UT to Mill Swamp - Monitoring Report
Fourth Monitoring Measurement
Third Year of Credit Release

Onslow County, North Carolina

NCDMS Project ID Number - 95019

Project Info: Credit Release Year: 3 of 7 (Fourth site measurement since construction)
Year of Data Collection: 2016
Year of Completed Construction: 2013
Submission Date: January 2017

Submitted To: NCDEQ – Division of Mitigation Services 1625 Mail Service Center
Raleigh, NC 27699
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UT to Mill Swamp - Monitoring Report
Third Monitoring Measurement
Second Year of Credit Release

Onslow County, North Carolina

NCDMS Project ID Number - 95019

Report Prepared and Submitted by Michael Baker Engineering, Inc.

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Michael Baker
INTERNATIONAL

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APPENDICES

1.0 EXECUTIVE SUMMARY

Michael Baker Engineering (Baker) restored 3,606 linear feet (LF) of perennial stream, 6.62 acres (AC) of riparian wetlands, and enhanced 600 LF of stream along an unnamed tributary (UT) to Mill Swamp in Onslow County, North Carolina (NC), (Appendix A). The UT to Mill Swamp Restoration Project (Site) is located in Onslow County, approximately three miles northwest of the Town of Richlands. The Site is located in the NC Division of Water Resources (NCDWR) sub-basin 03-05-02 and the NCDEQ Division of Mitigation Services ((DMS) formerly Ecosystem Enhancement Program) Targeted Local Watershed (TLW) 03030001-010020 of the White Oak River Basin. The project involved the restoration and enhancement of a Coastal Plain Headwater Small Stream Swamp system (NC WAM 2010, Schafale and Weakley 1990) from impairments within the project area due to past agricultural conversion, cattle grazing, and draining of floodplain wetlands by ditching activities.

The project goals directly addressed stressors identified in the White Oak River Basin Restoration Priority Plan (RBRP) such as degraded riparian conditions, channel modification, and excess sediment and nutrient inputs. The primary restoration goals, as outlined in the approved mitigation plan, are described below:

- Create geomorphically stable conditions along the unnamed tributaries across the Site,
- Implement agricultural Best Management Practices (BMPs) to reduce nonpoint source inputs to receiving waters,
- Protect and improve water quality by reducing bank erosion, nutrient and sediment inputs,
- Restore stream and wetland hydrology by connecting historic flow paths and promoting natural flood processes, and
- Restore and protect riparian buffer functions and corridor habitat in perpetuity by establishing a permanent conservation easement.

To accomplish these goals, the following objectives were identified:

- Restore existing incised, eroding, and channelized streams by providing access to their historic floodplains,
- Prevent cattle from accessing the riparian buffer, reducing excessive bank erosion,
- Increase aquatic habitat value by providing more bedform diversity, creating natural scour pools and reducing sediment from accelerated bank erosion,
- Plant native species riparian buffer vegetation along stream bank and floodplain areas, protected by a permanent conservation easement, to increase stormwater runoff filtering capacity, improve bank stability, and shade the stream to decrease water temperature,
- Improve aquatic and terrestrial habitat through improved substrate and in-stream cover, addition of woody debris, and reduction of water temperature, and
- Control invasive species vegetation within the project area and if necessary, continue treatments during the monitoring period.

The project as-built condition closely mimics that proposed by the design. Differences are outlined below:

- The Stream and Wetland Mitigation Plan (Mitigation Plan) specified the planting of riparian live stakes during construction; however, due to construction being completed during the growing season in May 2013 no live stakes were installed. During construction, it was determined that live stakes would be installed during the dormant season. It is noted that as of March 27, 2014, approximately 300 live stakes were installed along the stream banks in the restored single thread channel of the UT1c area.
- Permanent fencing along Reach UT3 was originally proposed 50 feet from both of the streambanks outside of the conservation easement; however, the landowner decided to use the northern pasture for hay production only, so fencing was installed only on the southern side of the reach to exclude cattle.

Special Notes:

In consideration of this report, the following timeline should be noted:

Completion of construction – 5/31/13

Completion of installation of tree and shrub bare roots – 6/13/13

Year 1 (2013) vegetation monitoring – 10/16/13

Live stake installation - 3/27/14

Year 1 (2013) supplemental vegetation monitoring – 5/18/14

Year 2* (2014) vegetation monitoring – 12/19/14

Year 2 (2015) vegetation monitoring – 11/13/15

Year 3 (2016) vegetation monitoring – November, 2016

Supplemental Year 1 (5/18/14) vegetation monitoring was conducted in order to provide additional mortality data. This additional monitoring effort was done since the time that had elapsed between the installation of the tree and shrub bare roots (6/13/13) and Year 1 vegetation monitoring (10/16/13) was only 125 days of the growing season (March 18th through November 16th). Trees and shrubs grew for an additional 61 days of growing season from 3/18/14 through 5/18/14 in early 2014 and were supplementally monitored. A total of 186 days of growing season had elapsed since the trees were planted and the supplemental Year 1 vegetation monitoring was conducted. An additional 181 days within the growing season (5/19/14 through 11/16/14) had elapsed prior to Year 2 (2014) vegetation monitoring, providing the required minimum of 180 days of growing season growth as stated in the approved Mitigation Plan. As such, Baker considered the data collected on 12/19/14 to be Year 2 data and the data collected on 11/13/15 to be Year 3 data. However, the US Army Corps of Engineers has declined to release the credits generated from Year 2 (2014) citing too short of a period between plant installation and monitoring. As such, the 2015 monitoring report was considered Year 2. All references to Year 2 henceforth will indicate monitoring activities conducted during 2015. Data collected during 2014 that was previously considered monitoring Year 2 will be labeled as Year 2*.

During Year 3 monitoring, the planted acreage performance categories were functioning at 99 percent with no bare areas and only one low stem density area to report. The average density of total planted stems, based on data collected from the six monitoring plots following Year 3 monitoring, is 472 stems per acre. It was observed during Year 3 vegetation monitoring that only plot 3 has not met the minimum interim success criteria of 320 trees per acre by the end of Year 3. However, all plots currently exceed the required seven-year stem density of 210 stems per acre.

Invasive species areas of concern were observed, documented and treated accordingly during Year 3. Following Year 3 monitoring, four areas (Areas 1, 2, 3, 4) of Chinese privet, totaling approximately 1.48 acres or 9.7

percent of the total planted area within UT1c (15.2 acres) were found to contain the invasive species. To control areas of invasive species, these areas were treated in October and November 2016 by mechanical removal and the use of the herbicide Glyphosate.

During Year 3 monitoring, groundwater monitoring demonstrated that five of the sixteen groundwater monitoring wells located along Reach UT1c met the wetland success criteria as stated in the Site Mitigation Plan. The gauges that met success criteria (MSAW1, MSAW4, MSAW5, MSAW8 and MSAW24) demonstrated consecutive hydroperiods of 12 percent or greater, which ranged from 24.6 to 31.2 percent of the growing season. The gauges that did not meet success criteria (See Table 12) demonstrated consecutive hydroperiods of 12 percent or less which ranged from 0.6 percent to 8.7 percent of the growing season. It is noted that MSAW7 and MSAW3 are not meeting success but are outside of the wetland restoration and hydric soils boundary. Baker will continue to monitor the hydrology into Year 4. It should also be noted that the wells meeting success criteria are located in the restored wetland area south of UT1c. The total restored wetland area south of UT1c equals 3.26 acres. The wetland area north of UT1c is 3.36 acres. The total wetland restoration acreage equals 6.62 acres. The total wetland acreage has been incorrectly reported in past monitoring reports as 4.0 acres of wetland restoration. Baker and DMS are contracted at 4.0 WMUs but the project wetland acreage is in excess of the contracted amount.

For the first three years of the project, it was observed that groundwater levels on the northern portion of UT1c were not performing as designed for many of the wetland monitoring wells. Therefore, it was determined that an additional six monitoring wells be installed in spring of 2016. Five wetland wells were installed in February 2016 (MSAW19, MSAW20, MSAW21, MSAW22, MSAW23) and one in March 2016 (MSAW24). Data from the additional five monitoring wells is located Appendix E.

During Year 2 monitoring, it was determined that monitoring wells (MSAW2, MSAW3, MSAW6, MSAW7, MSAW9 and MSAW10) were potentially providing erroneous data. The cause of the data errors was estimated to be two-fold. The first cause was estimated to be a hardware issue. During field investigations, it was determined that the water pressure sensor of some the pressure transducers had become clogged with bentonite. The transducers have since been unclogged and elevated within the well casing to reduce the likelihood of clogging, and the holes pumped out to remove remaining bentonite particles existing within the well casing. In addition, all pressure transducers are cleaned during each logger download. The second cause is estimated to be due to the installation of the wells during less than ideal conditions. Auguring well holes during in the wet conditions of the site potentially smeared the soil of the well hole wall which could decrease soil permeability.

Due to the aforementioned issues, six additional wells were installed in February 2016 along the left floodplain of UT1c. During subsequent well data collection, the automatic wells will be calibrated by measuring the ground water level before the data logger is removed from the well casing. This manual measurement will ensure accurate and real-time data provided by the well data logger.

Year 3 flow monitoring demonstrated that both flow gauges (MSFL1 and MSFL2) met the stated success criteria of 30 days or more of consecutive flow through reaches UT1a and UT1b. Both gauges demonstrated consecutive days of flow that ranged from 59.0 days (MSFL1, UT1a) to 105.0 days (MSFL2, UT1b). These gauges demonstrated similar patterns relative to rainfall events observed in the vicinity of the Site.

The Year 3 monitoring survey data of eight (8) cross-sections indicates that the Site is geomorphically stable and performing at 100 percent for the all parameters evaluated. The data collected are within the lateral/vertical stability and in-stream structure performance categories.

The Site was found to have had at least two post-construction above bankfull events based on the crest gauge readings during Year 3.

Summary information/data related to the Site and statistics related to performance of various project and monitoring elements can be found in the tables and figures in the report Appendices. Narrative background and supporting information formerly found in these reports can be found in the Baseline Monitoring Report and in the Mitigation Plan available on the North Carolina Division of Mitigation Services (NCDMS) website. All raw data supporting the tables and figures in the appendices is available from NCDMS upon request.

2.0 METHODOLOGY

The seven-year monitoring plan for the Site includes criteria to evaluate the success of the stream, wetland and vegetation components of the project. The methodology and report template used to evaluate these components adheres to the NCDMS monitoring guidance document dated November 7, 2011, which will continue to serve as the template for subsequent monitoring years. The specific locations of monitoring features: vegetation plots, permanent cross-sections, monitoring wells, flow gauges, and the crest gauge, are shown on the CCPV sheets found in Appendix B.

The Year 3 monitoring data were collected in October, November and December 2016. All visual site assessment data located in Appendix B were also collected in October and November 2016.

2.1 Stream Assessment – Reach UT1a & UT1b

The UT1a and UT1b mitigation approach involved the restoration of historic flow patterns and flooding functions in a multi-thread headwater stream system. Monitoring efforts focus on visual observations to document stability and the use of water level monitoring gauges to document groundwater and flooding functions.

2.1.1 Hydrology

Two automated groundwater gauges (pressure transducers) are installed along well transects, with a total of four well transects installed in the UT1a and UT1b areas. The automated loggers are programmed to collect data at 6-hour intervals to record groundwater levels in UT1a and UT1b areas. Groundwater data collected during Year 3 monitoring are located in Appendix E.

Additionally, two flow gauges (pressure transducers) were installed to document the occurrence of extended periods of shallow surface ponding, indicative of flow. The gauges attempt to document flooding connectivity between the restored UT1a and UT1b reaches for at least 30 consecutive days under normal climatic conditions. Flow data collected during Year 3 monitoring are located in Appendix E.

2.1.2 Photographic Documentation

The headwater stream reaches were photographed longitudinally beginning at the downstream portion of the Site and moving towards the upstream end of the Site. Photographs were taken looking upstream at delineated locations throughout the restored stream valley. The photograph points were established close enough together to provide an overall view of the reach lengths and valley crenulations. The angle of the photo depends on what angle provides the best view and was noted and continued in future photos. Selected UT1a and UT1b site photographs are located in Appendix B.

2.2 Stream Assessment – Reach UT1c

The UT1c mitigation approach involved the restoration of historic flow patterns and flooding functions in a single-thread headwater stream system. Monitoring efforts focus on visual observations, the use of groundwater level monitoring gauges, a crest gauge to document bankfull flooding events and established stream cross-sections to monitor channel stability.

Stream survey data was collected to a minimum of Class C Vertical and Class A Horizontal Accuracy using Leica TS06 Total Station and was georeferenced to the NAD83 State Plane Coordinate System, FIPS3200 in US Survey Feet, which was derived from the As-built Survey. This survey system collects point data with an accuracy of less than one tenth of a foot.

2.2.1 Morphologic Parameters and Channel Stability

Cross-sections were classified using the Rosgen Stream Classification System, and all monitored cross-sections fall within the quantitative parameters (i.e. BHR no more than 1.2 and ER no less than 2.2) defined for channels of the design stream type. Morphological survey data is presented in Appendix D.

A longitudinal profile was surveyed for the entire length of channel immediately after construction to document as-built baseline conditions for the first year of monitoring only. The survey was tied to a permanent benchmark and measurements included thalweg, water surface, bankfull, and top of low bank. Each of these measurements was taken at the head of each feature (e.g., riffle, pool) and at the maximum pool depth. Yearly longitudinal profiles will not be conducted during subsequent monitoring years unless channel instability has been documented or remedial actions/repairs are required by the USACE or DMS.

2.2.2 Hydrology

Following as-built conditions, ten automated groundwater-monitoring stations were installed in the UT1c wetland restoration area and follow USACE protocols (USACE 1997). Groundwater data collected during Year 3 monitoring are located in Appendix E.

For the first three years of the project, it was observed that groundwater levels on the northern portion of UT1c were not performing as designed for many of the wetland monitoring wells. Therefore, it was determined that an additional six monitoring wells be installed in spring of 2016. Five wetland wells were installed in February 2016 (MSAW19, MSAW20, MSAW21, MSAW22, MSAW23) and one in March 2016 (MSAW24). Data from the supplemental six monitoring wells is located Appendix E.

Total observed rainfall at the Albert Ellis airport (KOAJ) weather station located near Richlands, NC for the period of January through November 2016 was 54.77 inches. The WETS table for Hoffman Forest station (NC4144), Onslow County was used to calculate the 30-year average for the same period (January through November) and is 52.84 inches. According to the Albert Ellis gauge, total rainfall during the Year 3 monitoring period from January through October 2016 was 1.93 inches above the historic approximated average as compared to the Hoffman Forest station for Onslow County.

Although, total rainfall for 2016 was recorded at 1.93 inches above normal through November, it was a relatively dry year until two significant storm events moved across the area in the fall of 2016. The storms occurred on September 2nd and October 8th when Hurricane Matthew moved across Onslow County. As measured by the KOAJ rain gauge at the Albert Ellis airport, total rainfall for the September 2nd event was 6.65 inches and the Hurricane Matthew event was 6.92 inches. Combined, the two fall storms comprised 25.7% of the rain that fell in Onslow County from January to November 2016.

One crest gauge was installed on the floodplain at the bankfull elevation along the left top of bank on UT1c approximately at Station 45+50. The highest bankfull reading recorded in Year 3 was measured to be 2.32 feet and was estimated to have occurred on October 8, 2016. Crest gauge readings are presented in Appendix E.

2.2.3 Photographic Documentation

Reference photograph transects were taken at each permanent cross-section. The survey tape was centered in the photographs of the bank. The water line was located in the lower edge of the frame, and as much of the bank as possible is included in each photograph. Photographs were also taken of grade control structures along the restored stream, and limited to log weirs or log jams. Selected UT1c site photographs from Year 3 monitoring are shown in Appendix B.

2.2.4 Visual Stream Morphological Stability Assessment

The visual stream morphological stability assessment involves the qualitative evaluation of lateral and vertical channel stability, and the integrity and overall performance of in-stream structures throughout the Project reach as a whole. Habitat parameters, and pool depth maintenance, are also measured and scored. During Year 3 monitoring, the entire project reach was walked, noting geomorphic conditions of the stream bed profile (riffle/pool facets); both stream banks, and engineered in-stream structures. Photos were taken at every stream photograph reference station as discussed in the previous section, and in locations of potential SPAs, which were documented in the field for subsequent mapping on the CCPV figure if applicable. A more detailed summary of the methodology and results for the visual stream stability assessment can be found in Appendix B, which includes supporting data tables, and SPA photos if applicable.

2.3 Vegetation Assessment

In order to determine if success criteria are achieved, vegetation-monitoring quadrants were installed and are monitored annually across the Site in accordance with the CVS-NCEEP Protocol for Recording Vegetation, Version 4.1 (2007). The vegetation monitoring plots are a minimum of two percent of the planted portion of the Site, with six plots established randomly within the planted UT1a, UT1b and UT1c riparian buffer areas per Monitoring Levels 1 and 2. No monitoring quadrants were established within the undisturbed wooded areas of UT1a and UT1b. The sizes of individual quadrants are 100 square meters for woody tree species.

Additionally, the existing vegetation areas were visually monitored during the annual site visits to document any mortalities. Following Year 3 monitoring, it is reported that one vegetation plot (Plot 3) did not meet the Year 3 success criteria of 320 stems per acre. The monitoring data found that Plot 3 had 243 planted stems per acre. However, volunteer monitoring in Plot 3 had found six additional natural stems within the plot boundaries, making the actual stem density of Plot 3, 486 stems/acre. It is also noted, that the stem density of Plot 3 exceeds the required Year 7 density of 210 stems per acre as stated in the site's mitigation plan.

Invasive species areas of concern were observed and documented accordingly during Year 3. During, Year 3 monitoring, four areas (Areas 1, 2, 3, 4) totaling approximately 1.48 acres of the planted area were found to contain the invasive species, Chinese privet (*Lugustrum sinense*). The 1.48-acre area of privet was treated in October and November by mechanical removal and the use of the herbicide Glyphosate. These areas are scheduled to be treated again in 2017 during the appropriate treatment window.

At this time, no other areas of concern regarding the existing vegetation was observed along UT1a, UT1b or UT1c. Year 3 vegetation assessment information is provided in Appendix B and C.

3.0 REFERENCES

Carolina Vegetation Survey (CVS) and NC Division of Mitigation Services (NCDMS). 2007. CVS-NCDMS Data Entry Tool v. 2.3.1. University of North Carolina, Raleigh, NC.

Lee, M., Peet R., Roberts, S., Wentworth, T. 2007. CVS-NCDMS Protocol for Recording Vegetation, Version 4.1.

North Carolina Division of Mitigation Services. 2011. Monitoring Requirements and Performance Standards for Stream and/or Wetland Mitigation. November 7, 2011.

Rosgen, D. L. 1994. A Classification of Natural Rivers. Catena 22:169-199.

Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. North Carolina Natural Heritage Program. Division of Parks and Recreation, NCDENR. Raleigh, NC.

United States Army Corps of Engineers. 1997. Corps of Engineers Wetlands Research Program. Technical Note VN-rs-4.1. Environmental Laboratory. U.S. Army Engineer Waterways Experiment Station. Vicksburg, MS.

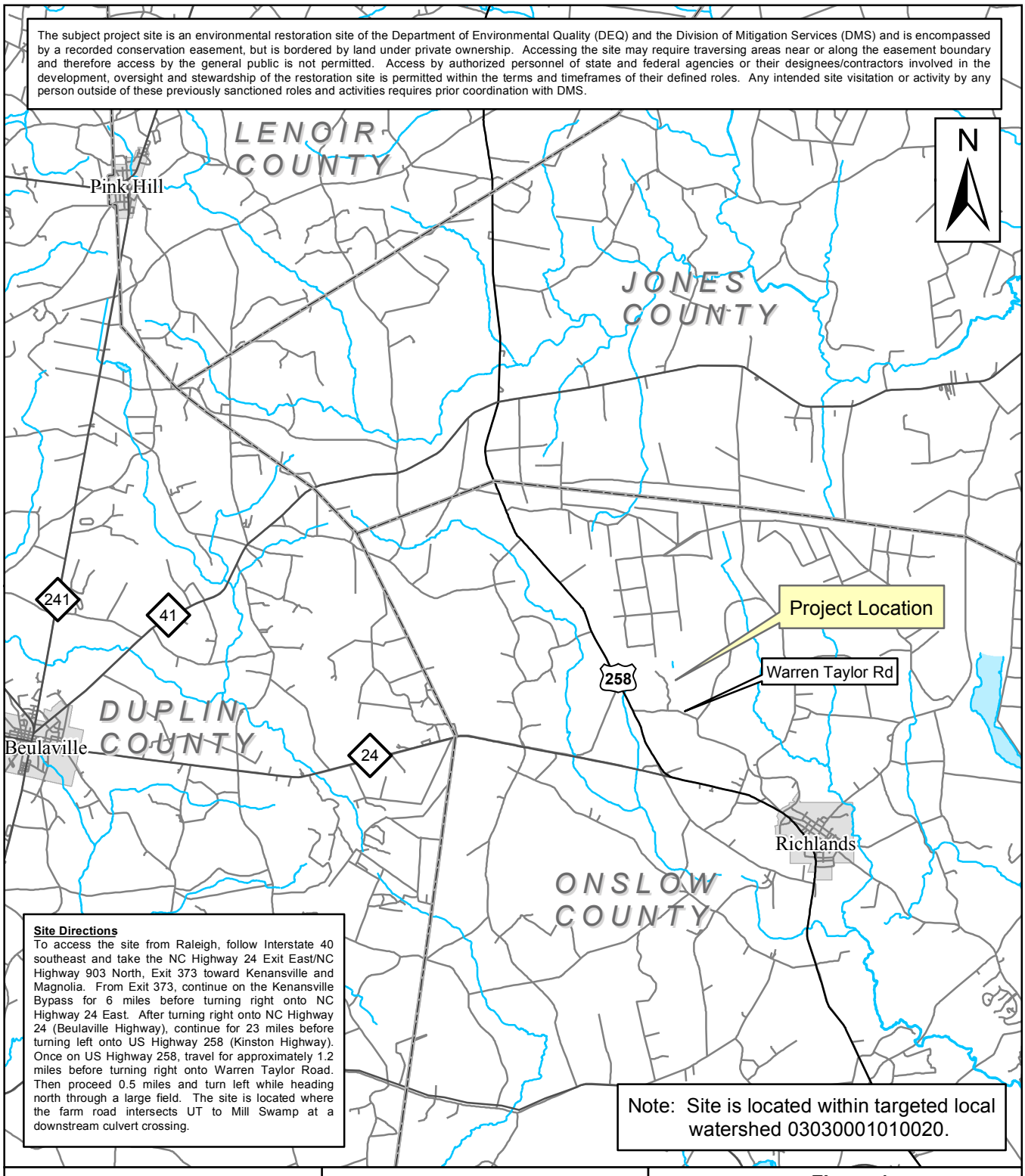
____. 2005. "Technical Standard for Water-Table Monitoring of Potential Wetland Sites," WRAP Technical Notes Collection (ERDC TN-WRAP-05-2), U.S. Army Engineer Research and Development Center. Vicksburg, MS.

____. 2003. Stream Mitigation Guidelines, April 2003, U.S. Army Corps of Engineers. Wilmington District.

Appendix A

Project Vicinity Map and Background Tables

The subject project site is an environmental restoration site of the Department of Environmental Quality (DEQ) and the Division of Mitigation Services (DMS) and is encompassed by a recorded conservation easement, but is bordered by land under private ownership. Accessing the site may require traversing areas near or along the easement boundary and therefore access by the general public is not permitted. Access by authorized personnel of state and federal agencies or their designees/contractors involved in the development, oversight and stewardship of the restoration site is permitted within the terms and timeframes of their defined roles. Any intended site visitation or activity by any person outside of these previously sanctioned roles and activities requires prior coordination with DMS.



Site Directions
To access the site from Raleigh, follow Interstate 40 southeast and take the NC Highway 24 Exit East/NC Highway 903 North, Exit 373 toward Kenansville and Magnolia. From Exit 373, continue on the Kenansville Bypass for 6 miles before turning right onto NC Highway 24 East. After turning right onto NC Highway 24 (Beulaville Highway), continue for 23 miles before turning left onto US Highway 258 (Kinston Highway). Once on US Highway 258, travel for approximately 1.2 miles before turning right onto Warren Taylor Road. Then proceed 0.5 miles and turn left while heading north through a large field. The site is located where the farm road intersects UT to Mill Swamp at a downstream culvert crossing.

Note: Site is located within targeted local watershed 03030001010020.

DMS Project # 95019

Onslow County

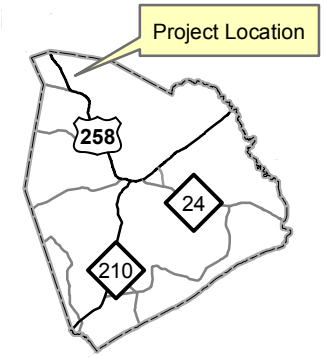


Figure 1
Project Vicinity Map
UT to Mill Swamp Site

DEQ -
Division of Mitigation Services

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0 0.5 1 2 3
Miles

Table 1. Project Components and Mitigation Credits
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Mitigation Credits

	Stream	Riparian Wetland		Non-riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorus Nutrient Offset
Type	R, E1	R	E					
Totals	4,006 SMU	6.62 WMU	0					

Project Components

Project Component or Reach ID	Stationing/ Location	Existing Footage/ Acreage	Approach	Restoration/ Restoration Equivalent	Restoration Footage or Acreage	Mitigation Ratio
Reach UT1a	10+00 – 16+00	600 LF	Enhancement Level I	400 SMU	600 LF	1.5:1
Reach UT1b	16+00 – 36+93	2,131 LF	Headwater Restoration	2,093 SMU	2,093 LF	1:1
Reach UT1c	37+24 – 52+37	1,350 LF	Single thread Restoration	1,513 SMU	1,513 LF	1:1
Reach UT3	10+00 – 23+69	1,060 LF	Cattle Exclusion	N/A	N/A	N/A
Wetland Area #1	See plan sheets	0.0 AC	Restoration	6.62 WMU	6.62 AC	1:1

Component Summation

Restoration Level	Stream (LF)	Riparian Wetland (AC)		Non-riparian Wetland (AC)	Buffer (SF)	Upland (AC)
		Riverine	Non-Riverine			
Restoration	3,606	4.0				
Enhancement I	600					
Enhancement II						
Creation						
Preservation						
High Quality Preservation						

BMP Elements

Element	Location	Purpose/Function	Notes

BMP Elements: BR= Bioretention Cell; SF= Sand Filter; SW= Stormwater Wetland; WDP= Wet Detention Pond; DDP= Dry Detention Pond; FS= Filter Strip; S= Grassed Swale; LS= Level Spreader; NI=Natural Infiltration Area

Table 2. Project Activity and Reporting History
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Activity or Report	Scheduled Completion	Data Collection Complete	Actual Completion or Delivery
Mitigation Plan Prepared	N/A	N/A	Aug-13
Mitigation Plan Amended	N/A	N/A	Sep-13
Mitigation Plan Approved	N/A	N/A	Nov-13
Final Design – (at least 90% complete)	N/A	N/A	Mar-13
Construction Begins	N/A	N/A	Apr-13
Temporary S&E mix applied to entire project area	N/A	N/A	N/A
Permanent seed mix applied to entire project area	N/A	N/A	Jun-13
Planting of live stakes	Fall/Winter 2013	N/A	Mar-14
Planting of bare root trees	N/A	N/A	Jun-13
End of Construction	N/A	N/A	May-13
Survey of As-built conditions (Year 0 Monitoring-baseline)	N/A	Aug-13	Aug-13
Year 1 Monitoring	Dec-13	Dec-13	Jun-14
[1]Year 2* Monitoring	Dec-14	Dec-14	Jan-15
Year 2 Monitoring	Nov-15	Nov-15	Dec-15
Year 3 Monitoring	Dec-16	Nov-16	Dec-16
Year 4 Monitoring	Dec-17	Nov-17	N/A
Year 5 Monitoring	Dec-18	Nov-18	N/A
Year 6 Monitoring	Dec-19	Nov-19	N/A
Year 7 Monitoring	Dec-20	Nov-20	N/A

[1] As stated in the **Special Notes** section of the Excutive Summary: the US Army Corps of Engineers declined to release the credits generated from Year 2 (2014) citing too short of a period between plant installation and monitoring following construction. As such, this report (2016) will be considered Year 3. All references to Year 3 included in this report will indicate monitoring activities conducted during 2016. Data collected during 2014 that was previously considered monitoring Year 2 is labeled as Year 2*

Table 3. Project Contacts **UT to Mill Swamp Restoration Project: DMS Project ID No. 95019**	
Designer	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 600 Cary, NC 27518 Contact: Jake Byers, Tel. (828) 412-6101
Construction Contractor	
River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Phillip Todd, Tel. 919-582-3575
Planting Contractor	
River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Phillip Todd, Tel. 919-582-3575
Seeding Contractor	
River Works, Inc.	6105 Chapel Hill Road Raleigh, NC 27607 Contact: Phillip Todd, Tel. 919-582-3575
Seed Mix Sources Nursery Stock Suppliers	Green Resources, Tel. 336-855-6363 Mellow Marsh Farm, 919-742-1200 ArborGen, 843-528-3204 Superior Tree, 850-971-5159
Monitoring Performers	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 600 Cary, NC 27518 Contact:
Stream Monitoring Point of Contact	Dwayne Huneycutt, Tel. 919-481-5745
Vegetation Monitoring Point of Contact	Dwayne Huneycutt, Tel. 919-481-5745
Wetland Monitoring Point of Contact	Dwayne Huneycutt, Tel. 919-481-5745

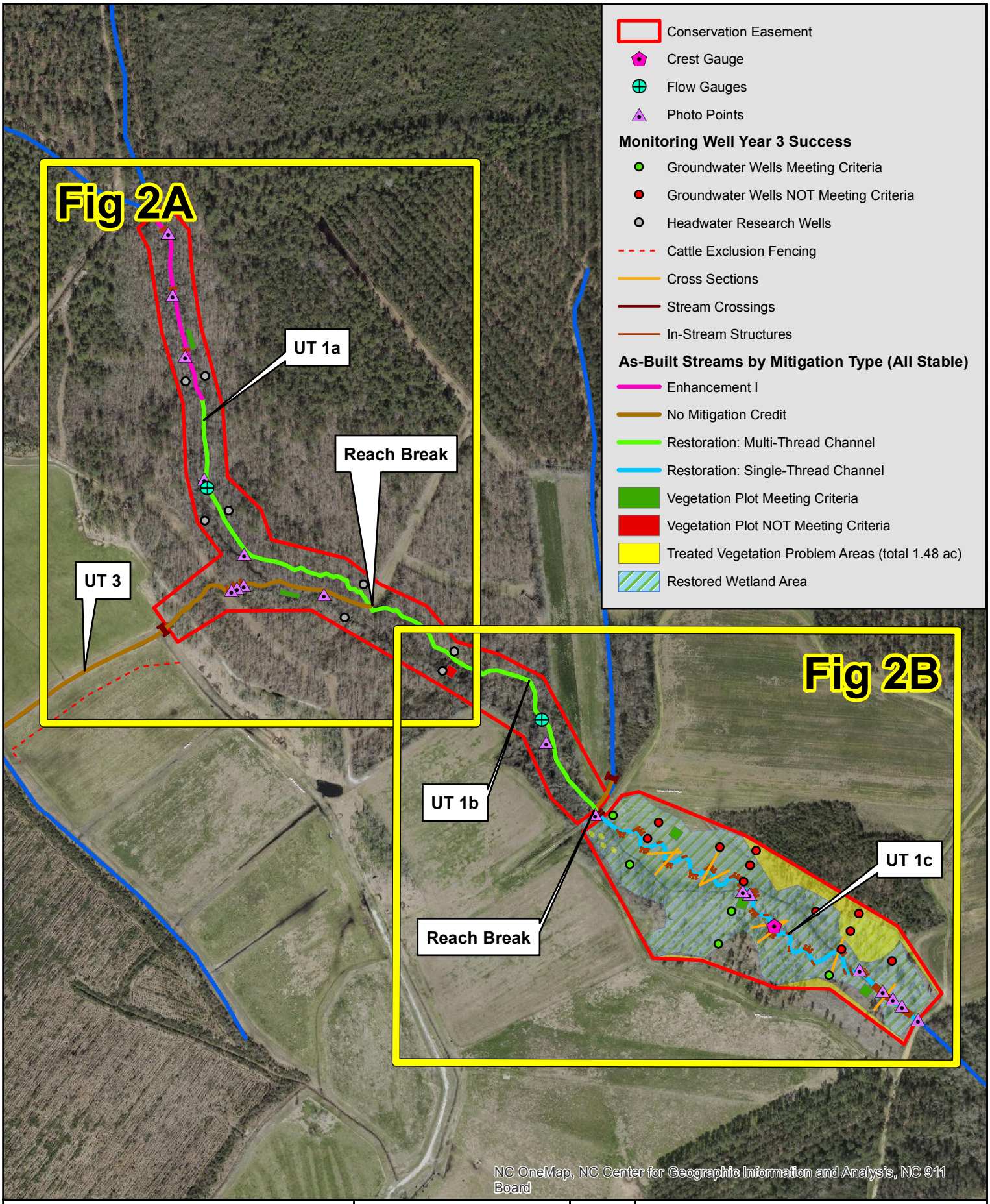
Table 4. Project Attributes
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Project Information			
Project Name	UT to Mill Swamp Restoration Project		
County	Onslow		
Project Area (acres)	19.6		
Project Coordinates (latitude and longitude)	34.9377 N, -77.5897 W		
Watershed Summary Information			
Physiographic Province	Inner Coastal Plain		
River Basin	White Oak		
USGS Hydrologic Unit 8-digit and 14-digit	03030001 / 03030001010020		
DWQ Sub-basin	03-05-02		
Project Drainage Area (AC)	421 (d/s main stem UT1)		
Project Drainage Area Percentage of Impervious Area	<1%		
CGIA Land Use Classification	2.01.03.99, Other Hay, Rotation, or Pasture; 413		
NCEEP Land Use Classification for UT to Mill Swamp Watershed (White Oak River Basin Restoration Priorities, 2010)	Forest (52%)		
	Agriculture (44%)		
	Impervious Cover (0.6%)		
Stream Reach Summary Information			
Parameters	**Reach UT1**	**Reach UT3**	
Length of Reach (LF)	4,091	1,060	
Valley Classification (Rosgen)	X	X	
Drainage Area (AC)	421	23	
NCDWQ Stream Identification Score	40.5	21	
NCDWQ Water Quality Classification	C; NSW	C; NSW	
Morphological Description (Rosgen stream type)	G/F (Channelized Headwater System)	Intermittent Ditch (N/A)	
Evolutionary Trend	Gc→F	Intermittent Ditch (N/A)	
Underlying Mapped Soils	Mk, St, Ly, FoA	Mk, St	
Drainage Class	Poorly drained, somewhat poorly drained	Poorly drained, somewhat poorly drained	
Soil Hydric Status	Hydric	Hydric	
Average Channel Slope (ft/ft)	0.0041	0.0058	
FEMA Classification	N/A	N/A	
Native Vegetation Community	Coastal Plain Small Stream Swamp	Coastal Plain Small Stream Swamp	
Percent Composition of Exotic/Invasive Vegetation	~10%	<5%	
Wetland Summary Information			
Parameters	**Wetland 1 (Non-Jurisdictional W1)**		
Size of Wetland (AC)	6.62 (3.36 north of UT1c, 3.26 south of UT1c)		
Wetland Type	Riparian Riverine		
Mapped Soil Series	Mk (Muckalee), St (Stallings), Ly (Lynchburg)		
Drainage Class	Poorly drained, somewhat poorly drained		
Soil Hydric Status	Hydric		
Source of Hydrology	Groundwater		
Hydrologic Impairment	Partially (disconnected floodplain from ditches and channel incision)		
Native Vegetation Community	Coastal Plain Small Stream Swamp, Successional		
Percent Composition of Exotic/Invasive Vegetation	9.7% (Before fall 2016 treatment event)		
Regulatory Considerations			
Regulation	**Applicable**	**Resolved**	**Supporting Documentation**
Waters of the United States – Section 404	Yes	Yes	See Mitigation Plan
Waters of the United States – Section 401	Yes	Yes	See Mitigation Plan
Endangered Species Act	No	N/A	See Mitigation Plan
Historic Preservation Act	No	N/A	See Mitigation Plan
Coastal Zone Management Act (CZMA)/ Coastal Area Management Act (CAMA)	No	N/A	See Mitigation Plan
FEMA Floodplain Compliance	No	N/A	See Mitigation Plan
Essential Fisheries Habitat	No	N/A	See Mitigation Plan

Source: White Oak River Basin Restoration Priorities, 2010 (http://www.http://portal.ncdenr.org/c/document_library/get_file?uuid=1c0b7e5a-9617-4a44-a5f8-df017873496b&groupId=60329)

Appendix B

Visual Assessment Data



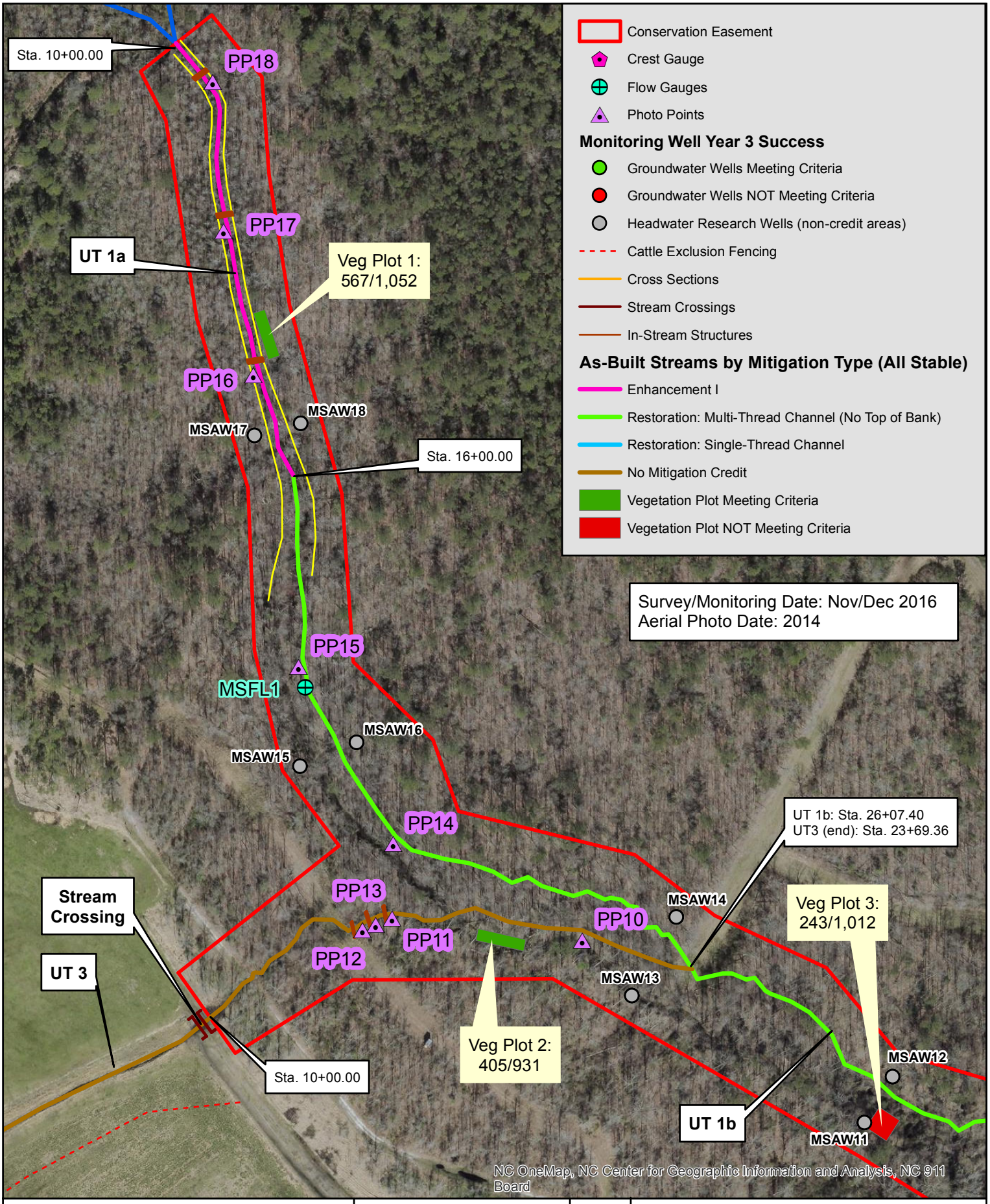
Michael Baker INTERNATIONAL

0 250 500 Feet

N

DMS Project # 95019

Figure 2 Index Map
Current Condition Plan View
Monitoring Year 3
UT to Mill Swamp Site



Michael Baker INTERNATIONAL

0 100 200 Feet

N

DMS Project # 95019

Figure 2A
Current Condition Plan View
Monitoring Year 3
UT to Mill Swamp Site

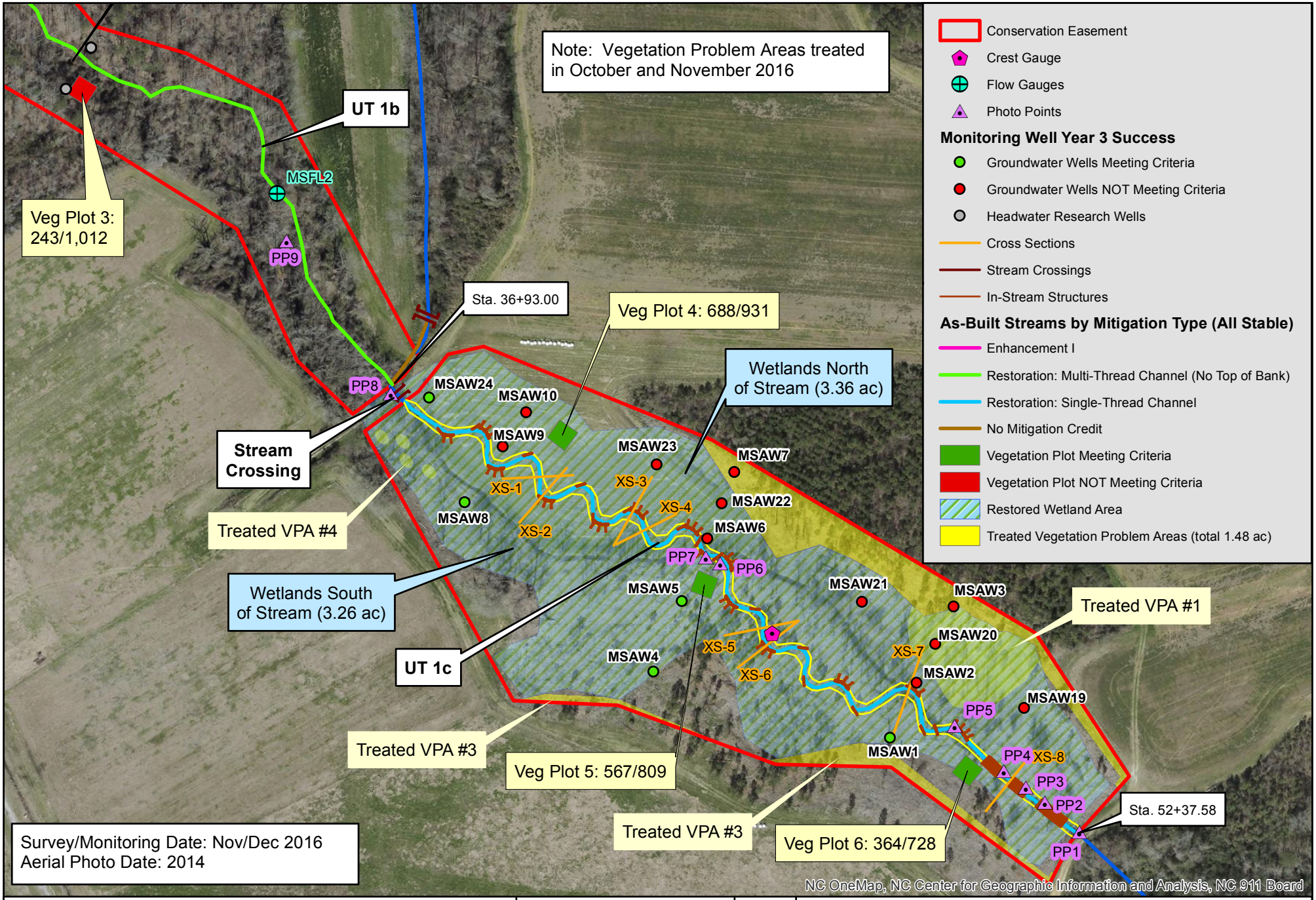

Note: Vegetation Problem Areas treated in October and November 2016
Conservation Easement
Crest Gauge
Flow Gauges
Photo Points
Monitoring Well Year 3 Success
Groundwater Wells Meeting Criteria
Groundwater Wells NOT Meeting Criteria
Headwater Research Wells
Cross Sections
Stream Crossings
In-Stream Structures
As-Built Streams by Mitigation Type (All Stable)
Enhancement I
Restoration: Multi-Thread Channel (No Top of Bank)
Restoration: Single-Thread Channel
No Mitigation Credit
Vegetation Plot Meeting Criteria
Vegetation Plot NOT Meeting Criteria
Restored Wetland Area
Treated Vegetation Problem Areas (total 1.48 ac)
UT 1b
MSFL2
Veg Plot 3: 243/1,012
PP9
Sta. 36+93.00
Veg Plot 4: 688/931
Wetlands North of Stream (3.36 ac)
PP8
MSAW24
MSAW10
MSAW9
MSAW23
MSAW7
XS-1
XS-3
XS-4
MSAW22
MSAW8
XS-2
MSAW6
PP7
PP6
Stream Crossing
Treated VPA #4
Wetlands South of Stream (3.26 ac)
MSAW5
MSAW21
MSAW3
Treated VPA #1
MSAW20
XS-5
XS-7
UT 1c
MSAW4
XS-6
MSAW2
MSAW19
PP5
Treated VPA #3
MSAW1
PP4
XS-8
PP3
PP2
Sta. 52+37.58
Veg Plot 5: 567/809
Treated VPA #3
Veg Plot 6: 364/728
PP1
Survey/Monitoring Date: Nov/Dec 2016
Aerial Photo Date: 2014
NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board
Michael Baker
INTERNATIONAL
0 100 200 Feet
N
DMS Project # 95019
Figure 2B
Current Condition Plan View
Monitoring Year 3
UT to Mill Swamp Site

Table 5a. Visual Steam Morphology Stability Assessment

UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach ID: UT1c

Assessed Length (LF): 1,513

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number per As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Veg.	Footage with Stabilizing Woody Veg.	Adjusted % for Stabilizing Woody Veg.
1. Bed	1.Vertical Stability	1. Aggradation			0	0	100%			
		2. Degradation			0	0%	100%			
	2. Riffle Condition	1. Texture Substrate	3	3			100%			
	3. Meander Pool Condition	1. Depth	22	22			100%			
		2. Length	22	22			100%			
	4. Thalweg Position	1. Thalweg centering at upstream of meander bend (Run)	19	19			100%			
		2. Thalweg centering at downstream of meander bend (Glide)	19	19			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	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely			0	0	100%	0	0	100%
	3. Mass Wasting	Banks slumping, caving or collapse			0	0	100%	0	0	100%
		Totals			0	0	100%	0	0	100%
3. Engineering Structures	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs	8	8			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	8	8			100%			
	2a. Piping	Structures lacking any substantial flow underneath sill or arms	8	8			100%			
	3. Bank Position	Bank erosion within the structures extent of influence does not exceed 15%	8	8			100%			
	4. Habitat	Pool forming structures maintaining - Max Pool Depth	8	8			100%			

Table 5b. Stream Problem Areas (SPAs) UT to Mill Swamp Restoration Project: DMS Project ID No. 95019			
Feature Issue	**Station Number**	**Suspected Cause**	**Photo Number**
None Observed	N/A	N/A	N/A

Table 6a. Vegetation Conditions Assessment

UT to Mill Swamp Restoration Project: EEP Project ID No. 95019

Reach ID: UT1a, UT1b, UT1c

Planted Acreage: UT1a, UT1b, UT1c = 15.2

Vegetation Category	Defintions	Mapping Threshold (acres)	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage [1]
1. Bare Areas	Very limited cover both woody and herbaceous material.	0.1	NA	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4 or 5 stem count criteria.	0.1	**VP3**	**1**	**0.025**	**0.16%**
			Total	**0**	**0.00**	**0.0%**
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems or a size class that are obviously small given the monitoring year.	0.25	NA	0	0.00	0.0%
			Cumulative Total	**0**	**0.00**	**0.0%**

Easement Acreage:

Vegetation Category	Defintions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
5. Invasive Areas of Concern **(Treated as 11/22/2016)**	Areas of points (if too small to render as polygons at map scale)	1000 ft²	**Yes**	**5**	**1.48**	**9.7%** prior to treatment (will be assessed in 2017 for new limits)
6. Easement Encroachment Areas	Areas of points (if too small to render as polygons at map scale)	none	NA	0	0.00	0.0%

Table 6b. Vegetation Problem Areas (VPAs) **UT to Mill Swamp Restoration Project: DMS Project ID No. 95019**			
Feature Issue	**Problem Area Number (as shown on CCPV)**	**Suspected Cause**	**Photo Number**
Invasive/Exotic Populations	#1 (See CCPV)	*Ligustrum sinense* (Treated 11/22/2016)	3,4,5,6
Invasive/Exotic Populations	#2 (See CCPV)	*Ligustrum sinense* (Treated 11/22/2016)	1,2
Invasive/Exotic Populations	#3 (See CCPV)	*Ligustrum sinense* (Treated 10/14/2016)	None
Invasive/Exotic Populations	#4 (See CCPV)	*Ligustrum sinense* (Treated 10/14/2016)	None

Photo Point 1 – Downstream at Culvert

Photo Point 2 – Log Jam

Photo Point 3 – Log Jam

Photo Point 4 – Log Weir/Log Jam

Photo Point 5 – Log Weir

Photo Point 6 – Log Weir

Photo Point 7 – Log Weir

Photo Point 8 – UT1b Downstream

Photo Point 9 – UT1b at Flow Gauge #2

Photo Point 10 – UT3 above confluence

Photo Point 11 – UT3 Log Weir

Photo Point 12 – UT3 Log Weir

Photo Point 13 – UT3 Log Weir

Photo Point 14 – UT1b view upstream

Photo Point 15 – UT1b view upstream

Photo Point 16 – Log Weir

Photo Point 17 – Log Weir

Photo Point 18 – Log Weir, UT1a tie-in

Crest gauge reading, 1.44 feet – February 5, 2016 storm

Crest gauge reading, 2.32 feet – October 8, 2016 (Hurricane Matthew)

Flow Gauge Camera #1 – February 4, 2016 (Storm event)

Flow Gauge Camera #1 – May 5, 2016 (Small spring rain event)

Flow Gauge Camera #2 – February 5, 2016 (Following February 4 storm event)

Flow Gauge Camera #2 – October 9, 2016 (Following Hurricane Matthew storm event)

Vegetation Plot 1

Vegetation Plot 2

Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Vegetation Plot 6

Vegetation Problem Areas (Before and After Treatment)

Privet Area #2 11/15/2015

Privet Area #2 10/25/2016

Privet Area #1 11/15/2015

Privet Area #1 11/22/2016

Privet Area #1 11/15/2015

Privet Area #1 11/22/2016

Appendix C

Vegetation Plot Data

Table 7. Vegetation Plot Criteria Attainment (Planted Stems)
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Plot ID	Vegetation Survival Threshold Met?	YR3 Planted Density / As-built Planted Stem Density*	2016 Tract Mean
1	Y	567/1052	472
2	Y	405/931	
3	N	243/1012	
4	Y	688/931	
5	Y	567/809	
6	Y	364/728	

Note: *Planted /As-Built Planted Stem Count reflects the changes in stem density based on the density of planted stems at the time of the As-Built Survey. Planted Stem Count reflects the changes in planted stem density ONLY. See Table 9c and 9d for volunteer species totals.

Table 8. CVS Vegetation Plot Metadata
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Report Prepared By	Dwayne Huneycutt
Date Prepared	11/29/2016 12:01
database name	MichaelBaker_2016_Candiff_UTMillSwamp.mdb
database location	L:\Monitoring\Veg Plot Info\CVS Data Tool\Candiff_UT to Mill Swamp
computer name	CARYLDHUNEYCUTT
file size	59187200
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.
Proj, total stems	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.
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	95019
project Name	UT to Mill Swamp
Description	
River Basin	White Oak
length(ft)	5237
stream-to-edge width (ft)	50
area (sq m)	48648.4
Required Plots (calculated)	12
Sampled Plots	6

Table 9a. CVS Stem Count of Planted Stems by Plot and Species
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

	Comment	Species	Species Type	CommonName	Total Planted Stems	No. of Plots	Average No. of Stems	plot 95019-01-0001-year:3	plot 95019-01-0002-year:3	plot 95019-01-0003-year:3	plot 95019-01-0004-year:3	plot 95019-01-0005-year:3	plot 95019-01-0006-year:3	
		Carpinus caroliniana	Shrub Tree	American hornbeam	4	3	1.33				2	1	1	
		Itea virginica	Shrub	Virginia sweetspire	1	1	1	1						
		Liriodendron tulipifera	Tree	tuliptree	3	1	3	3						
		Nyssa biflora	Tree	swamp tupelo	7	5	1.4	1	1	1	3		1	
		Persea palustris	Tree	swamp bay	3	3	1	1				1	1	
		Quercus laurifolia	Tree	laurel oak	2	2	1					1	1	
		Quercus lyrata	Tree	overcup oak	9	5	1.8	3	1			2	1	
		Quercus michauxii	Tree	swamp chestnut oak	15	5	3	3	2	3	1	4		
		Quercus nigra	Tree	water oak	2	2	1	1	1		1			
		Quercus pagoda	Tree	cherrybark oak	14	6	2.33	1	4	1	5	4	2	
		Quercus phellos	Tree	willow oak	7	4	1.75		1	1	4	1		
		Ulmus americana	Tree	American elm	2	2	1				1		2	
TOT:	**0**	**12**	**12**	**12**	**69**	**12**		**14**	**10**	**6**	**17**	**14**	**9**	

Table 9b. Vegetation Planted Stem Count Densities
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Common Name	Species	Plots						Year 3 Totals	Yearly Average Planted stems/acre
		1	2	3	4	5	6		
American hornbeam	*Carpinus caroliniana*				2	1	1	4	
Virginia sweetspire	*Itea virginica*	1						1	
tuliptree	*Liriodendron tulipifera*	3						3	
swamp tupelo	*Nyssa biflora*	1	1	1	3		1	7	
swamp bay	*Persea palustris*	1				1	1	3	
laurel oak	*Quercus laurifolia*					1	1	2	
overcup oak	*Quercus lyrata*	3	1			2	1	7	
swamp chestnut oak	*Quercus michauxii*	3	2	3	1	4		13	
water oak	*Quercus nigra*	1	1		1			3	
cherrybark oak	*Quercus pagoda*	1	4	1	5	4	2	17	
willow oak	*Quercus phellos*		1	1	4	1		7	
American elm	*Ulmus americana*				1		2	3	
***Number of Planted Stems Per Plot**		14	10	6	17	14	9	70	
Stems/acre Year 3 (Fall 2016)		567	405	243	688	567	364		472
Stems/acre Year 2 (Fall 2015)		567	405	283	688	567	283		465
Stems/acre Year 2* (Fall 2014)		607	445	486	688	607	486		553
Stems/acre Supplemental Year 1 (Spring 2014)		648	486	486	769	648	607		607
Stems/acre Year 1 (Fall 2013)		648	567	567	769	688	648		648
Stems/acre Initial		1052	931	1012	931	809	728		911

Note: *Planted Stem Count reflects the changes in planted stem density ONLY. See Table 9c and 9d for volunteer species totals.

Table 9c. CVS Density Per Plot

UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Current Plot Data (MY3 2016)

Scientific Name	Common Name	Species Type	95019-01-0001			95019-01-0002			95019-01-0003			95019-01-0004			95019-01-0005			95019-01-0006		
			P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T
Betula nigra	river birch	Tree																		
Carpinus caroliniana	American hornbeam	Tree										2		2	1		1	1		1
Fraxinus pennsylvanica	green ash	Tree	1		1															
Itea virginica	Virginia sweetspire	Shrub																		
Liquidambar styraciflua	sweetgum	Tree		10	10					3	3									
Liriodendron tulipifera	tuliptree	Tree	3	3	3					3	3									
Nyssa biflora	swamp tupelo	Tree	1		1	1		1	1		1	3		3				1		1
Persea palustris	swamp bay	tree	1		1										1		1	1		1
Quercus laurifolia	laurel oak	Tree													1		1	1		1
Quercus lyrata	overcup oak	Tree	3		3	1		1							2		2	1		1
Quercus michauxii	swamp chestnut oak	Tree	3		3	2		2	3		3	1		1	4		4			
Quercus nigra	water oak	Tree	1		1	1		1				1		1						
Quercus pagoda	cherrybark oak	Tree	1		1	4		4	1		1	5		5	4		4	2		2
Quercus phellos	willow oak	Tree				1		1	1		1	4		4	1		1			
Ulmus americana	American elm	Tree										1		1				2		2
Unknown		Shrub or Tree																		
		Stem count	14	13	24	10	0	10	6	6	12	17	0	17	14	0	14	9	0	9
		size (ares)	1			1			1			1			1			1		
		size (ACRES)	0.02			0.02			0.02			0.02			0.02			0.02		
		Species count	8	2	9	6	0	6	4	2	6	7	0	7	7	0	7	7	0	7
		Stems per ACRE	567	526	971	405	0	405	243	243	486	688	0	688	567	0	567	364	0	364

Annual Means

Scientific Name	Common Name	Species Type	MY3 (2016)			MY2 (2015)			MY2* (2014)			MY1 (2013)		
			P	V	T	P	V	T	P	V	T	P	V	T
Betula nigra	river birch	Tree							1		1			
Carpinus caroliniana	American hornbeam	Tree	4		4	4		4	3		3	5		5
Fraxinus pennsylvanica	green ash	Tree	1		1									
Itea virginica	Virginia sweetspire	Shrub				1		1	2		2	2		2
Liquidambar styraciflua	sweetgum	Tree		13	13									
Liriodendron tulipifera	tuliptree	Tree	3	6	6	3		3	6		6	7		7
Nyssa biflora	swamp tupelo	Tree	7		7	7		7	9		9	12		12
Persea palustris	swamp bay	tree	3		3	3		3	2		2	6		6
Quercus laurifolia	laurel oak	Tree	2		2	2		2						
Quercus lyrata	overcup oak	Tree	7		7	9		9	9		9	9		9
Quercus michauxii	swamp chestnut oak	Tree	13		13	15		15	20		20	21		21
Quercus nigra	water oak	Tree	3		3	2		2	3		3	6		6
Quercus pagoda	cherrybark oak	Tree	17		17	14		14	14		14	12		12
Quercus phellos	willow oak	Tree	7		7	7		7	9		9	10		10
Ulmus americana	American elm	Tree	3		3	2		2	4		4	4		4
Unknown		Shrub or Tree										2		2
		Stem count	70	19	86	69	0	69	82	0	82	96	0	96
		size (ares)	6			6			6			6		
		size (ACRES)	0.15			0.15			0.15			0.15		
		Species count	12	2	13	12	0	12	12	0	12	12	0	12
		Stems per ACRE	472	128	580	465	0	465	553	0	553	647	0	647

Color for Density

Exceeds requirements by 10%

Fails to meet requirements by more than 10%

Color for Volunteers

P = Planted

V = Volunteers

T = Total

Table 9d. Vegetation Summary and Totals
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Year 3 (3-Nov-2016)

Vegetation Plot Summary Information

Plot #	Riparian Buffer Stems[1]	Stream/ Wetland Stems[2]	Live Stakes	Invasives	Volunteers[3]	Total[4]	Unknown Growth Form
1	n/a	14	0	0	13	**24**	0
2	n/a	10	0	0	0	**10**	0
3	n/a	6	0	0	6	**12**	0
4	n/a	17	0	0	0	**17**	0
5	n/a	14	0	0	0	**14**	0
6	n/a	9	0	0	0	**9**	0

Wetland/Stream Vegetation Totals

(per acre)

Plot #	Planted Stream/ Wetland Stems[2]	Volunteers[3]	Total[4]	YR3 Success Criteria of 260 stems/acre Met?
1	567	405	971	Yes
2	405	0	405	Yes
3	243	243	486	No
4	688	0	688	Yes
5	567	0	567	Yes
6	364	0	364	Yes
Project Avg	**472**	**108**	**580**	**Yes**

Riparian Buffer Vegetation Totals

(per acre)

Plot #	Riparian Buffer Stems[1]	Success Criteria Met?
1	n/a	
2	n/a	
3	n/a	
4	n/a	
5	n/a	
6	n/a	
Project Avg	**n/a**	

Stem Class	**characteristics**
[1]Buffer Stems	Native planted hardwood trees. Does NOT include shrubs. No pines. No vines.
[2]Stream/ Wetland Stems	Native planted woody stems. Includes shrubs, does NOT include live stakes. No vines
[3]Volunteers	Native woody stems. Not planted. No vines.
[4]Total	Planted + volunteer native woody stems. Includes live stakes. Excl. exotics. Excl. vines.

Colors for Density

Exceeds requirements by 10%

Fails to meet requirements by more than 10%

Appendix D

Stream Survey Data

Table 10. Baseline Stream Data Summary
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach UT1c (1,513 LF)

Parameter	USGS Gauge	Regional Curve Interval (Harman et al, 1999)*			Pre-Existing Condition[1]					
Dimension and Substrate - Riffle		LL	UL	Eq.	Min	Mean	Med	Max	SD	n
BF Width (ft)	-----	23.0	80.0	9.9	6.8	-----	-----	8.7	-----	2
Floodprone Width (ft)	-----	-----	-----	-----	8.2	-----	-----	11.8	-----	2
BF Mean Depth (ft)	-----	2.3	5.8	1.3	0.8	-----	-----	1.0	-----	2
BF Max Depth (ft)	-----	-----	-----	-----	1.1	-----	-----	1.4	-----	2
BF Cross-sectional Area (ft²)	-----	80.0	300.0	16.2	5.6	-----	-----	8.6	-----	2
Width/Depth Ratio	-----	-----	-----	-----	8	-----	-----	9	-----	2
Entrenchment Ratio	-----	-----	-----	-----	1.2	-----	-----	1.4	-----	2
Bank Height Ratio	-----	-----	-----	-----	4.2	-----	-----	2.8	-----	2
d50 (mm)	-----	-----	-----	-----	-----	0.25	-----	-----	-----	1[2]
Pattern										
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rc:Bankfull width (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Profile										
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Max Depth (ft)	-----	-----	-----	-----	1.1	-----	-----	1.16	-----	2
Pool Volume (ft³)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Substrate and Transport Parameters										
Ri% / Ru% / P% / G% / S%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
SC% / Sa% / G% / B% / Be%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----			0.10 / 0.15 / 0.25 / 1.2 / 2.7[2]			
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters										
Drainage Area (SM)	-----	-----	-----	-----	-----	-----	-----	0.66	-----	-----
Impervious cover estimate (%)	-----	-----	-----	-----		-----	-----	-----	-----	-----
Rosgen Classification	-----	-----	-----	-----	-----	Gc	-----	-----	-----	-----
BF Velocity (fps)	-----	-----	-----	-----	0.8	-----	-----	1.2	-----	2
BF Discharge (cfs)	-----	290.0	2000.0	66.0	-----	6.48	-----	-----	-----	-----
35	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel length (ft)[2]	-----	-----	-----	-----	-----	4091	-----	-----	-----	-----
Sinuosity	-----	-----	-----	-----	-----	1.13	-----	-----	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	-----	-----	-----	-----	0.0045	-----	-----	-----	2
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bankfull Floodplain Area (acres)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BEHI VL% / L% / M% / H% / VH% / E%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel Stability or Habitat Metric	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Biological or Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

* Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. Wildland Hydrology. AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.

[1] Existing conditions survey data is compiled for the entire UT1 Reach within the project limits.

[2] Bulk samples taken since pebble count procedure is not applicable for sand-bed streams.

[3] Values were chosen based on sand-bed reference reach data and past project evaluations.

[4] Composite reference reach information from Johannah Creek, Johnston County; Panther Branch, Brunswick County; Rocky Swamp, Halifax County; and Beaver Dam Branch, Jones County

Table 10. Baseline Stream Summary
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach UT1c (1,513 LF)

	Reference Reach(es) Data											
	Beaverdam Branch						NC Coastal Plain Composite Data[4]					
Dimension and Substrate - Riffle	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
BF Width (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Floodprone Width (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BF Mean Depth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BF Max Depth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BF Cross-sectional Area (ft²)	-----	24	-----	-----	-----	2	7.8	-----	-----	95.9	-----	-----
Width/Depth Ratio	11	-----	-----	17	-----	2	8	-----	-----	14	-----	-----
Entrenchment Ratio	10	-----	-----	11	-----	2	4	-----	-----	13	-----	-----
Bank Height Ratio	1.0	-----	-----	1.3	-----	2	1.0	-----	-----	1.3	-----	-----
d50 (mm)	-----	0.5	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pattern												
Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rc:Bankfull width (ft/ft)	1.8	-----	-----	2.4	-----	-----	1.5	-----	-----	3.0	-----	-----
Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Meander Width Ratio	-----	-----	-----	-----	-----	-----	2.0	-----	-----	6.3	-----	-----
Profile												
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Spacing (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Max Depth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Volume (ft^3)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Substrate and Transport Parameters												
Ri% / Ru% / P% / G% / S%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
SC% / Sa% / G% / B% / Be%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
d16 / d35 / d50 / d84 / d95			0.3 / 0.4 / 0.5 / 0.9 / 1.2				-----	-----	-----	-----	-----	-----
Reach Shear Stress (competency) lb/f²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m²	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters												
Drainage Area (SM)	-----	-----	-----	3.0	-----	-----	1.0	-----	-----	19.5	-----	-----
Impervious cover estimate (%)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rosgen Classification	-----	C5c	-----	-----	-----	-----	-----	E5/C5	-----	-----	-----	-----
BF Velocity (fps)	-----	1.5	-----	-----	-----	-----	1.0	-----	-----	1.4	-----	-----
BF Discharge (cfs)	-----	37	-----	-----	-----	-----	10	-----	-----	127	-----	-----
35	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel length $(ft)^2$	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Sinuosity	-----	1.66	-----	-----	-----	-----	1.22	-----	-----	1.77	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	0.0004	-----	-----	-----	-----	0.0004	-----	-----	0.0022	-----	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Bankfull Floodplain Area (acres)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BEHI VL% / L% / M% / H% / VH% / E%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel Stability or Habitat Metric	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Biological or Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

* Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. Wildland Hydrology. AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.
1 Existing conditions survey data is compiled for the entire UT1 Reach within the project limits.
2 Bulk samples taken since pebble count procedure is not applicable for sand-bed streams.
3 Values were chosen based on sand-bed reference reach data and past project evaluations.
4 Composite reference reach information from Johannah Creek, Johnston County; Panther Branch, Brunswick County; Rocky Swamp, Halifax County; and Beaver Dam Branch, Jones County

Table 10. Baseline Stream Summary
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach UT1c (1,513 LF)

	Design						As-built					
Dimension and Substrate - Riffle	Min	Mean	Med	Max	SD	n	Min	Mean	Med	Max	SD	n
BF Width (ft)	-----	10.3	-----	-----	-----	1	10.1	-----	-----	13.8	-----	4
Floodprone Width (ft)	-----	>100	-----	-----	-----	1	80.1	-----	-----	105.0	-----	4
BF Mean Depth (ft)	-----	0.7	-----	-----	-----	1	0.6	-----	-----	1.2	-----	4
BF Max Depth (ft)	-----	1.0	-----	-----	-----	1	1.1	-----	-----	2.0	-----	4
BF Cross-sectional Area (ft^2)	-----	7.6	-----	-----	-----	1	7.5	-----	-----	12.3	-----	4
Width/Depth Ratio	-----	14	-----	-----	-----	1	8.3	-----	-----	19.4	-----	4
Entrenchment Ratio	-----	>10	-----	-----	-----	1	7.9	-----	-----	9.4	-----	4
Bank Height Ratio	-----	1.0	-----	-----	-----	1	1.0	-----	-----	1.1	-----	4
d50 (mm)	-----	0.25	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pattern												
Channel Beltwidth (ft)	35	-----	-----	60	-----	-----[3]	38.0	79.0	-----	120.0	-----	-----
Radius of Curvature (ft)	20	-----	-----	30	-----	-----[3]	21.0	26.0	-----	31.0	-----	-----
Rc:Bankfull width (ft/ft)	2.0	-----	-----	3.0	-----	-----[3]	38.0	79.0	-----	120.0	-----	-----
Meander Wavelength (ft)	80	-----	-----	110	-----	-----[3]	72.0	104.0	-----	124.0	-----	-----
Meander Width Ratio	3.5	-----	-----	6.0	-----	-----[3]	3.5	6.0	-----	8.0	-----	-----
Profile												
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Riffle Slope (ft/ft)	0.004	-----	-----	0.010	-----	-----	0.0046	0.0043	-----	0.0039	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----						-----
Pool Spacing (ft)	30	-----	-----	80	-----	-----	41	-----	72	57	-----	-----
Pool Max Depth (ft)	-----	1.6	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Pool Volume (ft^3)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Substrate and Transport Parameters												
Ri% / Ru% / P% / G% / S%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
SC% / Sa% / G% / B% / Be%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
d16 / d35 / d50 / d84 / d95	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----
Reach Shear Stress (competency) lb/f^2	-----	0.149	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m^2	-----	4.181	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Additional Reach Parameters												
Drainage Area (SM)	-----	-----	-----	0.66	-----	-----	-----	-----	-----	0.66	-----	-----
Impervious cover estimate (%)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rosgen Classification	-----	C5	-----	-----	-----	-----	-----	C5	-----	-----	-----	-----
BF Velocity (fps)	-----	1.76	-----	-----	-----	-----	-----	3.0	-----	-----	-----	-----
BF Discharge (cfs)	-----	12.9	-----	-----	-----	-----	-----	340.0	-----	-----	-----	-----
35	-----	-----	-----	-----	-----	-----	-----	3523	-----	-----	-----	-----
Channel length $(ft)^2$	-----	1453	-----	-----	-----	-----	-----	4238	-----	-----	-----	-----
Sinuosity	-----	1.24	-----	-----	-----	-----	-----	1.20	-----	-----	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	0.0038	-----	-----	-----	-----	-----	0.0042	-----	-----	-----	-----
BF slope (ft/ft)	-----	-----	-----	-----	-----	-----	-----	0.0054	-----	-----	-----	-----
Bankfull Floodplain Area (acres)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
BEHI VL% / L% / M% / H% / VH% / E%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Channel Stability or Habitat Metric	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Biological or Other	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----

* Harman, W.A., G.D. Jennings, J.M. Patterson, D.R. Clinton, L.O. Slate, A.G. Jessup, J.R. Everhart, and R.E. Smith. 1999. Bankfull hydraulic geometry relationships for North Carolina streams. Wildland Hydrology. AWRA Symposium Proceedings. D.S. Olsen and J.P. Potyondy, eds. American Water Resources Association. June 30-July 2, 1999. Bozeman, MT.
1 Existing conditions survey data is compiled for the entire UT1 Reach within the project limits.
2 Bulk samples taken since pebble count procedure is not applicable for sand-bed streams.
3 Values were chosen based on sand-bed reference reach data and past project evaluations.
4 Composite reference reach information from Johannah Creek, Johnston County; Panther Branch, Brunswick County; Rocky Swamp, Halifax County; and Beaver Dam Branch, Jones County

Table 11. Cross-section Morphology Data

UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach UT1c (1,513 LF)

	Cross-section X-1 (Riffle)								Cross-section X-2 (Pool)								Cross-section X-3 (Pool)								Cross-section X-4 (Riffle)							
Dimension and substrate	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+
Based on fixed baseline bankfull elevation																																
BF Width (ft)	11.9	11.1	11.3	10.1	8.8				15.4	22.5	21.25	12.70	11.94				21.3	39.23	33.48	19.55	18.06				11.2	11.5	11.34	9.63	9.66			
BF Mean Depth (ft)	0.63	0.63	0.70	0.64	0.75				1.07	0.72	0.71	1.00	0.99				0.63	0.48	0.46	0.66	0.65				0.67	0.74	0.77	0.66	0.68			
Width/Depth Ratio	18.9	17.7	16.1	15.9	11.7				14.4	31.2	30.1	12.6	12.0				33.9	82.4	72.8	29.6	27.84				16.5	15.4	14.7	14.63	14.25			
BF Cross-sectional Area (ft²)	7.5	6.9	8.0	6.4	6.6				16.6	16.2	15	12.8	11.9				13.4	18.7	15.4	12.9	11.7				7.5	8.5	8.7	6.3	6.6			
BF Max Depth (ft)	1.35	1.28	1.63	1.63	1.72				2.40	2.17	2.12	1.75	1.75				1.53	1.77	1.76	1.60	1.78				1.11	1.25	1.47	1.50	1.61			
Width of Floodprone Area (ft)	104.5	104.4	104.5	104.5	104.5				107.9	107.9	107.94	107.94	107.95				117.0	116.7	116.68	116.66	116.68				104.5	104.5	104.46	104.43	104.48			
Entrenchment Ratio	8.8	9.4	9.2	10.3	11.9				7.0	4.8	5.1	8.5	9				5.5	3	3.5	6	6.5				9.4	9.1	9.2	10.8	10.8			
Bank Height Ratio	1.0	1.1	1.0	1.0	1.1				1.0	1.0	1.0	1.0	1.1				1.0	0.8	0.9	1	1				1.1	1.0	1	1.1	1.2			
Wetted Perimeter (ft)	13.2	12.3	12.7	11.4	10.3				17.6	23.9	22.7	14.7	13.9				22.5	40.2	34.4	20.9	19.4				12.5	12.9	12.9	11.0	11.0			
Hydraulic Radius (ft)	0.6	0.6	0.6	0.6	0.6				0.9	0.7	0.7	0.9	0.9				0.6	0.5	0.4	0.6	0.6				0.6	0.7	0.7	0.6	0.6			
Based on current/developing bankfull feature																																
BF Width (ft)																																
BF Mean Depth (ft)																																
Width/Depth Ratio																																
BF Cross-sectional Area (ft²)																																
BF Max Depth (ft)																																
Width of Floodprone Area (ft)																																
Entrenchment Ratio																																
Bank Height Ratio																																
Wetted Perimeter (ft)																																
Hydraulic Radius (ft)																																
d50 (mm)																																

	Cross-section X-5 (Riffle)								Cross-section X-6 (Pool)								Cross-section 7 (Pool)								Cross-section X-8 (Riffle)							
Dimension and substrate	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2*	MY2	MY3	MY4	MY5	MY+
Based on fixed baseline bankfull elevation																																
BF Width (ft)	13.8	14.6	13.4	11.5	11.2				15.1	31.0	22.9	13.3	13.9				15.5	16.6	16.3	15.8	15.6				10.1	10.7	12.2	9.6	10.2			
BF Mean Depth (ft)	0.71	0.74	0.71	0.66	0.72				0.75	0.39	0.49	0.73	0.80				1.07	1.11	1.09	1.08	1.17				1.22	1.27	1.34	1.42	1.64			
Width/Depth Ratio	19.4	19.8	19.0	17.3	15.5				20.1	78.8	46.4	18.4	17.5				14.5	14.9	15.0	14.7	13.4				8.3	8.4	9.1	6.8	6.2			
BF Cross-sectional Area (ft²)	9.9	10.8	9.5	7.6	8.0				11.3	12.2	11.3	9.7	11.1				16.7	18.4	17.7	17.0	18.2				12.3	13.6	16.3	13.7	16.7			
BF Max Depth (ft)	1.31	1.42	1.62	1.50	1.56				1.78	1.56	1.71	1.65	1.80				1.97	2.08	2.22	2.03	2.52				1.96	2.15	2.65	2.11	2.62			
Width of Floodprone Area (ft)	112.3	112.3	112.3	112.3	112.3				114.3	114.3	114.3	114.3	114.3				132.4	132.4	132.3	132.3	132.4				80.1	82.9	86.3	80.4	85.4			
Entrenchment Ratio	8.1	7.7	8.4	9.8	10.1				7.6	3.7	5.0	8.6	8.2				8.5	8.0	8.1	8.4	8.5				7.9	7.8	7.1	8.3	8.4			
Bank Height Ratio	1.0	1.0	1.1	1.1	1.2				1.0	1.0	1.0	1.0	1.0				1.0	1.0	1.0	1.0	1.0				1.1	1.0	1.0	1.0	1.2			
Wetted Perimeter (ft)	15.3	16.1	14.9	12.8	12.6				16.6	31.8	23.9	14.8	15.5				17.7	18.8	18.5	17.9	17.9				12.5	13.2	14.8	12.5	13.4			
Hydraulic Radius (ft)	0.6	0.7	0.6	0.6	0.6				0.7	0.4	0.5	0.7	0.7				0.9	1.0	1.0	0.9	1.0				1.0	1.0	1.1	1.1	1.2			
Based on current/developing bankfull feature																																
BF Width (ft)																																
BF Mean Depth (ft)																																
Width/Depth Ratio																																
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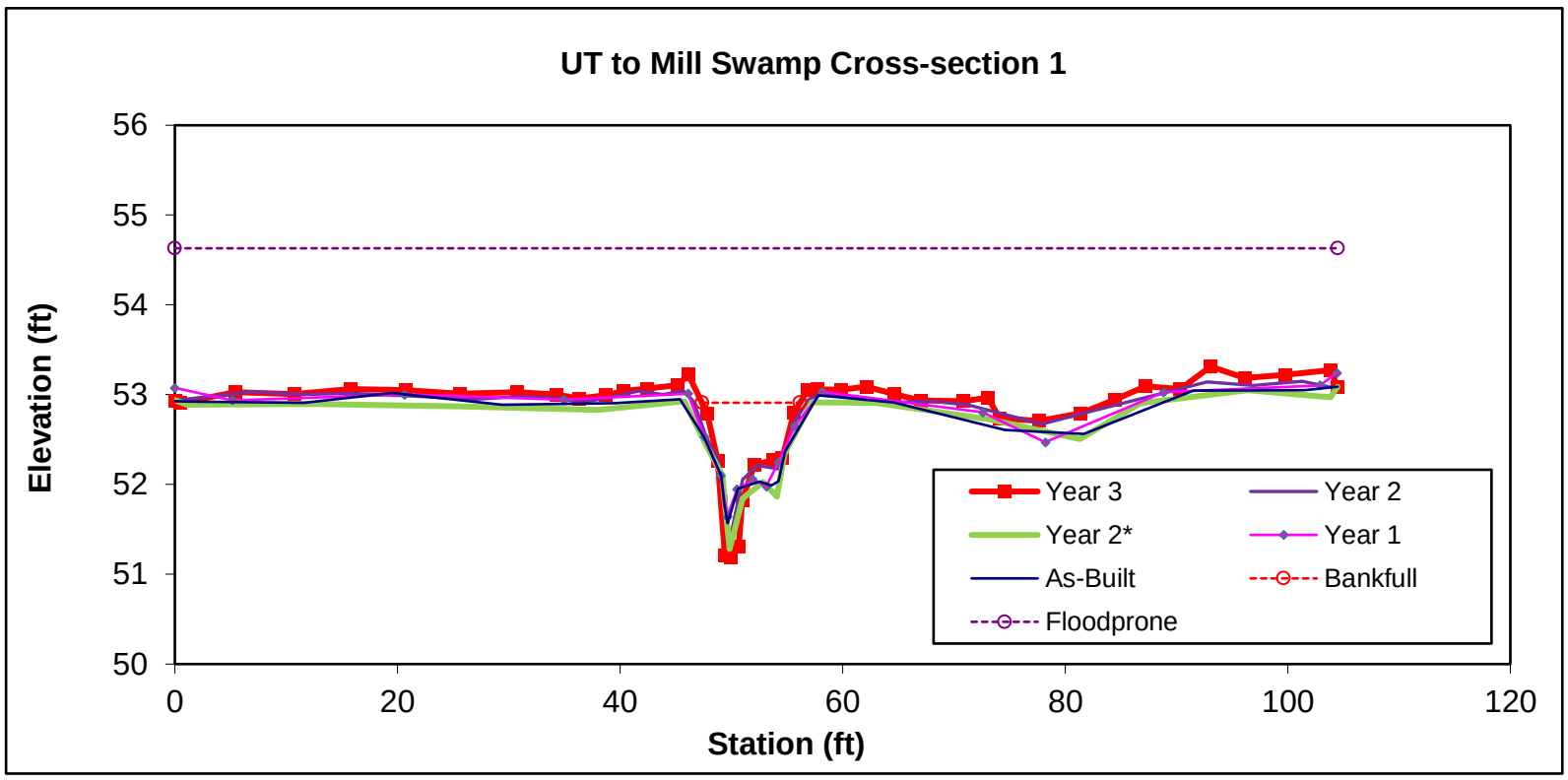
BF Max Depth (ft)																																
Width of Floodprone Area (ft)																																
Entrenchment Ratio																																
Bank Height Ratio																																
Wetted Perimeter (ft)																																
Hydraulic Radius (ft)																																
d50 (mm)																																

Permanent Cross-section 1

(Year 3 Data - Collected November 2016)

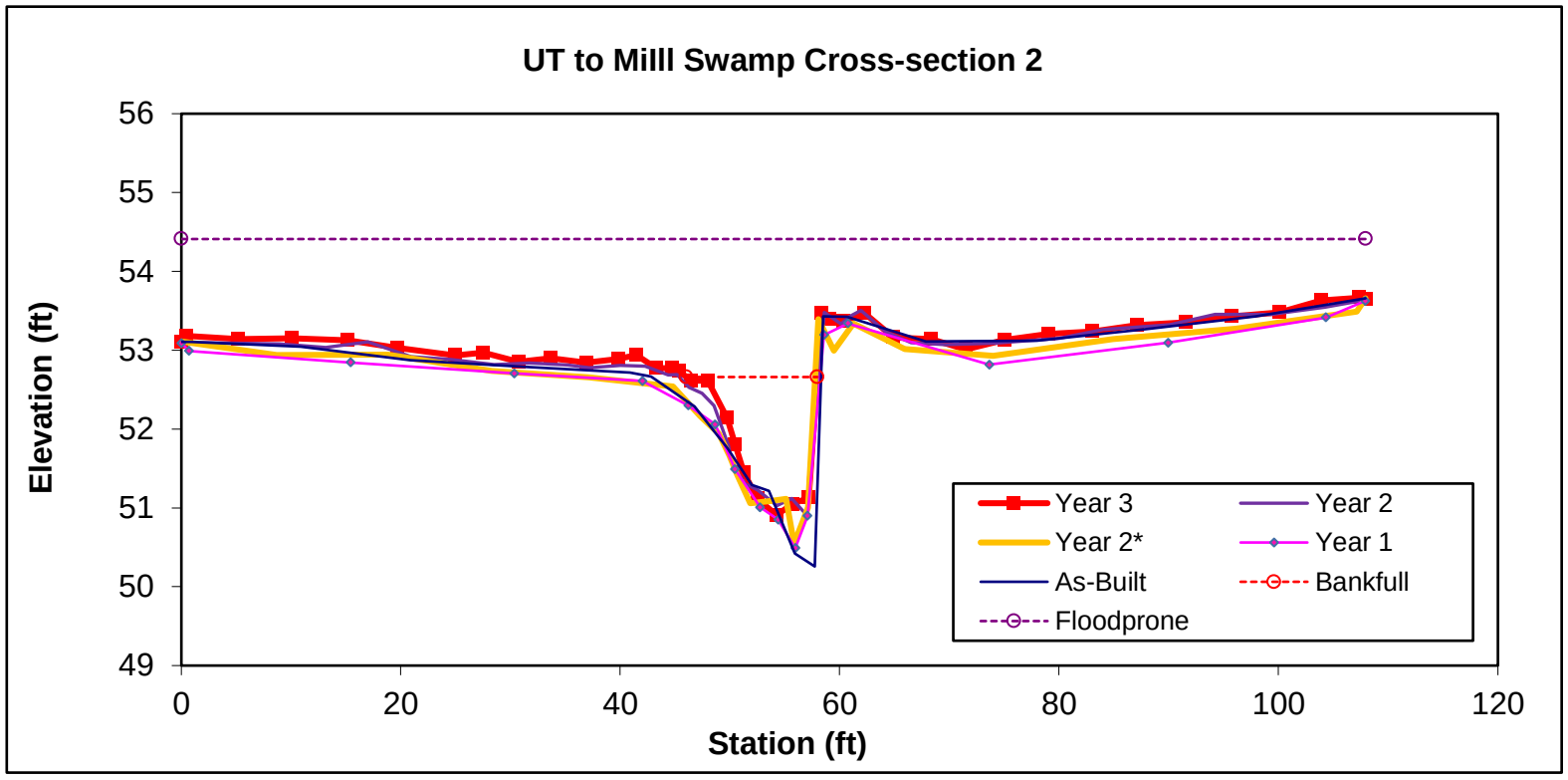
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	6.6	8.81	0.75	1.72	11.69	1.1	11.9	52.91	53.05



Permanent Cross-section 2

(Year 3 Data - Collected November 2016)

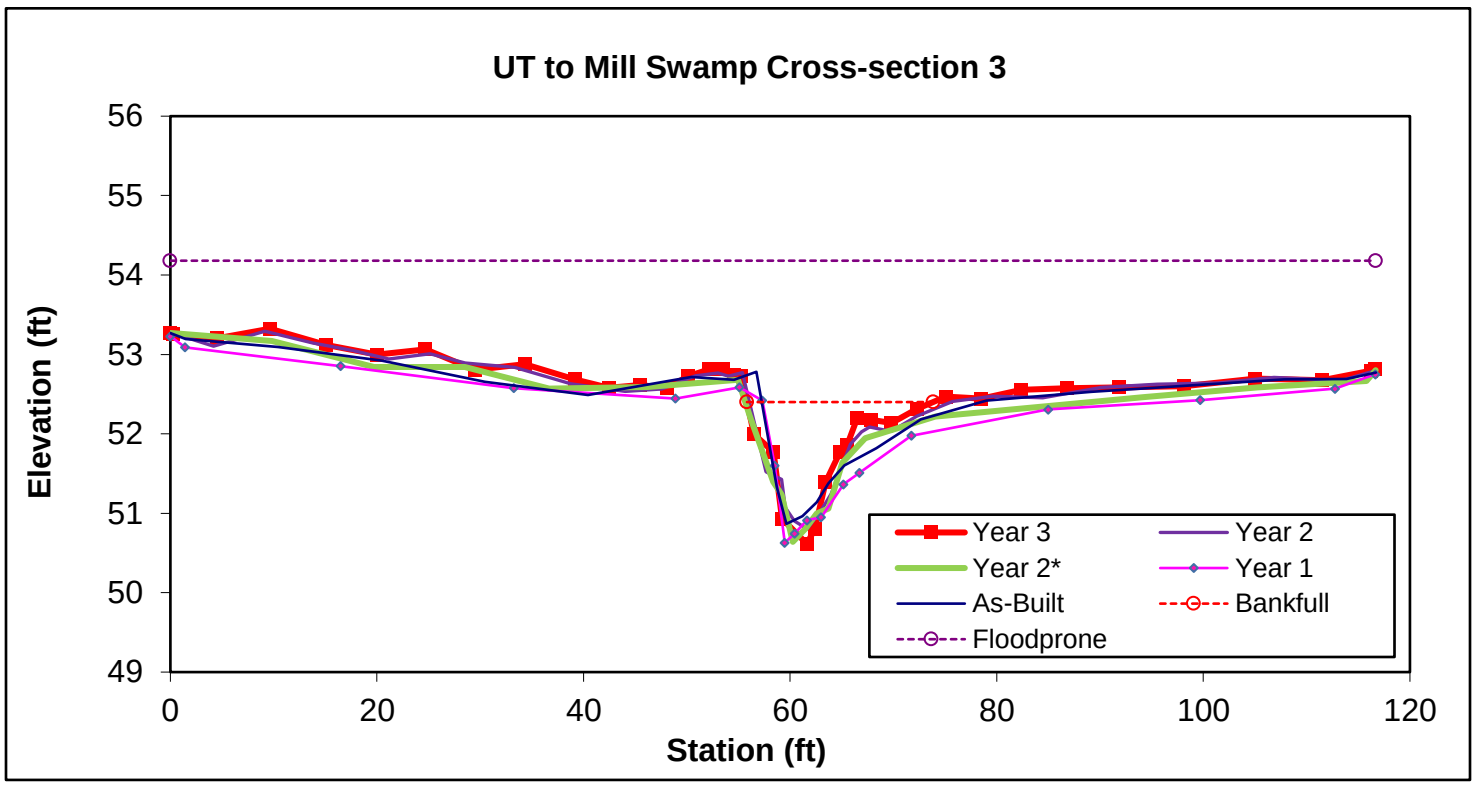
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		11.9	11.94	0.99	1.75	12.02	1.1	9	52.66	52.77



Permanent Cross-section 3

(Year 3 Data - Collected November 2016)

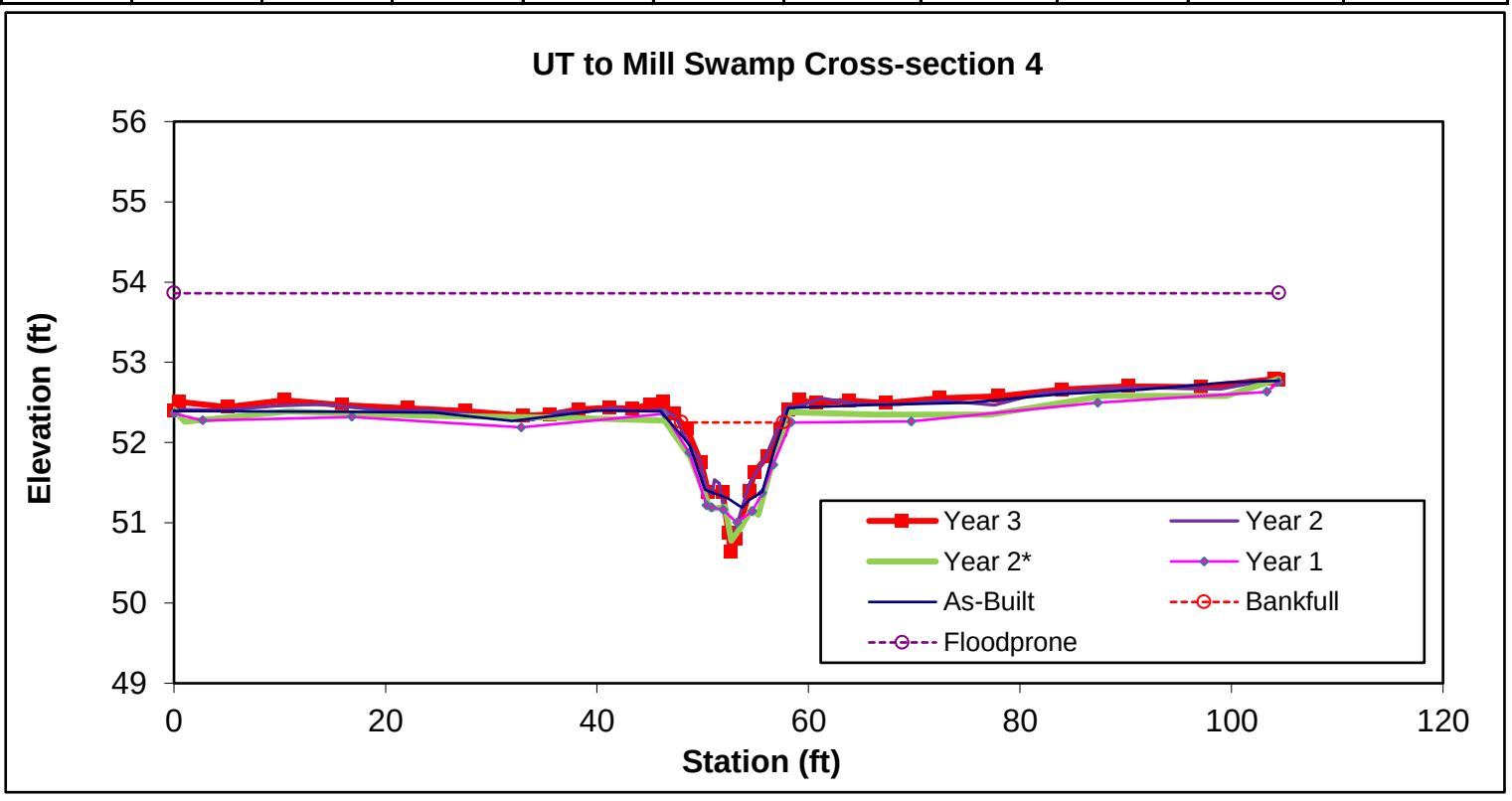
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		11.7	18.06	0.65	1.78	27.84	1	6.5	52.4	52.47



Permanent Cross-section 4

(Year 3 Data - Collected November 2016)

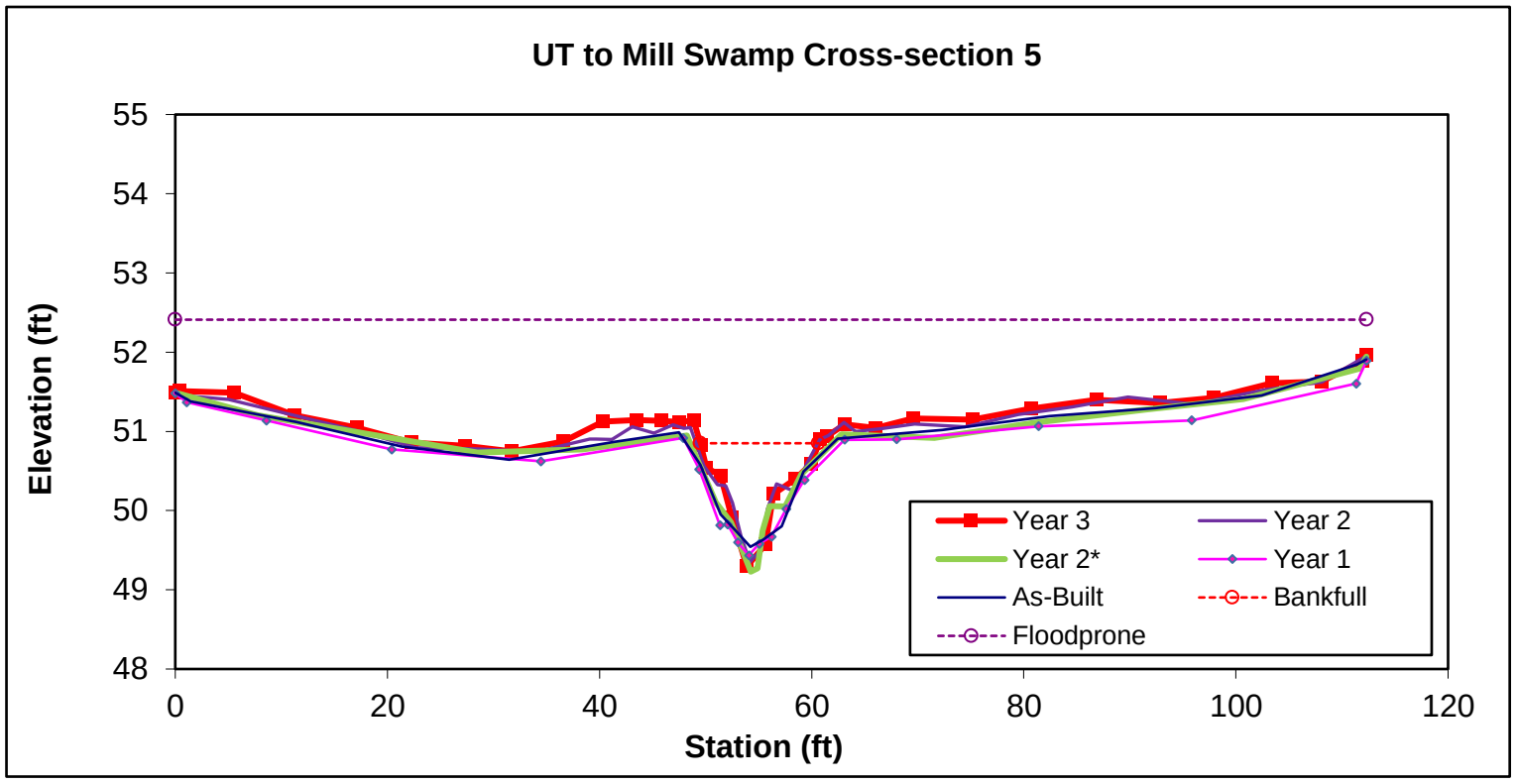
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	6.6	9.66	0.68	1.61	14.25	1.2	10.8	52.25	52.5



Permanent Cross-section 5

(Year 3 Data - Collected November 2016)

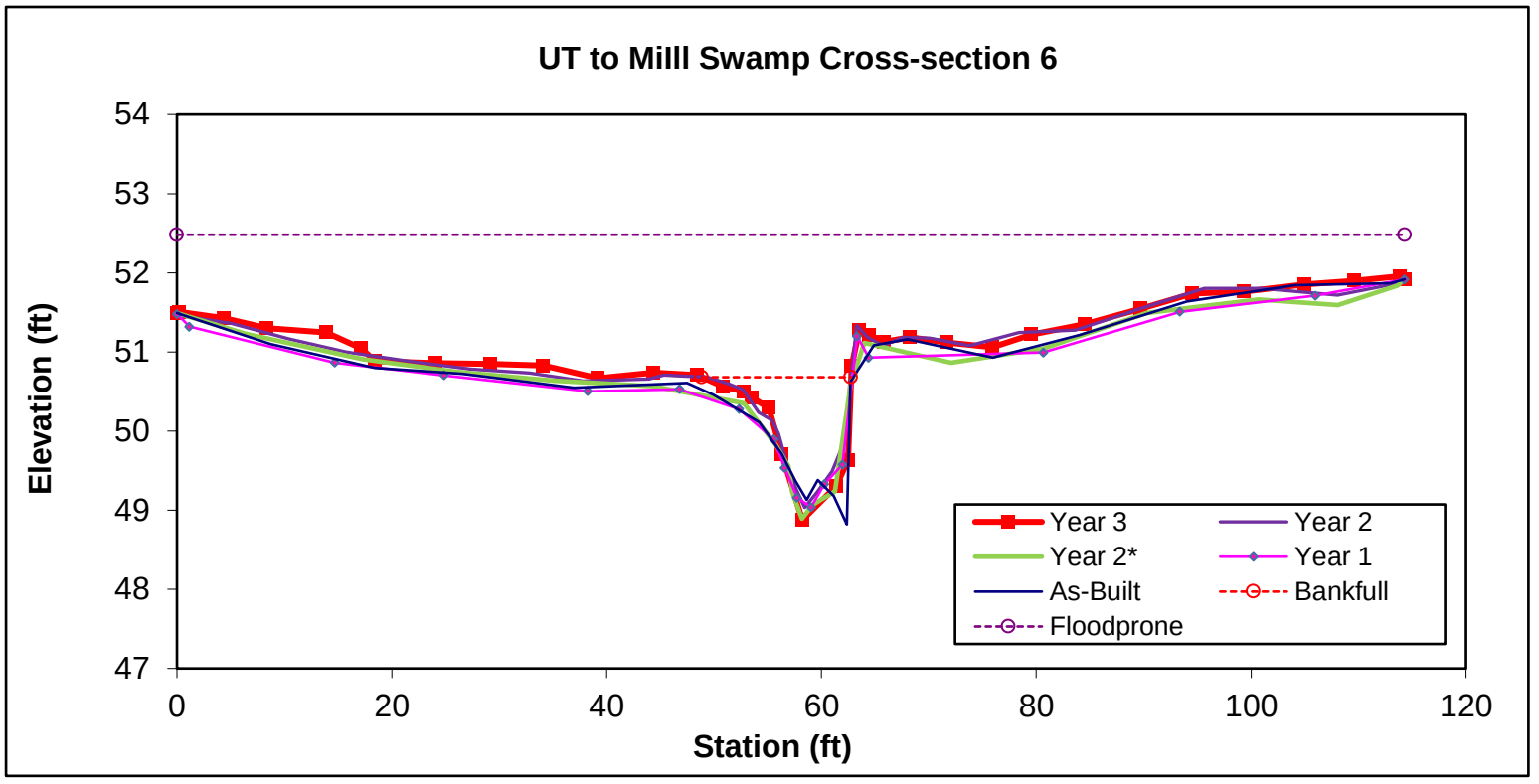
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	C	8	11.15	0.72	1.56	15.54	1.2	10.1	50.85	51.09



Permanent Cross-section 6

(Year 3 Data - Collected November 2016)

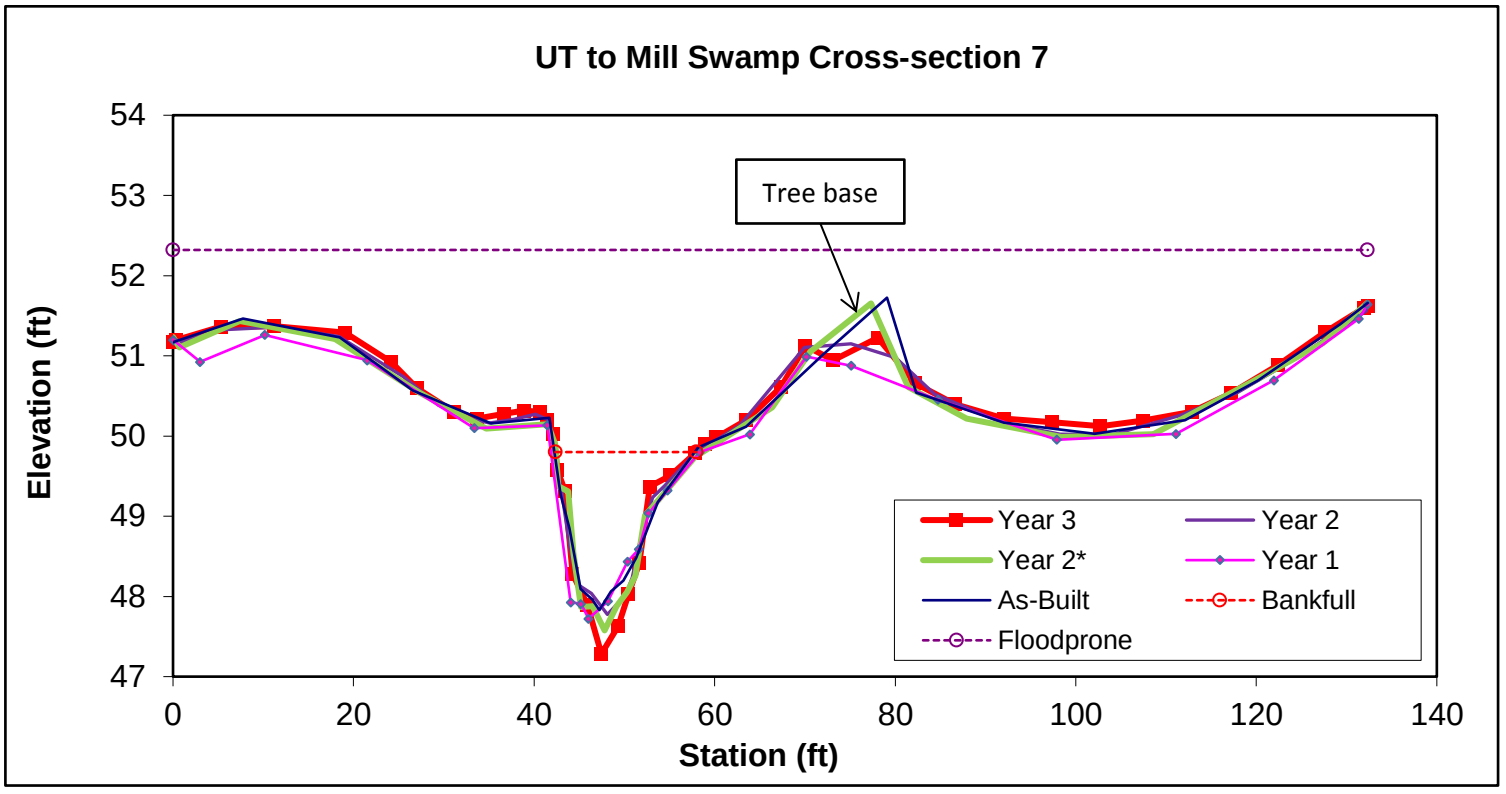
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		11.1	13.9	0.8	1.8	17.47	1	8.2	50.68	50.71



Permanent Cross-section 7

(Year 3 Data - Collected November 2016)

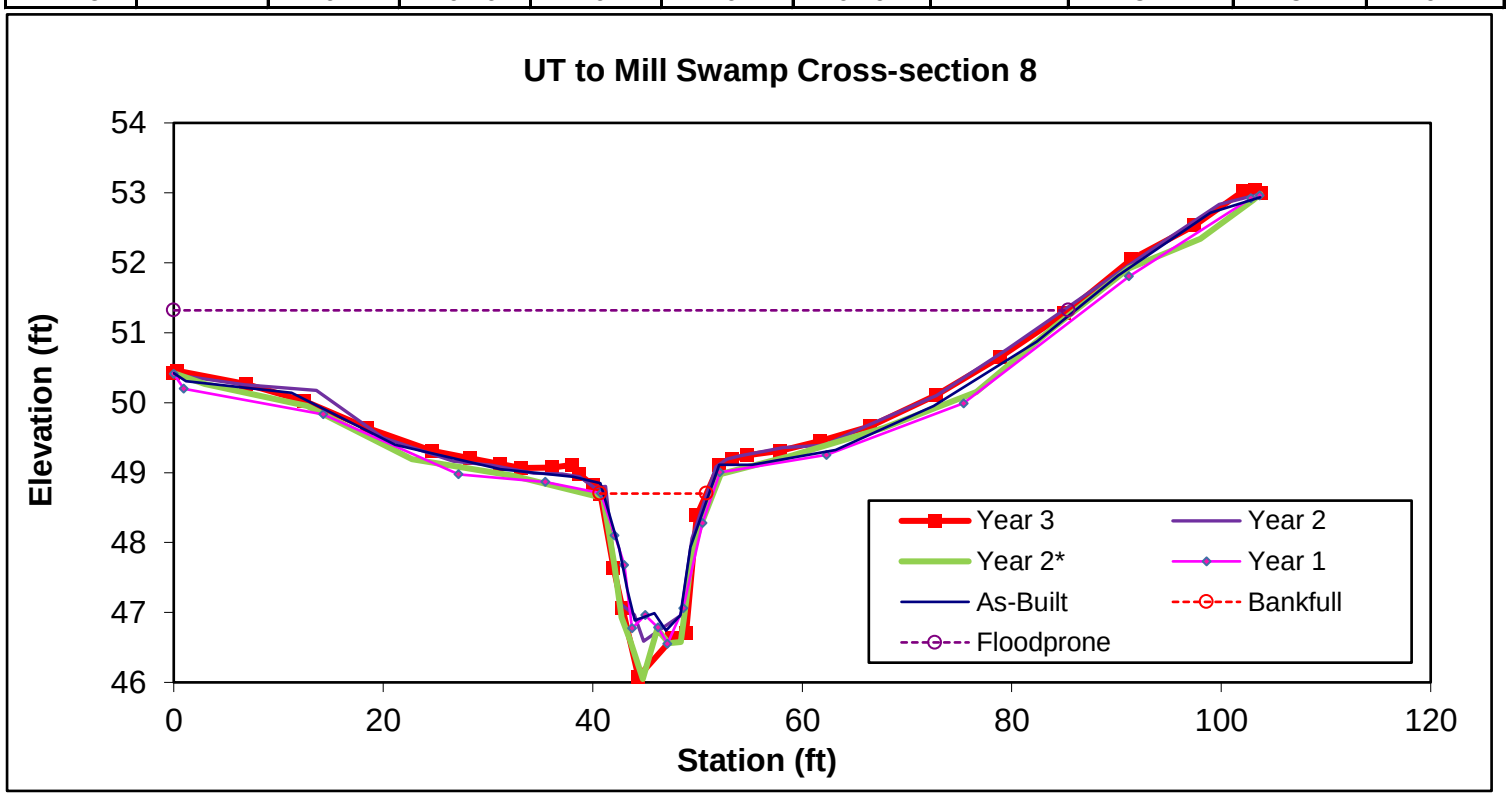
Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Pool		18.2	15.59	1.17	2.52	13.37	1	8.5	49.8	49.9



Permanent Cross-section 8

(Year 3 Data - Collected November 2016)

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	TOB Elev
Riffle	E	16.7	10.16	1.64	2.62	6.19	1.2	8.4	48.7	49.1



Appendix E

Hydrologic Data

Table 12. Wetland Restoration Area Well Success
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Well ID	Percentage of Consecutive Days <12 inches from Ground Surface[1]				Most Consecutive Days Meeting Criteria[2]				Percentage of Cumulative Days <12 inches from Ground Surface[1]				Cumulative Days Meeting Criteria[3]			
	Year 3 (2016)	Year 2 (2015)	Year 2* (2014)	Year 1 (2013)	Year 3 (2016)	Year 2 (2015)	Year 2* (2014)	Year 1 (2013)	Year 3 (2016)	Year 2 (2015)	Year 2* (2014)	Year 1 (2013)	Year 3 (2016)	Year 2 (2015)	Year 2* (2014)	Year 1 (2013)
UT1c Cross-sectional Well Arrays (Installed July 2013)																
MSAW1	24.6	20.8	29.1	4.4	59.8	50.5	70.8	10.8	66.5	52.1	56.8	53.5	161.5	126.5	138.0	130.0
MSAW2	4.0	6.5	3.3	0.7	9.8	15.8	8.0	1.8	19.8	26.3	20.2	3.5	48.0	64.0	49.0	8.5
MSAW3	0.6	0.6	0.3	0.0	1.5	1.5	0.8	0.0	0.8	2.1	1.0	0.0	2.0	5.0	2.5	0.0
MSAW4	31.2	36.4	27.8	10.3	75.8	88.5	67.5	25.0	83.4	61.0	74.2	97.0	202.8	148.3	180.3	235.7
MSAW5	31.1	19.7	21.2	3.3	75.5	47.8	51.5	8.0	58.3	51.6	51.9	40.5	141.8	125.5	126.0	98.4
MSAW6	4.2	7.0	3.8	1.1	10.3	17.0	9.3	2.8	19.7	28.3	23.3	9.5	47.8	68.8	56.5	23.1
MSAW7	2.1	2.7	3.7	0.2	5.0	6.5	9.0	0.5	7.1	14.6	10.9	0.3	17.3	35.5	26.5	0.7
MSAW8	31.1	37.7	47.3	14.1	75.5	91.5	115.0	34.3	83.0	66.3	73.9	96.8	201.8	161.0	179.6	235.2
MSAW9	5.7	8.6	4.5	2.5	13.8	21.0	11.0	6.0	41.7	28.6	33.0	44.5	101.3	69.5	80.3	108.1
MSAW10	2.1	5.3	0.6	0.0	5.0	13.0	1.5	0.0	16.8	13.1	1.1	0.0	40.8	31.8	2.8	0.0
Supplemental UT1c Monitoring Wells (Installed February/March 2016)																
**MSAW19	8.7	--	--	--	21.3	--	--	--	43.8	--	--	--	106.5	--	--	--
**MSAW20	3.7	--	--	--	9.0	--	--	--	10.1	--	--	--	24.5	--	--	--
**MSAW21	3.7	--	--	--	9.0	--	--	--	12.7	--	--	--	30.8	--	--	--
**MSAW22	2.8	--	--	--	6.8	--	--	--	14.0	--	--	--	34.0	--	--	--
**MSAW23	3.1	--	--	--	7.5	--	--	--	23.7	--	--	--	57.5	--	--	--
**MSAW24	31.2	--	--	--	75.8	--	--	--	72.1	--	--	--	175.3	--	--	--
UT1a d UT1b Cross-sectional Well Arrays (Installed July 2013)																
MSAW11	40.1	32.3	21.2	4.7	97.5	78.5	51.5	11.5	84.9	76.7	72.4	38.5	206.3	186.5	176.0	93.6
MSAW12	7.6	10.1	15.4	0.7	18.5	24.5	37.5	1.8	27.4	24.9	19.1	7.0	66.5	60.5	46.5	17.0
MSAW13	40.0	40.0	46.5	6.5	97.3	97.3	113.0	15.8	84.8	82.2	80.0	81.5	206.0	199.8	194.5	198.0
MSAW14	17.9	18.3	39.1	0.6	43.5	44.5	95.0	1.5	61.6	46.7	31.0	4.0	149.8	113.5	75.3	9.7
MSAW15	1.6	2.4	0.9	0.8	4.0	5.8	2.3	2.0	6.7	5.1	3.9	4.0	16.3	12.5	9.5	9.7
MSAW16	2.1	2.3	2.8	2.4	5.0	5.5	6.8	5.8	7.1	11.5	13.0	14.5	17.3	28.0	31.5	35.2
MSAW17	0.3	0.7	0.1	0.0	0.8	1.8	0.3	0.0	0.5	1.3	0.1	0.0	1.3	3.3	0.3	0.0
MSAW18	2.2	7.4	10.2	3.8	5.3	18.0	24.8	9.3	10.7	20.8	15.3	18.5	26.0	50.5	37.3	45.0

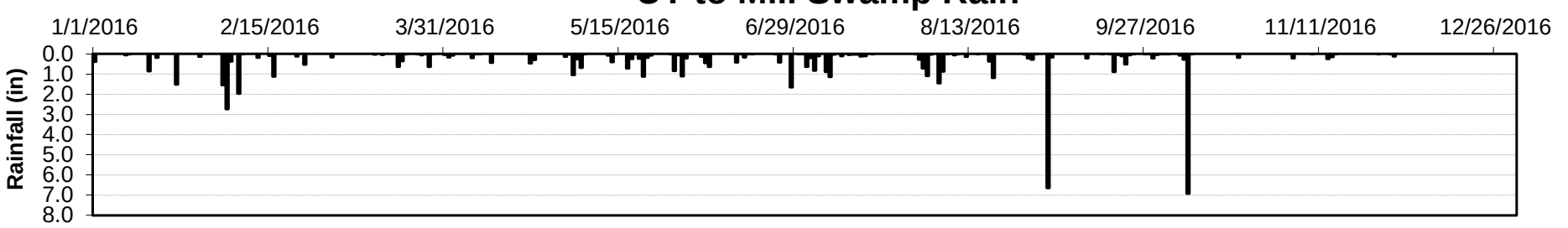
Notes:
[1]Indicates the percentage of most consecutive or cumulative number of days within the monitored growing season with a water 12 inches or less from the soil surface.
[2]Indicates the most consecutive number of days within the monitored growing season with a water table 12 inches or less from the soil surface.
[3]Indicates the cumulative number of days within the monitored growing season with a water table 12 inches or less from the soil surface.

Growing season for Onslow County is from March 18 to November 16 and is **243** days long. 12% of the growing season is **29** days.

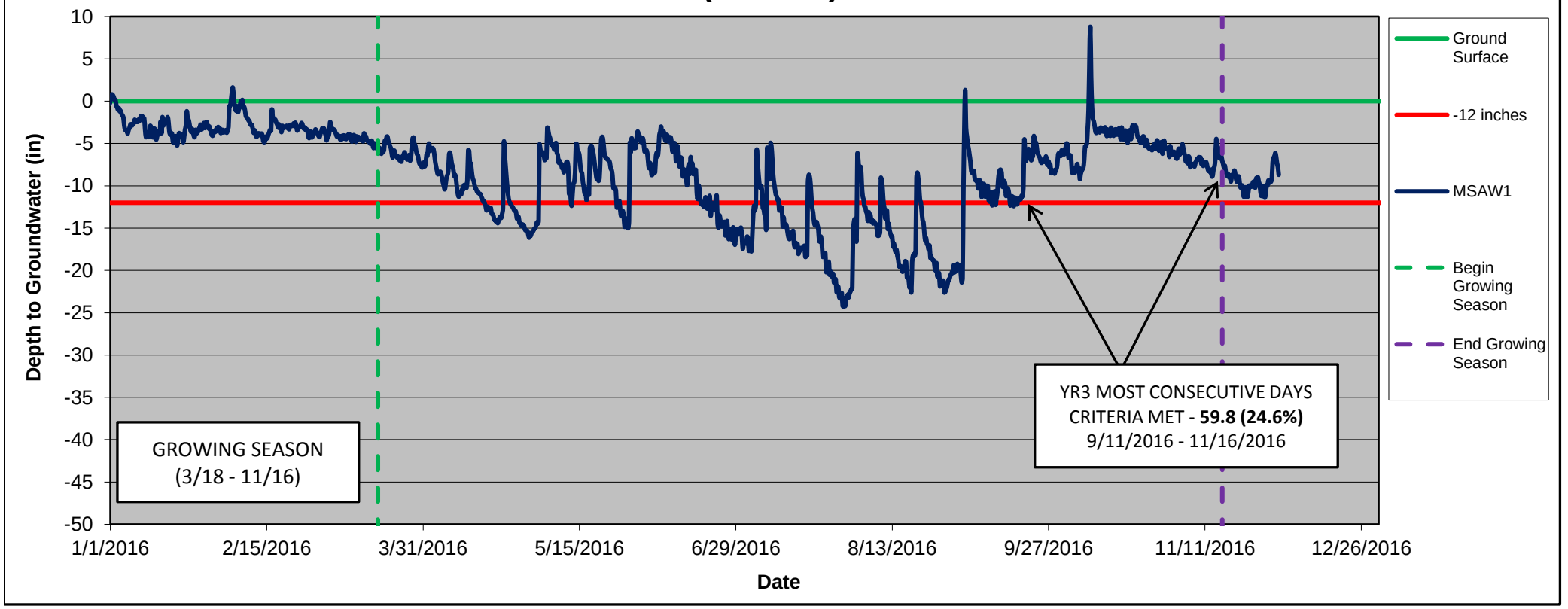
HIGHLIGHTED indicates wells that *did not* to meet the success criteria for the most consecutive number of days within the monitored growing season with a water 12 inches or less from the soil surface. Following Year 3 wetland monitoring, five of sixteen wells exhibited hyrdroperiods greater than 12% during the 2016 growing season. These wells will be observed closely throughout monitoring Year 4.

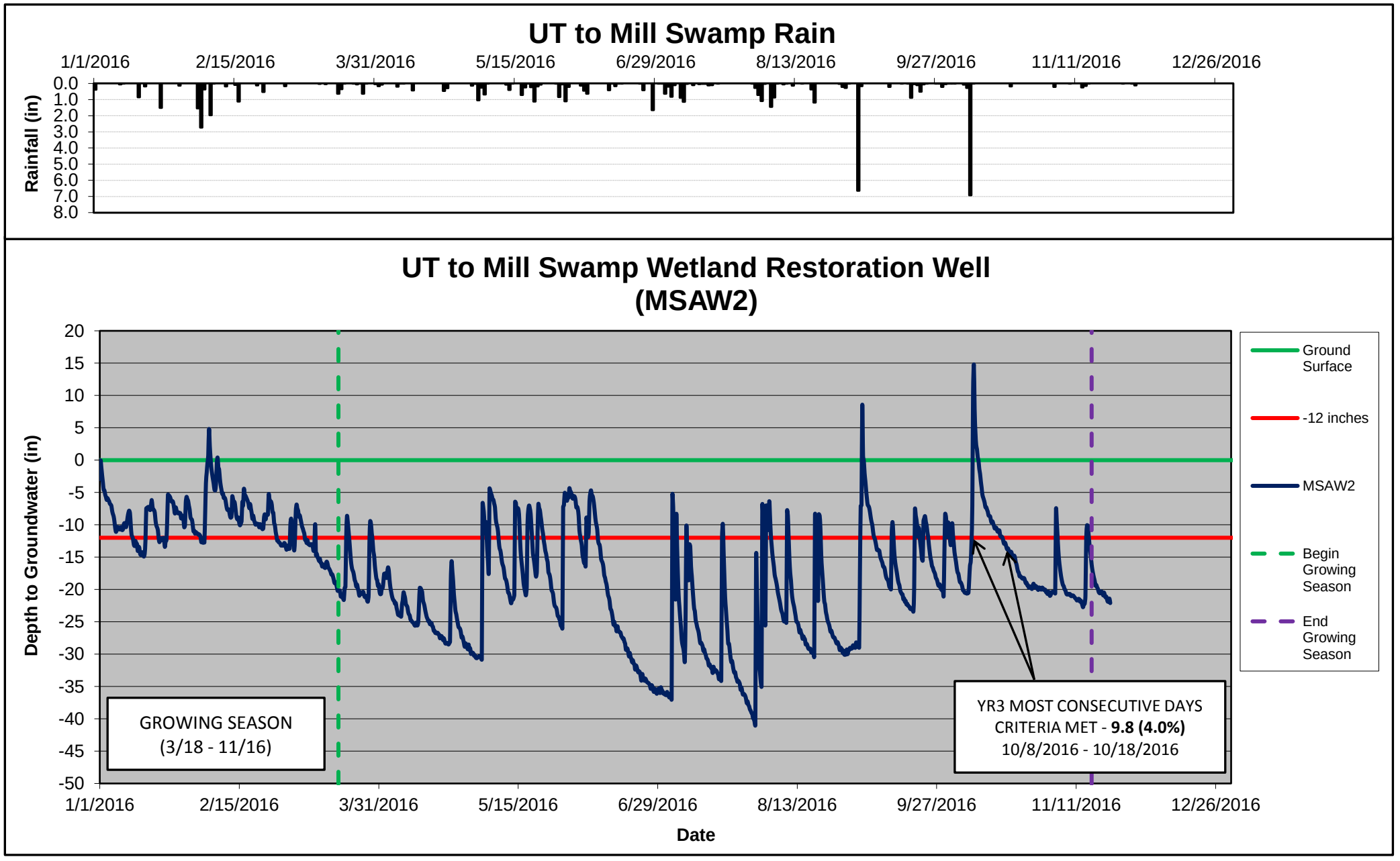
**To gather additional well data in the UT1c restoration area, In-Situ groundwater monitoring dataloggers AW19 -AW23 were installed on 2/26/2016, AW24 was installed on 3/10/2016. The installation of the additional dataloggers was completed during the 2016 spring wet season when groundwater levels are normally closer to the ground surface.

UT to Mill Swamp Rain

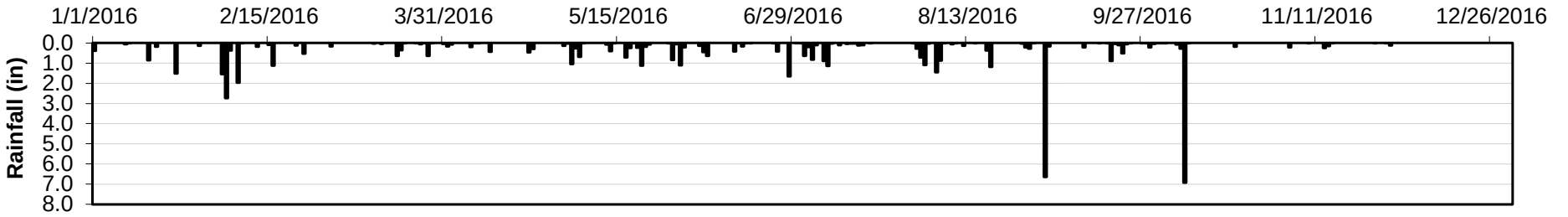


UT to Mill Swamp Wetland Restoration Well (MSAW1)

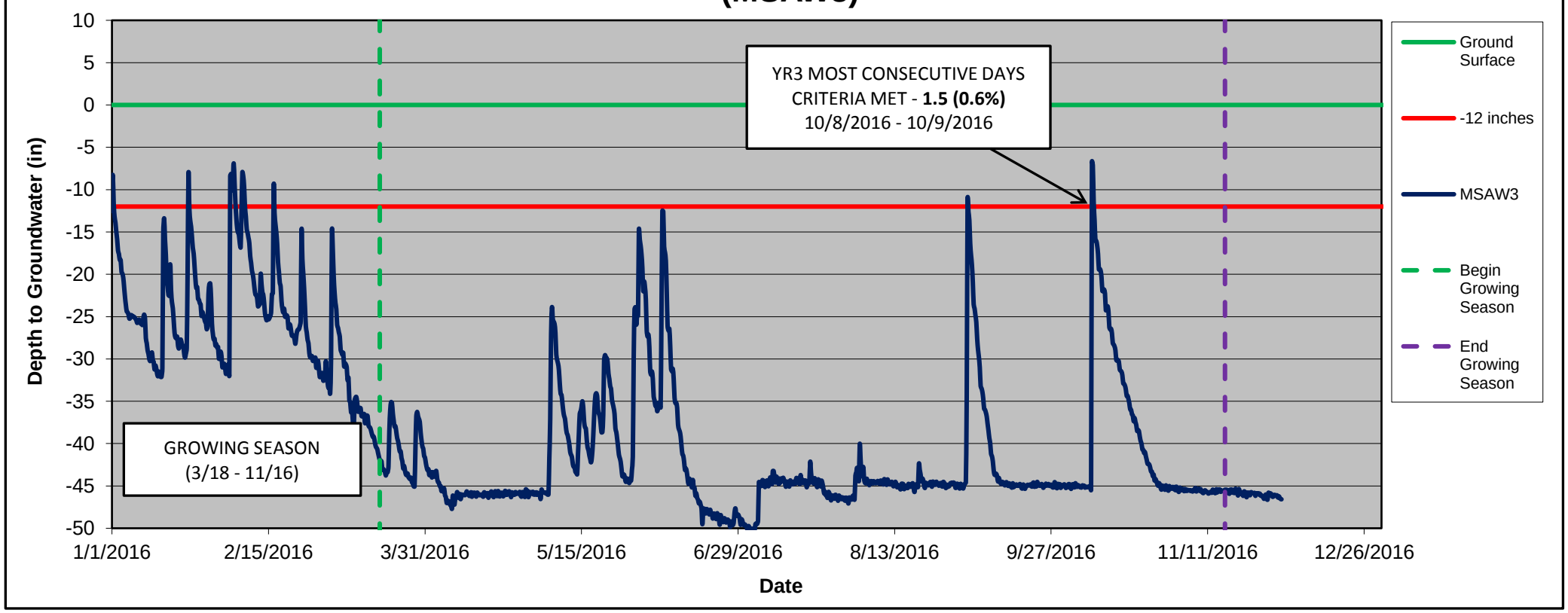


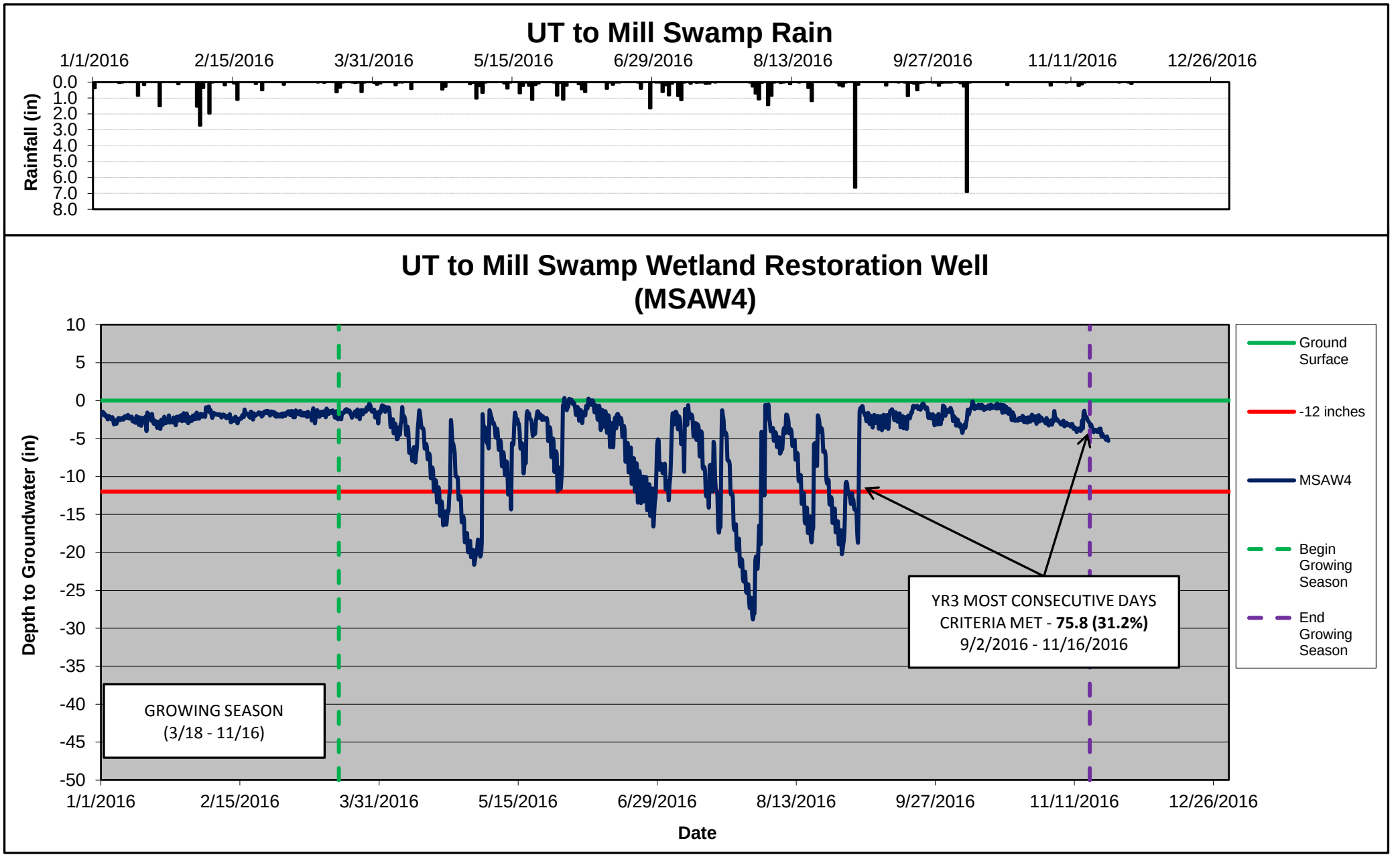

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW2)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW2
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 9.8 (4.0%)
10/8/2016 - 10/18/2016
Date

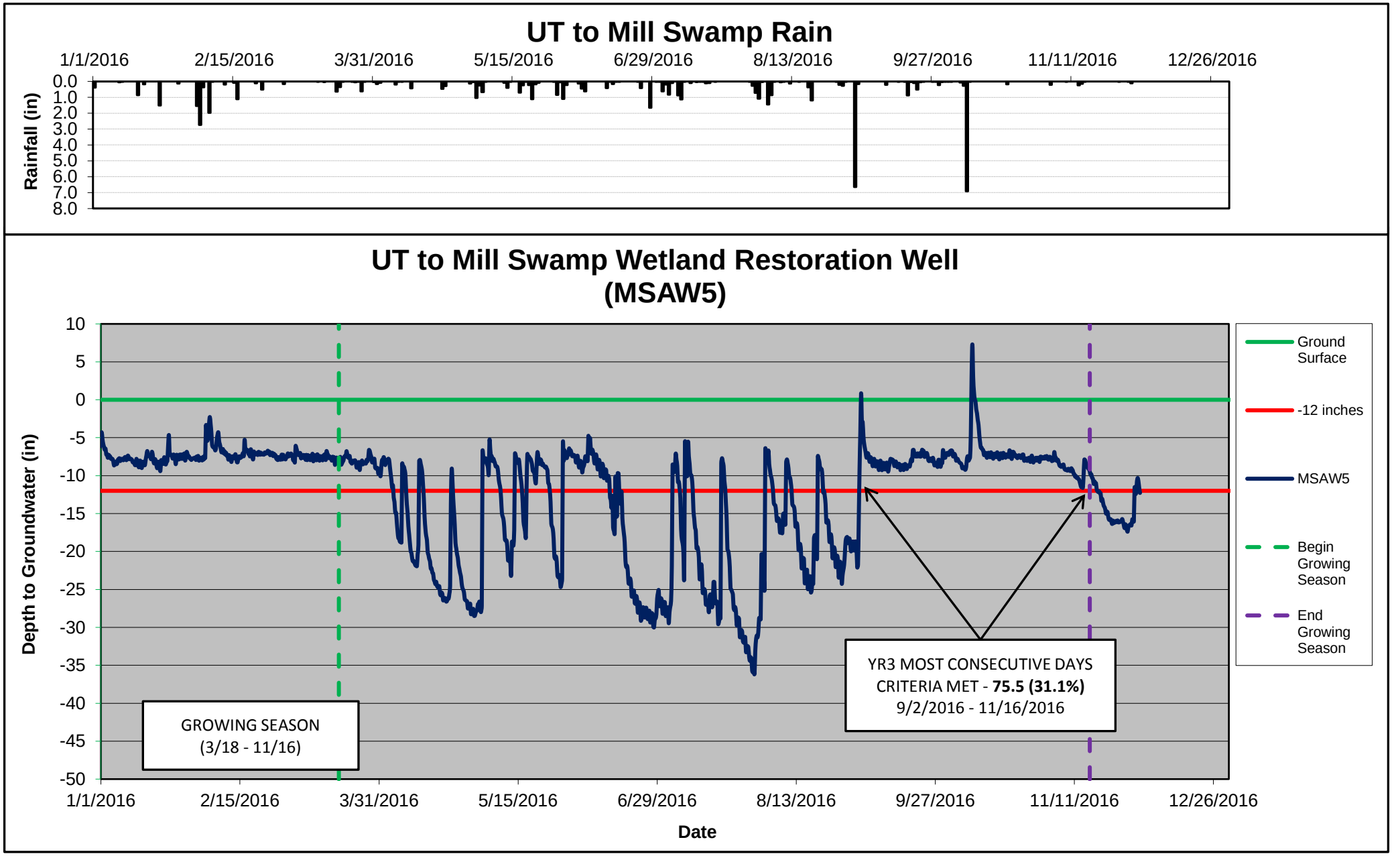
UT to Mill Swamp Rain

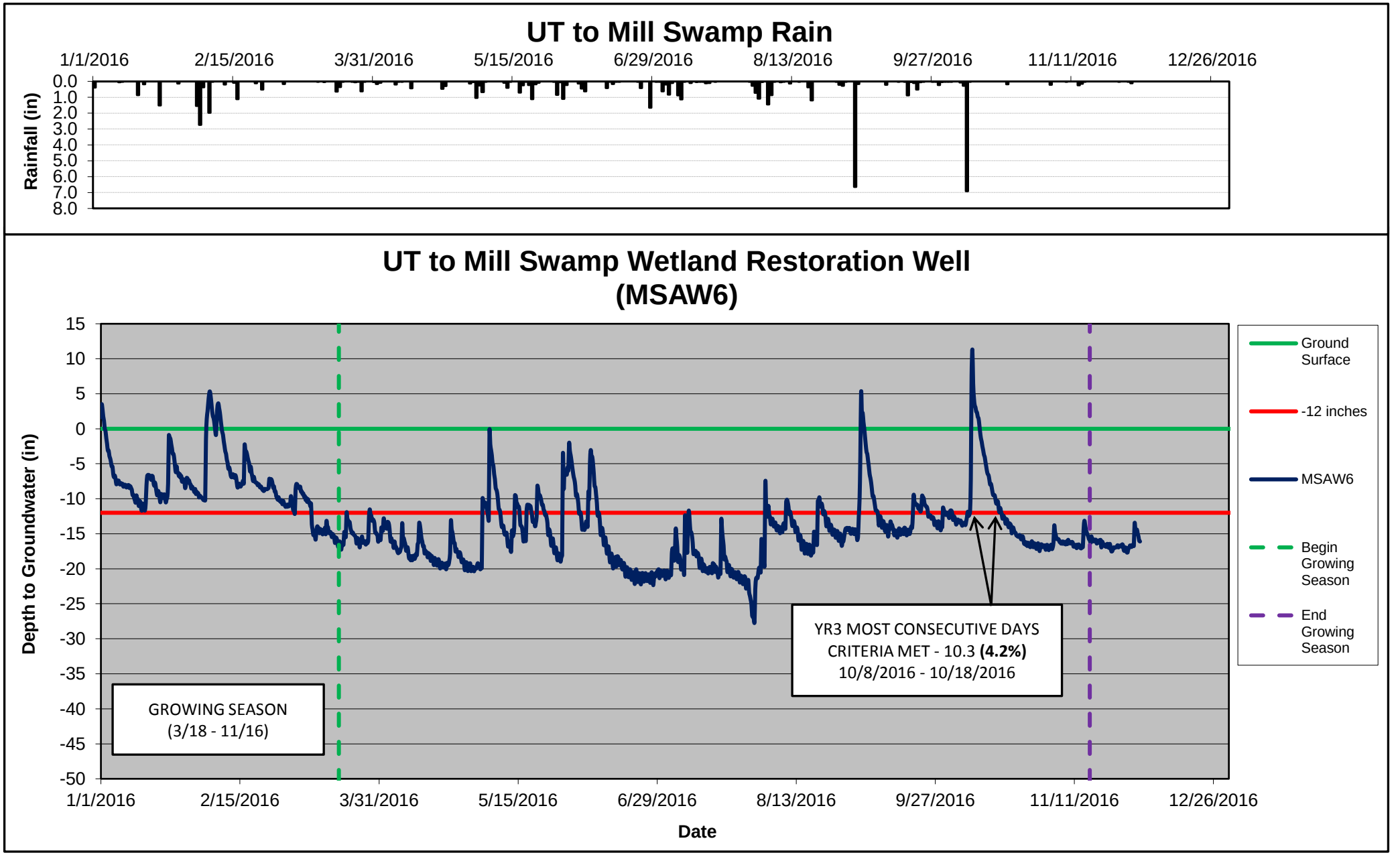


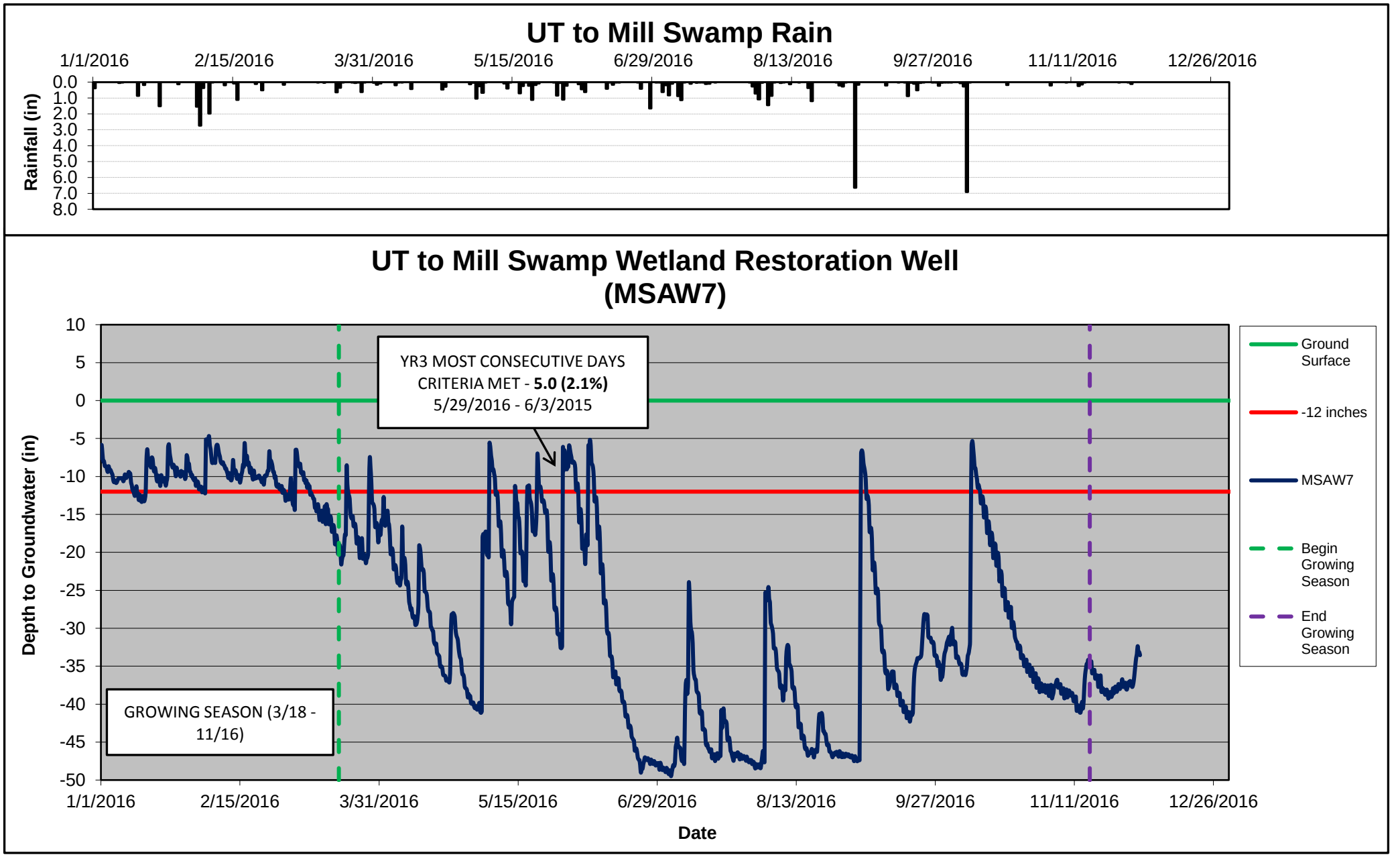
UT to Mill Swamp Wetland Restoration Well (MSAW3)



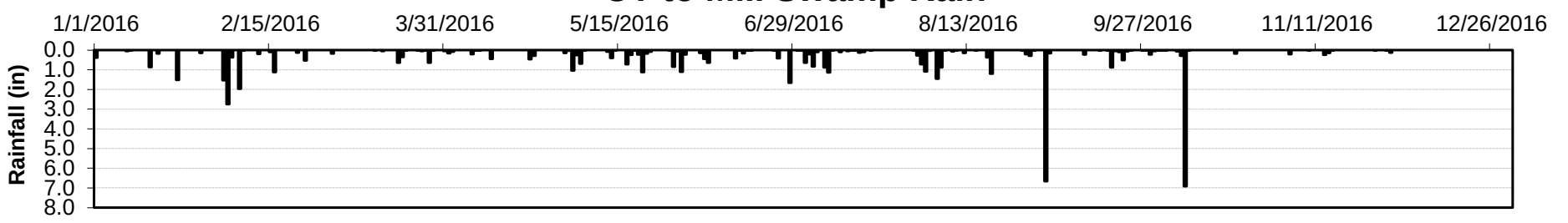

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW4)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW4
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 75.8 (31.2%)
9/2/2016 - 11/16/2016
Date


UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW5)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW5
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 75.5 (31.1%)
9/2/2016 - 11/16/2016
Date

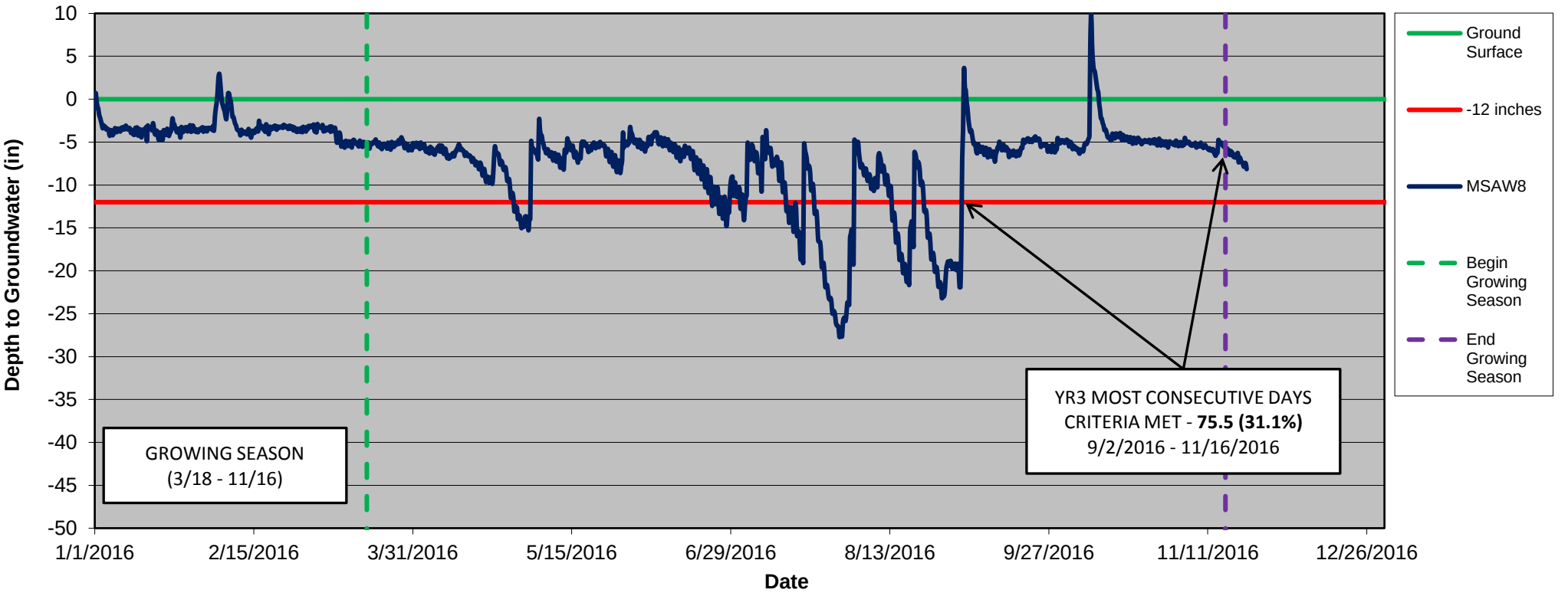

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW6)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 10.3 (4.2%)
10/8/2016 - 10/18/2016
Ground Surface
-12 inches
MSAW6
Begin Growing Season
End Growing Season
Date

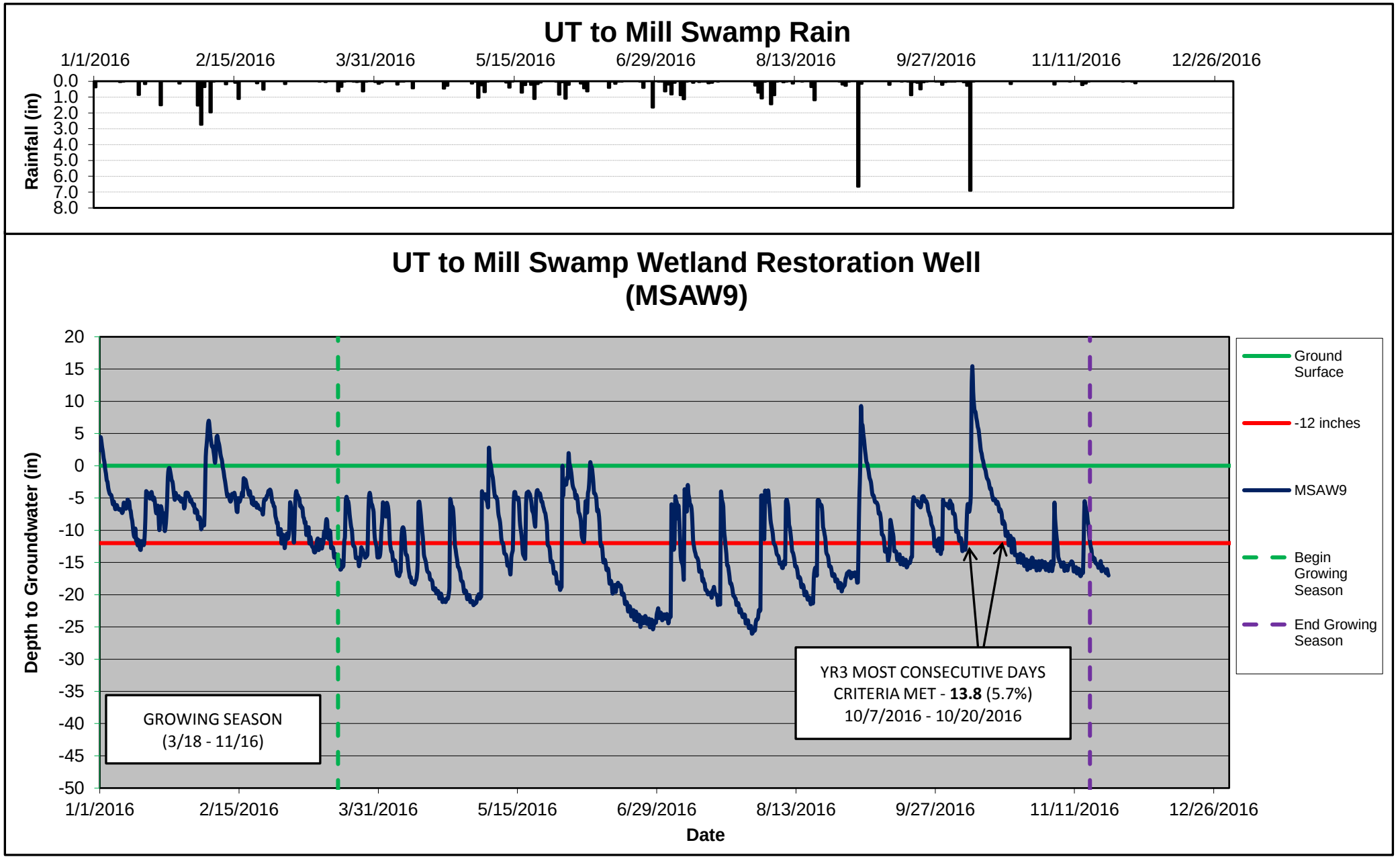

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well (MSAW7)
YR3 MOST CONSECUTIVE DAYS CRITERIA MET - 5.0 (2.1%)
5/29/2016 - 6/3/2015
GROWING SEASON (3/18 - 11/16)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Date
Ground Surface
-12 inches
MSAW7
Begin Growing Season
End Growing Season

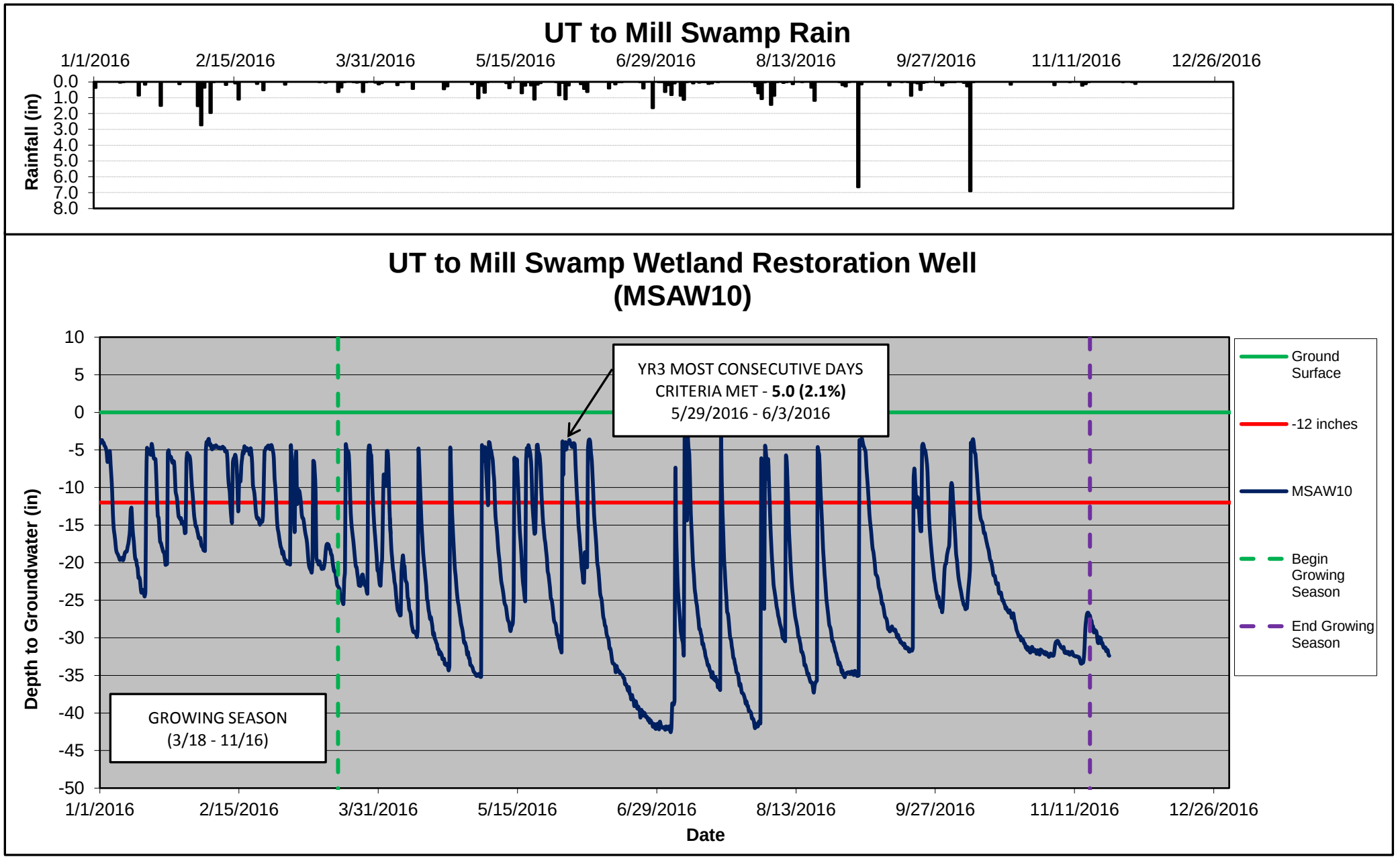
UT to Mill Swamp Rain

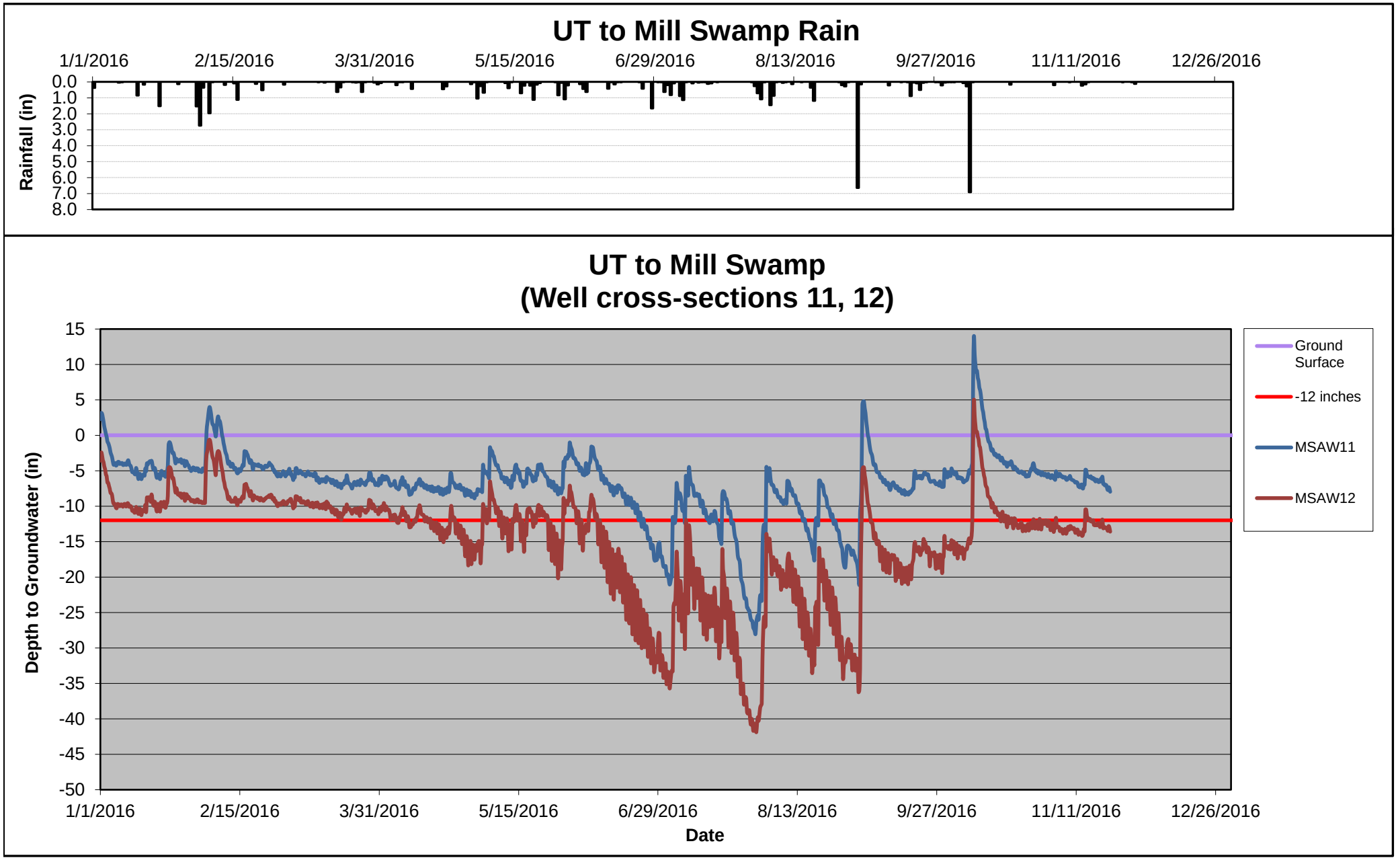


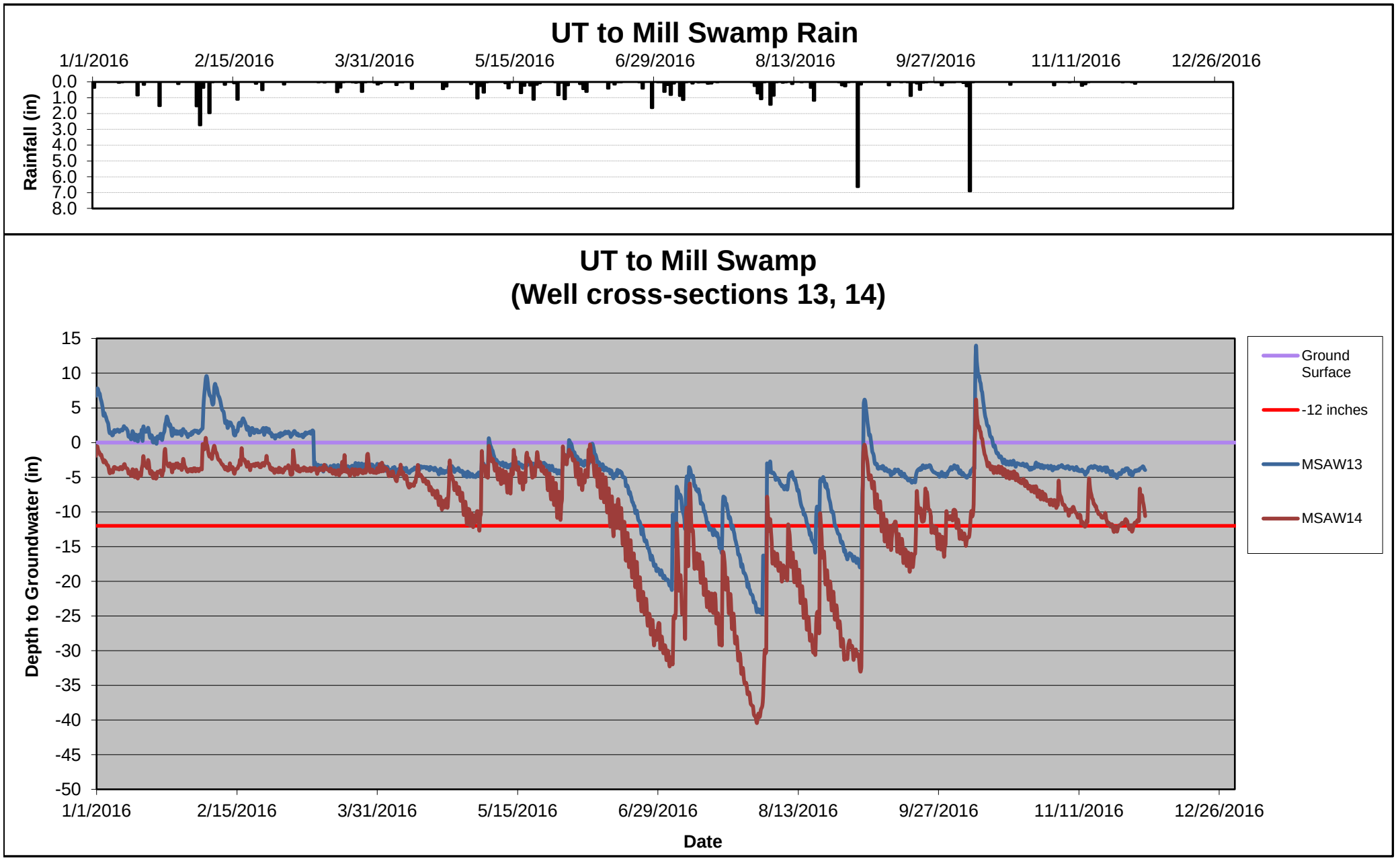
UT to Mill Swamp Wetland Restoration Well (MSAW8)

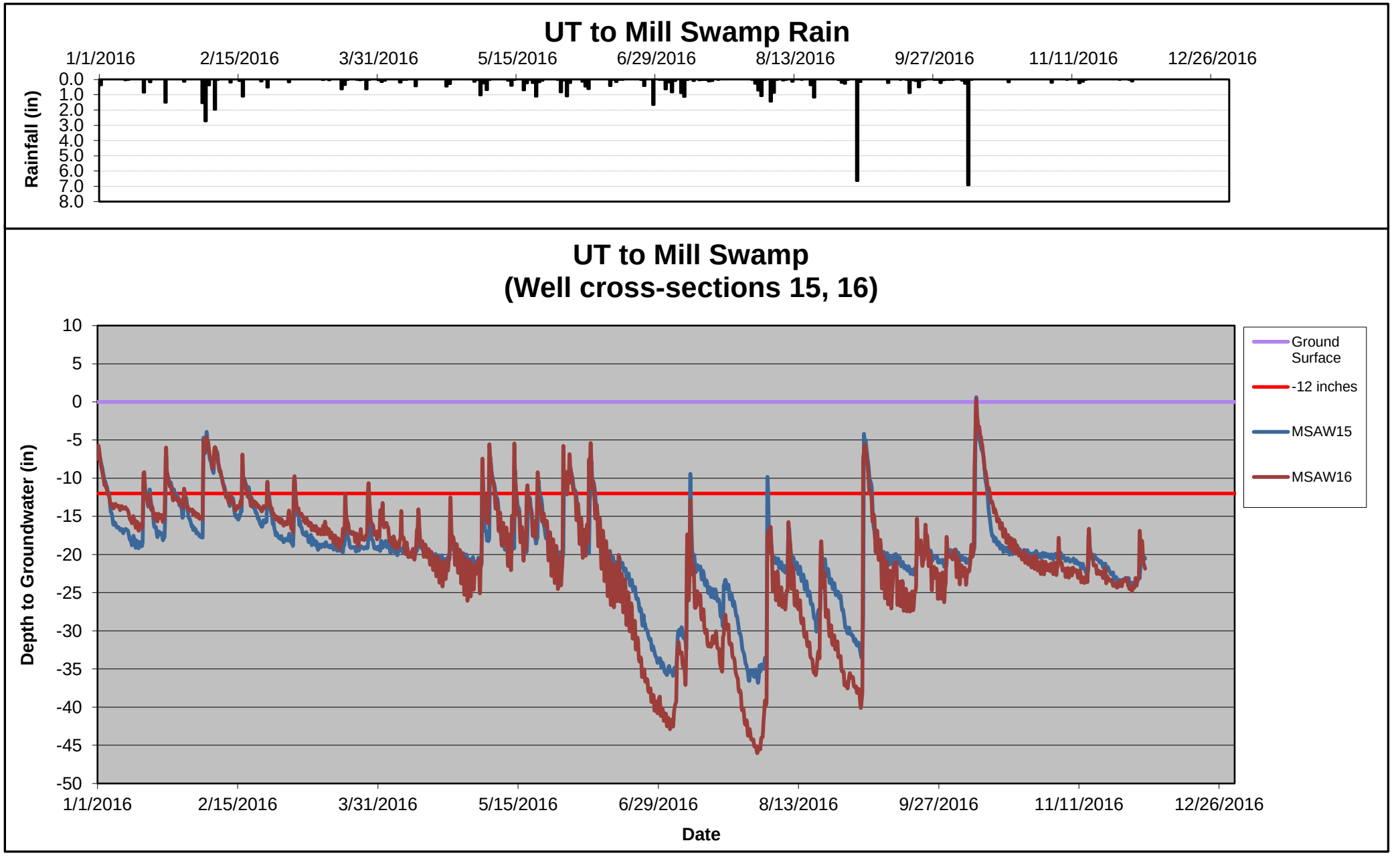


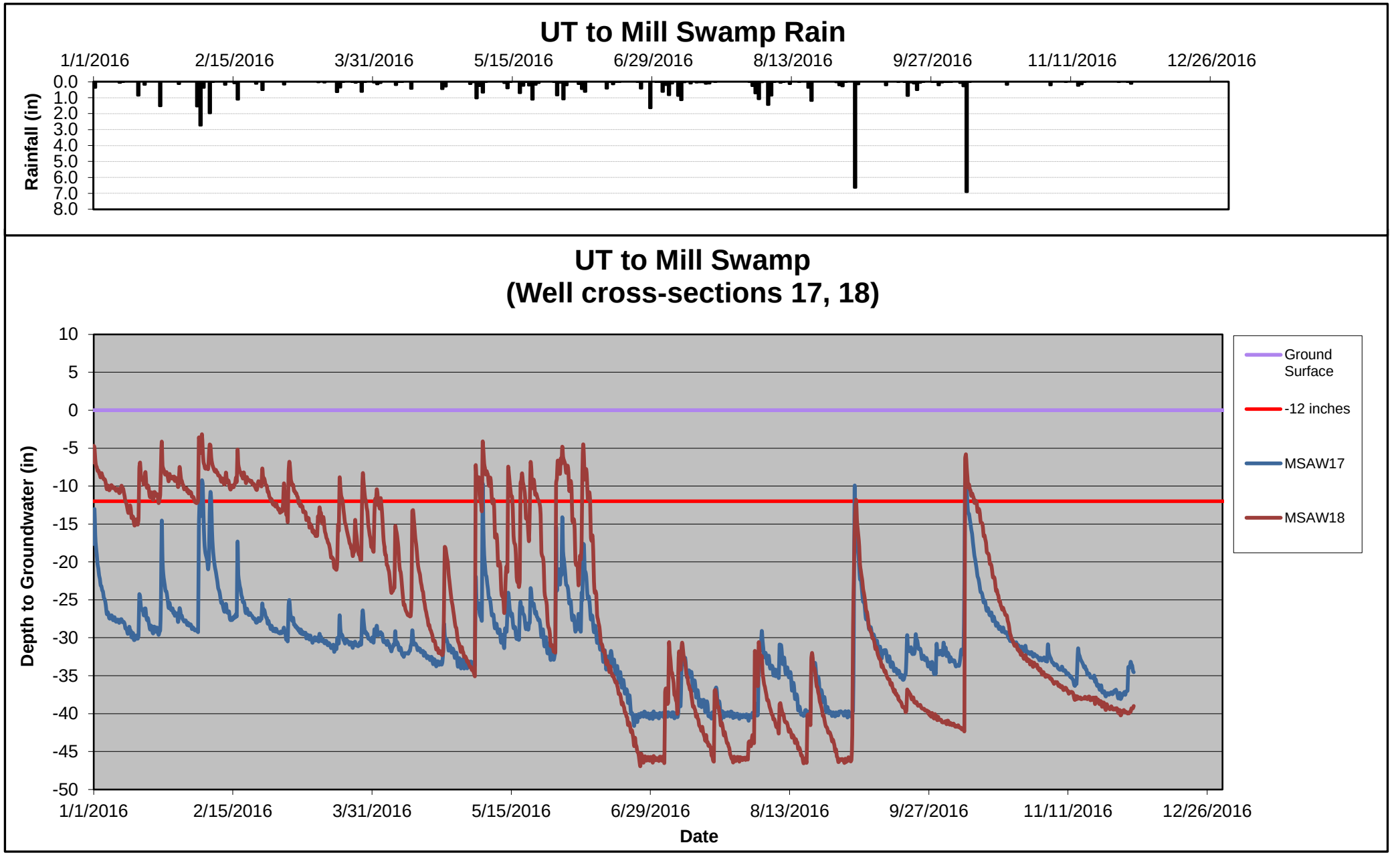

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW9)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW9
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 13.8 (5.7%)
10/7/2016 - 10/20/2016
Date

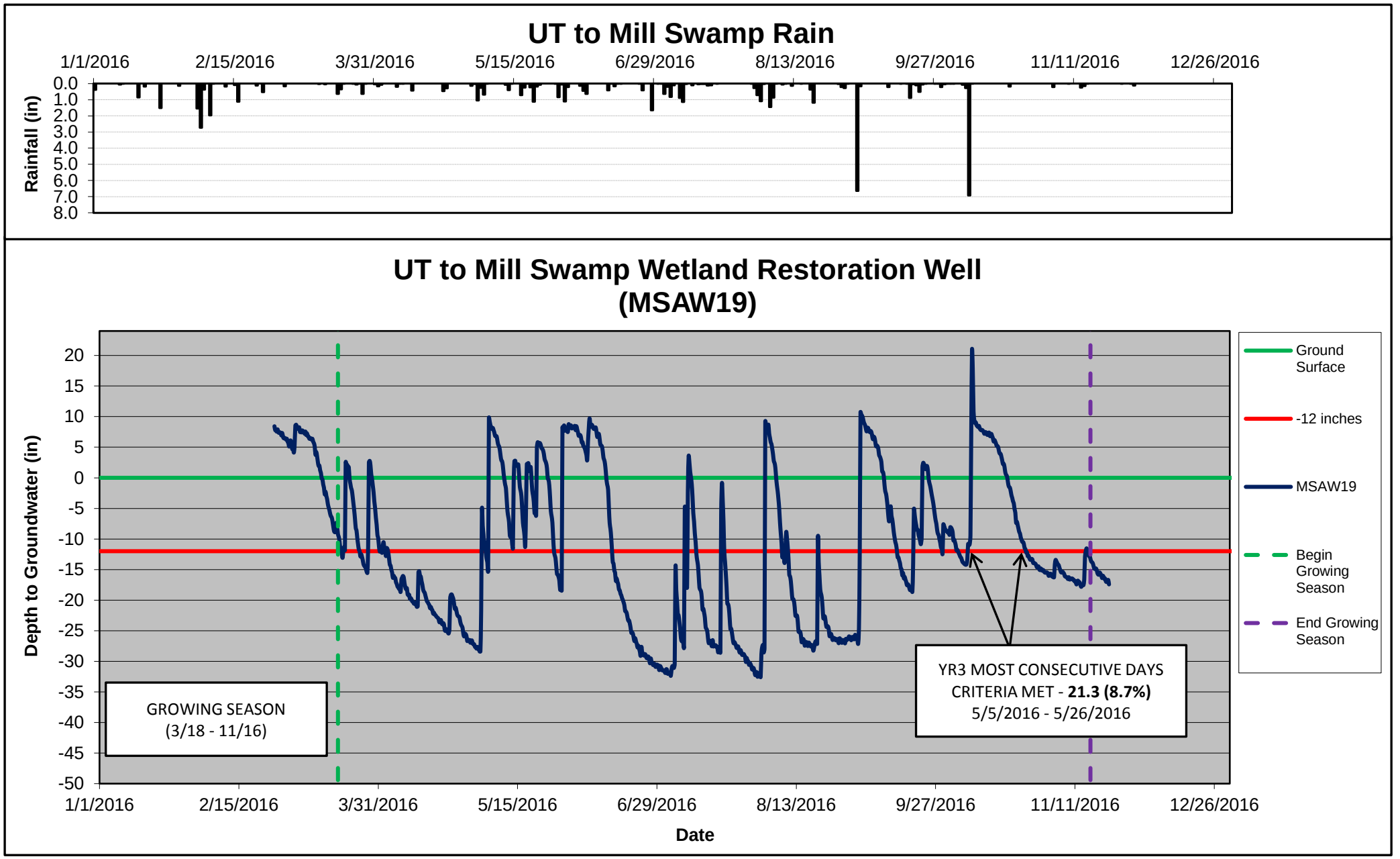

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW10)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 5.0 (2.1%)
5/29/2016 - 6/3/2016
GROWING SEASON
(3/18 - 11/16)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW10
Begin Growing Season
End Growing Season
Date

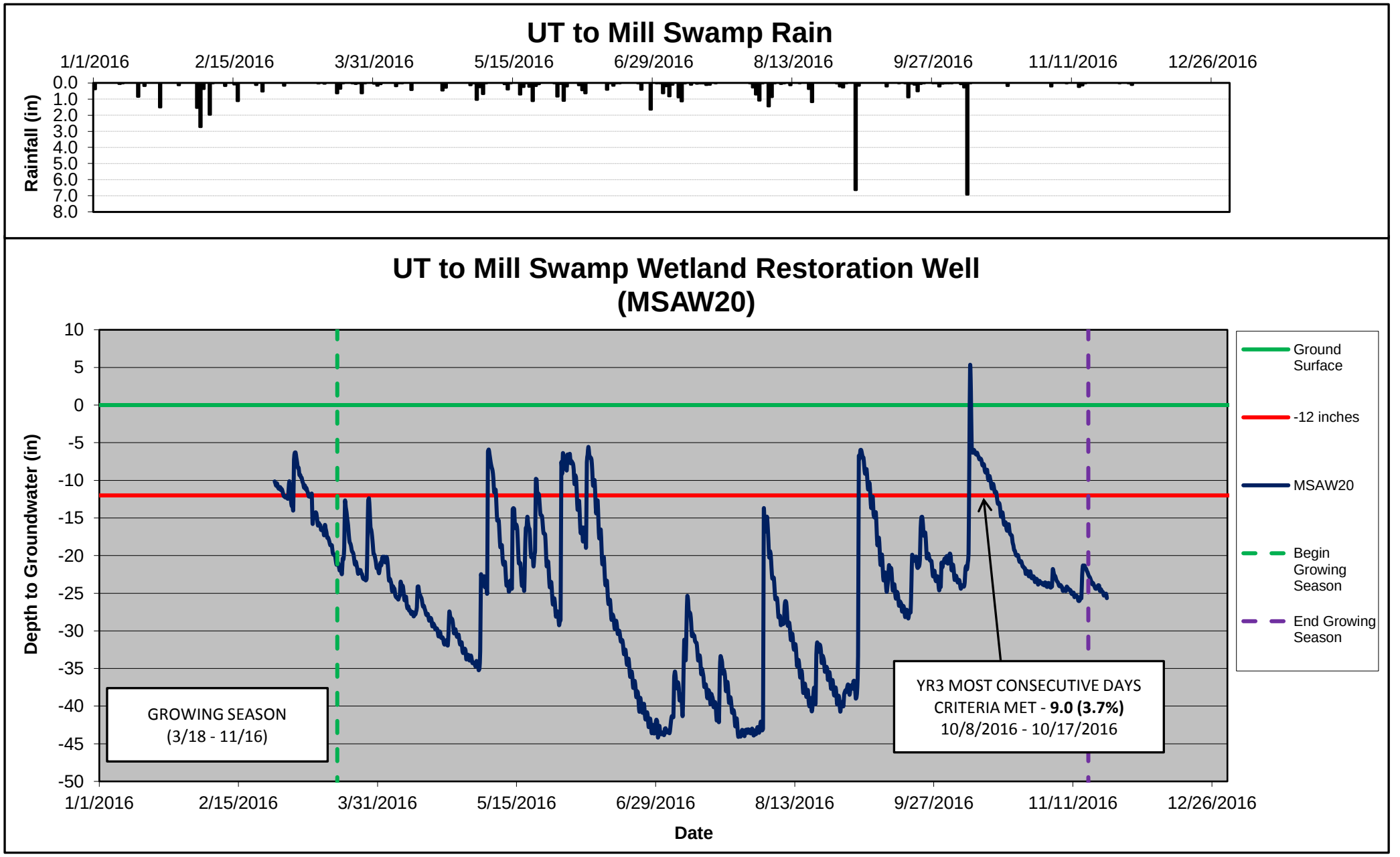

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp
(Well cross-sections 11, 12)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Date
Ground Surface
-12 inches
MSAW11
MSAW12

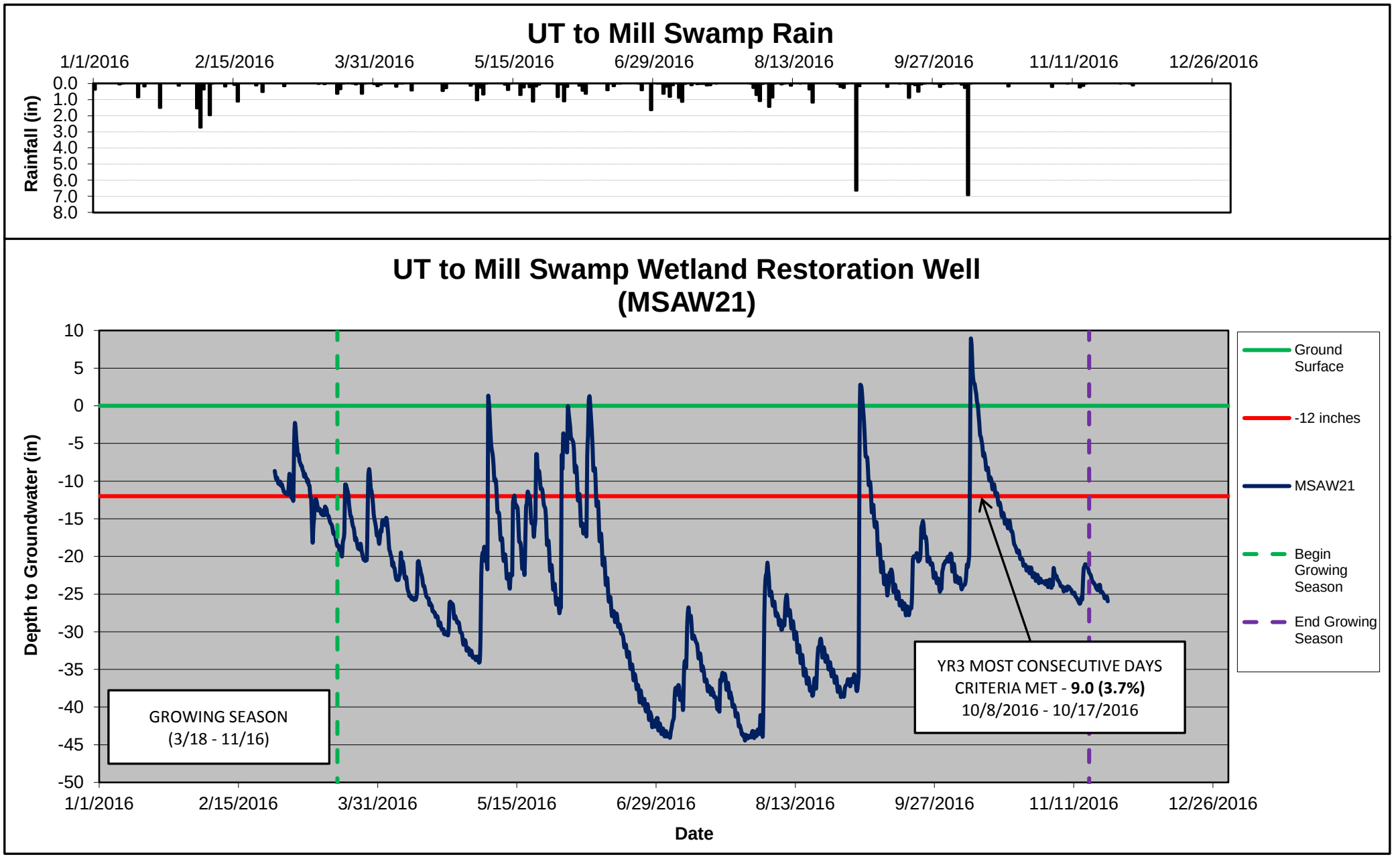

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp
(Well cross-sections 13, 14)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Date
Ground Surface
-12 inches
MSAW13
MSAW14

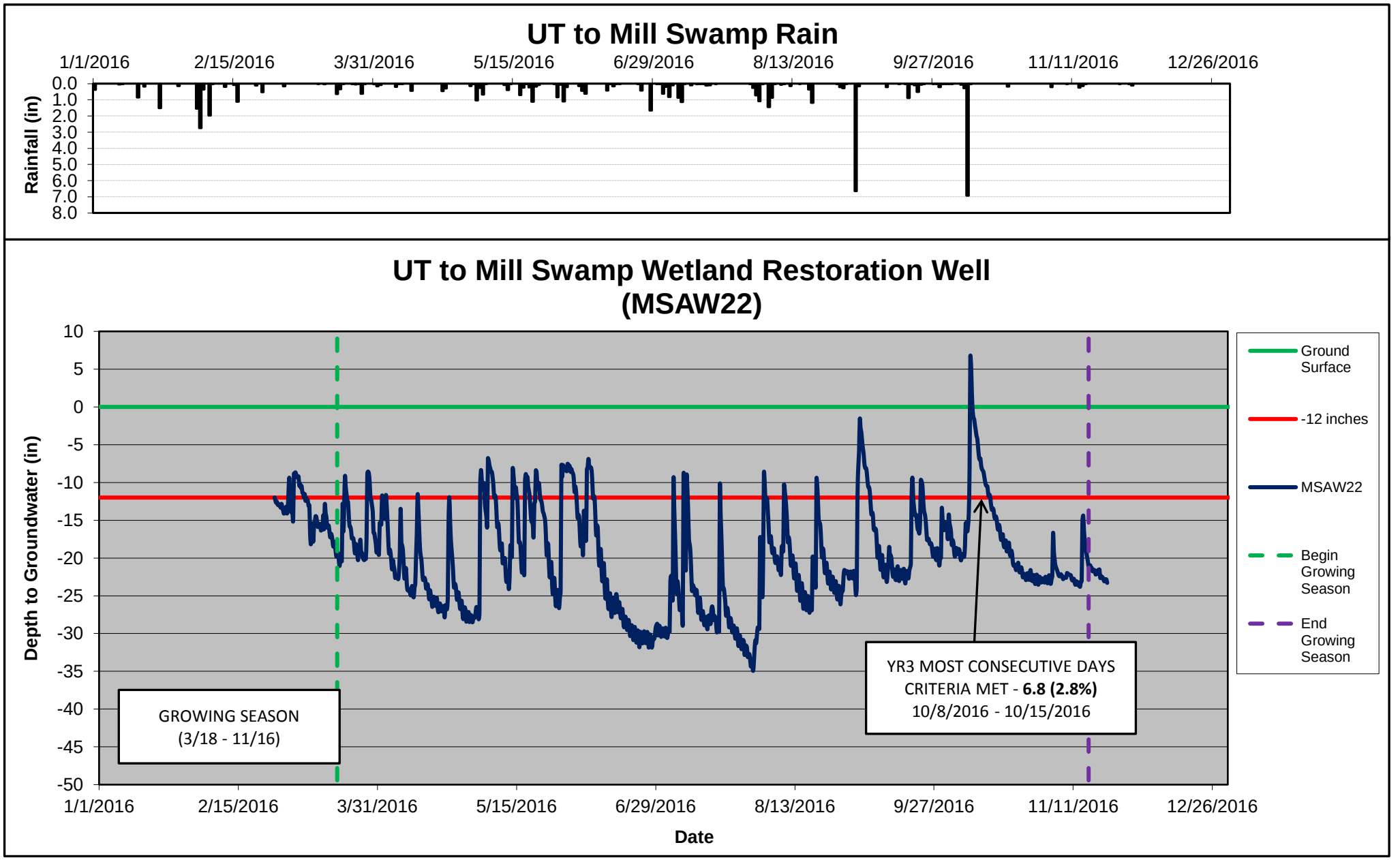

UT to Mill Swamp Rain
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
UT to Mill Swamp
(Well cross-sections 15, 16)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW15
MSAW16
Date


UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp
(Well cross-sections 17, 18)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Date
Ground Surface
-12 inches
MSAW17
MSAW18

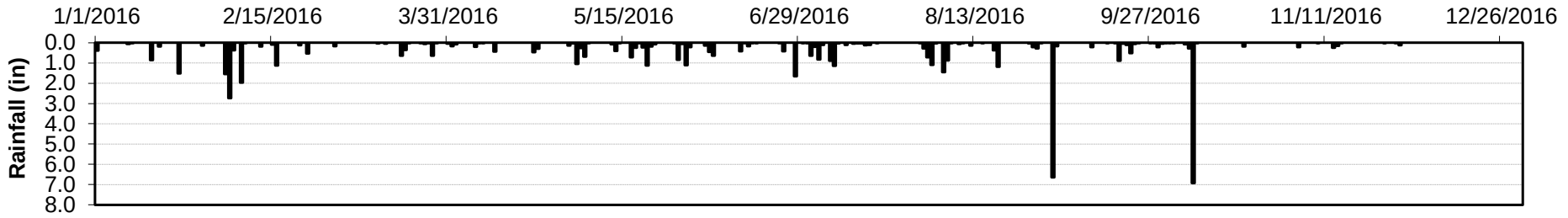

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW19)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 21.3 (8.7%)
5/5/2016 - 5/26/2016
Ground Surface
-12 inches
MSAW19
Begin Growing Season
End Growing Season
Date


UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW20)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW20
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 9.0 (3.7%)
10/8/2016 - 10/17/2016
Date

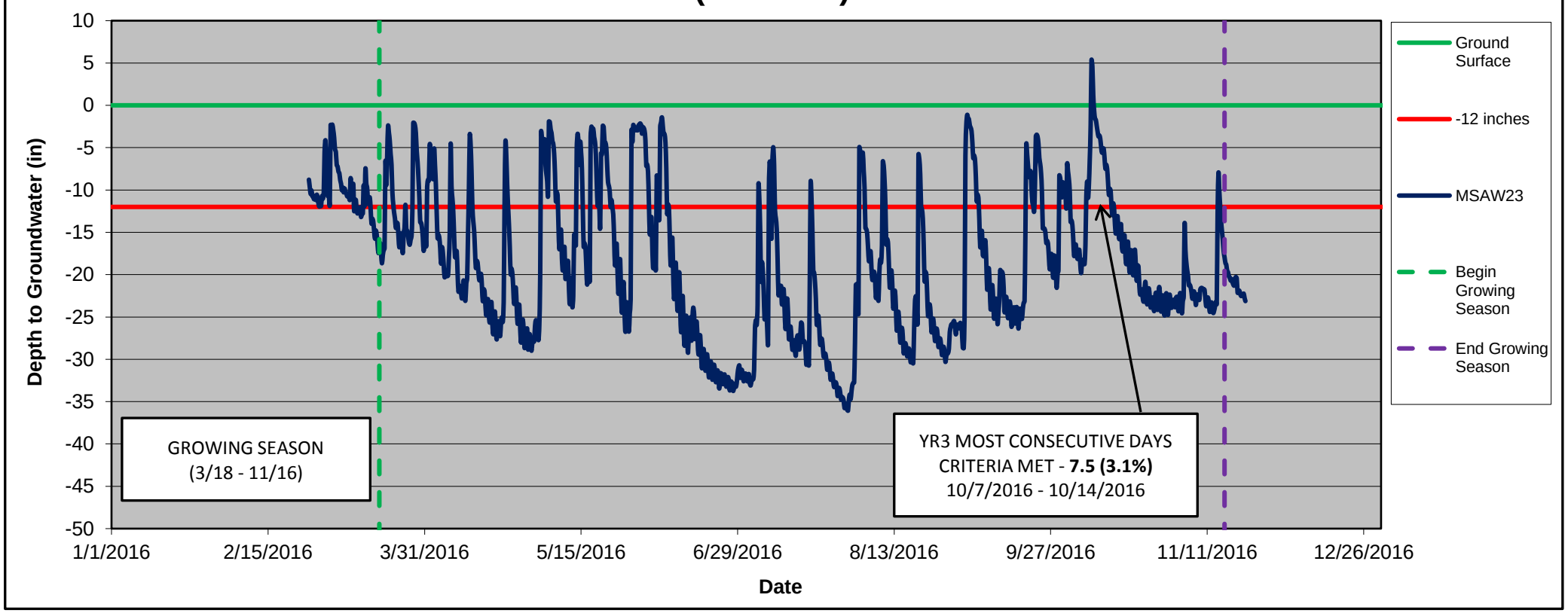

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW21)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW21
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 9.0 (3.7%)
10/8/2016 - 10/17/2016
Date


UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW22)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW22
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 6.8 (2.8%)
10/8/2016 - 10/15/2016
Date

UT to Mill Swamp Rain



UT to Mill Swamp Wetland Restoration Well (MSAW23)



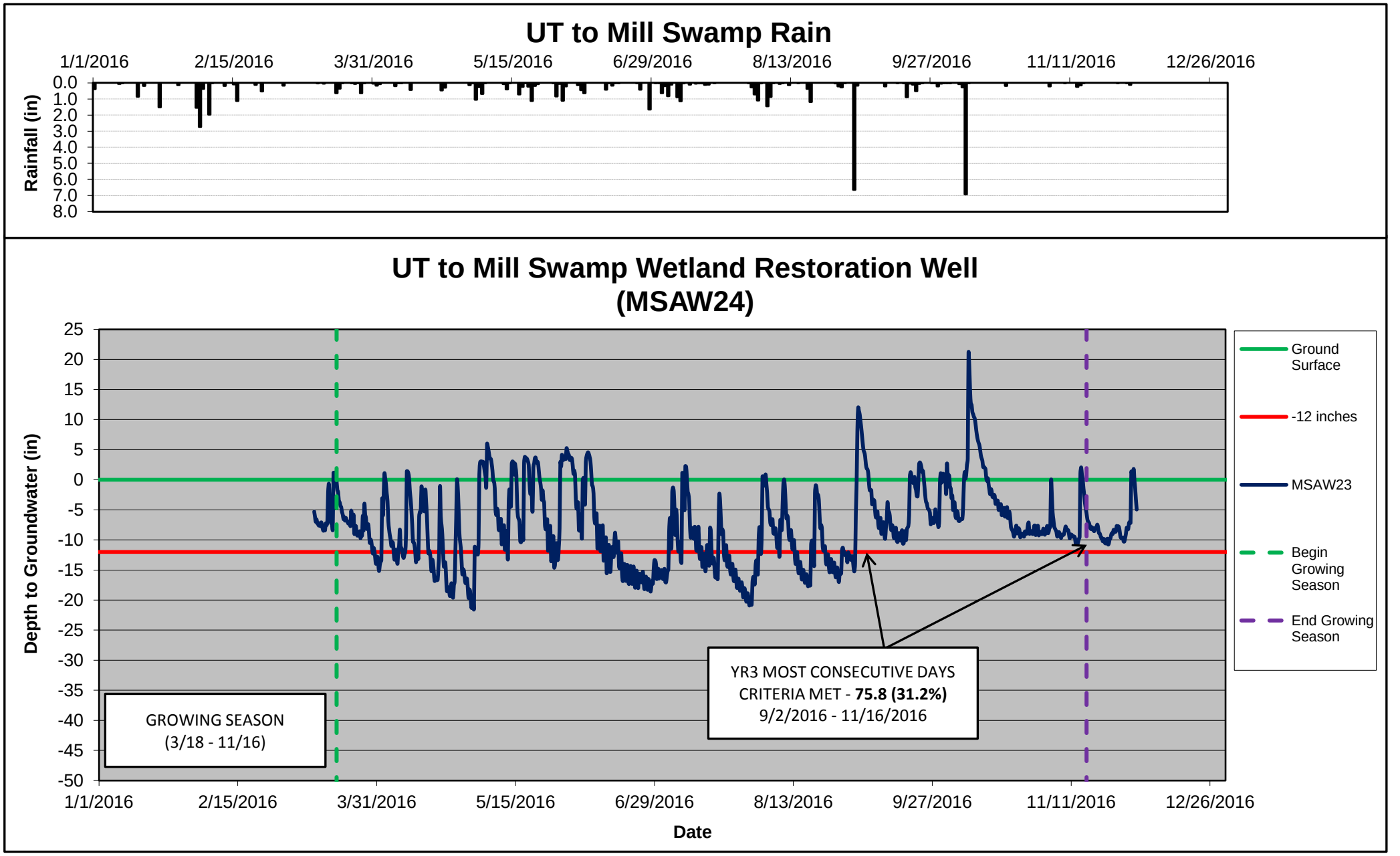

UT to Mill Swamp Rain
1/1/2016
2/15/2016
3/31/2016
5/15/2016
6/29/2016
8/13/2016
9/27/2016
11/11/2016
12/26/2016
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
6.0
7.0
8.0
UT to Mill Swamp Wetland Restoration Well
(MSAW24)
Depth to Groundwater (in)
25
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW23
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR3 MOST CONSECUTIVE DAYS
CRITERIA MET - 75.8 (31.2%)
9/2/2016 - 11/16/2016
Date

Table 13. Flow Gauge Success
St. Clair Creek Restoration Project: DMS Project ID No. 95019

Well ID	Consecutive Days of Flow[1]	Cumulative Days of Flow[2]
UT1a Flow Gauge		
MSFL1	59.0	187.0
UT1b Flow Gauge		
MSFL2	105.0	231.0

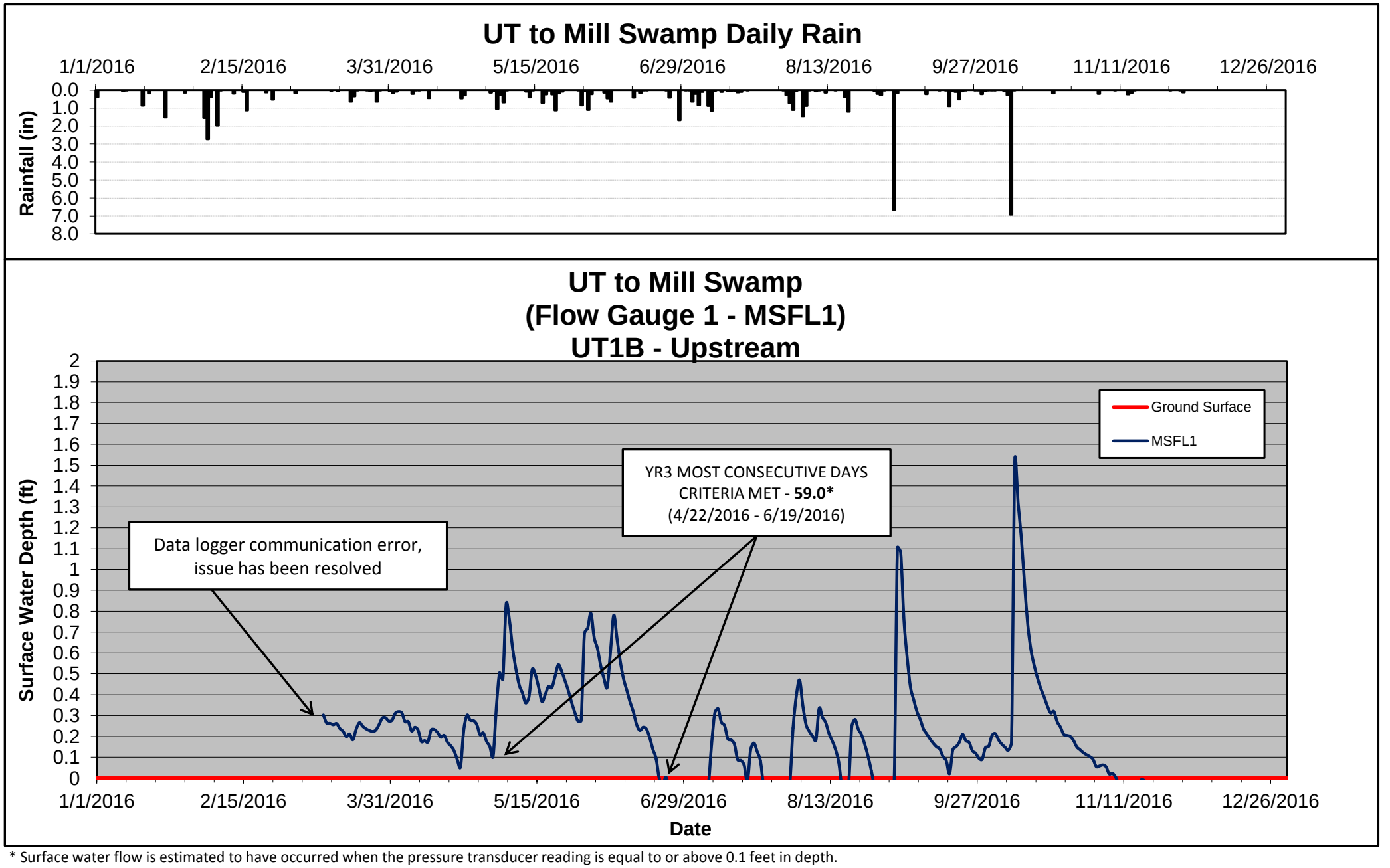
Notes:

[1]Indicates the number of consecutive days within the monitoring year where flow was measured.

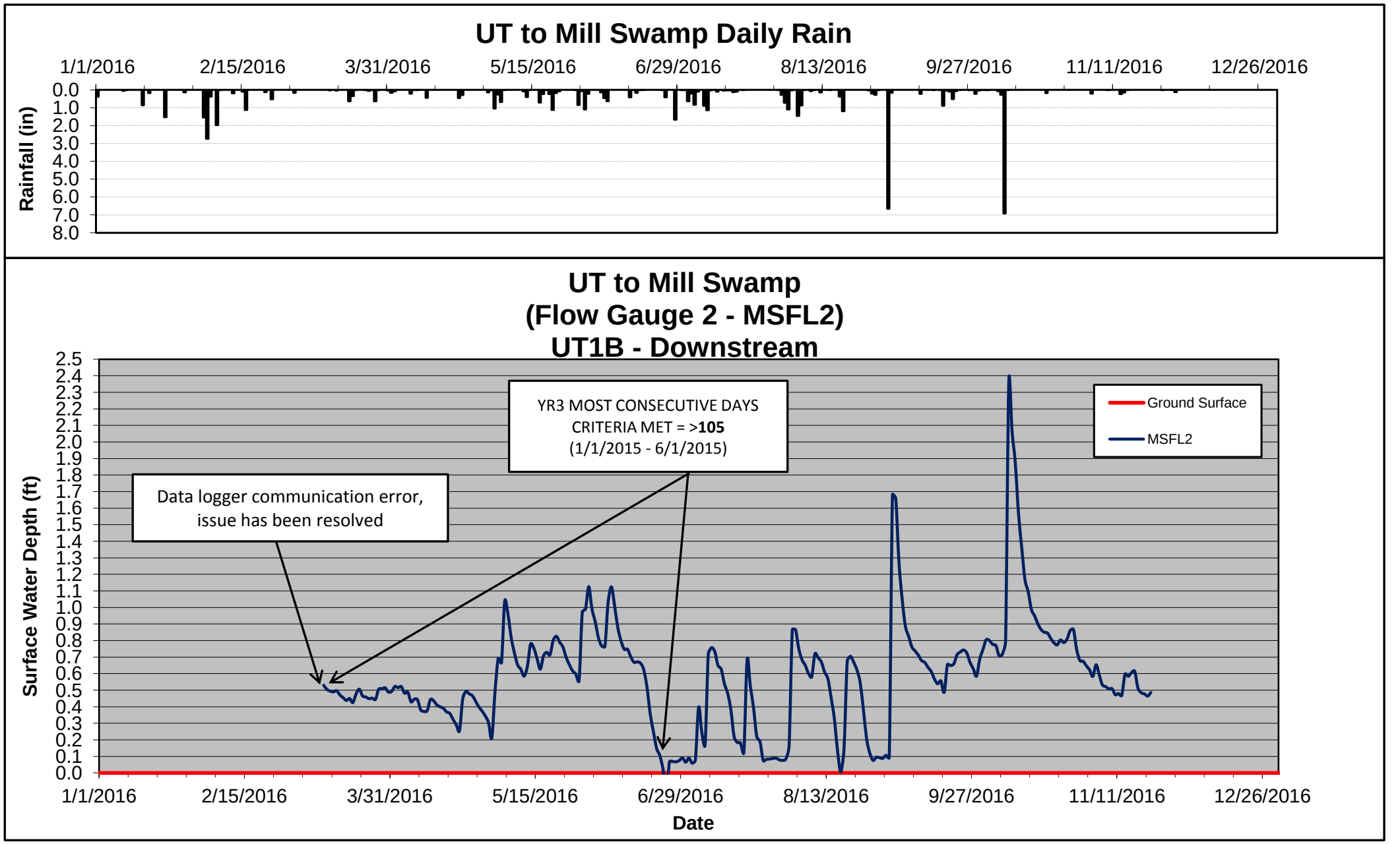
[2]Indicates the number of cumulative days within the monitoring year where flow was measured.

Flow success criteria for the Site is stated as: A surface water flow event will be considered perennial when the flow duration occurs for a minimum of 30 days.

2016 flow data reported is 3/10/2016 to 12/2/2016. Data from loggers before 3/10/2016 was not retreivable from data loggers due to an unkown logging issue. Logging issue has been resolved.



* Surface water flow is estimated to have occurred when the pressure transducer reading is equal to or above 0.1 feet in depth.



* Surface water flow is estimated to have occurred when the pressure transducer reading is equal to or above 0.1 feet in depth.

Figure 6. Observed Rainfall versus Historic Average

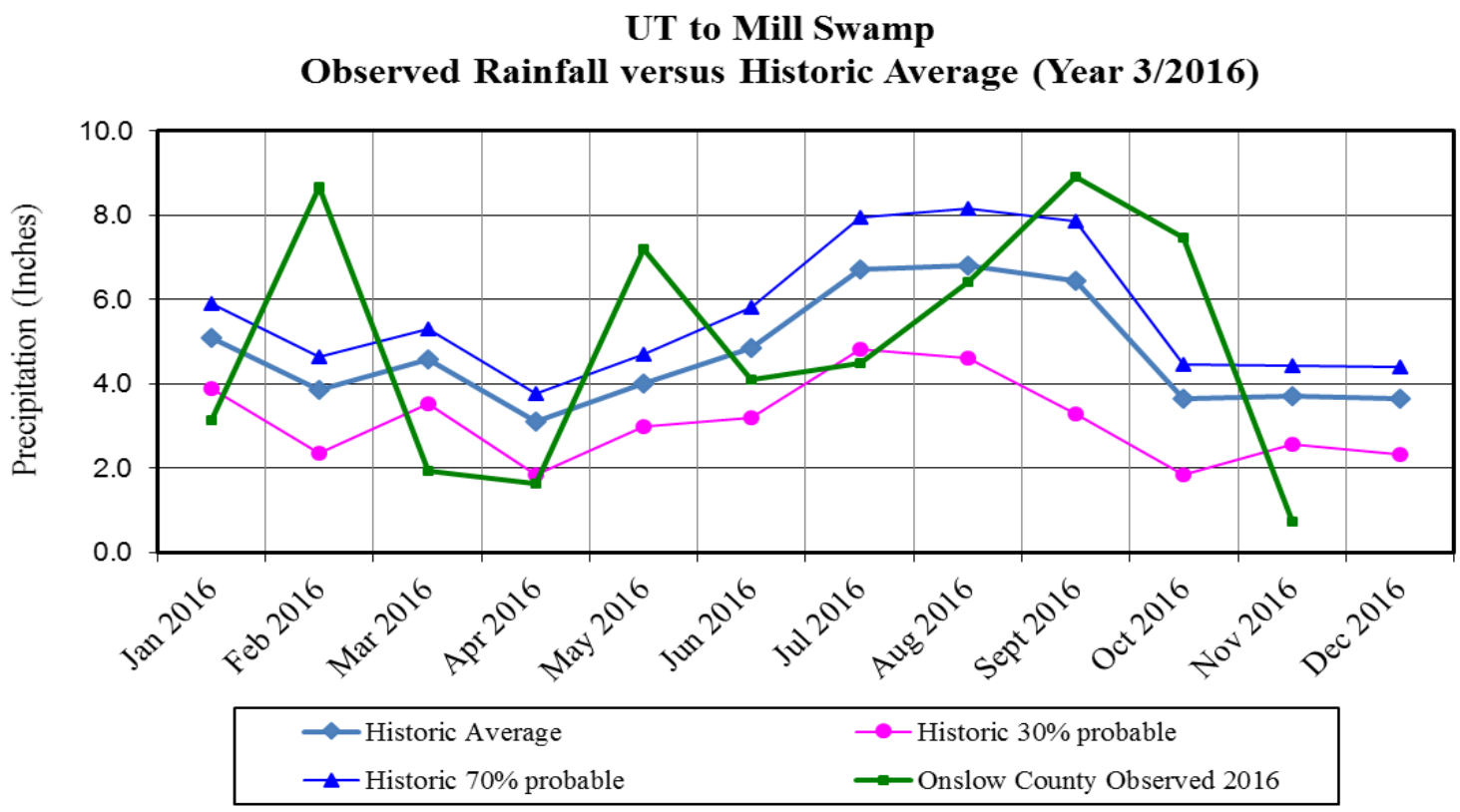


Table 14. Verification of Bankfull Events
UT to Mill Swamp Restoration Project: DMS Project No. 95019

Date of Data Collection	Estimated Occurrence of Bankfull Event	Method of Data Collection	M3 Crest (feet)
Year 1 (2013)			
10/16/2013	10/11/2013	Crest Gauge	0.17
12/24/2013	12/15/2013	Crest Gauge	0.19
Year 2* (2014)			
3/27/2014	3/7/2014	Crest Gauge	0.32
10/14/2014	8/4/2014	Crest Gauge	0.56
12/19/2014	11/26/2014	Crest Gauge	0.27
Year 2 (2015)			
1/24/2015	1/24/2015	Crest Gauge	0.59
4/27/2015	2/26/2015	Crest Gauge	1.07
6/23/2015	5/11/2015	Crest Gauge	1.61
11/12/2015	10/3/2015	Crest Gauge	1.54
Year 3 (2016)			
3/10/2016	2/5/2016	Crest Gauge	1.44
11/22/2016	10/8/2016 (Hurricane Matthew)	Crest Gauge	2.32