2	3	7	7	3	0	0	44	440
D8	2	2	2	0	4	3	2	17	3	4	0	0	39	684
TOTAL	2	4	12	2	67	5	15	50	12	15	2	4	190	3333
Average Tree Density: 750														

Table 9. Riparian Plot Vegetation Summary Data

Species	Riparian Plot Numbers				
	Year	R1	R5	R6	R10
Betula nigra **(River birch)**	2005	2	1	0	0
	2006	2	1	0	0
	2007	1	1	0	0
	2008	5	4	3	1
	2009	5	4	3	1
	2010	5	4	3	1
	2011	7	5	5	1
Fraxinus pennsylvanica **(Green ash)**	2005	0	1	1	1
	2006	1	1	3	3
	2007	0	1	2	3
	2008	12	0	3	12
	2009	12	0	3	11
	2010	12	0	3	11
	2011	11	0	4	11
Quercus laurifolia **(Laurel oak)**	2005	0	0	0	0
	2006	0	0	0	0
	2007	0	0	1	1
	2008	2	0	0	0
	2009	2	0	0	0
	2010	2	0	0	1
	2011	2	0	0	2
Quercus lyrata **(Overcup oak)**	2005	1	1	4	0
	2006	0	0	4	0
	2007	0	1	3	0
	2008	5	2	2	7
	2009	6	4	2	8
	2010	6	4	2	8
	2011	6	6	5	11
Quercus michauxii **(Swamp chestnut oak)**	2005	0	0	0	1
	2006	0	0	0	0
	2007	0	0	0	2
	2008	0	1	2	6
	2009	0	1	2	6
	2010	0	1	2	6
	2011	0	1	2	8

Table 9. (continued)

Salix nigra **(Black willow)**	2005	1	1	7	0
	2006	1	3	7	0
	2007	1	3	5	0
	2008	10	1	0	0
	2009	10	2	0	0
	2010	10	2	0	0
	2011	13	0	0	0

Table 10. Wetland Plot Vegetation Summary Data

Species	**Wetland Plot Numbers**				
	Year	**D2**	**D3**	**D5**	**D8**
Betula nigra **(River birch)**	2005	0	3	0	1
	2006	0	3	1	1
	2007	1	4	4	2
	2008	2	4	3	1
	2009	2	4	4	2
	2010	2	4	6	2
	2011	2	3	5	2
Fraxinus pennsylvanica **(Green ash)**	2005	3	11	0	4
	2006	2	16	0	4
	2007	4	32	6	11
	2008	6	33	10	3
	2009	4	38	9	7
	2010	4	38	10	7
	2011	6	44	13	4
Quercus laurifolia **(Laurel oak)**	2005	7	0	0	0
	2006	3	0	2	0
	2007	8	2	4	4
	2008	1	1	3	0
	2009	4	4	5	1
	2010	4	4	4	1
	2011	3	7	3	2
Quercus lyrata **(Overcup oak)**	2005	14	11	4	0
	2006	5	11	4	3
	2007	8	8	10	15
	2008	14	11	4	19
	2009	14	9	6	18

Table 10. (continued)

Quercus lyrata **(Overcup oak)**	2010	14	9	6	18
	2011	17	9	7	17
Quercus michauxii **(Swamp chestnut oak)**	2005	2	0	2	4
	2006	2	0	1	4
	2007	2	0	6	6
	2008	2	0	8	5
	2009	2	0	8	6
	2010	2	0	8	6
	2011	2	0	7	3
Quercus pagoda **(Cherrybark oak)**	2005	0	0	8	7
	2006	3	0	1	0
	2007	0	0	0	1
	2008	0	0	0	0
	2009	0	0	0	0
	2010	0	0	0	0
	2011	0	0	0	0
Quercus phellos **(Willow oak)**	2005	2	1	0	0
	2006	0	2	0	0
	2007	1	1	0	0
	2008	0	0	0	0
	2009	0	0	0	0
	2010	0	0	0	0
	2011	0	0	0	0
Salix nigra **(Black willow)**	2005	0	0	0	0
	2006	0	0	0	0
	2007	0	0	0	0
	2008	0	0	0	0
	2009	0	0	0	0
	2010	0	0	0	0
	2011	0	0	0	0

5.0 REFERENCES

State Climate Office of North Carolina. CRONOS precipitation database [online]. Retrieved 11-28-11.

NRCS USDA. National Water and Climate Center. Climate Information- Wetlands Retrieval for Anson County Growing Season [online]. Retrieved 11-28-11. http://www.wcc.nrcs.usda.gov/cgibin/getwetco.pl?state=nc

Stream Mitigation Guidelines, April 2003. Authored by a workgroup consisting of USACE (Wilmington District, USEPA, NCWRC and NCDWQ). Riparian Restoration pg. 18.

APPENDIX A

FIGURES

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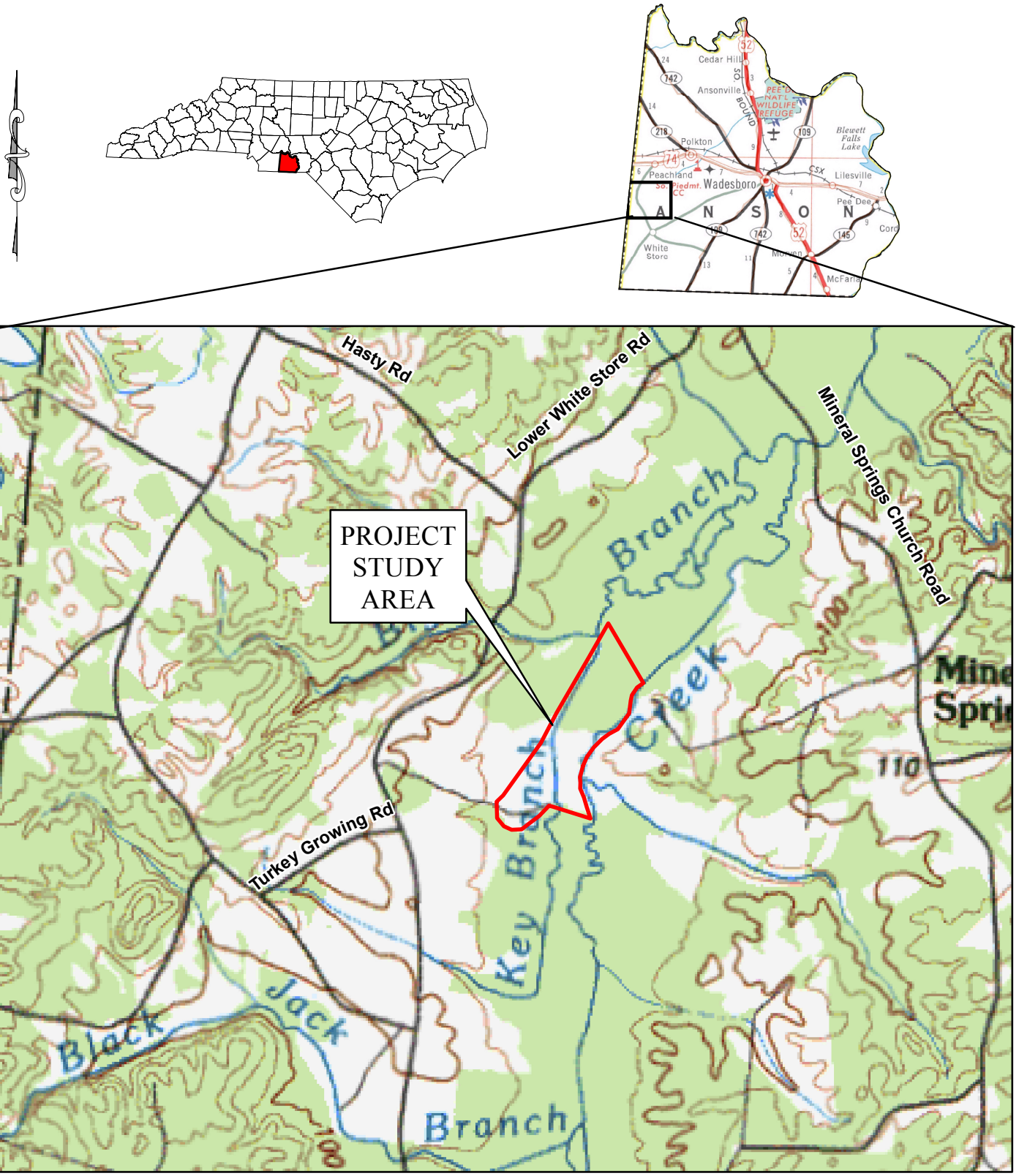

Directions:
Go west on Hwy 74 from Wadesboro in Anson County to Peachland.
Turn left onto Mineral Springs Church Rd. and then right onto Lower White Store Road.
Pass Hasty Rd. and then just before Turkey Growing Rd, turn left into Key Branch Site on a gravel road.

ATKINS

Client: Ecosystem Enhancement Program

SITE LOCATION

KEY BRANCH STREAM & WETLAND RESTORATION SITE

Anson County, North Carolina

Dwn By:	Ckd By:
TAL	MCG

Date: NOV 2011

Scale: AS SHOWN

PBS&J Project No. 100005068

FIGURE 1

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LEGEND

- EXISTING CONTOURS
- PROJECT STUDY AREA
- PRESERVED WETLANDS (6 AC.)
- PROPOSED WETLAND RESTORATION (91.4 AC.)
- EXISTING FOREST (NOT PLANTED) (26.9 AC.)
- CONSTRUCTED STREAM CHANNEL
- 2010 SURVEYED STREAM CHANNEL
- 2011 SURVEYED STREAM CHANNEL
- KBSG–1 STREAM MONITORING GAUGE
- APPROXIMATE EXTENT OF BEAVER IMPOUNDMENT

GROUNDWATER MONITORING GAUGES

MAXIMUM PERCENT OF GROWING SEASON WITH CONTINUOUS SATURATION IN TOP 12 INCHES

- >12.5%
- 5–12%
- <5%

VEGETATION PLOTS

- R6 RIPARIAN <260 STEMS/ACRE
- D3 WETLAND <260 STEMS/ACRE
- R6 RIPARIAN >260 STEMS/ACRE
- D3 WETLAND >260 STEMS/ACRE
- STREAM FLOW

APPROXIMATE EXTENT OF BEAVER IMPOUNDMENT (4.70 ACRES±) (DOES NOT INCLUDE UPSTREAM IMPACTS WITHIN STREAM CHANNEL)

R1 D5 R6 D3

KBMG–9 KBMG–10 KBMG–11 KBMG–12 KBMG–13 KBMG–14

XSECT 7 XSECT 8 XSECT 9 XSECT 10 XSECT 11 XSECT 12

MATCHLINE (SEE SHEET 2)

250' 0 250'

SCALE: 1" = 250'

ATKINS

REVISIONS	
1	12/07/2011

Client: Ecosystem Enhancement Program

Project:

KEY BRANCH STREAM & WETLAND RESTORATION SITE

ANSON COUNTY, NORTH CAROLINA

Title:

CURRENT CONDITIONS PLAN VIEW

Dwn. By:	Ckd. By:
RLG	JWG
Date:	Scale:
DEC 2011	1"=250'

Project No.: 100005068

FIGURE

2A

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MATCHLINE (SEE SHEET 1)

KBMG-8

R10

28+00

29+00

30+00

27+00

26+00

25+00

D2

24+00

23+00

22+00

21+00

KBMG-3

KBMG-7

KBSG-1

19+00

18+00

17+00

16+00

15+00

14+00

13+00

12+00

11+00

10+00

9+00

8+00

7+00

6+00

5+00

4+00

3+00

2+00

1+00

0+00

XSECT 1

XSECT 2

XSECT 3

XSECT 4

XSECT 5

KBMG-6

BEGIN LONGITUDINAL PROFILE FOR MONITORING STATION 0+00

LOCATION OF BEAVER DAMS

R5

KBMG-1

KBMG-2

D8

KBMG-5

APPROXIMATE EXTENT OF BEAVER IMPOUNDMENT (0.22 ACRES±) (DOES NOT INCLUDE DOWNSTREAM IMPACTS WITHIN STREAM CHANNEL)

250' 0 250'

SCALE: 1" = 250'

LEGEND

- EXISTING CONTOURS
- PROJECT STUDY AREA
- PRESERVED WETLANDS (6 AC.)
- PROPOSED WETLAND RESTORATION (91.4 AC.)
- EXISTING FOREST (NOT PLANTED) (26.9 AC.)
- CONSTRUCTED STREAM CHANNEL
- 2010 SURVEYED STREAM CHANNEL
- 2011 SURVEYED STREAM CHANNEL
- KBSG-1 STREAM MONITORING GAUGE
- APPROXIMATE EXTENT OF BEAVER IMPOUNDMENT

GROUNDWATER MONITORING GAUGES

MAXIMUM PERCENT OF GROWING SEASON WITH CONTINUOUS SATURATION IN TOP 12 INCHES

- >12.5%
- 5-12%
- <5%

VEGETATION PLOTS

- R6 RIPARIAN <260 STEMS/ACRE
- D3 WETLAND <260 STEMS/ACRE
- R6 RIPARIAN >260 STEMS/ACRE
- D3 WETLAND >260 STEMS/ACRE
- STREAM FLOW

ATKINS

REVISIONS	
1	12/07/2011

Client: Ecosystem Enhancement Program

Project:

KEY BRANCH STREAM & WETLAND RESTORATION SITE

ANSON COUNTY, NORTH CAROLINA

Title:

CURRENT CONDITIONS PLAN VIEW

Dwn. By:	Ckd. By:
RLG	JWG
Date:	Scale:
DEC 2011	1"=250'

Project No.: 100005068

FIGURE

2B

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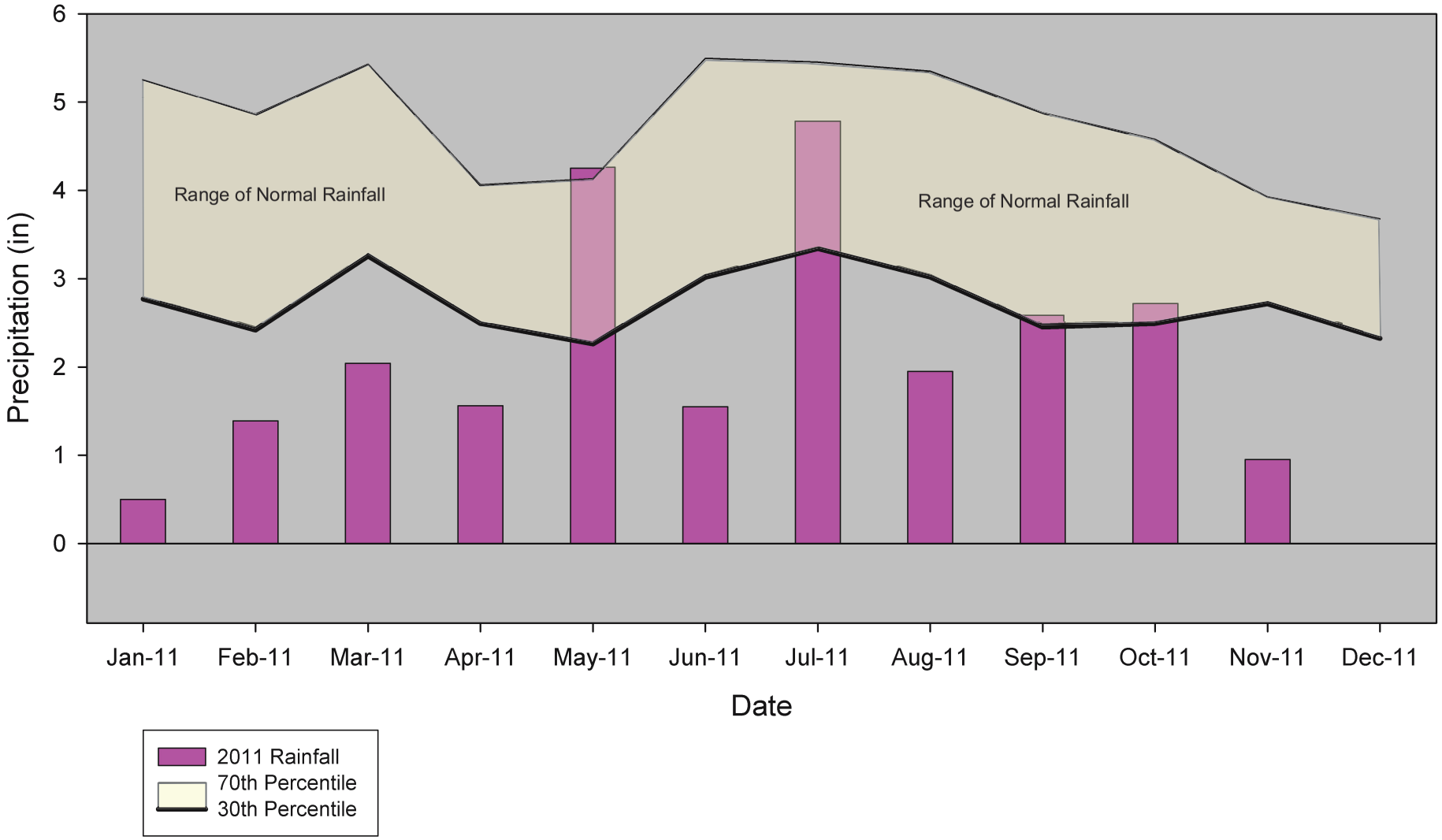
Fig 3. Key Branch 30-70 Percentile Graph (2011)
Wadesboro, NC



Data Source: State Climate Office of NC (CRONOS Database)

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APPENDIX B

GROUNDWATER GAUGE HYDROGRAPHS

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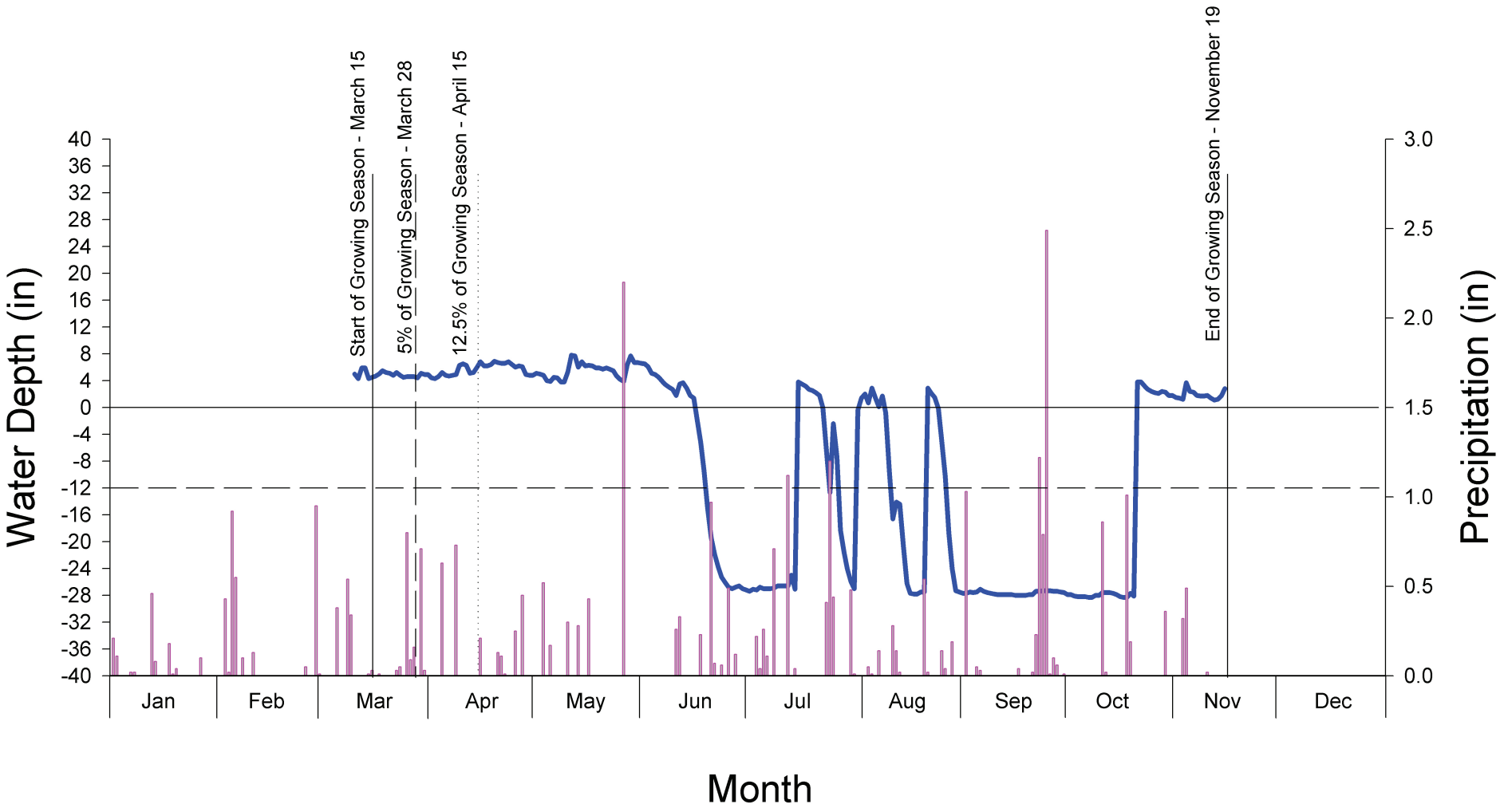
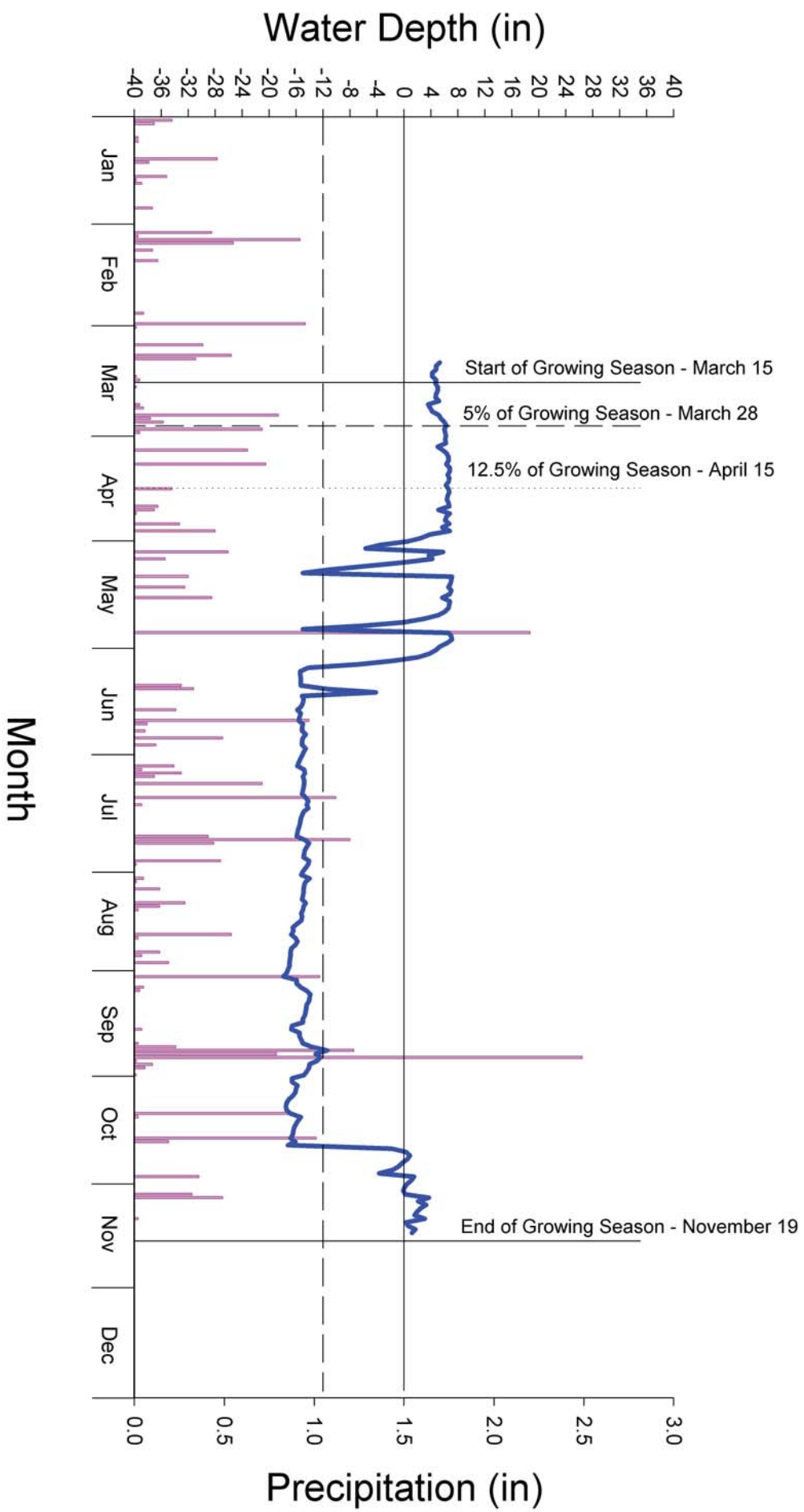
Key Branch

2011

Monitoring Gauge 1 - 1130E7CF

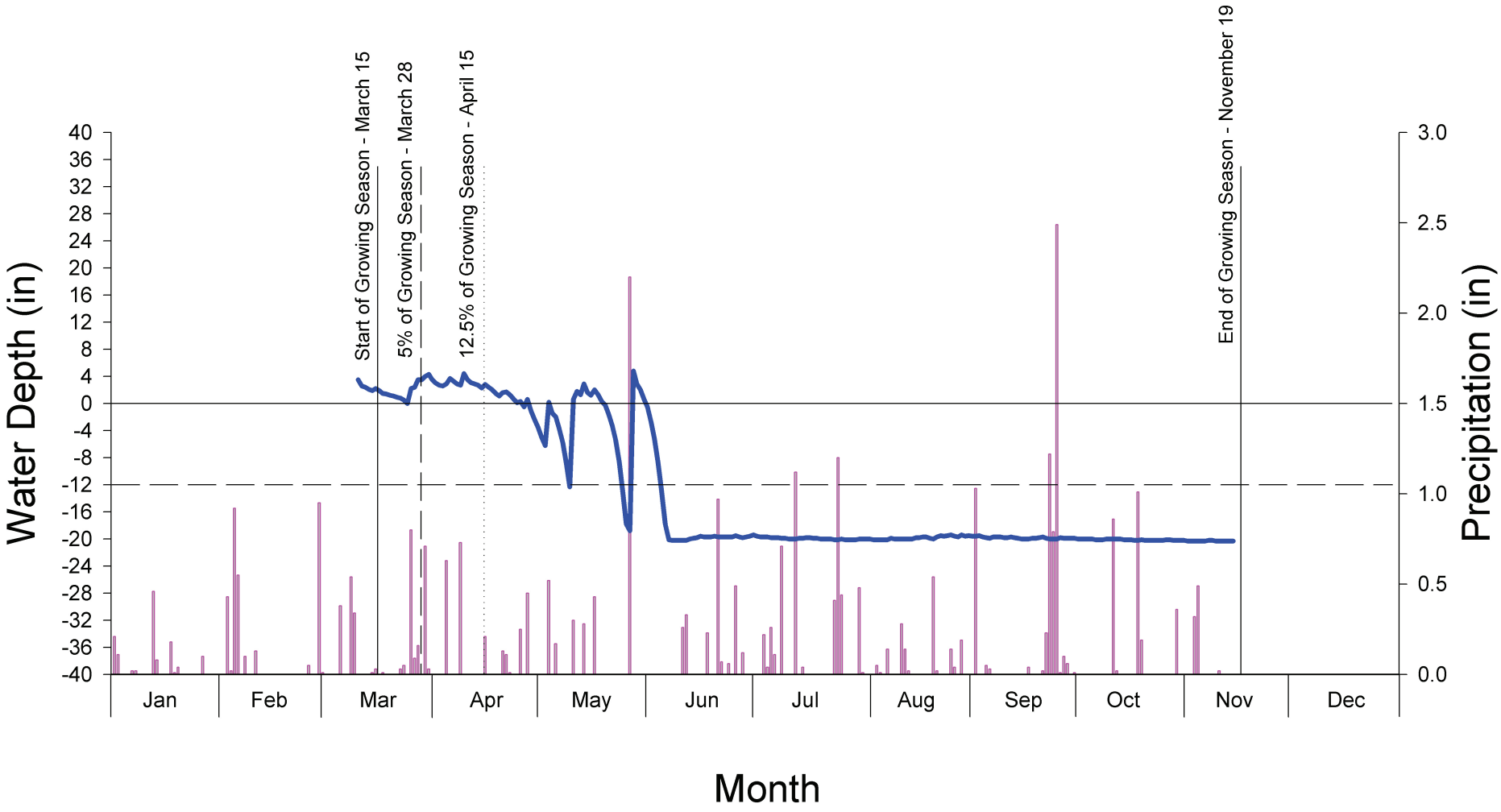


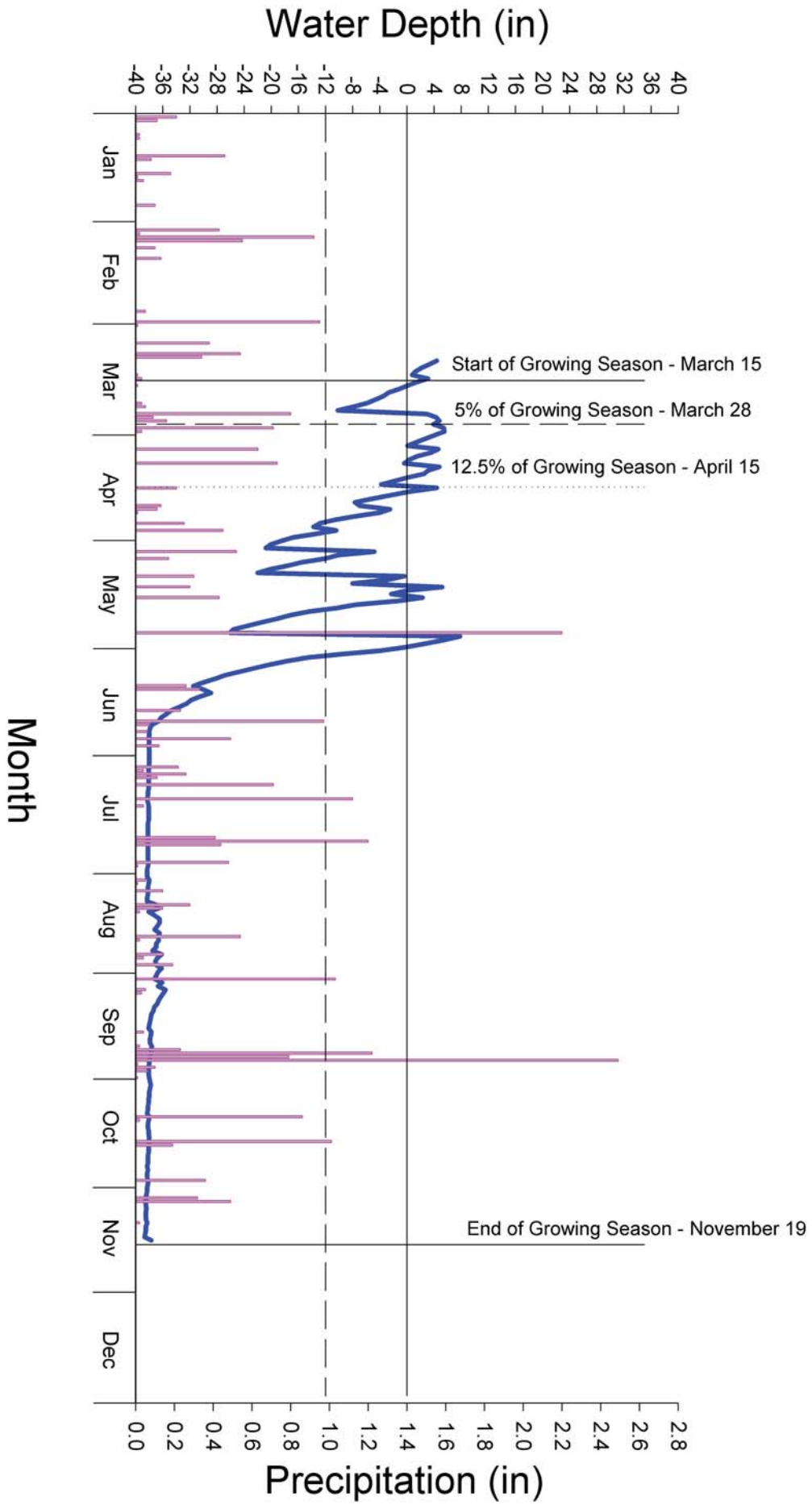

Key Branch
2011
Monitoring Gauge 2 - AB35E52
Water Depth (in)
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Precipitation (in)

Key Branch

2011

Monitoring Gauge 3 - A28C2B0

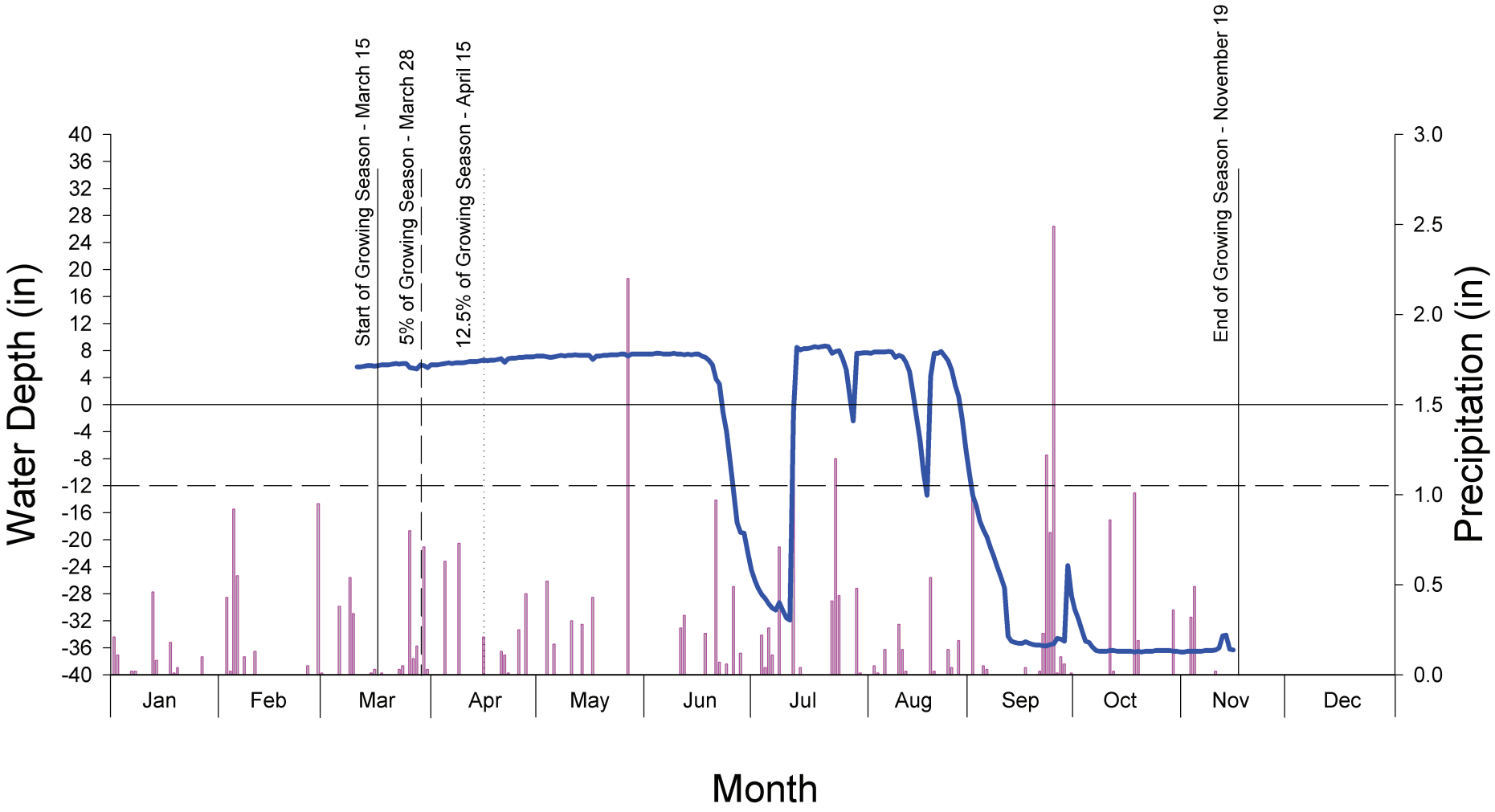


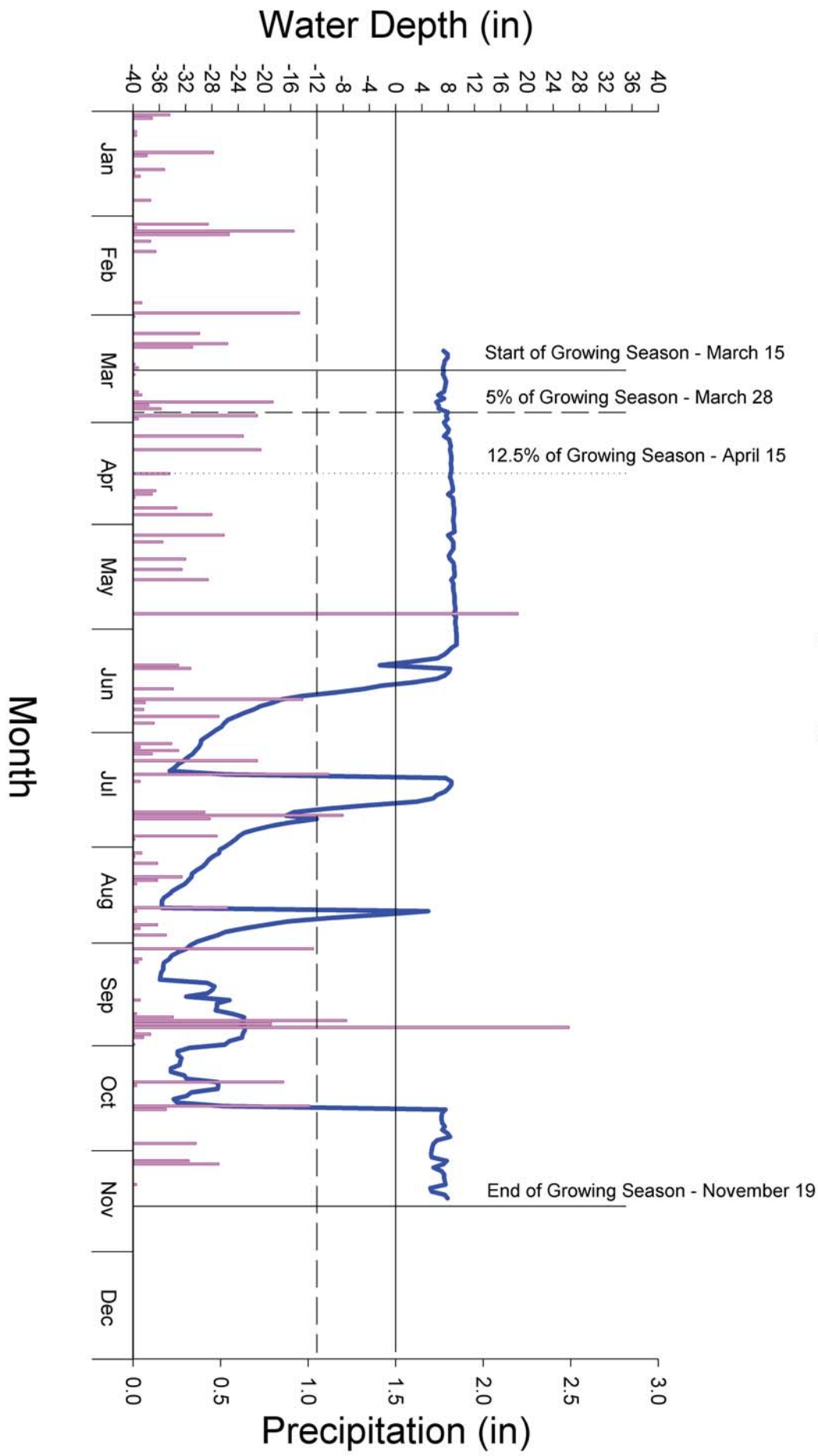

Key Branch
2011
Monitoring Gauge 5 - A286E29
Water Depth (in)
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
0.0
0.2
0.4
0.6
0.8
1.0
1.2
1.4
1.6
1.8
2.0
2.2
2.4
2.6
2.8
Precipitation (in)

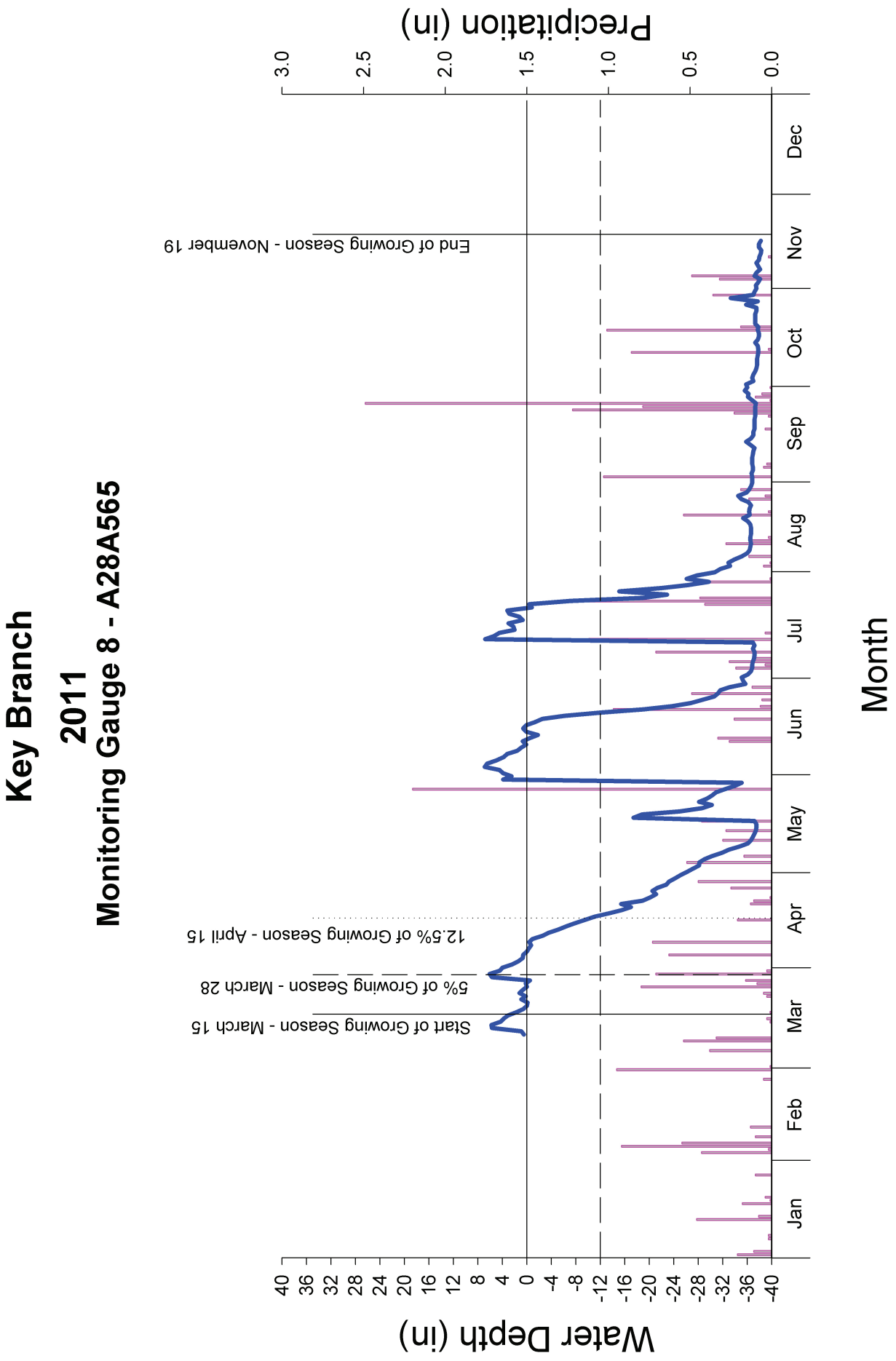
Key Branch

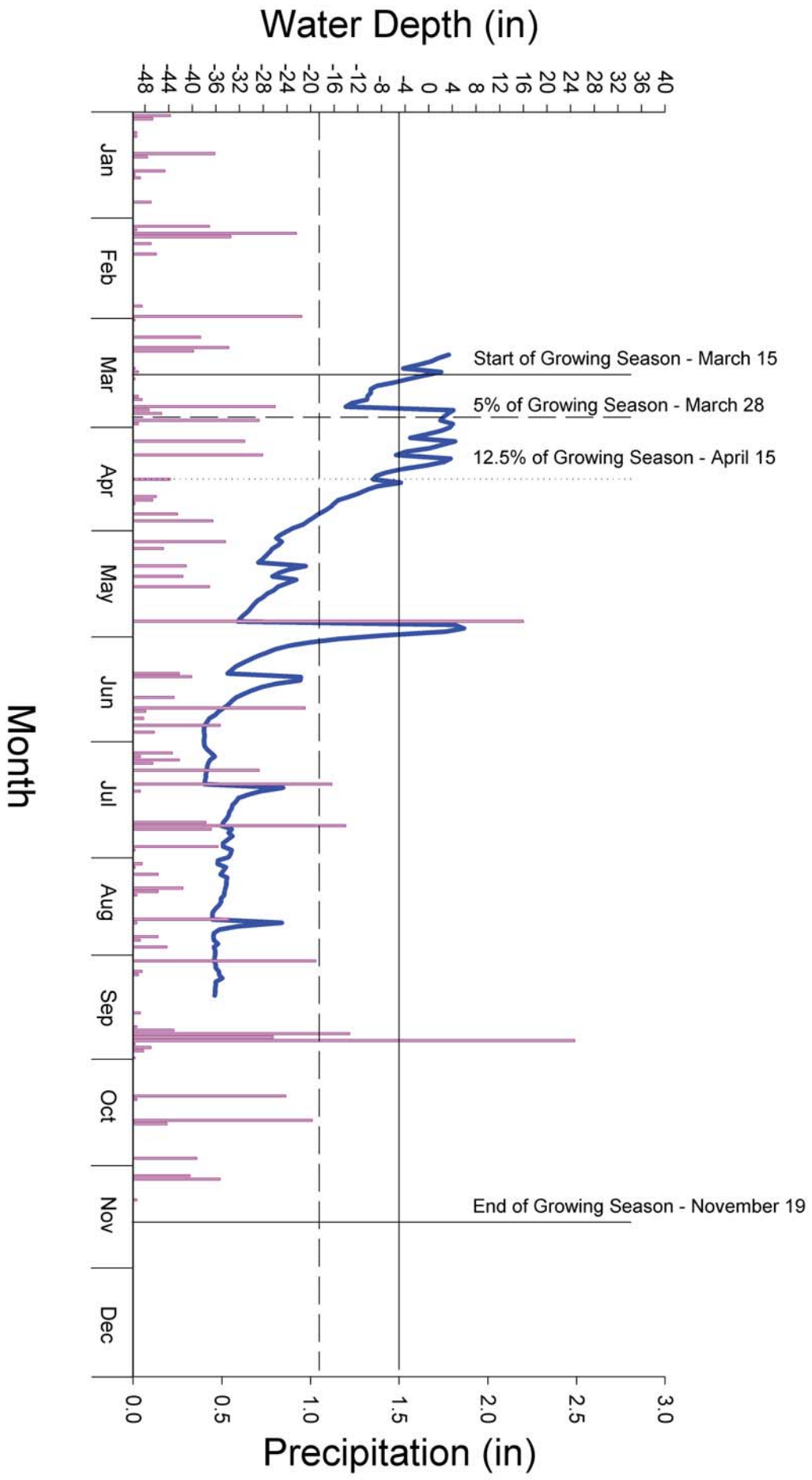
2011

Monitoring Gauge 6 - 9DE7A19




Key Branch
2011
Monitoring Gauge 7 - 9DE535B
Water Depth (in)
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Precipitation (in)

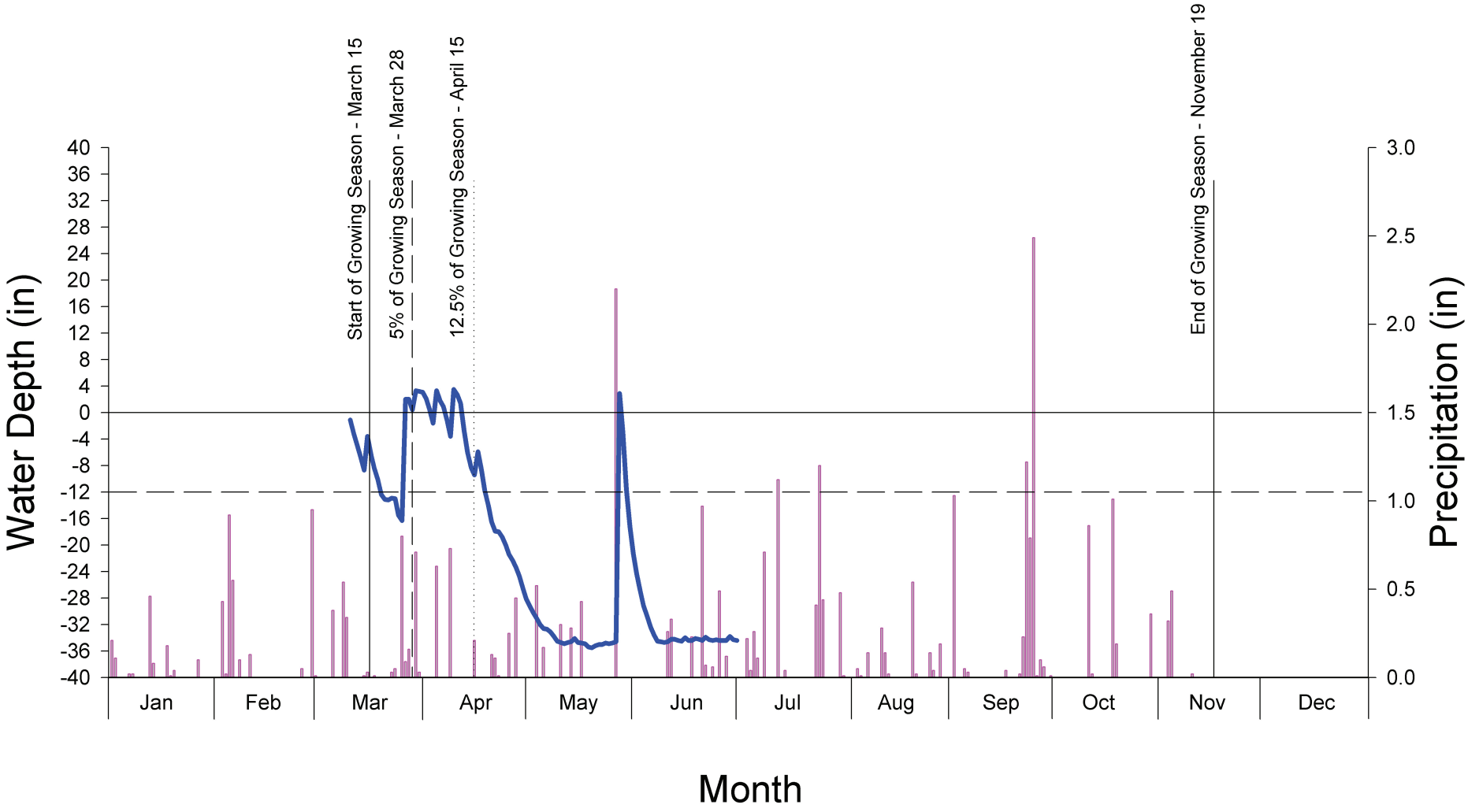

Key Branch
2011
Monitoring Gauge 8 - A28A565
Water Depth (in)
Precipitation (in)
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19

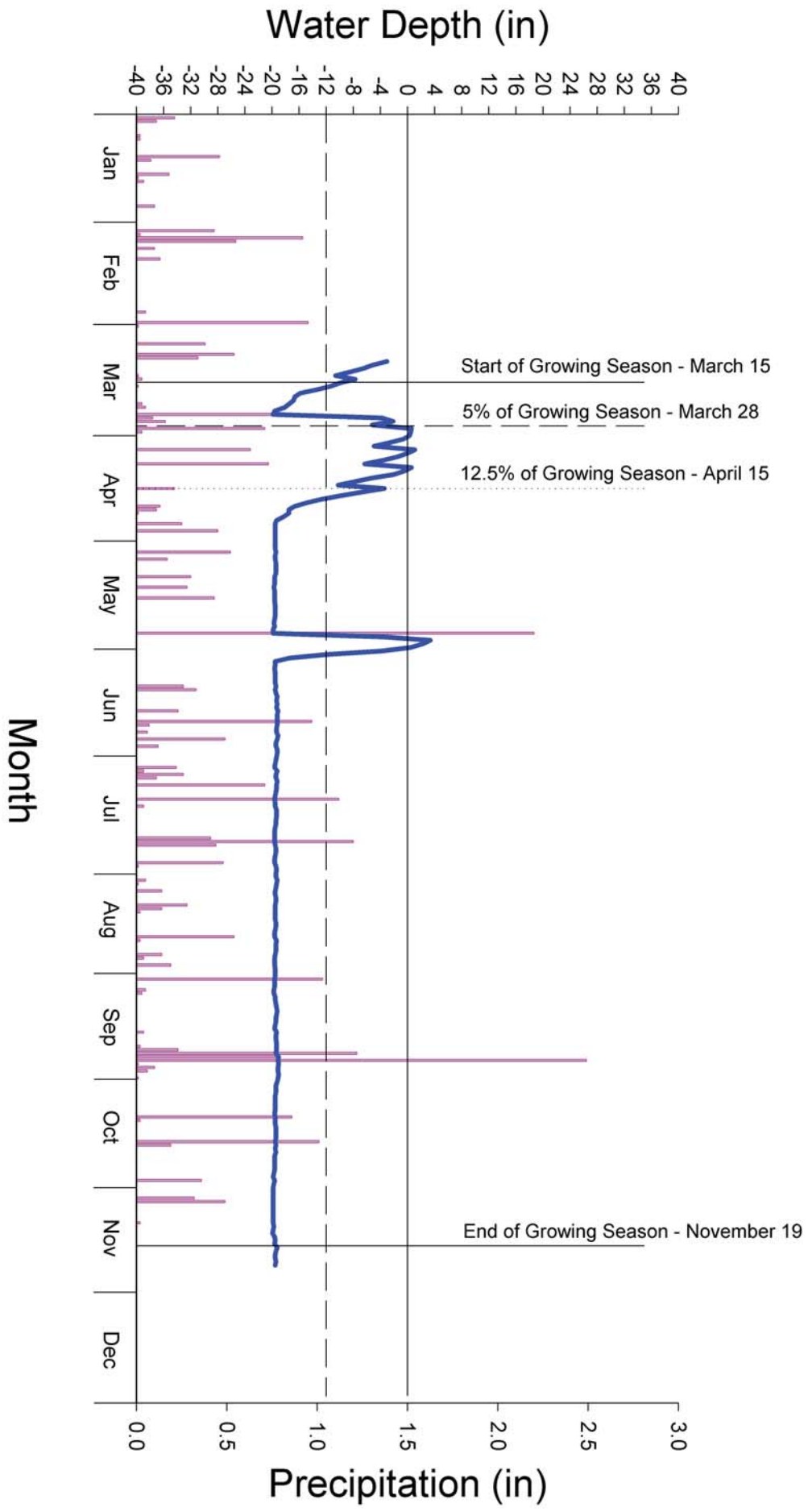

Key Branch
2011
Monitoring Gauge 9 - A28A3CC
Water Depth (in)
-48
-44
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Precipitation (in)

Key Branch

2011

Monitoring Gauge 10 - 13153910

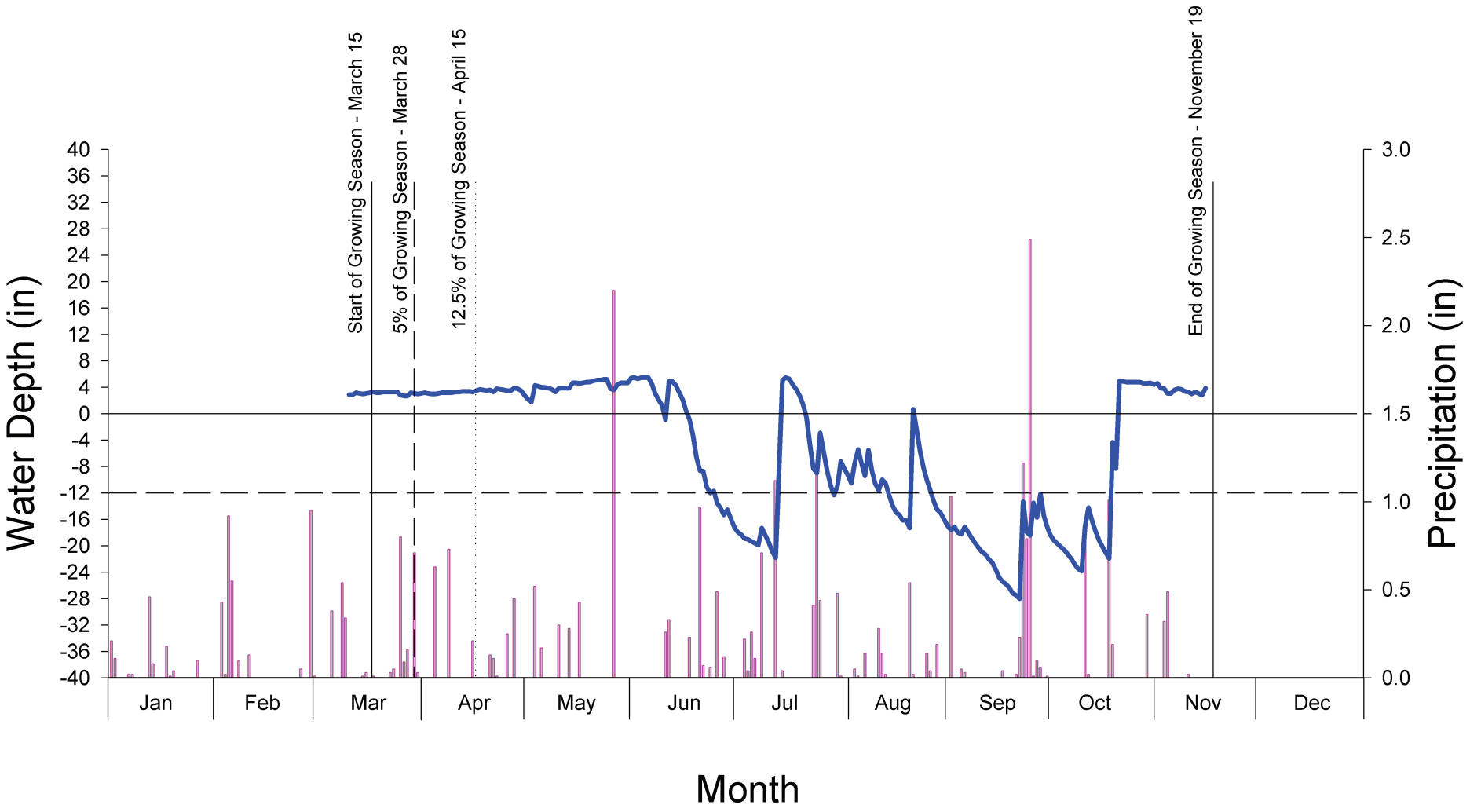


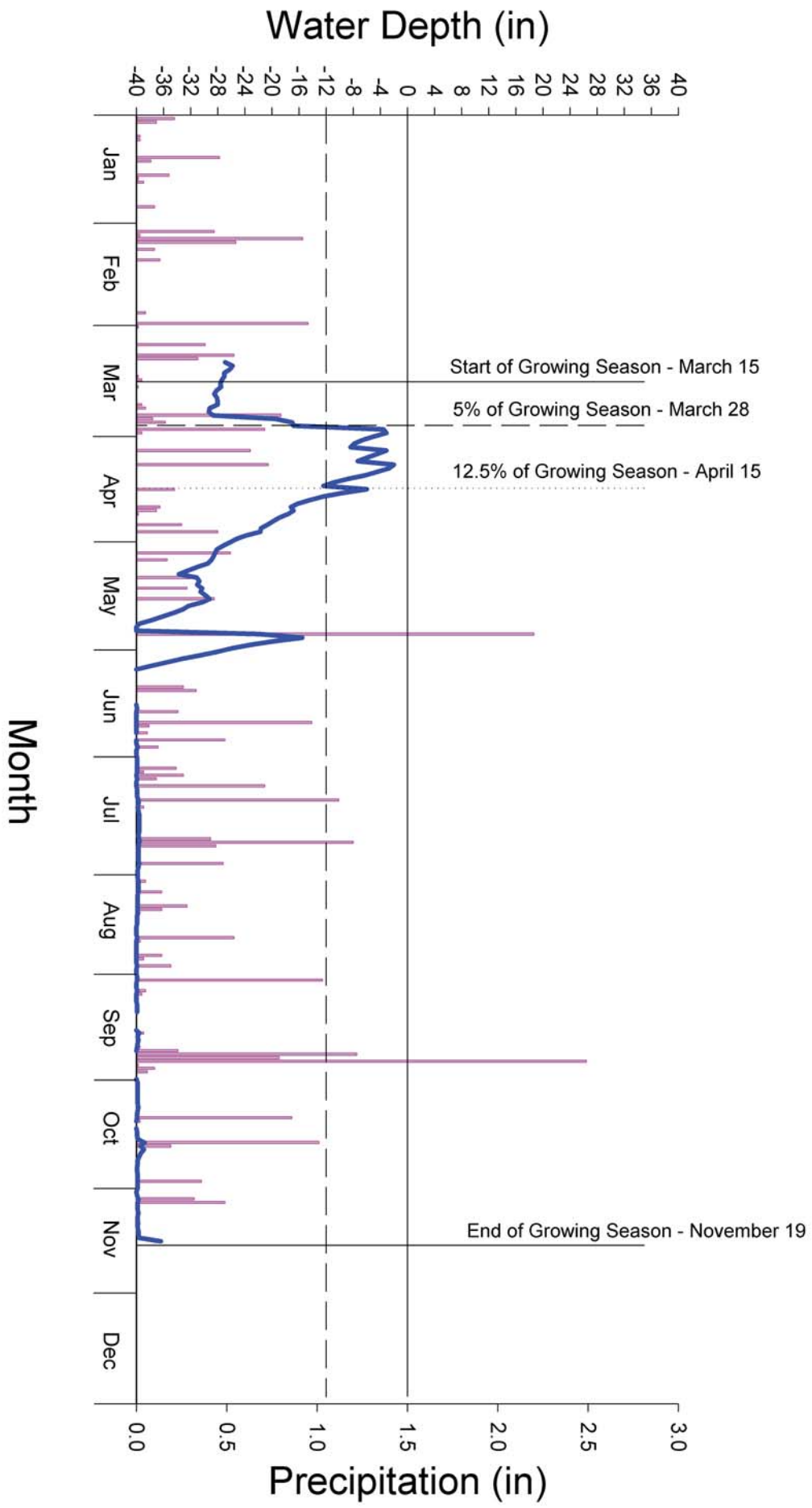

Key Branch
2011
Monitoring Gauge 11 - A279BD0
Water Depth (in)
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Precipitation (in)

Key Branch

2011

Monitoring Gauge 12 - A287DCE

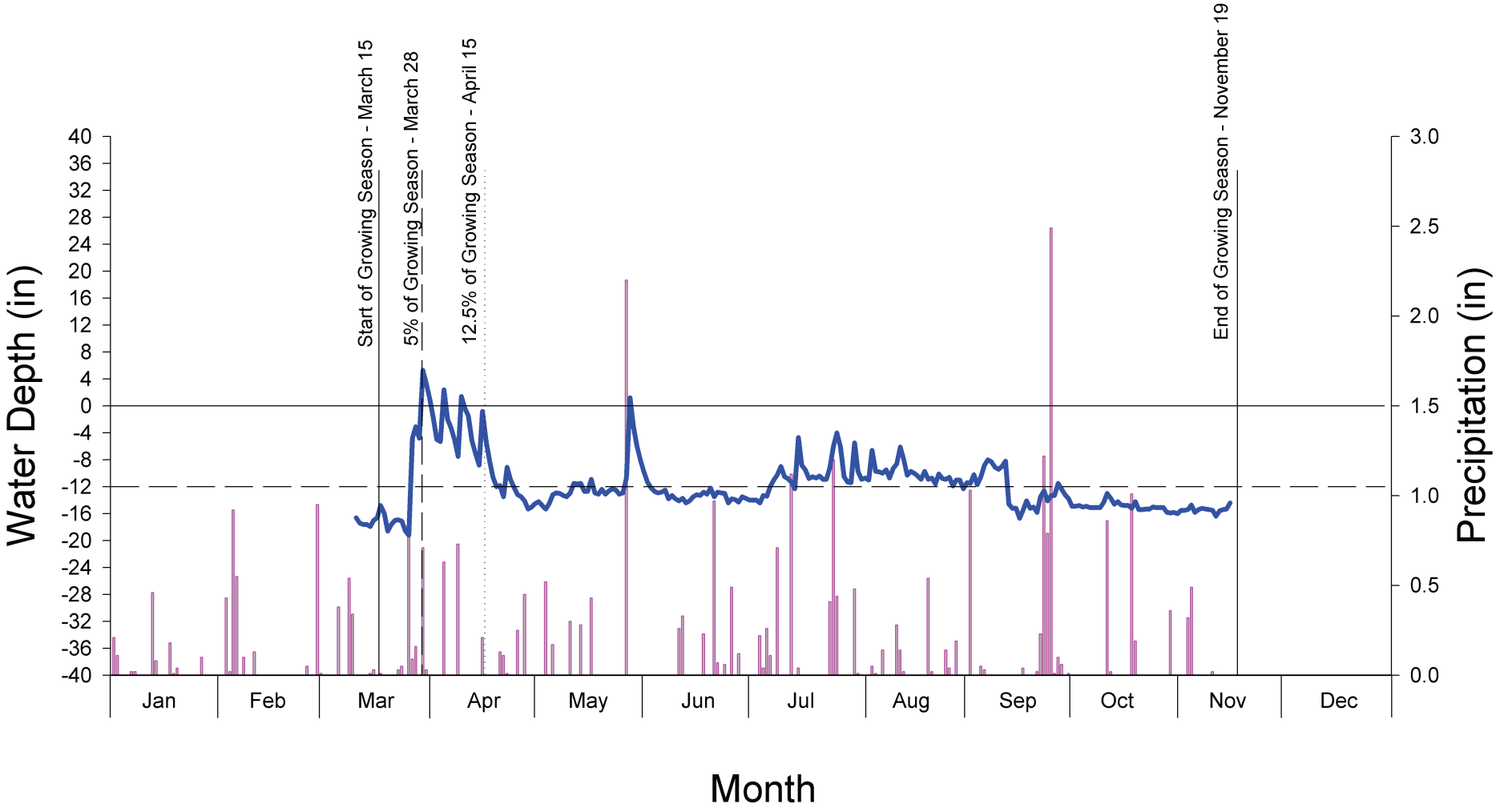



Key Branch
2011
Monitoring Gauge 13 - A27BDE0
Water Depth (in)
-40
-36
-32
-28
-24
-20
-16
-12
-8
-4
0
4
8
12
16
20
24
28
32
36
40
Start of Growing Season - March 15
5% of Growing Season - March 28
12.5% of Growing Season - April 15
End of Growing Season - November 19
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
0.0
0.5
1.0
1.5
2.0
2.5
3.0
Precipitation (in)

Key Branch

2011

Monitoring Gauge 14 - A28BFDE



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APPENDIX C

SITE PHOTOS

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D2 – Vegetation Plot - facing north

D3 – Vegetation Plot - facing north

D5 – Vegetation Plot - facing south

D8 – Vegetation Plot - facing north

R1 – Vegetation Plot - facing north

R5 – Vegetation Plot - facing northwest

R6 – Vegetation Plot - facing southwest

R10 – Vegetation Plot - facing south

After beaver dam removal at top of site. November 23, 2010

Beavers had returned to top of site by February 23, 2011

Beaver pond at top of site – May 5, 2011

2nd beaver dam near top of site - May 5, 2011

APPENDIX D

STREAM SURVEY DATA

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EEP Project No. 206

D1

Key Branch Restoration Site

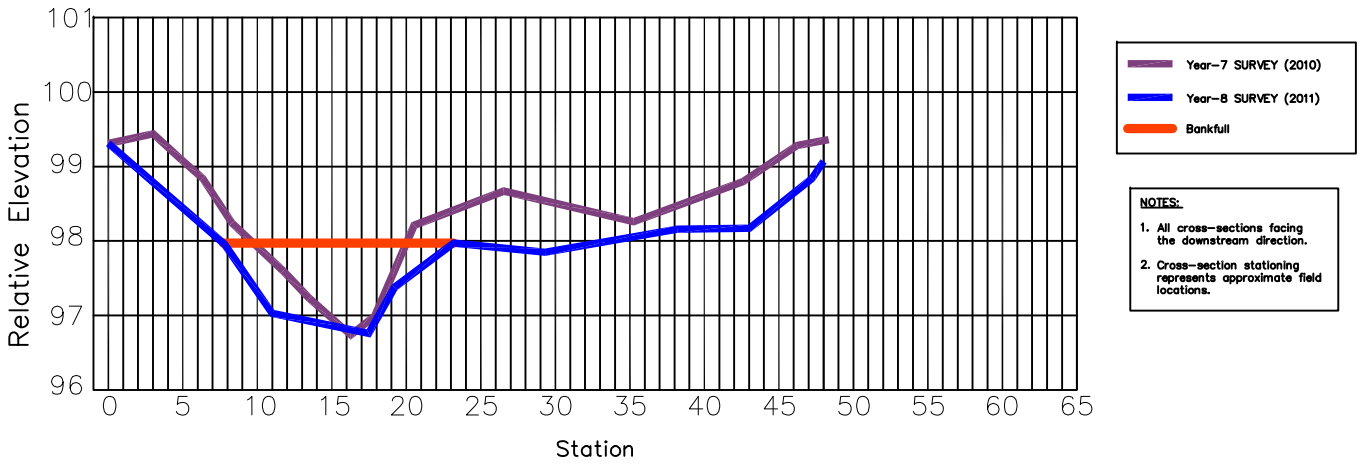
Survey Data

Station		Elevation	Feature
0		99.31	@LPIN
7.44		97.96	
10.68		97.03	
17.12		96.76	
18.86		97.38	
22.82		97.97	
28.96		97.85	
37.82		98.16	
42.67		98.17	
46.88		98.84	
48.00		99.07	@RPIN

Summary Data

Bankful Cross-Sectonal Area	11.1
Bankful Width	15.4
Bankful Mean Depth	0.7
Bankful Max Depth	1.2
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 1 – Glide



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Title: Cross-Section 1

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 1
Survey Date 11/14/11 – 11/15/11	Survey Weather Sunny	Field Team Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location Station 14+00

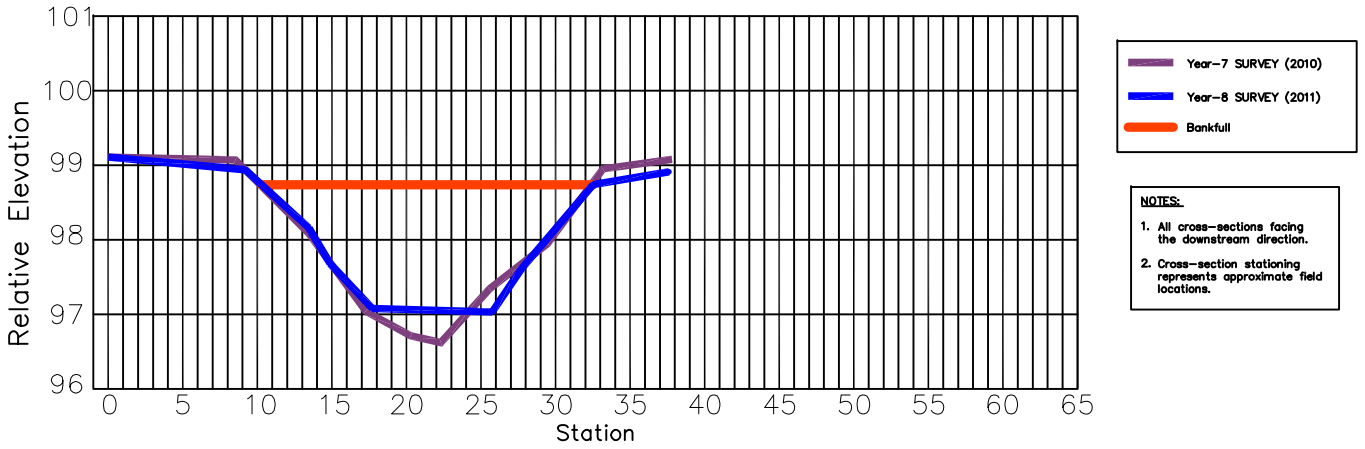
Survey Data

Station		Elevation	Feature
0		99.11	@LPIN
9.18		98.94	
13.45		98.16	
14.87		97.68	
17.69		97.08	
25.75		97.03	
27.71		97.61	
32.52		98.74	
37.60		98.91	@RPIN

Summary Data

Bankful Cross-Sectonal Area	24.9
Bankful Width	22.3
Bankful Mean Depth	1.1
Bankful Max Depth	1.7
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 2 - Run



Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 2

ATKINS

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 2
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 17+00

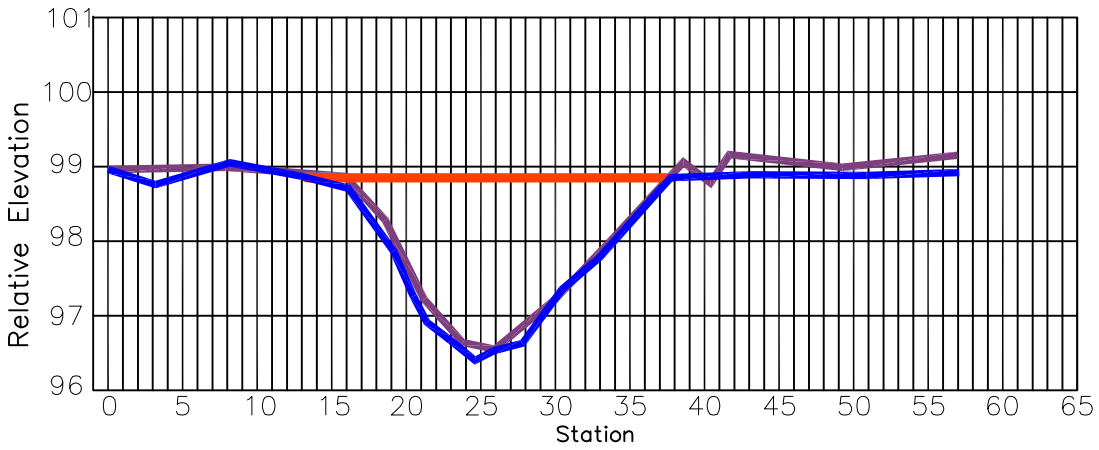
Survey Data

Station		Elevation	Feature
0		98.96	@LPIN
7.85		98.97	
13.16		98.94	
17.92		97.86	
20.44		97.44	
23.09		96.72	
24.99		96.61	
26.27		96.49	
27.93		96.75	
29.50		97.00	
30.40		97.35	
31.75		97.95	
34.78		98.79	
37.94		98.96	
42.71		99.13	
47.69		98.84	
50.88		99.43	@RPIN

Summary Data

Bankful Cross-Sectonal Area	30.4
Bankfull Width	24.4
Bankfull Mean Depth	1.2
Bankfull Max Depth	2.5
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 3 - Pool



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 3

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 3
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 22+50

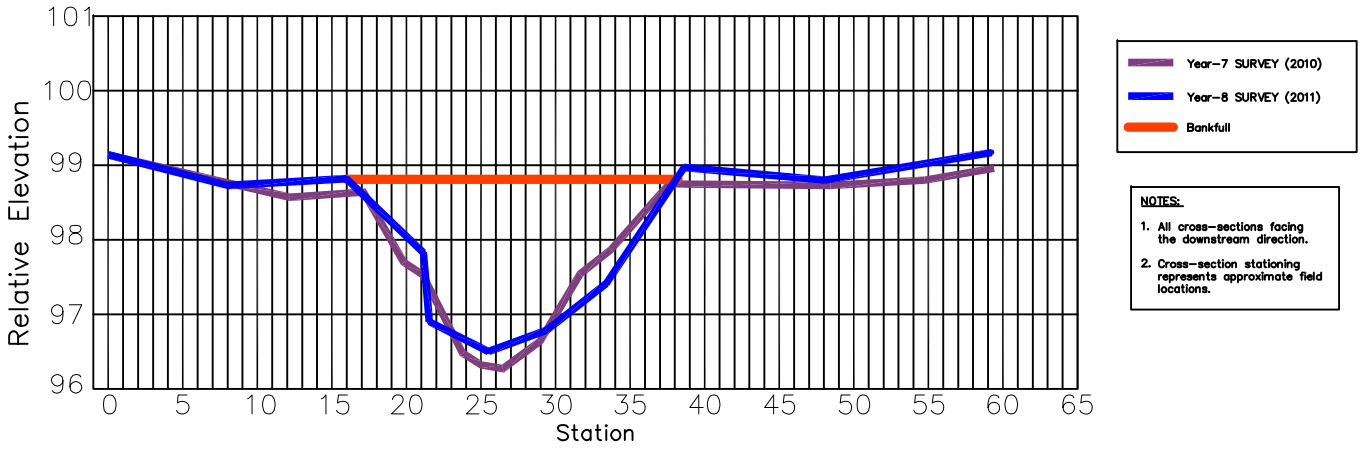
Survey Data

Station		Elevation	Feature
0		99.14	@LPIN
3.91			
13.35			
18.58			
22.55			
36.46			
30.44			
30.84			
36.02			
43.96			
51.97			@RPIN

Summary Data

Bankful Cross-Sectonal Area	29.3
Bankfull Width	22.1
Bankfull Mean Depth	1.3
Bankfull Max Depth	2.3
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 4 - Pool



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 4

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 4
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 26+50

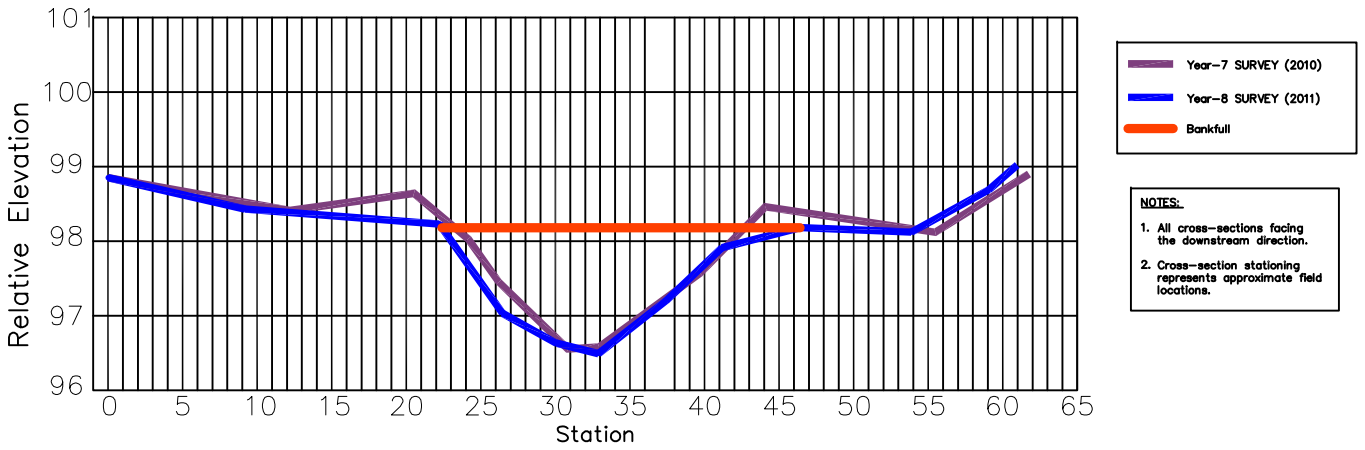
Survey Data

Station		Elevation	Feature
0		98.85	@LPIN
9.17		98.52	
22.21		98.33	
26.46		97.12	
30.06		96.72	
32.88		96.58	
37.41		97.29	
41.16		97.99	
46.41		98.27	
53.86		98.21	
59.08		98.79	
60.97		99.02	@RPIN

Summary Data

Bankful Cross-Sectonal Area	20.9
Bankfull Width	24.0
Bankfull Mean Depth	0.9
Bankfull Max Depth	1.7
Width/Depth Ratio	26.7
Entrenchment Ratio	4.2
Classification	C6

Cross-Section 5 – Riffle



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Cross-section, looking at left bank

Title: Cross-Section 5

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 5
Survey Date: 11/14/11 – 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 31+00

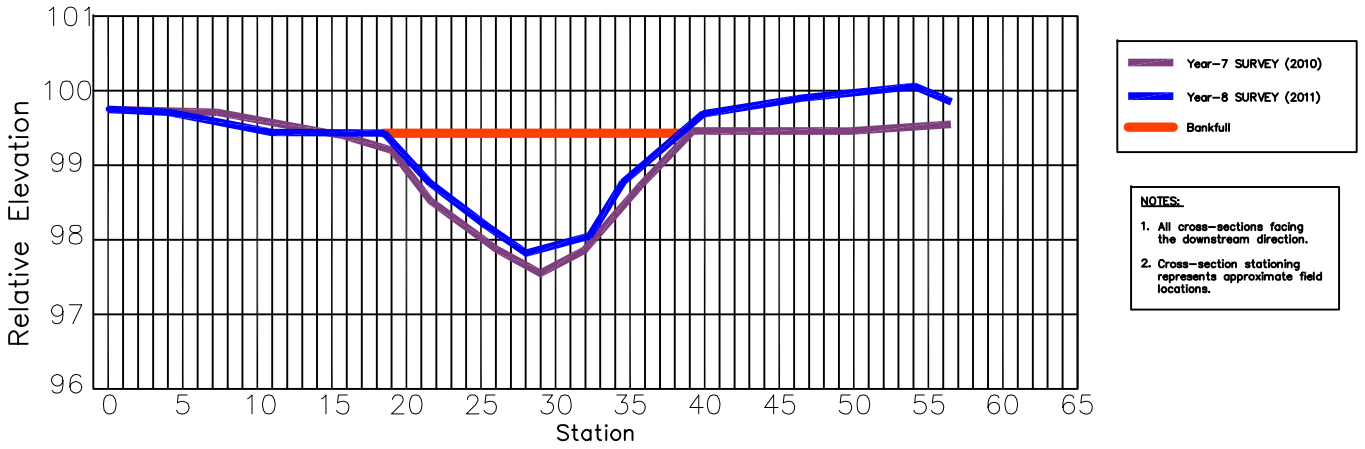
Survey Data

Station		Elevation	Feature
0		99.75	@LPIN
4.02		99.72	
10.97		99.45	
18.51		99.43	
21.59		98.76	
25.34		98.20	
28.03		97.82	
32.29		98.05	
34.51		98.77	
39.9		99.69	
46.46		99.91	
54.06		100.06	
56.55		99.85	@RPIN

Summary Data

Bankful Cross-Sectonal Area	18.4
Bankful Width	19.9
Bankful Mean Depth	0.9
Bankful Max Depth	1.6
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 6 - Glide



Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 6

ATKINS

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 6
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 35+00

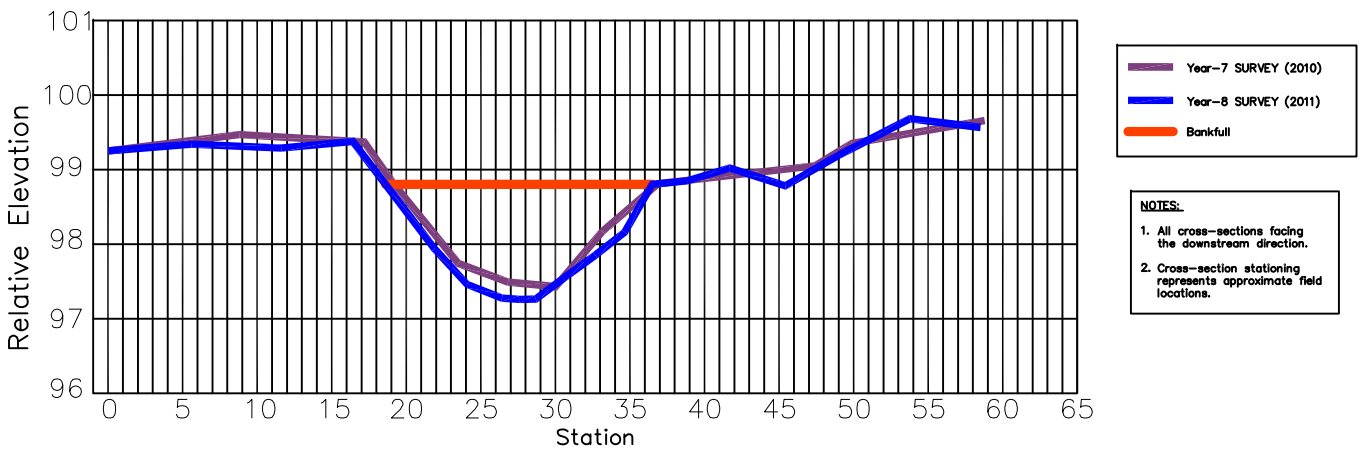
Survey Data

Station		Elevation	Feature
0		99.25	@LPIN
5.60		99.63	
11.61		99.58	
16.42		99.67	
21.89		98.23	
24.08		97.75	
26.41		97.57	
27.62		97.55	
28.67		97.55	
30.54		97.83	
32.67		98.14	
34.65		98.45	
36.49		99.09	
38.84		99.14	
41.69		99.31	
45.42		99.07	
49.01		99.48	
53.78		99.97	
58.51		99.86	@RPIN

Summary Data

Bankful Cross-Sectonal Area	17.6
Bankful Width	17.9
Bankful Mean Depth	1.0
Bankful Max Depth	1.5
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 7 - Run



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Cross-section, looking at left bank

Title: Cross-Section 7

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 7
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 39+50

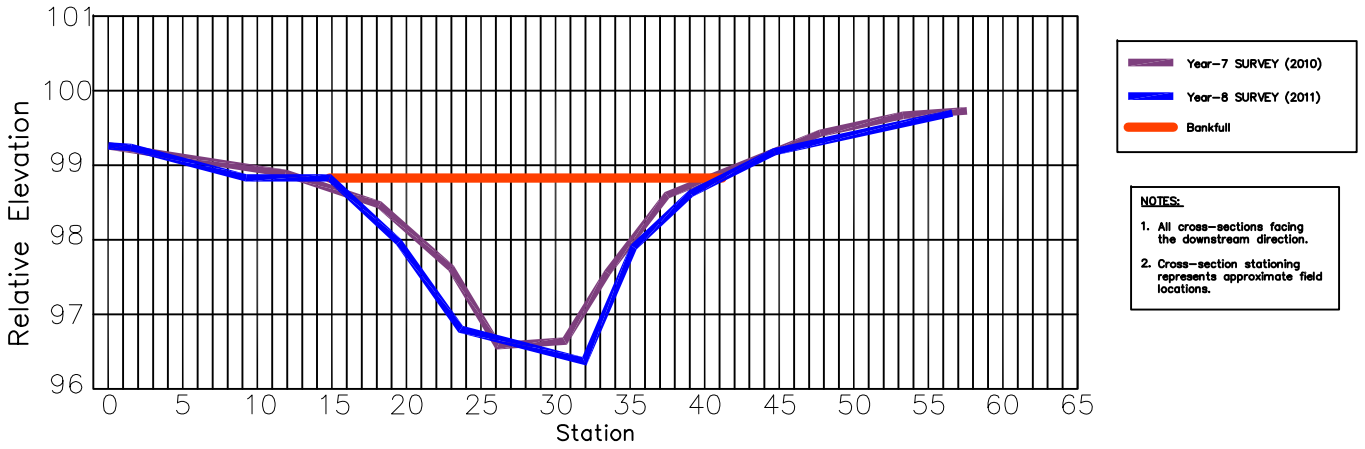
Survey Data

Station		Elevation	Feature
0		99.26	@LPIN
1.52		98.95	
9.25		98.39	
14.84		97.67	
19.48		96.14	
23.64		96.57	
31.93		97.74	
35.23		98.60	
39.06		98.60	
44.66		99.01	
56.60		99.03	@RPIN

Summary Data

Bankful Cross-Sectonal Area	34.3
Bankfull Width	26.3
Bankfull Mean Depth	1.3
Bankfull Max Depth	2.4
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 8 - Pool



Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 8

ATKINS

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 8
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 44+00

EEP Project No. 206

D9

Key Branch Restoration Site

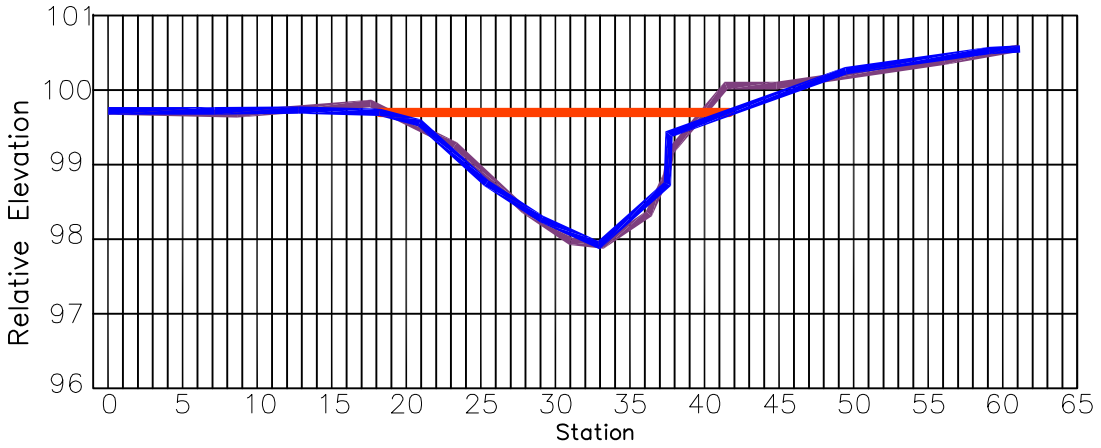
Survey Data

Station		Elevation	Feature
0		99.72	@LPIN
7.14		99.56	
12.76		99.57	
18.22		99.53	
20.90		99.40	
25.37		98.68	
29.08		98.01	
32.92		97.76	
37.52		99.25	
37.61		98.57	
49.47		100.09	
59.09		100.37	
61.16		100.69	@RPIN

Summary Data

Bankful Cross-Sectonal Area	20.1
Bankfull Width	23.4
Bankfull Mean Depth	0.9
Bankfull Max Depth	1.8
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 9 – Glide



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 9

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 9
Survey Date: 11/14/11 – 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 48+00

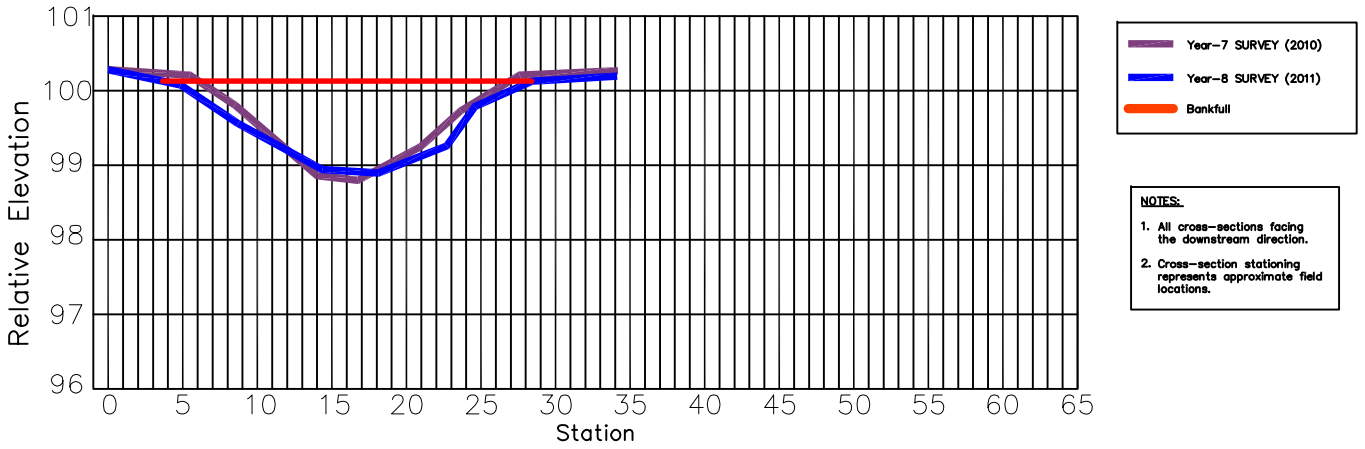
Survey Data

Station		Elevation	Feature
0		100.28	@LPIN
4.84		100.08	
8.71		99.56	
14.36		98.94	
18.12		98.90	
22.70		99.26	
24.60		99.79	
28.41		100.13	
34.14		100.20	@RPIN

Summary Data

Bankful Cross-Sectonal Area	17.3
Bankfull Width	24.8
Bankfull Mean Depth	0.7
Bankfull Max Depth	1.2
Width/Depth Ratio	35.4
Entrenchment Ratio	4.0
Classification	C6

Cross-Section 10 – Riffle



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Title: Cross-Section 10

ATKINS

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 10
Survey Date: 11/14/11 – 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 53+00

Key Branch Restoration Site

D10

EEP Project No. 206

EEP Project No. 206

D11

Key Branch Restoration Site

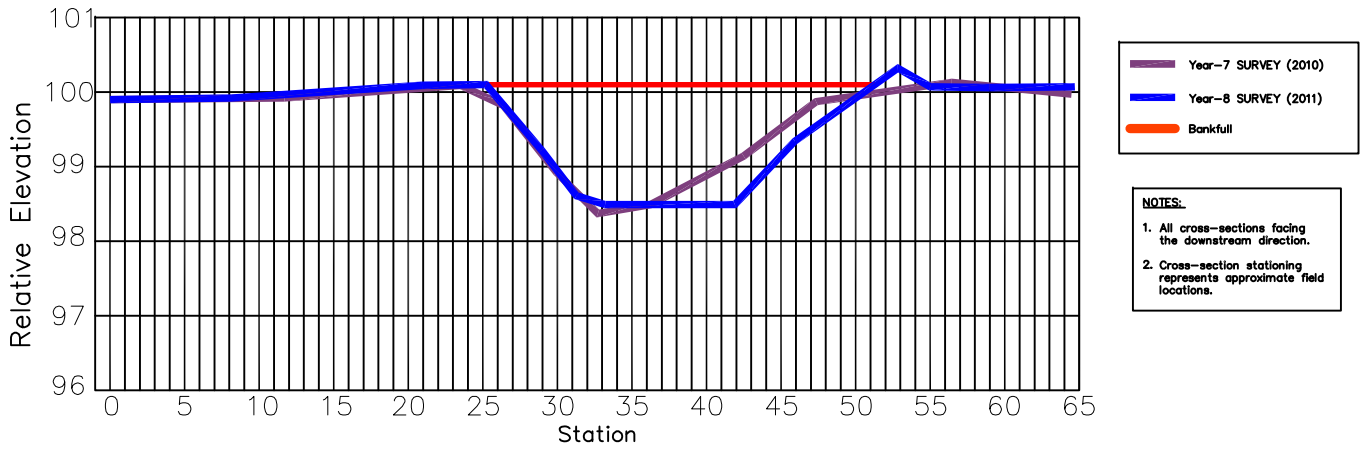
Survey Data

Station		Elevation	Feature
0		99.90	@LPIN
8.17		99.92	
20.92		100.09	
25.21		100.10	
28.94		99.22	
31.27		98.61	
33.20		98.49	
41.89		98.49	
45.93		99.34	
52.84		100.32	
58.96		100.06	
64.70		100.07	@RPIN

Summary Data

Bankful Cross-Sectonal Area	28.4
Bankfull Width	26.2
Bankfull Mean Depth	1.1
Bankfull Max Depth	1.6
Width/Depth Ratio	N/A
Entrenchment Ratio	N/A
Classification	N/A

Cross-Section 11 - Run



Cross-section, upstream looking downstream

Cross-section, looking at right bank

Title: Cross-Section 11

ATKINS

Ecosystem Enhancement

Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 11
Survey Date: 11/14/11 - 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 56+75

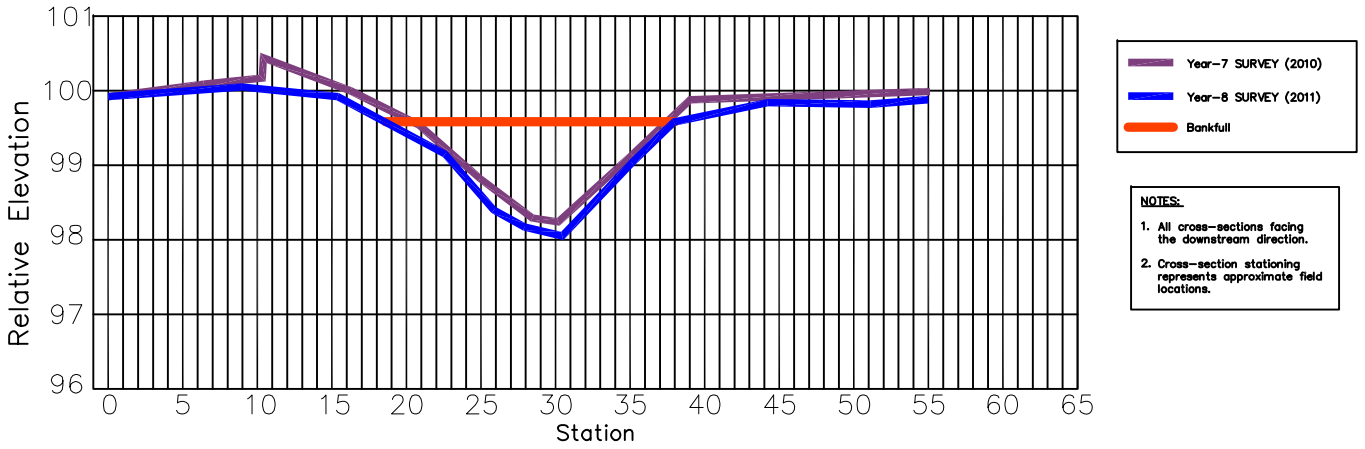
Survey Data

Station		Elevation	Feature
0		99.92	@LPIN
8.95		100.05	
15.39		99.92	
22.58		99.15	
25.86		98.40	
27.92		98.17	
30.45		98.05	
35.10		99.03	
37.93		99.59	
44.22		99.84	
51.13		99.82	
55.00		99.88	@RPIN

Summary Data

Bankful Cross-Sectonal Area	15.6
Bankfull Width	19.4
Bankfull Mean Depth	0.8
Bankfull Max Depth	1.5
Width/Depth Ratio	24.3
Entrenchment Ratio	5.2
Classification	C6

Cross-Section 12 – Riffle



NOTES:

1. All cross-sections facing the downstream direction.
2. Cross-section stationing represents approximate field locations.

Cross-section, upstream looking downstream

Title: Cross-Section 12

ATKINS

Ecosystem Enhancement

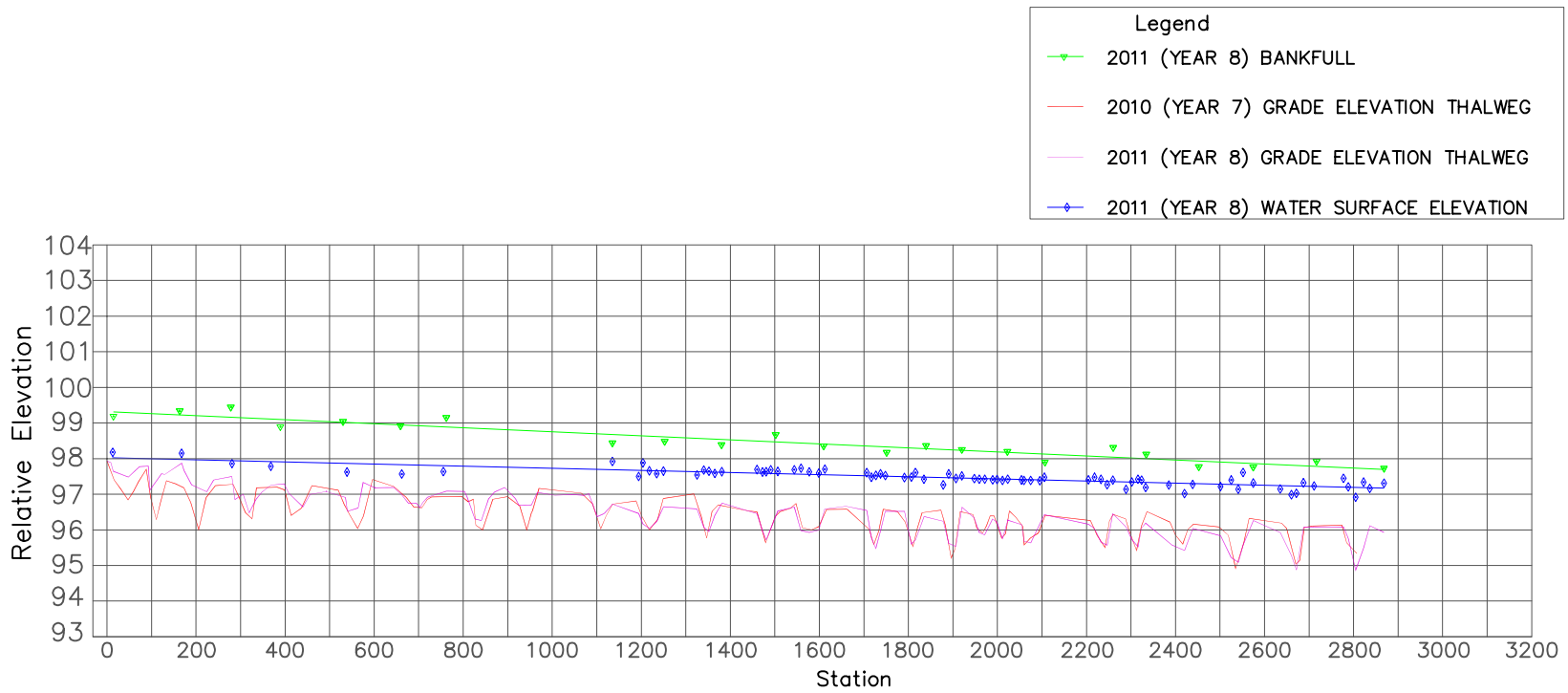
Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Cross-Section 12
Survey Date: 11/14/11 – 11/15/11	Survey Weather: Sunny	Field Team: Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location: Station 61+00

Key Branch Restoration Site

D12

EEP Project No. 206

Longitudinal Profile



BANKFULL SLOPE: 0.00056
WATER SURFACE SLOPE: 0.00029

Title	Longitudinal Profile		
Project	Key Branch Wetland and Stream Restoration Site, Anson County	Project #	206
		Figure	Longitudinal Profile
Survey Date 11/14/11 – 11/15/11	Survey Weather Sunny	Field Team Jeremy Schmid, Jeff Siceloff, Kirsten Hunt	Location Station