UT to Mill Swamp Restoration Project
Seventh Monitoring Measurement
Sixth Year of Credit Release - Final

Onslow County, North Carolina

DMS Project ID Number – 95019, DEQ Contract No. 003992

USACE Action ID: SAW-2011-02193, DWR# 20120916

Project Info:	Credit Release Year: 6 of 7 (Seventh site monitoring since construction) Year of Data Collection: 2019 Year of Completed Construction: 2013 Submission Date: February 2020
Submitted To:	NCDEQ – Division of Mitigation Services 1652 Mail Service Center Raleigh, NC 27699-1652

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NCDMS Project ID Number – 95019, DEQ Contract No. 003992

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Report Prepared and Submitted by Michael Baker Engineering, Inc.

NC Professional Engineering License # F-1084

Michael Baker
INTERNATIONAL

Mitigation Project Name	**UT to Mill Swamp Restoration Project**	**County**	**Onslow**	**USACE Action ID**	2011-02193
DMS ID	**95019**	**Date Project Instituted**	**7/18/2011**	**NCDWR Permit No**	2012-0916
River Basin	**White Oak**	**Date Prepared**	**7/15/2019**		
Cataloging Unit	**03030001**				

Credit Release Milestone	Stream Credits						Wetland Credits							
	Scheduled Releases (Stream)	Warm	Cool	Cold	Anticipated Release Year (Stream)	Actual Release Date (Stream)	Scheduled Releases (Forested)	Riparian Riverine	Riparian Non-riverine	Non-riparian	Scheduled Releases (Coastal)	Coastal	Anticipated Release Year (Wetland)	Actual Release Date (Wetland)
Potential Credits (Mitigation Plan)		**3,921.000**						**4.000**						
Potential Credits (As-Built Survey)		**4,006.000**						**4.000**						
Potential Credits (IRT Approved)		**3,909.000**						**4.000**						
1 (Site Establishment)	**N/A**				N/A	N/A	**N/A**				**N/A**		N/A	N/A
2 (Year 0 / As-Built)	**30%**	1,201.800			2013	3/21/2014	**30%**	1.200			**N/A**		2013	3/21/2014
3 (Year 1 Monitoring)	**10%**	400.600			2014	4/23/2015	**10%**	0.400			**N/A**		2014	4/23/2015
4 (Year 2 Monitoring)	**10%**	400.600			2015	4/27/2016	**10%**	0.400			**N/A**		2015	4/27/2016
5 (Year 3 Monitoring)	**10%**	390.900			2016	10/20/2017	**5%**	0.200			**N/A**		2016	10/20/2017
IRT Adjustment*		-58.200				10/20/2017								
Unreleased wetland credits - Year 3 Monitoring							**5%**	0.200					2016	8/27/2018
6 (Year 4 Monitoring)	**5%**	195.450			2017	8/27/2018	**10%**	0.400			**N/A**		2017	8/27/2018
7 (Year 5 Monitoring)	**10%**	390.900			2018	4/26/2019	**10%**	0.400			**N/A**		2018	4/26/2019
8 (Year 6 Monitoring)	**5%**				2019		**10%**				**N/A**		2019	
9 (Year 7 Monitoring)	**10%**				2020		**10%**				**N/A**		2020	
Stream Bankfull Standard	**10%**	400.600			2016	4/27/2016	**N/A**				**N/A**			
Total Credits Released to Date		**3,322.650**						**3.200**						

NOTES:

10/20/2017: *NOTE: Adjustment required due to IRT concerns on how the as-built credits were calculated

CONTINGENCIES:

Signature of Wilmington District Official Approving Credit Release

27 Sept 2019

Date

1 - For DMS, no credits are released during the first milestone

2 - For DMS projects, the second credit release milestone occurs automatically when the as-built report (baseline monitoring report) has been made available to the NCIRT by posting it to the NCEEP Portal, provided the following criteria have been met:

1) Approval of the final Mitigation Plan
2) Recordation of the preservation mechanism, as well as a title opinion acceptable to the USACE covering the property
3) Completion of all physical and biological improvements to the mitigation site pursuant to the mitigation plan
4) Reciept of necessary DA permit authorization or written DA approval for porjects where DA permit issuance is not required

3 - A 10% reserve of credits is to be held back until the bankfull event performance standard has been met

Mitigation Project Name	**UT to Mill Swamp Restoration Project**	**County**	**Onslow**	**USACE Action ID**	2011-02193
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River Basin	**White Oak**	**Date Prepared**	**7/15/2019**		
Cataloging Unit	**03030001**				

DEBITS (released credits only)

			Ratios	1	1.5	2.5	5	1	3	2	5	1	3	2	5	1	3	2	5
				Stream Restoration	Stream Enhancment I	Stream Enhancement II	Stream Preservation	Riparian Restoration	Riparian Creation	Riparian Enhancement	Riparian Preservation	Nonriparian Restoration	Nonriparian Creation	Nonriparian Enhancement	Nonriparian Preservation	Coastal Marsh Restoration	Coastal Marsh Creation	Coastal Marsh Enhancement	Coastal Marsh Preservation
IRT Approved As-Built Amounts (feet and acres)				**3,509.000**	**600.000**			**4.000**											
IRT Approved As-Built Amounts (mitigation credits)				**3,509.000**	**400.000**			**4.000**											
Percentage Released				**85.000%**	**85.000%**			**80.000%**											
Released Amounts (feet / acres)				**2,982.650**	**510.000**			**3.200**											
Released Amounts (credits)				**2,982.650**	**340.000**			**3.200**											
NCDWR Permit	USACE Action ID	Project Name																	
2010-0396	2008-02353	Carolina Plantations		229.600															
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		852.200	180.000														
	2010-00436	Camp Lejeune Base Entry Point & Road Modifications						0.240											
2012-0270	2010-01797	Hangar P683P687 & Airfield Roads, NCAS New River						0.960											
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		334.600															
	2010-00436	MCB Camp Lejeune Base Entry Road		26.000	60.000														
2012-0270	2010-01797	Hangar P683P687 & Airfield Roads, NCAS New River						0.280											
2010-0197	2013-02113	Camp Lejeune Base Entry Point and Florence Road Bridge Replacement						0.120											
2011-0309	2011-00666	Onslow Quarry Access-Martin Marietta Materials		160.000															
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		200.600	60.000														
2010-0197	2013-02113	Camp Lejeune Base Entry Point and Florence Road Bridge Replacement						0.180											
2007-0245	2007-00286-067	Marine Corps Special Operations Command 2nd phase		16.000															
2010-0396	2008-02353	Carolina Plantations		144.000															
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		493.300	120.000														
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		175.450	30.000														
2010-0197	2010-00436	MCB Camp Lejeune Base Entry Road		11.850															
2012-0270	2010-01797	Hangar P683P687 and Airfield Roads, NCAS New River		339.050	60.000														

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DMS ID	**95019**	**Date Project Instituted**	**7/18/2011**	**NCDWR Permit No**	2012-0916
River Basin	**White Oak**	**Date Prepared**	**7/15/2019**		
Cataloging Unit	**03030001**				

Remaining Amounts (feet / acres)	**0.000**	**0.000**			**1.420**											
Remaining Amounts (credits)	**0.000**	**0.000**			**1.420**											

Michael Baker
INTERNATIONAL

Innovation Done Right...We Make a Difference

February 4, 2020

Jeremiah Dow
Project Manager
NCDEQ Division of Mitigation Services
1652 Mail Service Center
Raleigh, NC 27699-1652

Subject: Task 12: Response Letter to DMS review comments regarding the Draft Year 6 Monitoring Report for the UT to Mill Swamp Restoration Project (#95019)
White Oak River Basin – CU#03030001, Onslow County, North Carolina
DEQ Contract No. 003992, Baker No. 124578

Mr. Dow,

As per your request, please find enclosed one hardcopy of the Final Year 6 Monitoring Report and our responses to your review comments received on February 3, 2020 regarding the UT to Mill Swamp Restoration Project located in Onslow County, NC. We will also provide a secure ftp link with which to download the final updated digital files based on the comments.

1. Digital drawings:
   a. The following stream centerline GIS shapefiles do not match reported assets in the credit table: Reach UT1B (2,079 lf in shapefile, 1,996 lf in the Table) and Reach UT1A (613 lf in the shapefile, 600 lf in the Table). Please provide DMS with features that accurately capture the assets reported in the "Restoration Footage or Acreage" column of Table 1.

   Response: The revised stream centerline shapefile is included in the final e-submission files. It matches with the reported assets found in Table 1 for Reach UT1a (both 600 lf) and for UT1c (both 1,513 lf). However, it had previously been determined by DMS and the IRT in Year 4 that the length of Reach UT1b should be calculated using valley length as it is a headwater channel system, not by stream centerline as per our survey. DMS accepted a valley length of 1,996 ft for this reach, which determined the approved stream credit total of 3,909 ft. Thus, this GIS shapefile for UT1b created from survey data used to build the as-built plan sheets and cited in the as-built report will not match the asset table. But his is not due to an error or fault in the shapefile, but rather to a change in how the reach length was calculated. In Year 4, a note was added at the bottom of Table 1 to explain the change from previous monitoring reports and the stationing data for UT1b in the table shows the original length calculation that *does* match the GIS shapefile.

2. Cover Page: Please change the word “Permits:” to USACE Action ID.

   Response: Revision made as requested.

3. Appendix B
   a. Figure 2A: Please label the photo points with their assigned numbers.
   b. Figure 2B: Please add the gauges colored yellow to the legend.
   c. It would be helpful to indicate the location of Flow Camera #1 on the CCPV.

   Response: Revisions made as requested.

If you have any questions or require additional information, please feel free to contact me at 919-481-5731 or via email at Scott.King@mbakerintl.com.

Sincerely,

Scott King, LSS, PWS

Enclosures

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* Note: The figures and tables marked above with an asterisk are not included as part of this Year 6 Monitoring Report, but were left listed in the Table of Contents to explain the otherwise out-of-sequence figure/table numbering and appendix designations. For clarity, Michael Baker wishes to preserve the continuity of the labeling for these features between monitoring years to avoid confusion (e.g. to allow Appendix C to always contain vegetation data, and Table 13 to always be the flow gauge success table, etc. in each monitoring report). These figures and tables had been included in past reports and will be included again as part of the Year 7 monitoring report for 2020.

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 total planted acreage was approximately 15.2 acres, and the permanent conservation easement is 19.6 acres. 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) 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 3-foot bare roots installed in the area around Vegetation Plot 3 only – March 20, 2017

Year 4 (2017) vegetation assessment was conducted in October of 2017, but no formal monitoring plot data is required to be collected as part of Year 4 monitoring effort.

Year 5 (2018) vegetation monitoring – 10/30/18

Year 6 (2019) vegetation assessment was conducted in October and December of 2019, but no formal monitoring plot data is required to be collected as part of Year 6 monitoring effort.

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*.

In accordance with the Mitigation Plan and the DMS guidance document "Monitoring Requirements and Performance Standards for Stream and/or Wetland Mitigation" dated 11/7/2011, no formal vegetation plot monitoring was performed, nor were any stream cross-sectional surveys conducted as part of this Year 6 monitoring effort. A visual assessment of these project features is emphasized this year, with the full vegetation plot and cross-section survey work to resume for the Year 7 monitoring in 2020.

The Year 6 visual monitoring of the Site indicate that it is geomorphically stable and performing at 100 percent for the all stream morphology parameters evaluated (Table 5a). There are no unstable beds, banks, or structures, and there are no Stream Problem Areas (SPA) to report. Cross-section survey work will again be conducted for the MY7 report in 2020.

During Year 6 monitoring, the planted acreage performance categories were functioning at 100 percent with no bare areas to report, no current low stem density areas, and no areas of poor growth rates. The formal vegetation plot data monitoring will again be conducted for the MY7 report in 2020.

Invasive species areas of concern were observed and documented during Year 6 monitoring. Two areas of scattered Chinese privet (*Ligustrum sinense*) re-sprouts totaling 0.96 acres were discovered in portions of the floodplain along both banks of the middle and lower sections of Reach UT1c. They are identified as a Vegetation Problem Area (VPA) in Table 6b and will be treated as soon as temperatures are appropriate for spraying. Much of the VPA area on the left bank had previously been treated for privet in March of 2019. The exact locations of these areas are shown on the CCPV.

During Year 6 monitoring, groundwater monitoring demonstrated that nine of the fifteen 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, MSAW2, MSAW3, MSAW4, MSAW5, MSAW6, MSAW8, MSAW9, and MSAW19) demonstrated consecutive hydroperiods of 12 percent or greater, and ranged from 13.5 to 38.1 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 4.5 to 9.4 percent of the growing season. As a reminder, with IRT approval during a field visit on 5/1/18, wells MSAW3 and MSAW7 were relocated on 6/7/18 to more useful monitoring locations as they had previously been located in areas located *outside* of the wetland restoration and hydric soils boundary in the adjacent upland area. For Year 6 monitoring, MSAW3 passed with 13.5%, while MSAW7 did not pass, but did achieve 9.4% (23 days), which is nevertheless a significant length of time.

Year 6 flow monitoring demonstrated that flow gauge MSFL1 (on upper UT1b) met the stated success criteria of 30 days or more of flow through upper UT1b with 78 days of consecutive flow and 170 days of total cumulative flow. The gauge demonstrated similar patterns relative to rainfall events for the Site. As reported last year, flow gauge MSFL2 (on lower UT1b) unexpectedly and permanently failed during the winter of 2017/2018. It will not be replaced as it had already met the required project success criteria in each of its previous monitoring years with consecutive flow lengths of 35, 131, 152, 105, and 164 days, along with cumulative yearly flow totals of 79, 327, 186, 231, and 243 days (see Table 13). Thus, this gauge has already significantly exceeded the required success criteria of documenting two separate flow events within the project monitoring period. Flow data for this reach will continue to be collected for the remaining project monitoring period from gauge MSFL1 alone (located on upper UT1b). All flow data collected during Year 6 monitoring are located in Appendix E.

The Site was also found to have had at least one above-bankfull event based on the crest gauge reading (and confirmed with flow gauge data) during Year 6 monitoring. The recorded event was measured to be 2.10 feet above bankfull and was associated with a significant storm on 9/5/19.

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 Requirements and Performance Standards for Stream and/or Wetland Mitigation* guidance document dated 11/7/11 (NCDMS 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 final Year 6 monitoring gauge data were collected in December 2019. All visual site assessment data located in Appendix B were collected in December 2019 as well.

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 for the purpose of collecting headwater research data for these upper reach sections. The automated loggers are programmed to collect data at 6-hour intervals to record groundwater levels in UT1a and UT1b areas. Graphs of the groundwater data collected for these gauges during Year 6 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 gauge MSFL2 (on lower UT1b) permanently failed during the winter of 2017/2018 and was not replaced as it had already met the required project success criteria in each previous monitoring year. Flow data for this reach will continue to be collected for the remaining project monitoring period from gauge MSFL1 alone (located on upper UT1b). All flow data collected during Year 6 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 taken at established reference stations are found 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 is 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

A longitudinal profile was surveyed for the entire length of channel immediately after construction to document as-built baseline monitoring conditions (Year 0) 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.

As per the Mitigation Plan and DMS monitoring guidance for this project, no cross-section survey data were collected for this Year 6 Monitoring assessment. Consequently, none of the cross-sectional survey graphs (Figure 5) or morphology data (Table 11) are presented in Appendix D as in previous monitoring reports. This data will again be included as part of the Year 7 report in 2020.

2.2.2 Hydrology

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. In MY6, at least one above-bankfull event associated with a significant storm event was documented by the crest gauge and confirmed by the flow gauge readings. All crest gauge reading data are presented in Appendix E and gauge photographs are presented in Appendix B.

2.2.3 Photographic Documentation

Representative project photographs for MY6 were taken at the previously established photograph reference stations located along the enhanced and restored stream sections and are presented 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 6 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. All stream reaches appear stable and functioning. All stream beds are vertically stable, the pools are maintaining depth, stream banks are stable and vegetating, and in-stream structures are physically intact

and performing as designed. No Stream Problem Areas (SPAs) were documented during Year 6 monitoring. 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.

2.3 Wetland Assessment

Following construction, ten automated groundwater monitoring wells were installed in the UT1c wetland restoration area following USACE protocols (USACE 2005). The gauges themselves are all In-Situ brand Rugged Troll 100 data loggers. An additional six monitoring wells were installed in the spring of 2016 in the left floodplain of UT1c for a more detailed evaluation there. During an IRT site visit on 5/1/18, it was suggested that two of the wells (MSAW3 and MSAW7) originally located on, or just outside, the wetland boundary line be relocated to help confirm restored wetland areas elsewhere in the floodplain. As such, in June 2018 those two wells were relocated to the suggested areas as shown in the CCPV found in Appendix B. Also, during Year 5 monitoring, the gauge at well MSAW10 unexpectedly and permanently failed in the summer of 2018. Given that it had never passed the success criteria hydroperiod requirement, it will not be replaced at this stage of the project. Graphs of the groundwater data collected from each well during Year 6 monitoring are found in Appendix E.

Total observed rainfall at the Albert Ellis airport (KOAJ) weather station located near Richlands, NC for the previous 12-month period from December 2018 through November 2019 was 43.8 inches. The WETS table for Hoffman Forest station (NC4144) in Onslow County was used to calculate the 30-year average for that same 12-month period and documents an average of 56.5 inches of rainfall, with an historic 30% probable of 51.9 inches and an historic 70% probable of 60.5 inches. Thus, the site appears to have gone below the 30% probable by 8.1 inches. In fact, much of the county was under a Stage D1 Moderate Drought from early May through early September. However, the fall of 2018 and early winter of 2018/2019 had been historically wet (in particular from Hurricane Florence, which dropped approximately 13 inches of rainfall on the site on September 15th alone). Additionally, the rainfall that the site did receive in the early portion of 2019 was evenly distributed, if overall less than normal.

2.4 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.

As per the Mitigation Plan and DMS monitoring guidance for this project, there was no formal vegetation plot monitoring conducted for the Year 6 monitoring effort, and thus no vegetation data summary tables are included in Appendix C as in previous monitoring reports. However, as reported in Table 6a (Appendix B), the planted acreage performance categories were functioning at 100 percent with no bare areas to report, no current low stem density areas, and no areas of poor growth rates. Vegetation plot data monitoring will again be conducted for the MY7 report in 2020.

Invasive species areas of concern were observed and documented during Year 6 monitoring. Two areas of scattered Chinese privet (*Ligustrum sinense*) re-sprouts totaling 0.96 acres were discovered in portions of the floodplain along both banks of the middle and lower sections of Reach UT1c. They are identified as a Vegetation Problem Area (VPA) in Table 6b and will be treated as soon as temperatures are appropriate for spraying. Much of the VPA area on the left bank had previously been treated for privet in March of 2019. The

exact locations of these areas are shown on the CCPV. No other areas of concern regarding the existing vegetation was observed along UT1a, UT1b or UT1c. All Year 6 vegetation assessment information and photographs are provided in Appendix B.

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.

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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.

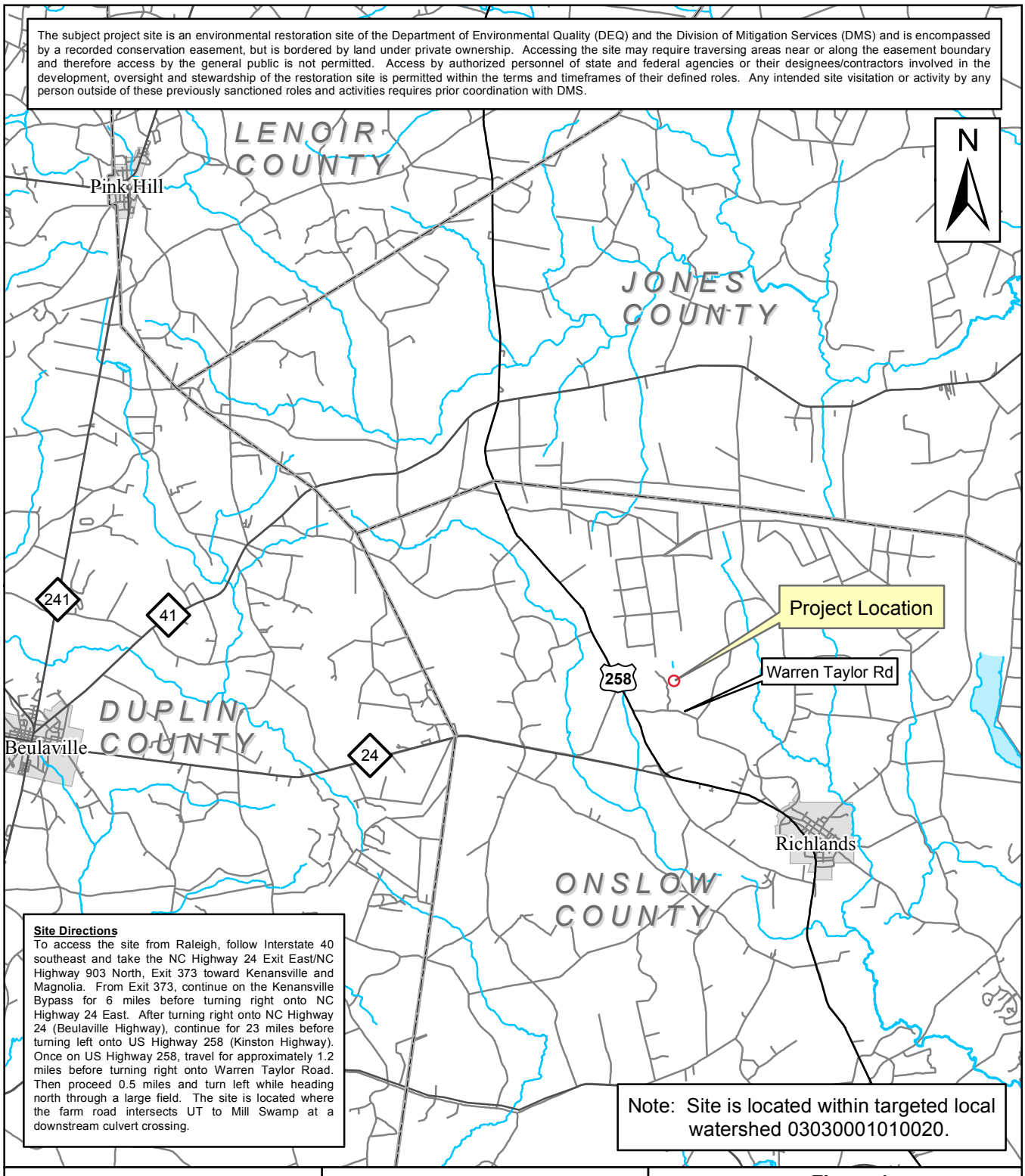
____. 2005. "Technical Standard for Water-Table Monitoring of Potential Wetland Sites," WRAP Technical Notes Collection (ERDC TN-WRAP-05-2), U.S. Army Engineer Research and Development Center. Vicksburg, MS.

____. 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

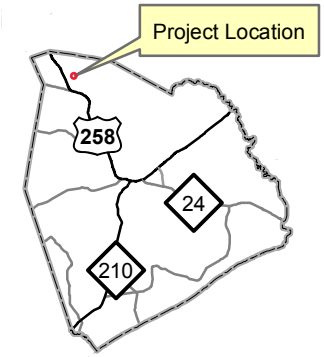


Figure 1
Project Vicinity Map
UT to Mill Swamp Site

DEQ -
Division of Mitigation Services

Michael Baker
INTERNATIONAL

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	3,909 SMU	4.0 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	1,996 SMU	1,996 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	4.0 WMU	4.0 AC	1:1

Component Summation

Restoration Level	Stream (LF)	Riparian Wetland (AC)		Non-riparian Wetland (AC)	Buffer (SF)	Upland (AC)
		Riverine	Non-Riverine			
Restoration	3,509	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

*Note: Credit calculations were originally calculated along the as-built thalweg but were revised starting in Monitoring Year 4 to be calculated along stream centerlines and valley length after discussions with the NC-IRT stemming from the April 3, 2017 Credit Release Meeting.

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	Jan-18
Year 5 Monitoring	Dec-18	Dec-18	Dec-18
Year 6 Monitoring	Dec-19	Dec-19	Jan-20
Year 7 Monitoring	Dec-20	N/A	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 (2019) will be considered Year 6. All references to Year 6 included in this report will indicate monitoring activities conducted during 2019. 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: Katie Mckeithan, Tel. (919) 481-5703
Construction Contractor	
River Works, Inc.	114 W. Main St. Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
Planting Contractor	
River Works, Inc.	114 W. Main St. Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
Seeding Contractor	
River Works, Inc.	114 W. Main St. Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
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	Scott King, Tel. 919-481-5731
Vegetation Monitoring Point of Contact	Scott King, Tel. 919-481-5731
Wetland Monitoring Point of Contact	Scott King, Tel. 919-481-5731

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

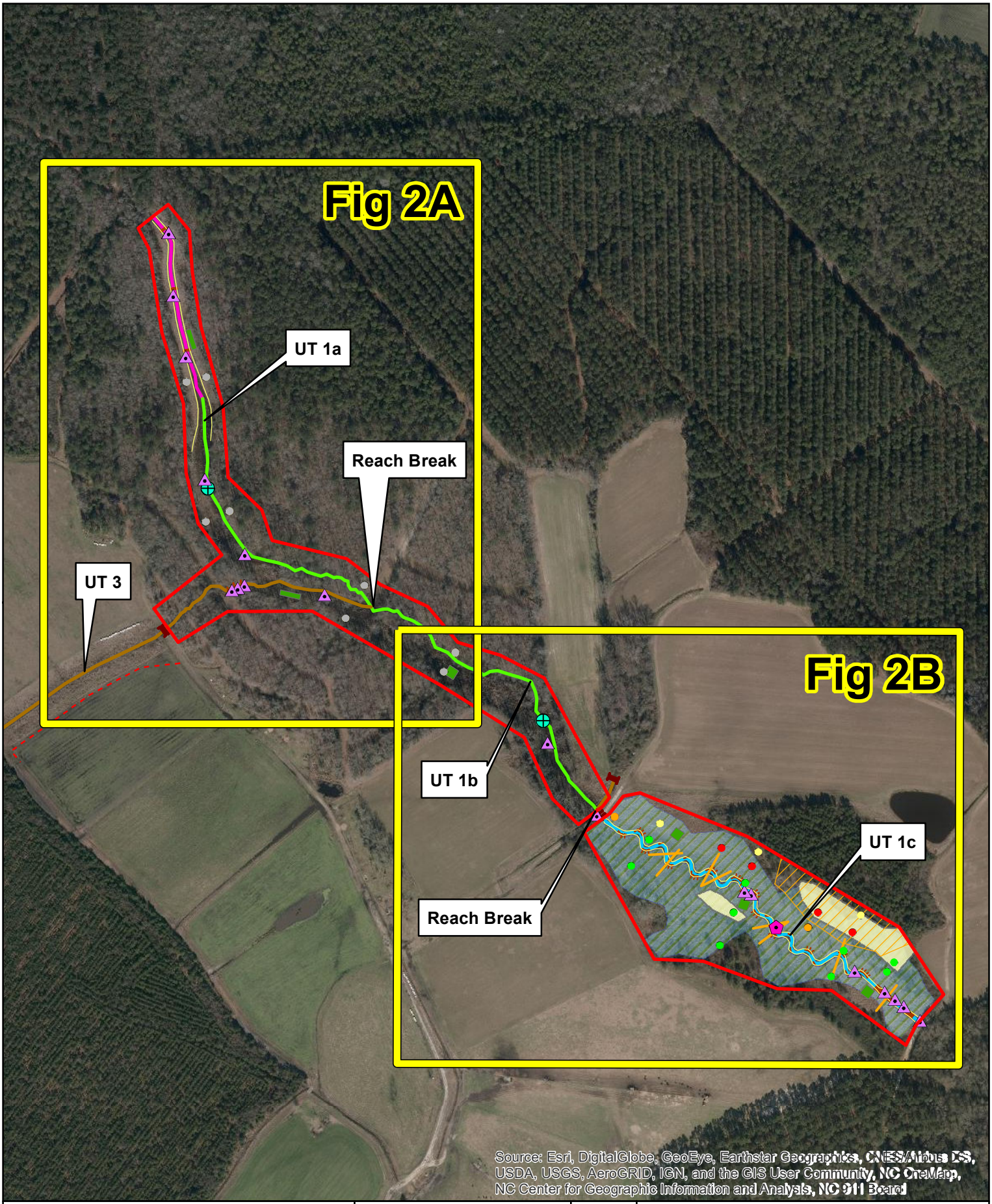
Project Information		
Project Name	UT to Mill Swamp Restoration Project	
County	Onslow	
Project Area (acres)	19.6	
Project Coordinates (latitude and longitude)	34.9377 N, -77.5897 W	
Watershed Summary Information		
Physiographic Province	Inner Coastal Plain	
River Basin	White Oak	
USGS Hydrologic Unit 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



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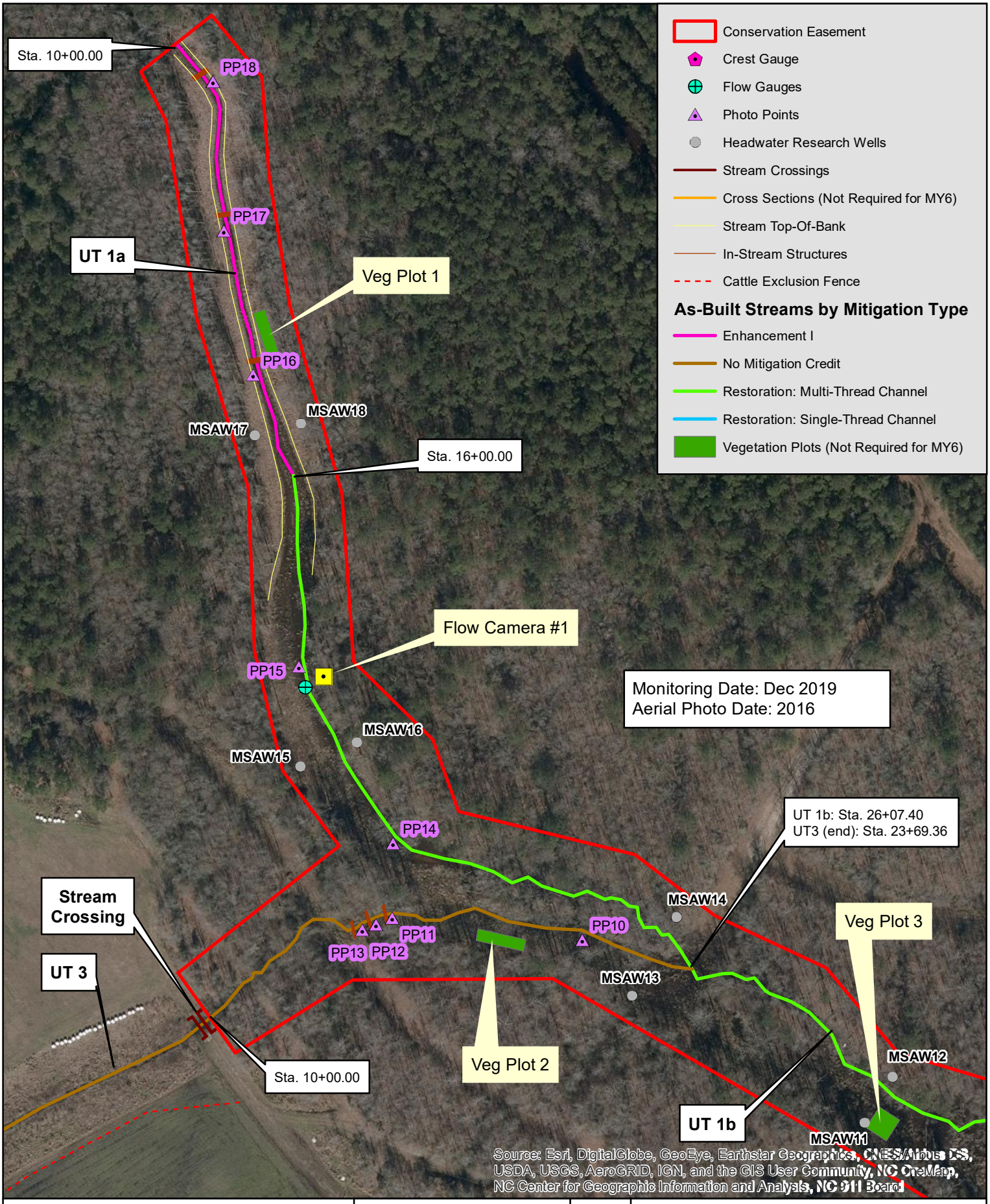
0 250 500 Feet

N

DMS Project # 95019

Figure 2 Index Map
Current Condition Plan View
Monitoring Year 6
UT to Mill Swamp Site



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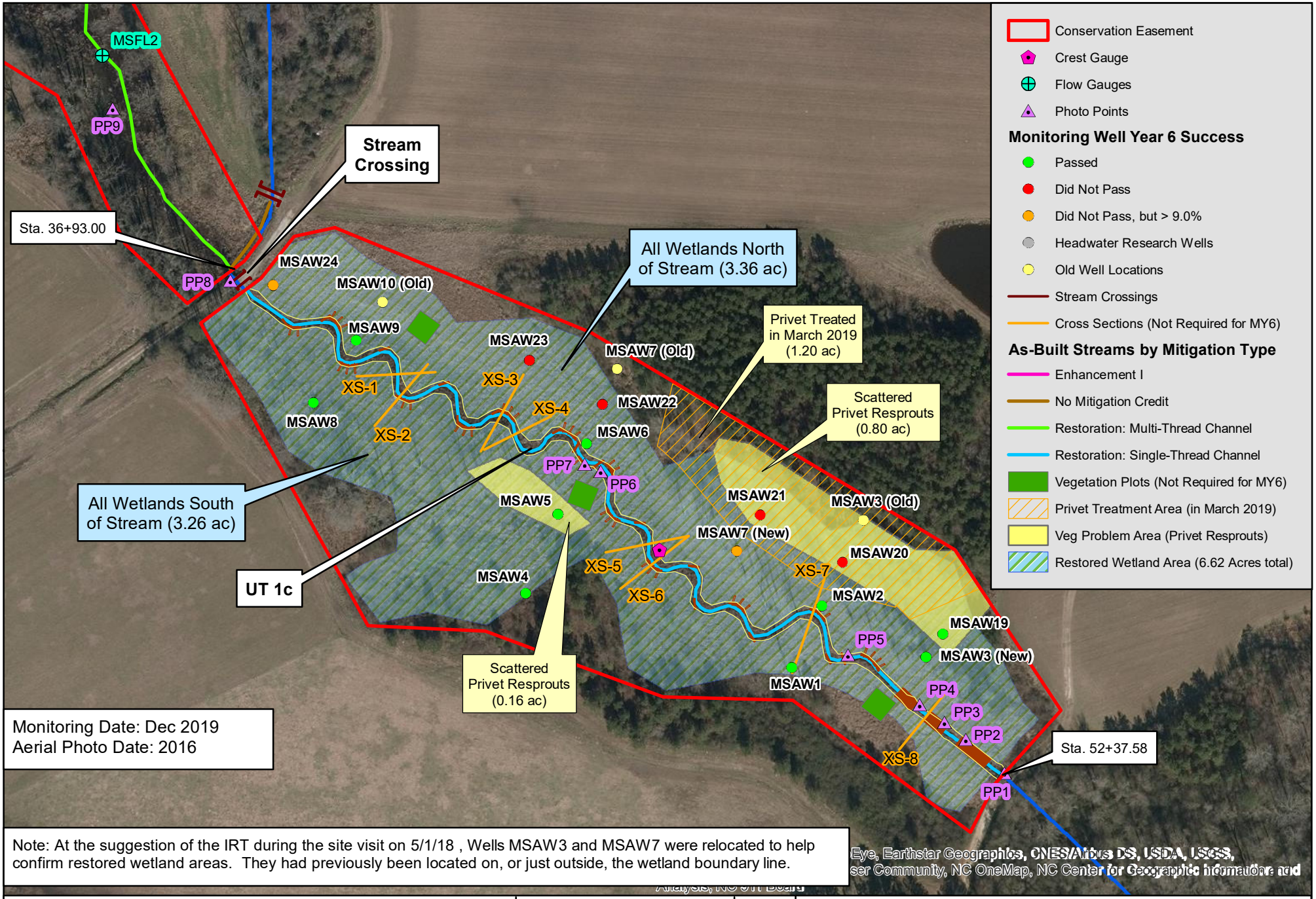
0 100 200 Feet

N

DMS Project # 95019

Figure 2A
Current Condition Plan View
Monitoring Year 6
UT to Mill Swamp Site



Note: At the suggestion of the IRT during the site visit on 5/1/18 , Wells MSAW3 and MSAW7 were relocated to help confirm restored wetland areas. They had previously been located on, or just outside, the wetland boundary line.

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0 100 200 Feet

N

DMS Project # 95019

Figure 2B
Current Condition Plan View
Monitoring Year 6
UT to Mill Swamp Site

Table 5a. Visual Stream 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**
N/A	N/A	N/A	N/A

Table 6a. Vegetation Conditions Assessment UT to Mill Swamp Restoration Project: EEP Project ID No. 95019						
Total Planted Acreage:	**15.2**					
Vegetation Category	**Defintions**	**Mapping Threshold (acres)**	**CCPV Depiction**	**Number of Polygons**	**Combined Acreage**	**% of Planted Acreage**
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	NA	0	0.00	0.0%
			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:	**19.6**					
Vegetation Category	**Defintions**	**Mapping Threshold**	**CCPV Depiction**	**Number of Polygons**	**Combined Acreage**	**% of Easement Acreage**
5. Invasive Areas of Concern	Areas of points (if too small to render as polygons at map scale)	1000 ft²	Yellow polygon	2	0.96	4.9%
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	Station Numbers / Location	Suspected Cause	Photos
Chinese privet (*Ligustrum sinense*)	Found scattered in the floodplain in sections of the middle right bank (~Station 44+00) and the lower left bank (~Stations 46+00 to 50+00) of UT1c. See CCPV for exact locations.	Re-sprouts	See Appendix B

UT to Mill Swamp: Stream Station Photographs (12/9/19)

Photo Point 1 – UT1c Upstream at Culvert

Photo Point 2 – Log Jam

Photo Point 3 – Log Weir/Log Jam

Photo Point 4 – Log Jam

Photo Point 5 – Log Jam

Photo Point 6 – UT1c Downstream

UT to Mill Swamp: Stream Station Photographs (12/9/19)

Photo Point 7 – UT1c Upstream

Photo Point 8 – UT1b Upstream

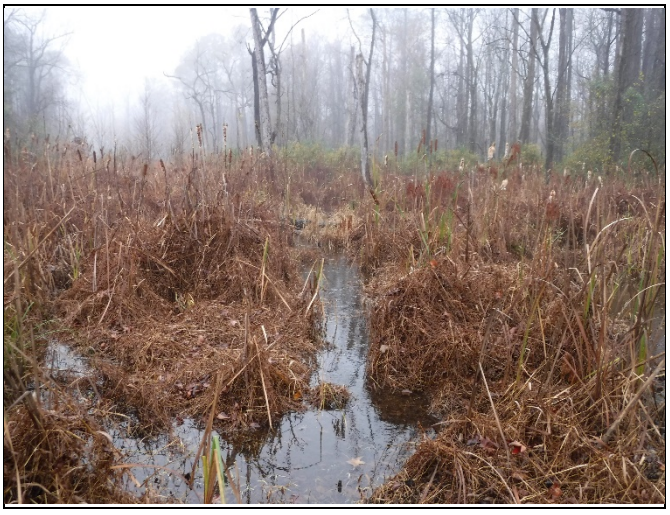


Photo Point 9 – UT1b at Flow Gauge #2

Photo Point 10 – UT3 above confluence

Photo Point 11 – UT3 Log Weir

Photo Point 12 – UT3 Log Weir

UT to Mill Swamp: Stream Station Photographs (12/9/19)

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

UT to Mill Swamp: Crest Gauge and Flow Camera Photographs

Crest gauge reading: 2.10 ft from 9/5/19 storm event

Close-up of crest gauge reading: 2.10 ft from 9/5/19 storm event

Debris and wrack lines in the floodplain from overbank event on UT-1a (photo from 12/6/19)

Debris and wrack lines in the floodplain from overbank event on UT-1b (photo from 12/6/19)

Flow Camera #1 on 2/28/19 (flow in channel)

Flow Camera #1 on 3/22/19 (flow in channel)

UT to Mill Swamp: Vegetation Problem Area Photographs

VPA (*Ligustrum sinense* resprouts) 12/6/19

VPA (*Ligustrum sinense* resprouts) 12/6/19

VPA (*Ligustrum sinense* resprouts) 12/6/19

VPA (*Ligustrum sinense* resprouts) 12/6/19

Appendix C

Vegetation Plot Data*

***No vegetation plot monitoring was required for Year 6**

Appendix D

Stream Survey Data*

***No cross-section stream survey monitoring was required for Year 6**

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 (ft^2)	-----	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 (ft^3)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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/f^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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 Data Summary (continuted)

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

Reach UT1c (1,513 LF)

Parameter	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 (ft^2)	-----	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/ft^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Max part size (mm) mobilized at bankfull (Rosgen Curve)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Stream Power (transport capacity) W/m^2	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
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 Data Summary (continued)
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Reach UT1c (1,513 LF)

Parameter	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

Appendix E

Hydrologic Data

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

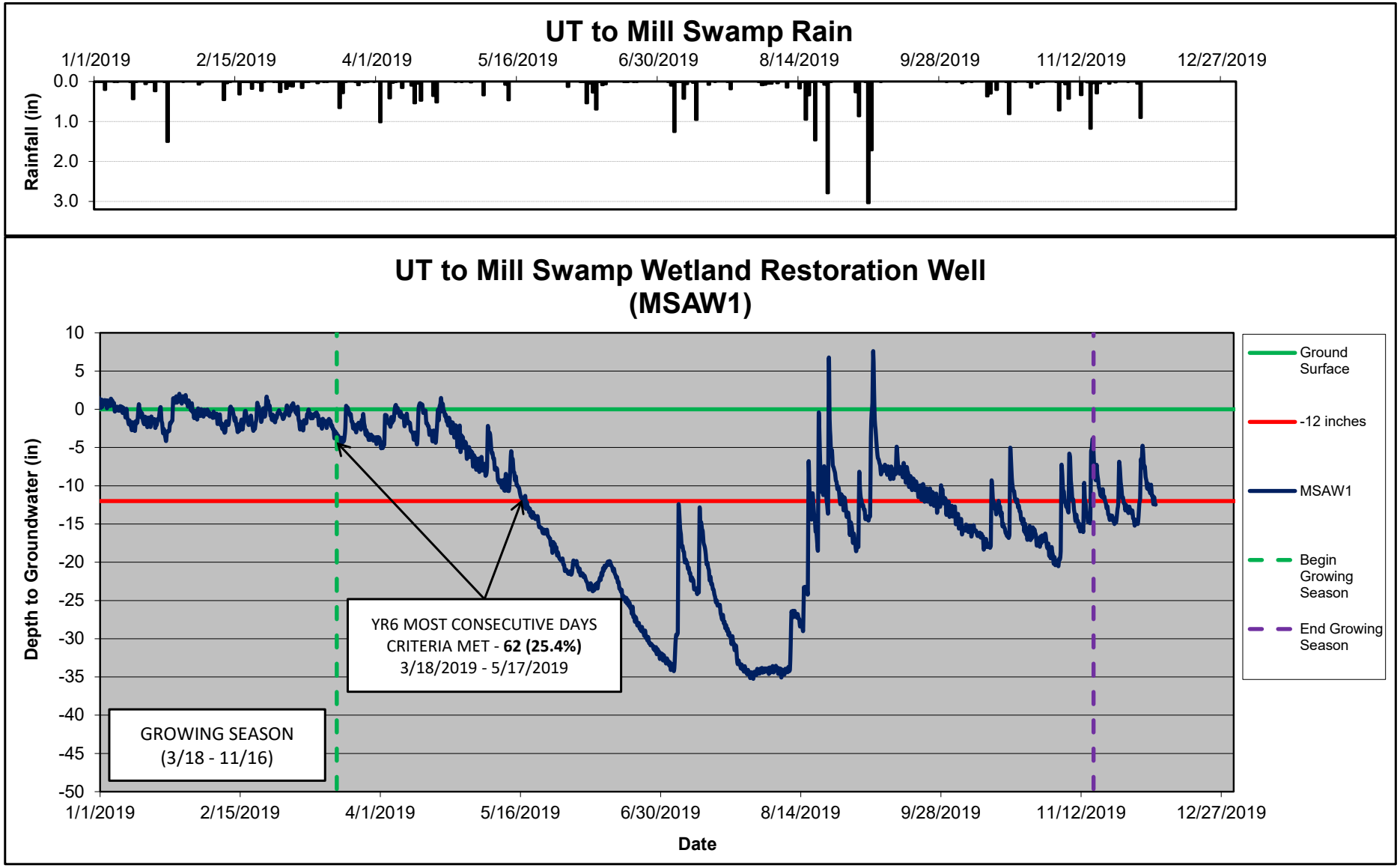
Well ID	Percentage of Consecutive Days <12 inches from Ground Surface[1]							Most Consecutive Days Meeting Criteria[2]							Percentage of Cumulative Days <12 inches from Ground Surface[1]							Cumulative Days Meeting Criteria[3]						
	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)
UT1c Cross-Sectional Well Arrays (Installed July 2013)																												
MSAW1	4.4	29.1	20.8	24.6	14.8	100.0	25.4	11	71	51	60	36	244	62	53.5	56.8	52.1	66.5	37.4	100.0	45.9	130	138	127	162	91	244	112
MSAW2	0.7	3.3	6.5	4.0	2.5	12.3	13.9	2	8	16	10	6	30	34	3.5	20.2	26.3	19.8	22.2	40.2	29.9	9	49	64	48	54	98	73
MSAW3†	0.0	0.3	0.6	0.6	0.4	13.1	13.5	0	1	2	2	1	32	33	0.0	1.0	2.1	0.8	0.4	27.9	21.3	0	3	5	2	1	68	52
MSAW4	10.3	27.8	36.4	31.2	46.1	100.0	24.6	25	68	89	76	112	244	60	97.0	74.2	61.0	83.4	80.2	100.0	61.1	236	180	148	203	195	244	149
MSAW5	3.3	21.2	19.7	31.1	25.1	23.4	20.1	8	52	48	76	61	57	49	40.5	51.9	51.6	58.3	52.7	91.4	45.5	98	126	126	142	128	223	111
MSAW6	1.1	3.8	7.0	4.2	10.7	15.2	14.8	3	9	17	10	26	37	36	9.5	23.3	28.3	19.7	24.3	67.6	32.4	23	57	69	48	59	165	79
MSAW7†	0.2	3.7	2.7	2.1	1.6	13.1	9.4	1	9	7	5	4	32	23	0.3	10.9	14.6	7.1	6.6	49.2	24.2	1	27	36	17	16	120	59
MSAW8	14.1	47.3	37.7	31.1	36.2	100.0	38.1	34	115	92	76	88	244	93	96.8	73.9	66.3	83.0	79.4	100.0	45.5	235	180	161	202	193	244	111
MSAW9	2.5	4.5	8.6	5.7	5.3	16.0	15.6	6	11	21	14	13	39	38	44.5	33.0	28.6	41.7	39.1	77.5	41.0	108	80	70	101	95	189	100
MSAW10[4]	0.0	0.6	5.3	2.1	4.9	5.3	--	0	2	13	5	12	13	--	0.0	1.1	13.1	16.8	30.5	20.9	--	0	3	32	41	74	51	--
Supplemental UT1c Monitoring Wells (Installed February/March 2016)																												
**MSAW19	--	--	--	8.7	12.8	19.3	13.9	--	--	--	21	31	47	34	--	--	--	43.8	42.4	66.0	30.7	--	--	--	107	103	161	75
**MSAW20	--	--	--	3.7	3.7	12.3	4.5	--	--	--	9	9	30	11	--	--	--	10.1	19.3	42.2	15.2	--	--	--	25	47	103	37
**MSAW21	--	--	--	3.7	10.7	12.7	7.0	--	--	--	9	26	31	17	--	--	--	12.7	17.7	48.4	21.7	--	--	--	31	43	118	53
**MSAW22	--	--	--	2.8	3.3	12.7	5.3	--	--	--	7	8	31	13	--	--	--	14.0	23.0	43.4	21.3	--	--	--	34	56	106	52
**MSAW23	--	--	--	3.1	9.5	12.7	5.3	--	--	--	8	23	31	13	--	--	--	23.7	32.5	52.0	24.6	--	--	--	58	79	127	60
**MSAW24	--	--	--	31.2	26.3	13.9	9.0	--	--	--	76	64	34	22	--	--	--	72.1	83.1	64.8	26.2	--	--	--	175	202	158	64
Headwater Research Cross-Sectional Well Arrays on UT1a and UT1b (Installed July 2013)																												
MSAW11	4.7	21.2	32.3	40.1	36.0	50.0	38.2	12	52	79	98	88	122	93	38.5	72.4	76.7	84.9	68.3	99.6	63.9	94	176	187	206	166	243	156
MSAW12	0.7	15.4	10.1	7.6	14.5	25.4	21.7	2	38	25	19	35	62	53	7.0	19.1	24.9	27.4	15.1	84.0	32.2	17	47	61	67	37	205	79
MSAW13	6.5	46.5	40.0	40.0	36.0	50.0	38.0	16	113	97	97	88	122	93	81.5	80.0	82.2	84.8	66.0	99.2	64.4	198	195	200	206	161	242	157
MSAW14	0.6	39.1	18.3	17.9	25.6	23.4	19.0	2	95	45	44	62	57	46	4.0	31.0	46.7	61.6	32.7	84.8	28.1	10	75	114	150	80	207	69
MSAW15	0.8	0.9	2.4	1.6	1.1	3.7	1.3	2	2	6	4	3	9	3	4.0	3.9	5.1	6.7	2.0	20.1	3.3	10	10	13	16	5	49	8
MSAW16	2.4	2.8	2.3	2.1	1.2	13.5	3.9	6	7	6	5	3	33	10	14.5	13.0	11.5	7.1	2.2	40.2	12.7	35	32	28	17	5	98	31
MSAW17	0.0	0.1	0.7	0.3	0.2	3.7	1.9	0	0	2	1	1	9	5	0.0	0.1	1.3	0.5	0.2	9.4	4.5	0	0	3	1	1	23	11
MSAW18	3.8	10.2	7.4	2.2	1.2	4.9	4.0	9	25	18	5	3	12	10	18.5	15.3	20.8	10.7	3.6	23.0	4.1	45	37	51	26	9	56	10

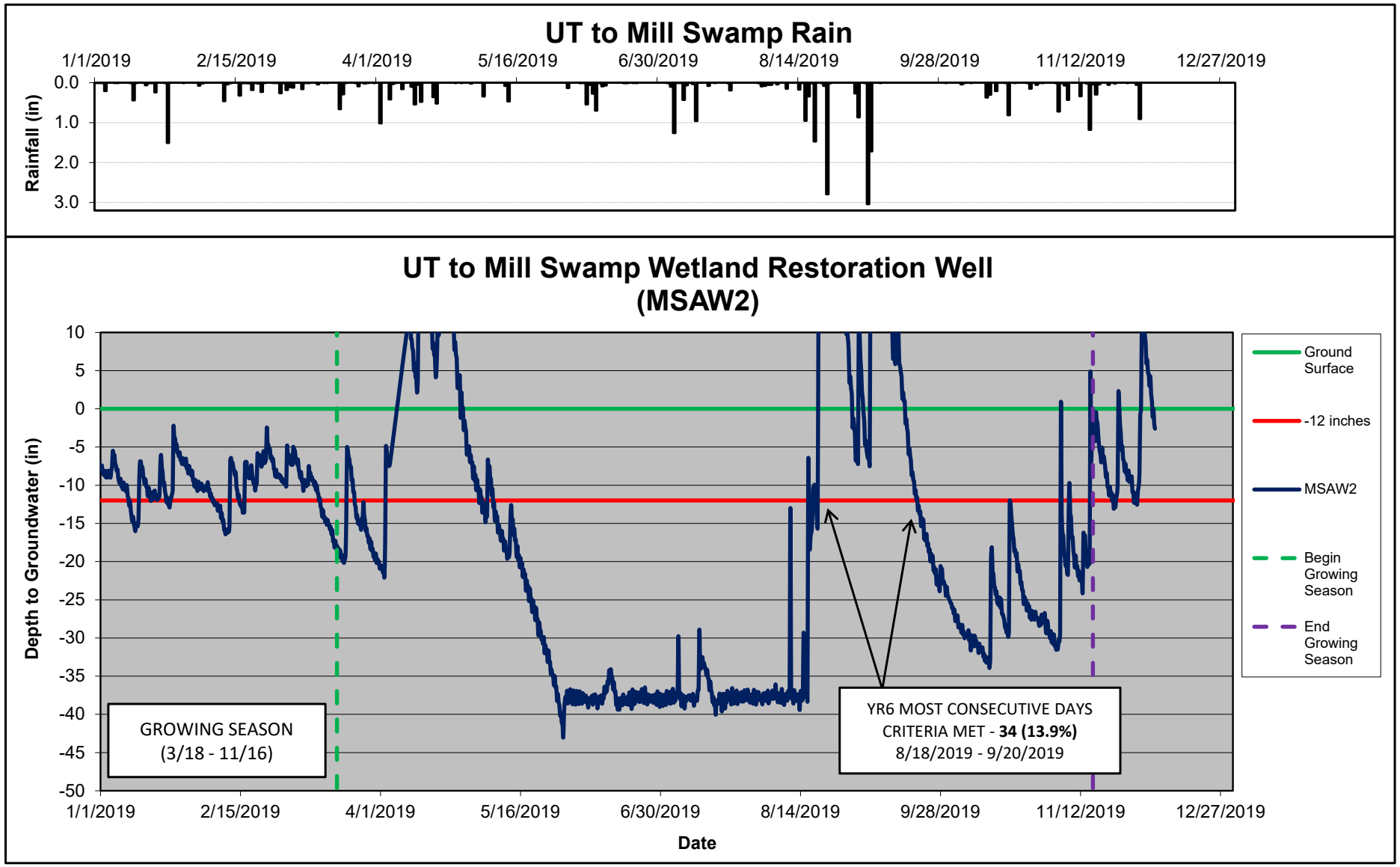
Notes:
[1]Indicates the percentage of the single greatest consecutive or cumulative number of days within the monitored growing season with a water 12 inches or less from the soil surface.
[2]Indicates the single greatest consecutive number of days within the monitored growing season with a water table 12 inches or less from the soil surface.
[3]Indicates the total cumulative number of days within the monitored growing season with a water table 12 inches or less from the soil surface.
[4]Well MSAW10 unexpectedly and permanently failed in the summer of 2018.
† Wells MSAW3 and MSAW7 were relocated on 6/7/18 as per IRT suggestion during a field visit on 5/1/18. See CCPV in Appendix B for new and previous locations.
The growing season for Onslow County is from March 18 to November 16 and is **244** days long. 12% of the growing season is **29** days.

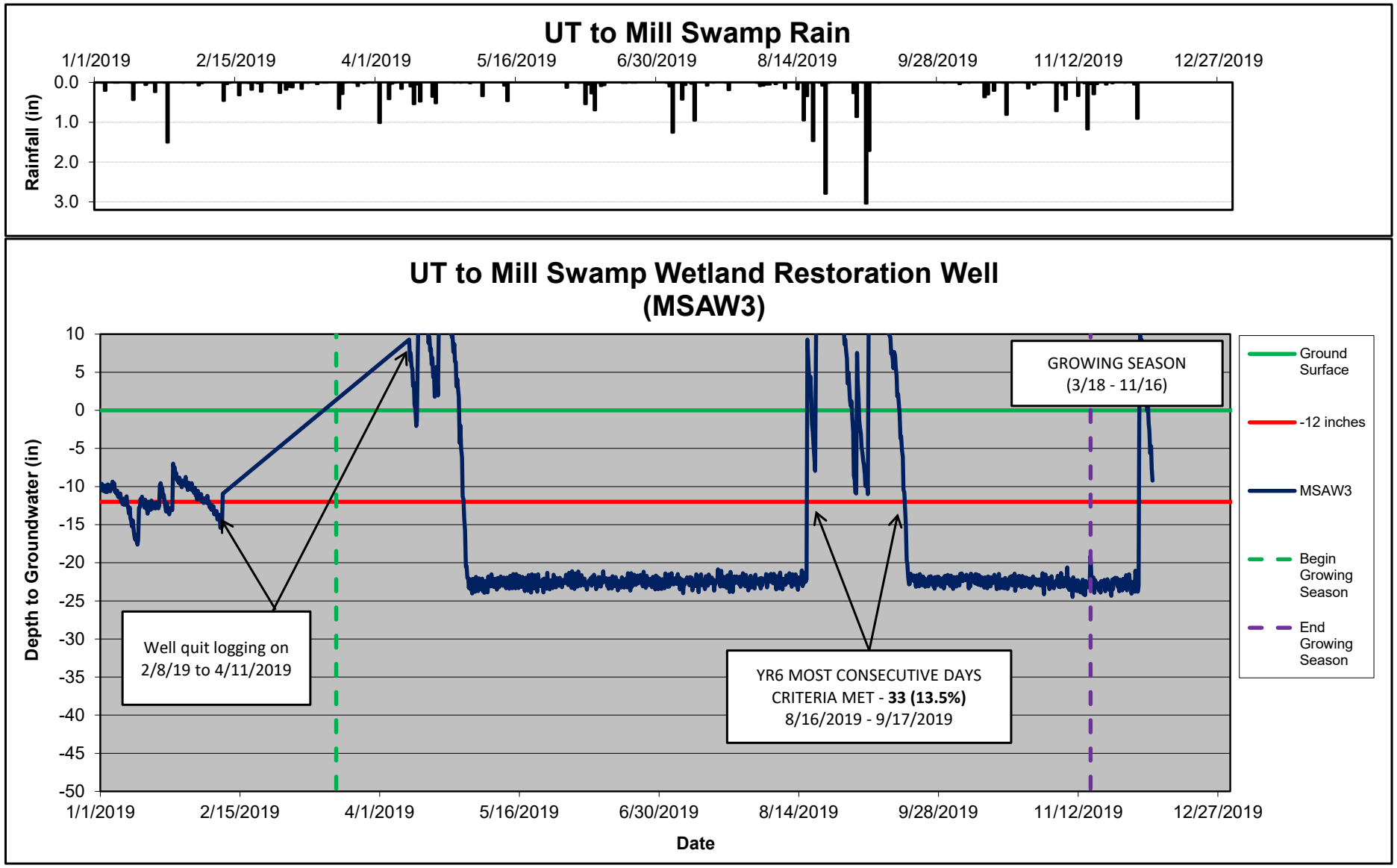
HIGHLIGHTED indicates wells that *did not* to meet the success criteria for the most consecutive number of days within the monitored growing season with a water 12 inches or less from the soil surface. Following Year 6 wetland monitoring, nine of the fifteen wells located in credited areas exhibited hyrdroperiods greater than 12% during the 2019 growing season. Well MSAW10 permanently failed in the summer of 2018.

**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 were normally closer to the ground surface.

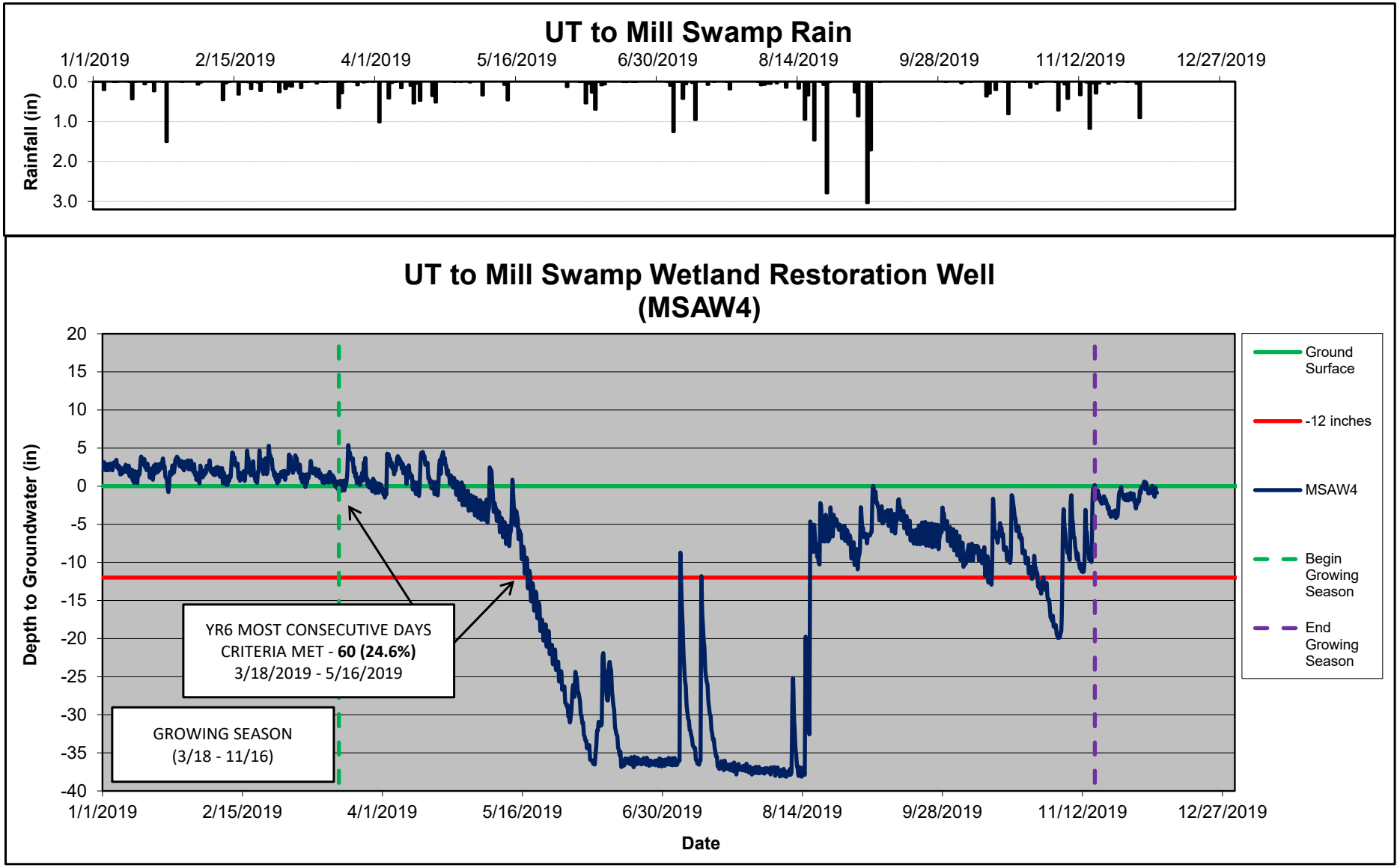
Figure 4. Wetland Gauge Graphs

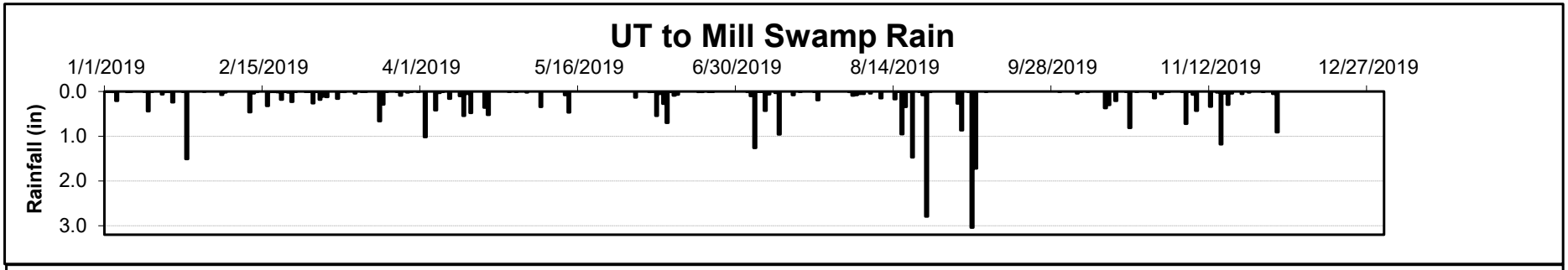


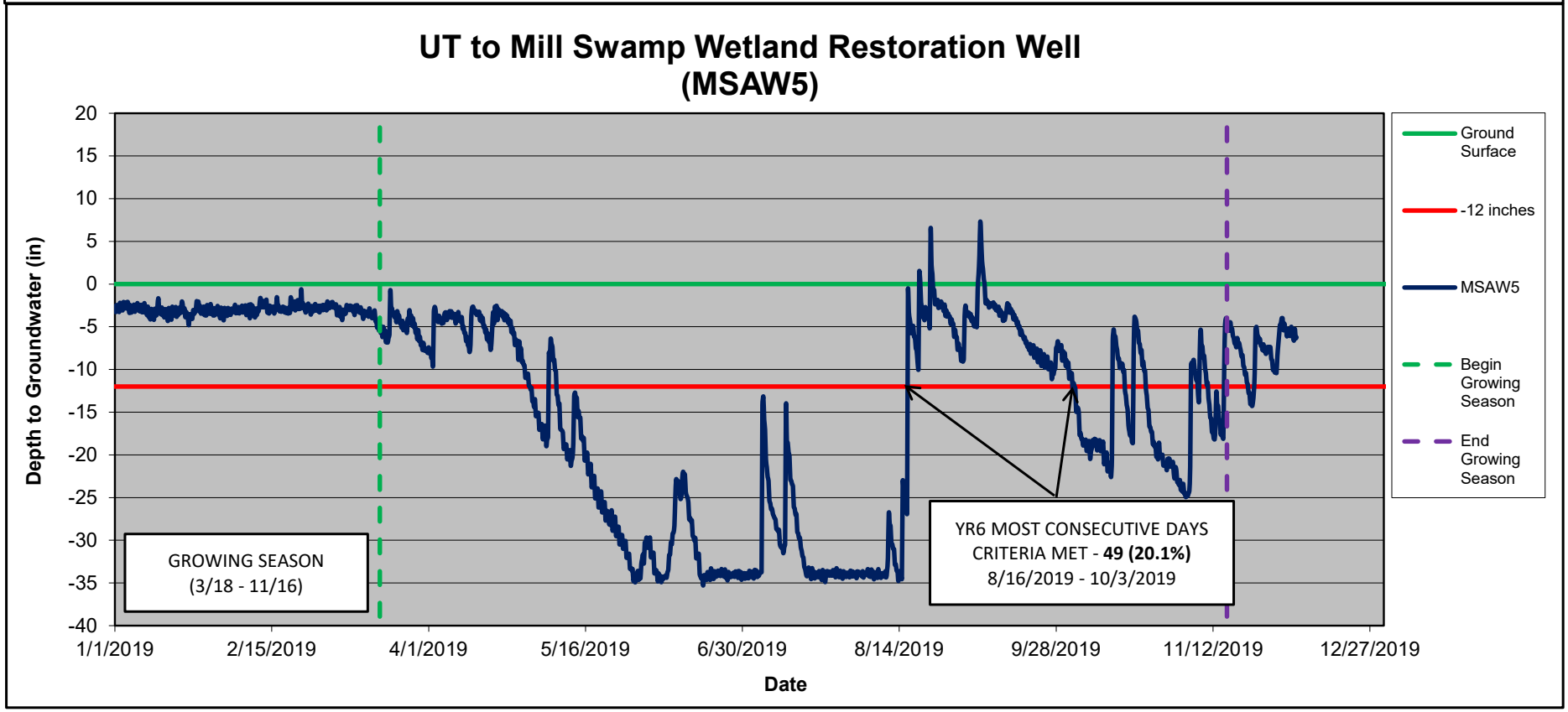

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW2)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 34 (13.9%)
8/18/2019 - 9/20/2019
Ground Surface
-12 inches
MSAW2
Begin Growing Season
End Growing Season
Date

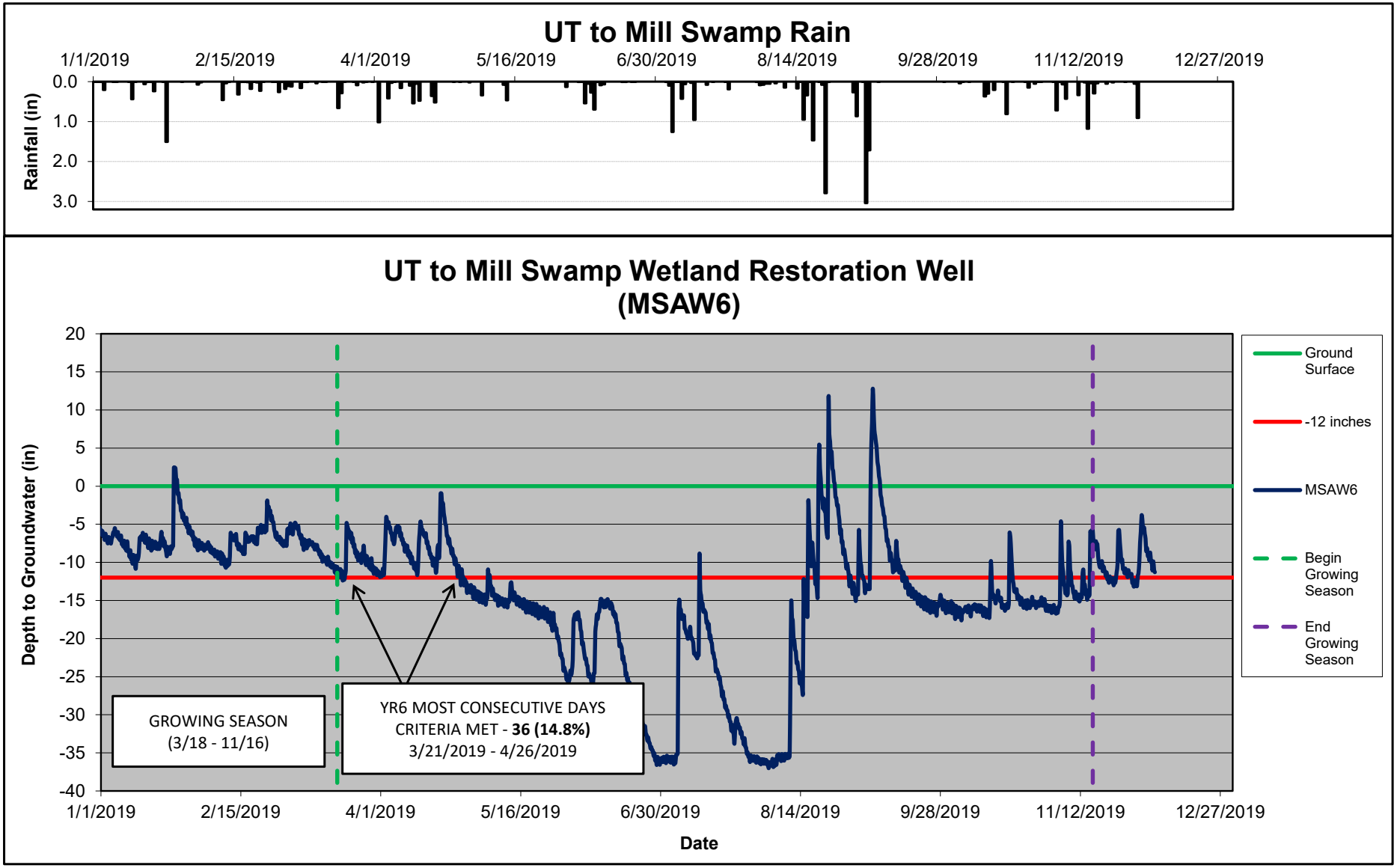


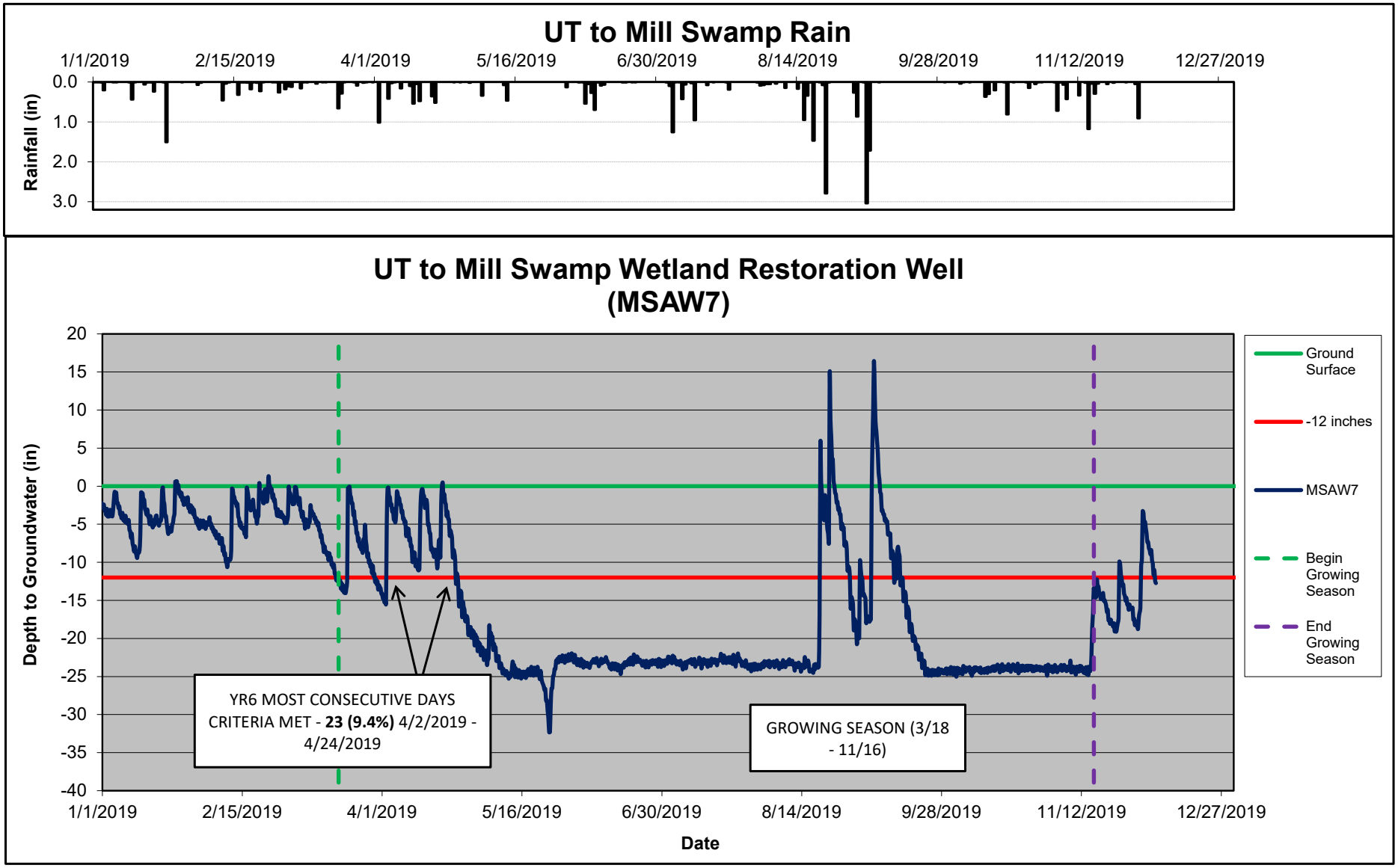
Note: Well MSAW3 was relocated by IRT suggestion on 6/7/18 as shown on the CCPV in Appendix B.


UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW4)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 60 (24.6%)
3/18/2019 - 5/16/2019
GROWING SEASON
(3/18 - 11/16)
Ground Surface
-12 inches
MSAW4
Begin Growing Season
End Growing Season
Date

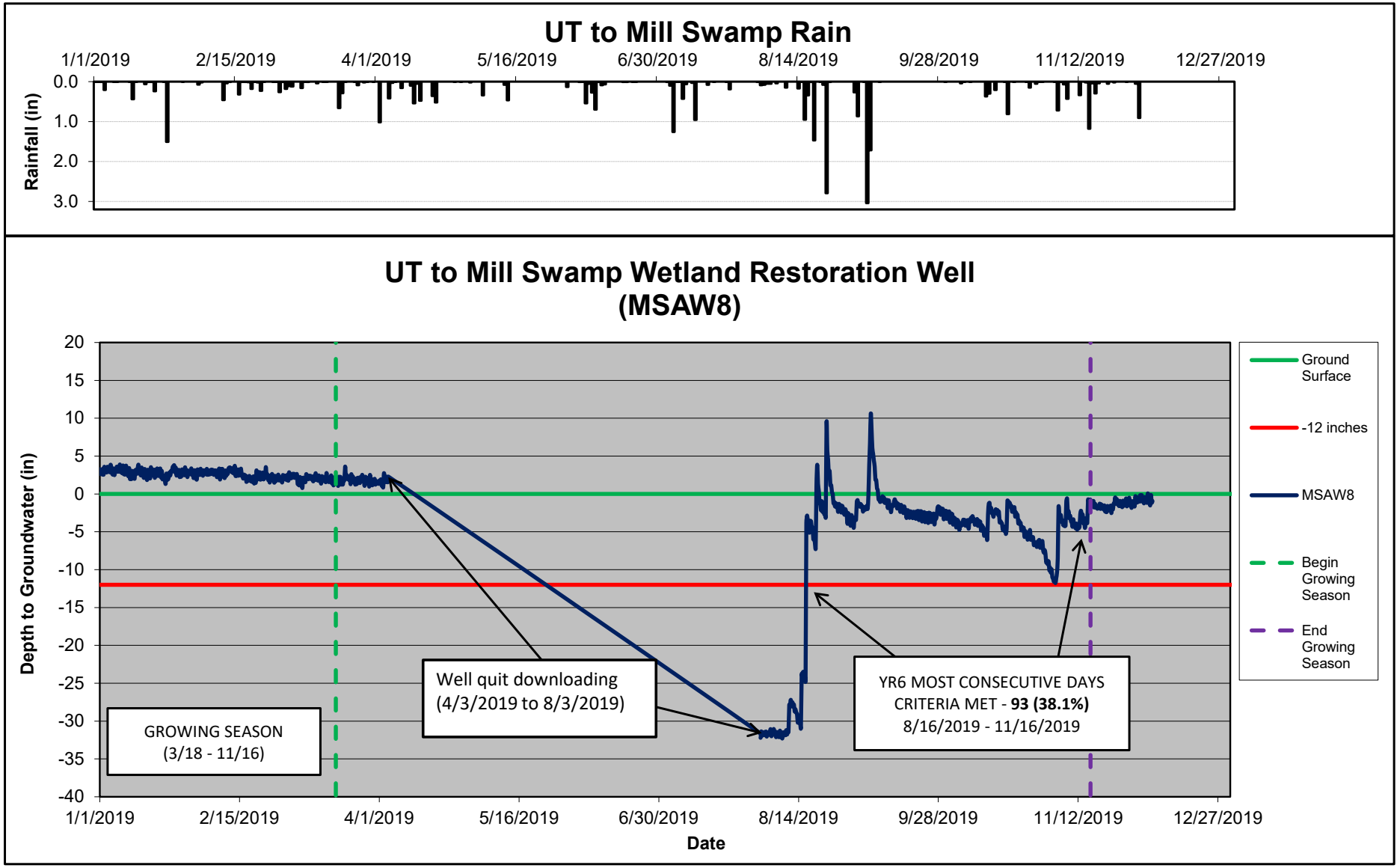

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0

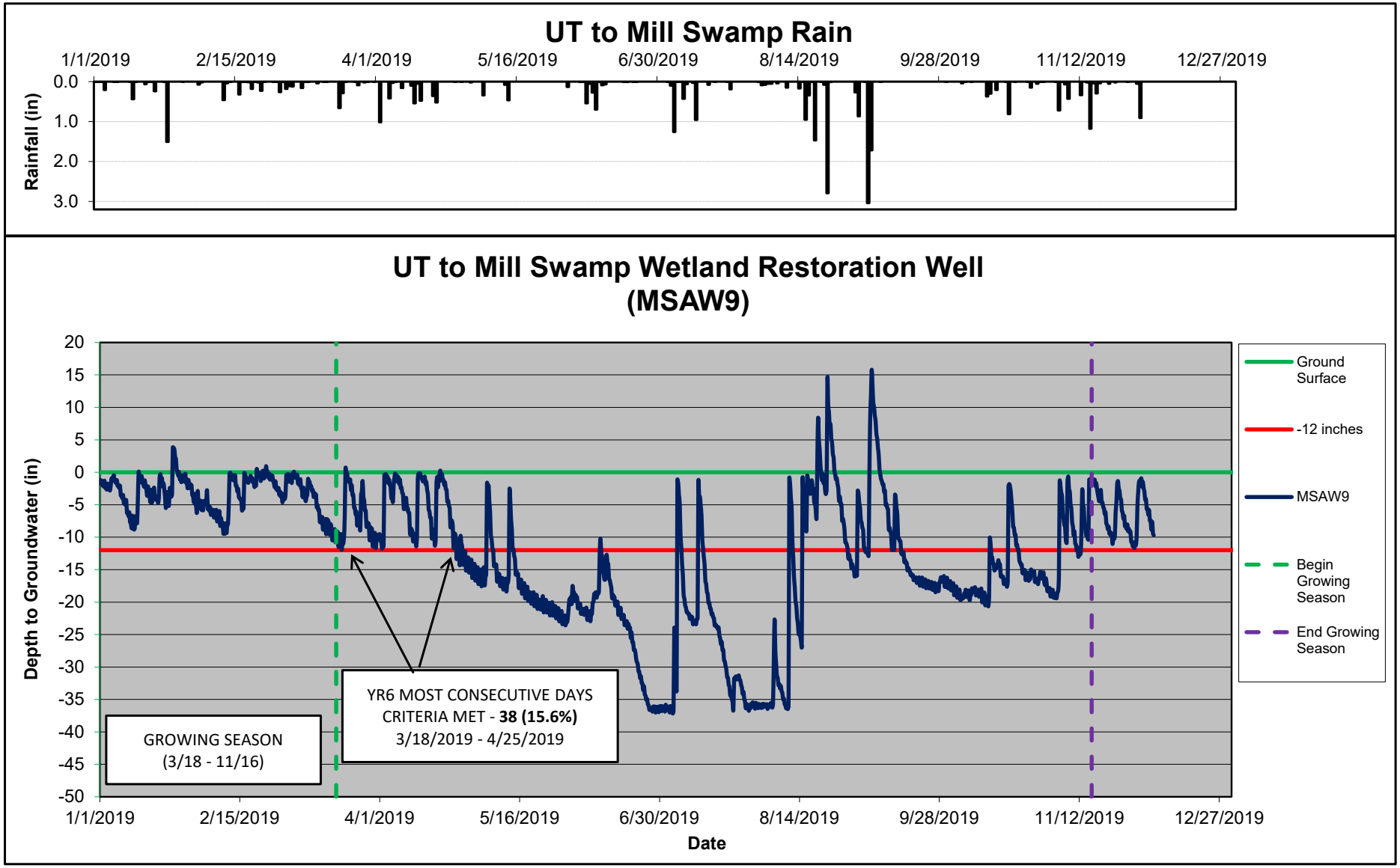

UT to Mill Swamp Wetland Restoration Well
(MSAW5)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Date
Ground Surface
-12 inches
MSAW5
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 49 (20.1%)
8/16/2019 - 10/3/2019

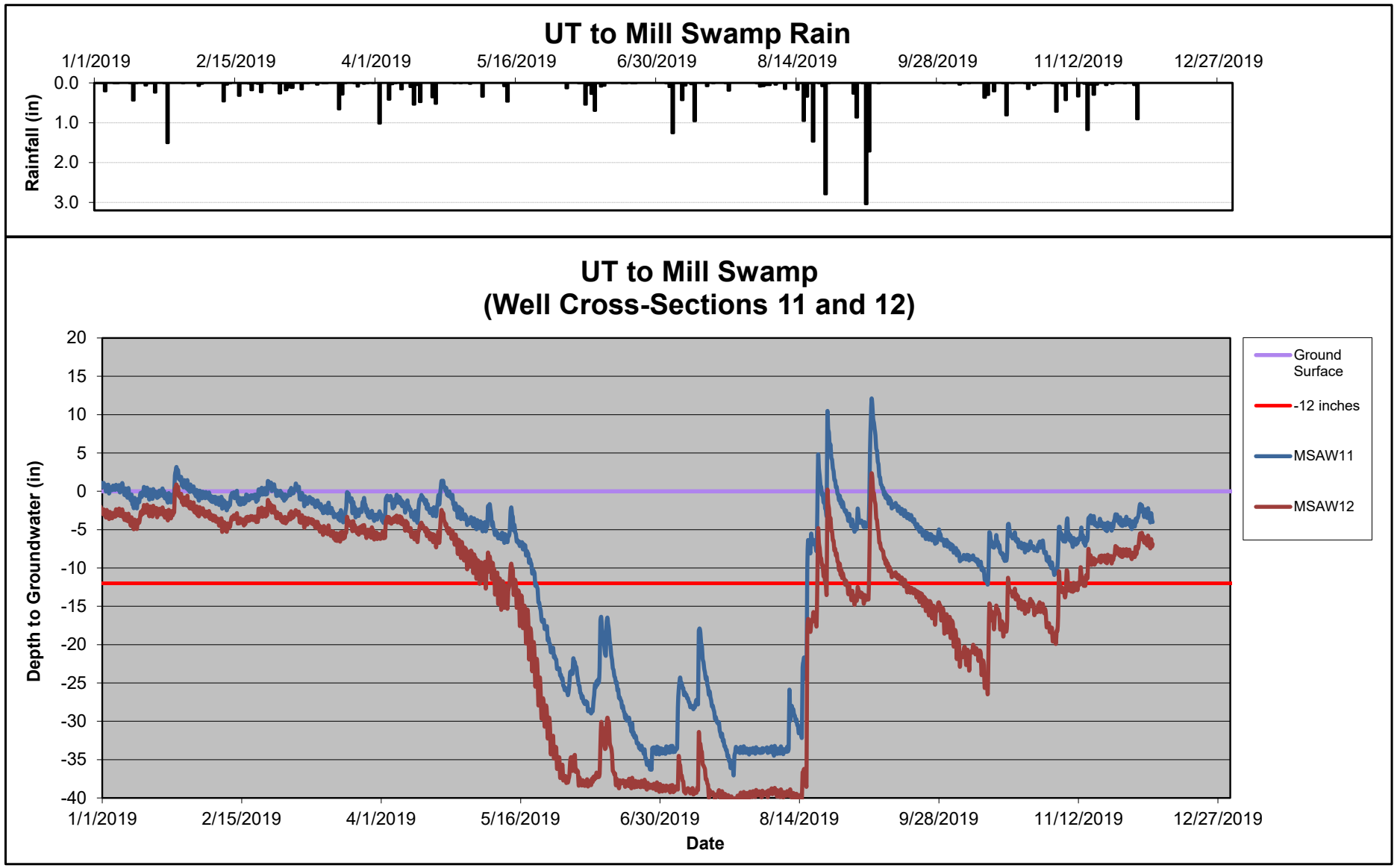

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW6)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 36 (14.8%)
3/21/2019 - 4/26/2019
Ground Surface
-12 inches
MSAW6
Begin Growing Season
End Growing Season
Date

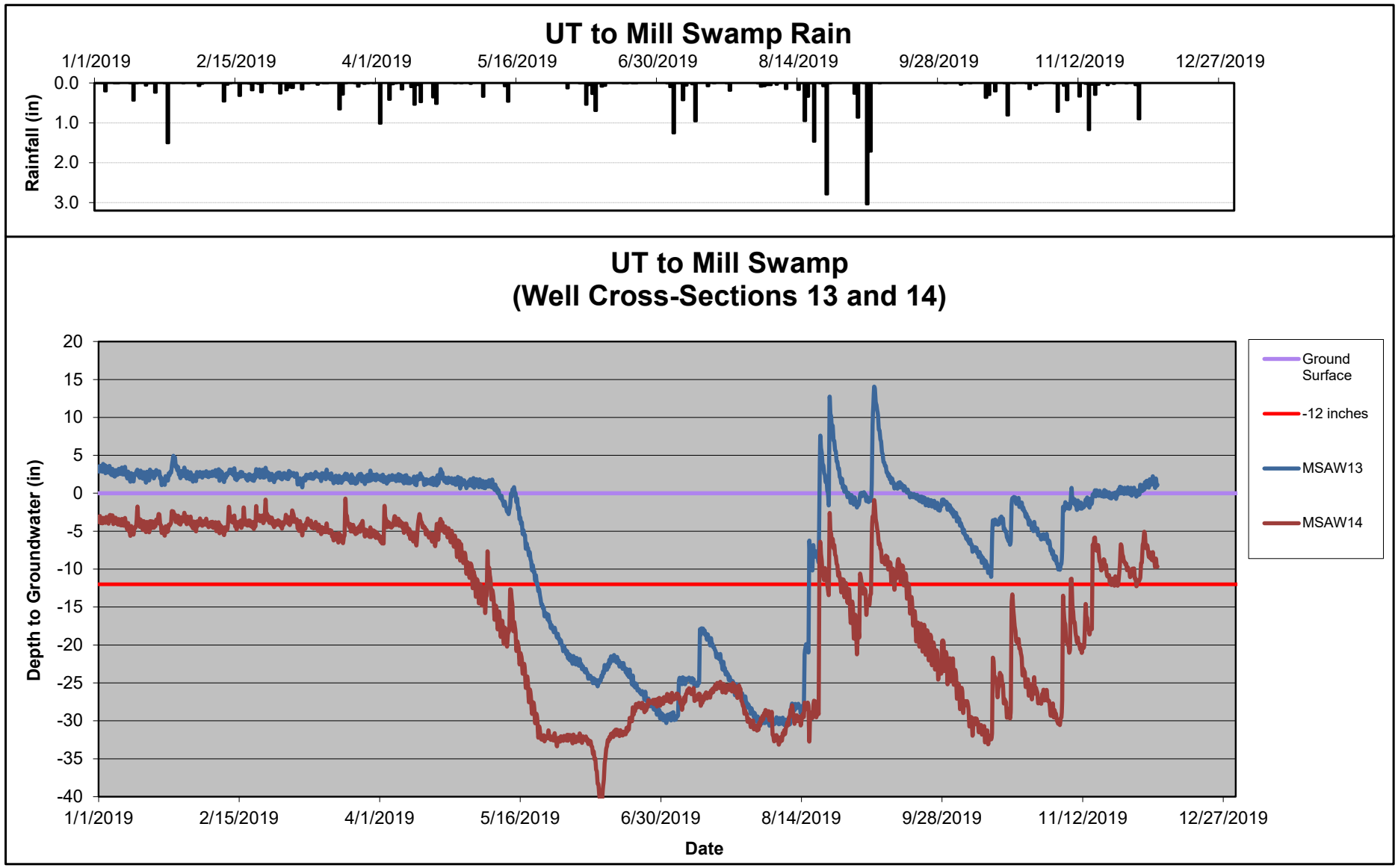


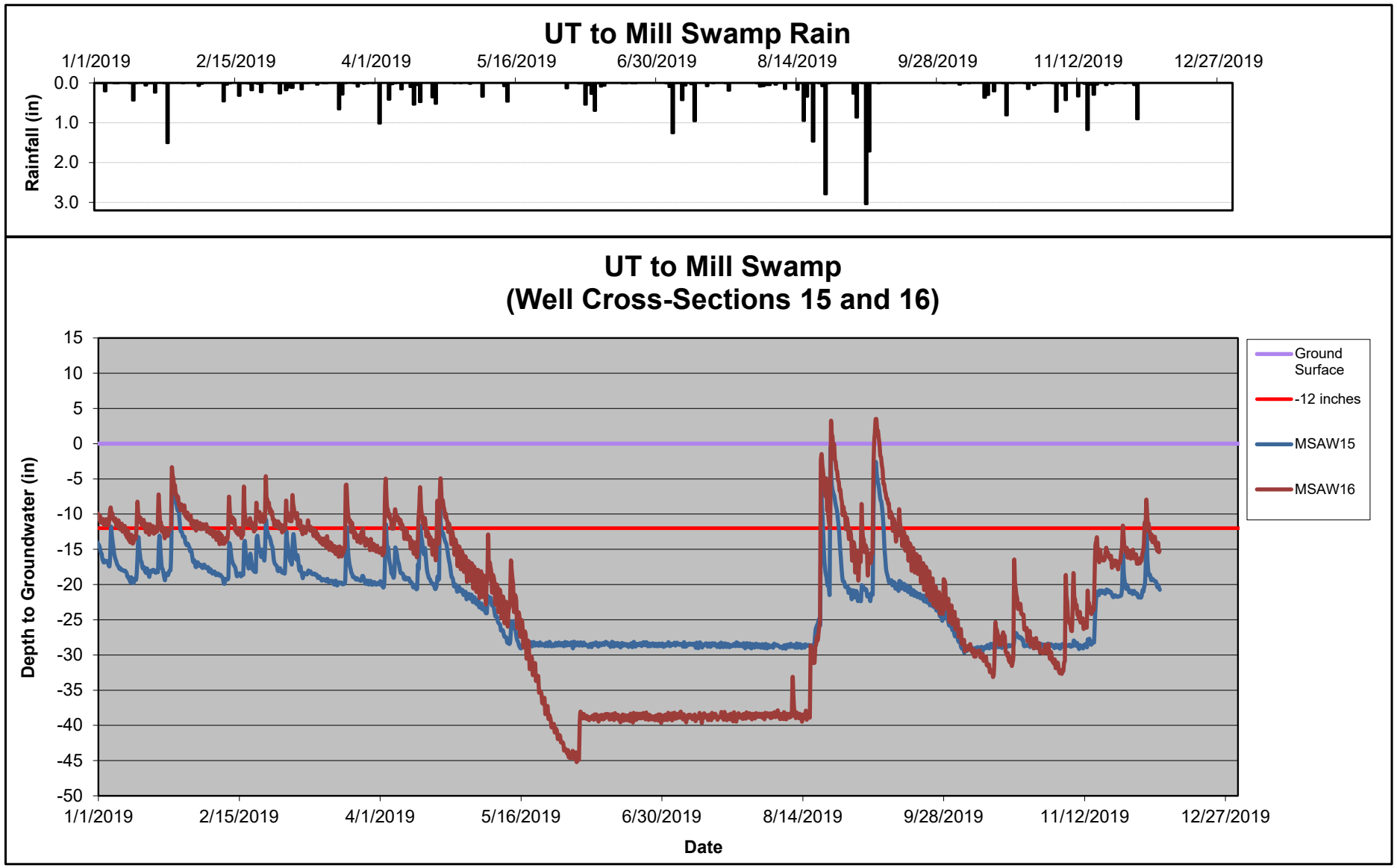
Note: Well MSAW7 was relocated by IRT suggestion on 6/7/18 as shown on the CCPV in Appendix B.

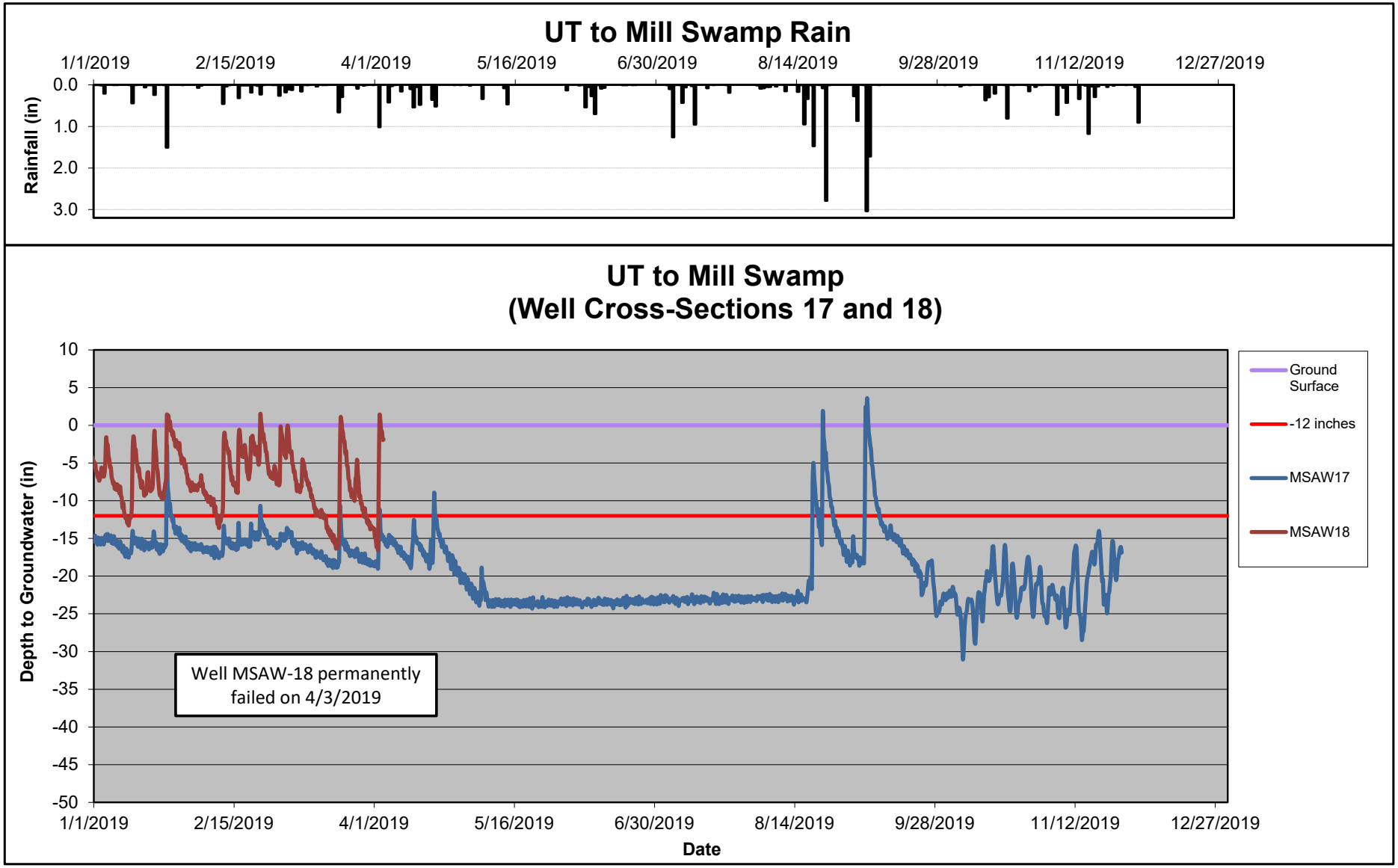

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW8)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW8
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
Well quit downloading
(4/3/2019 to 8/3/2019)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 93 (38.1%)
8/16/2019 - 11/16/2019
Date

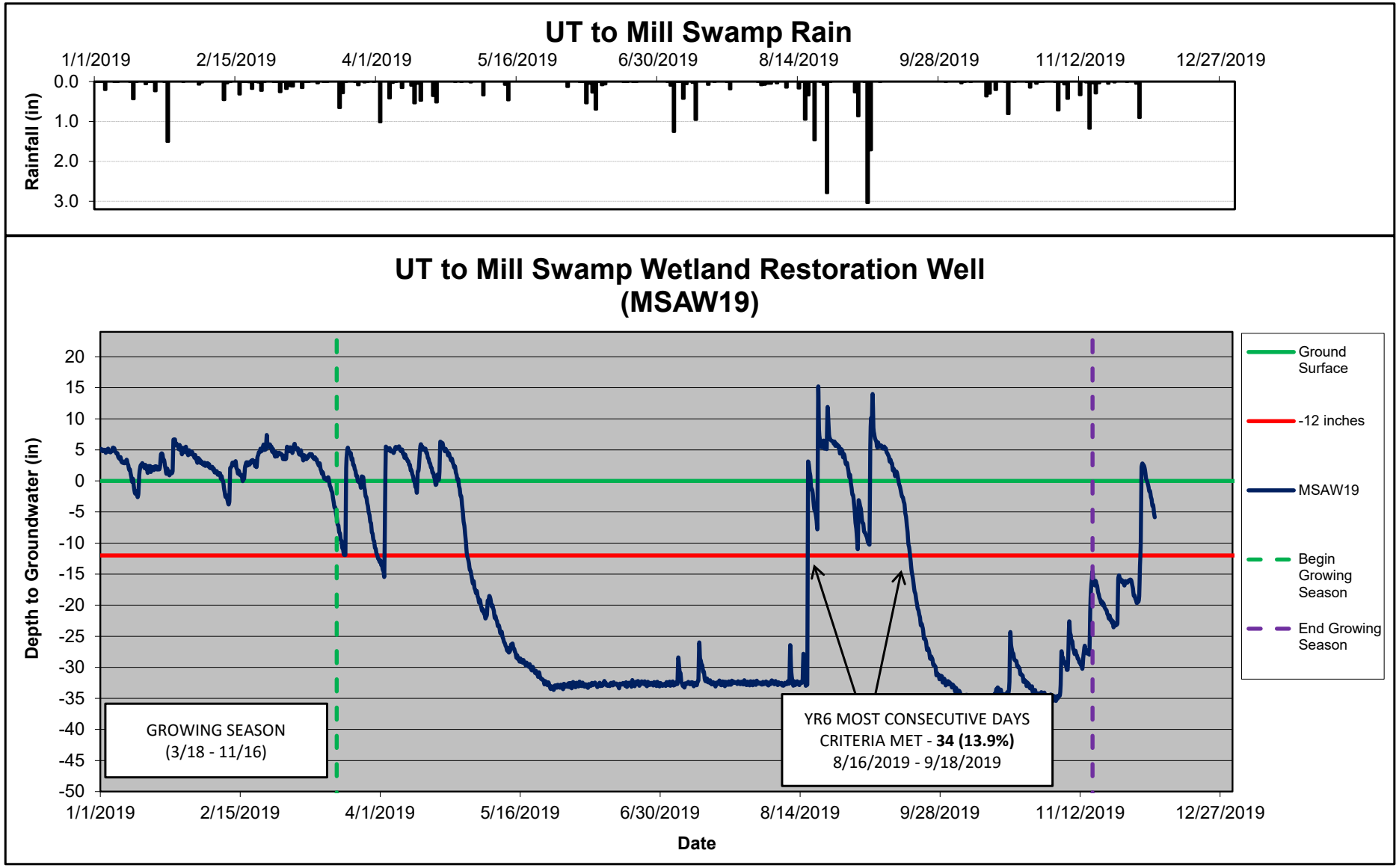

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW9)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 38 (15.6%)
3/18/2019 - 4/25/2019
Ground Surface
-12 inches
MSAW9
Begin Growing Season
End Growing Season
Date

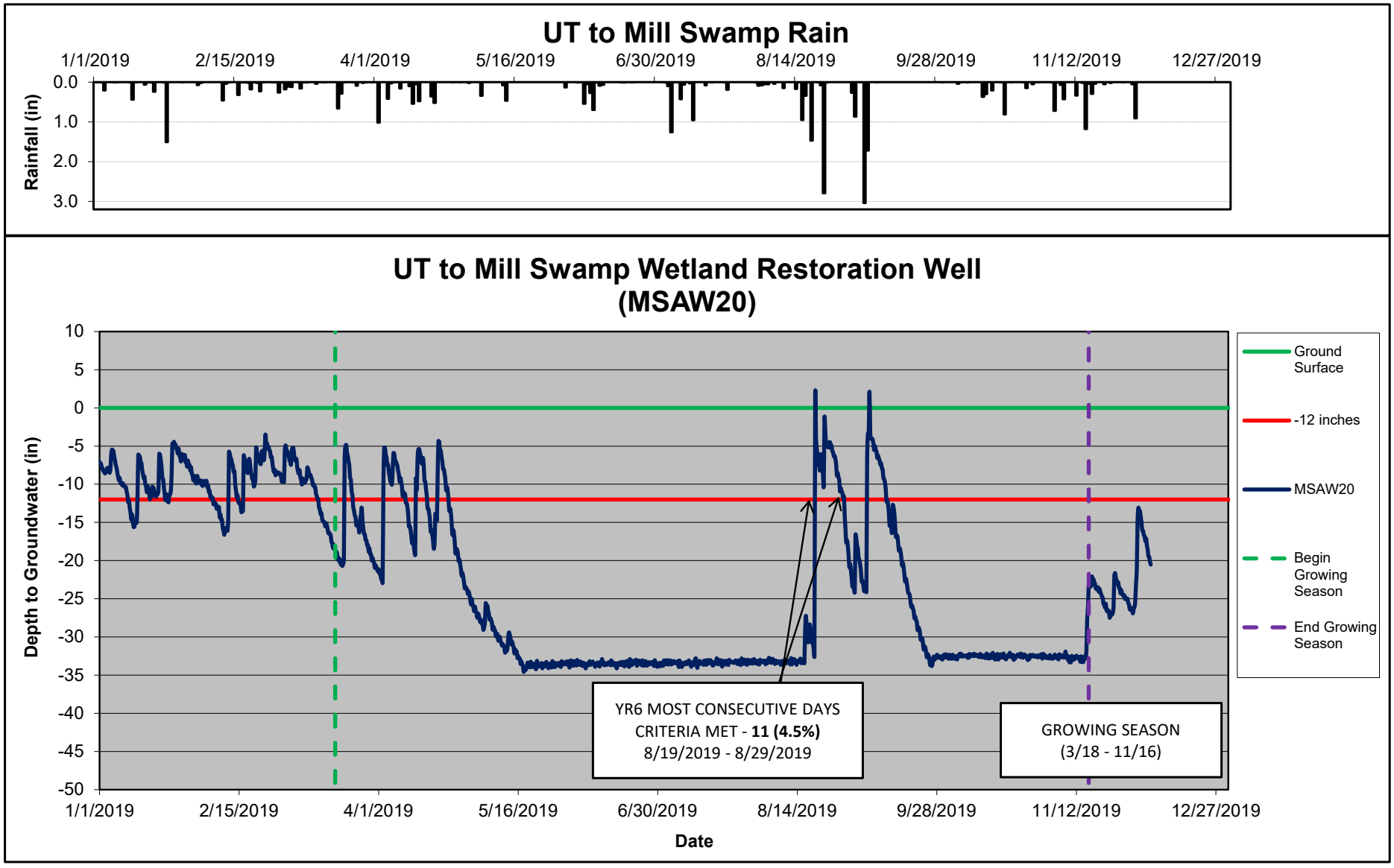

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp
(Well Cross-Sections 11 and 12)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Date
Ground Surface
-12 inches
MSAW11
MSAW12

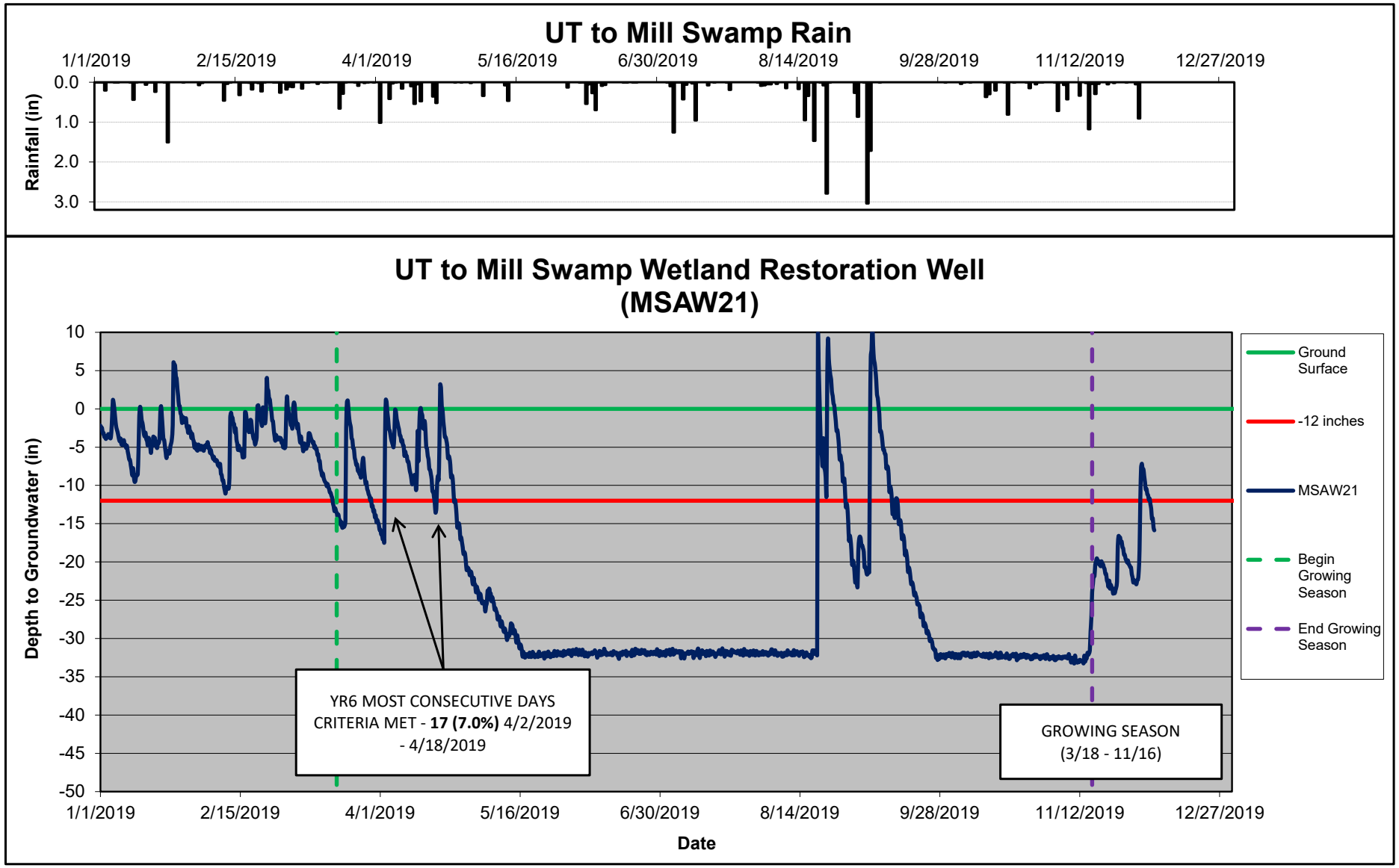

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp
(Well Cross-Sections 13 and 14)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW13
MSAW14
Date

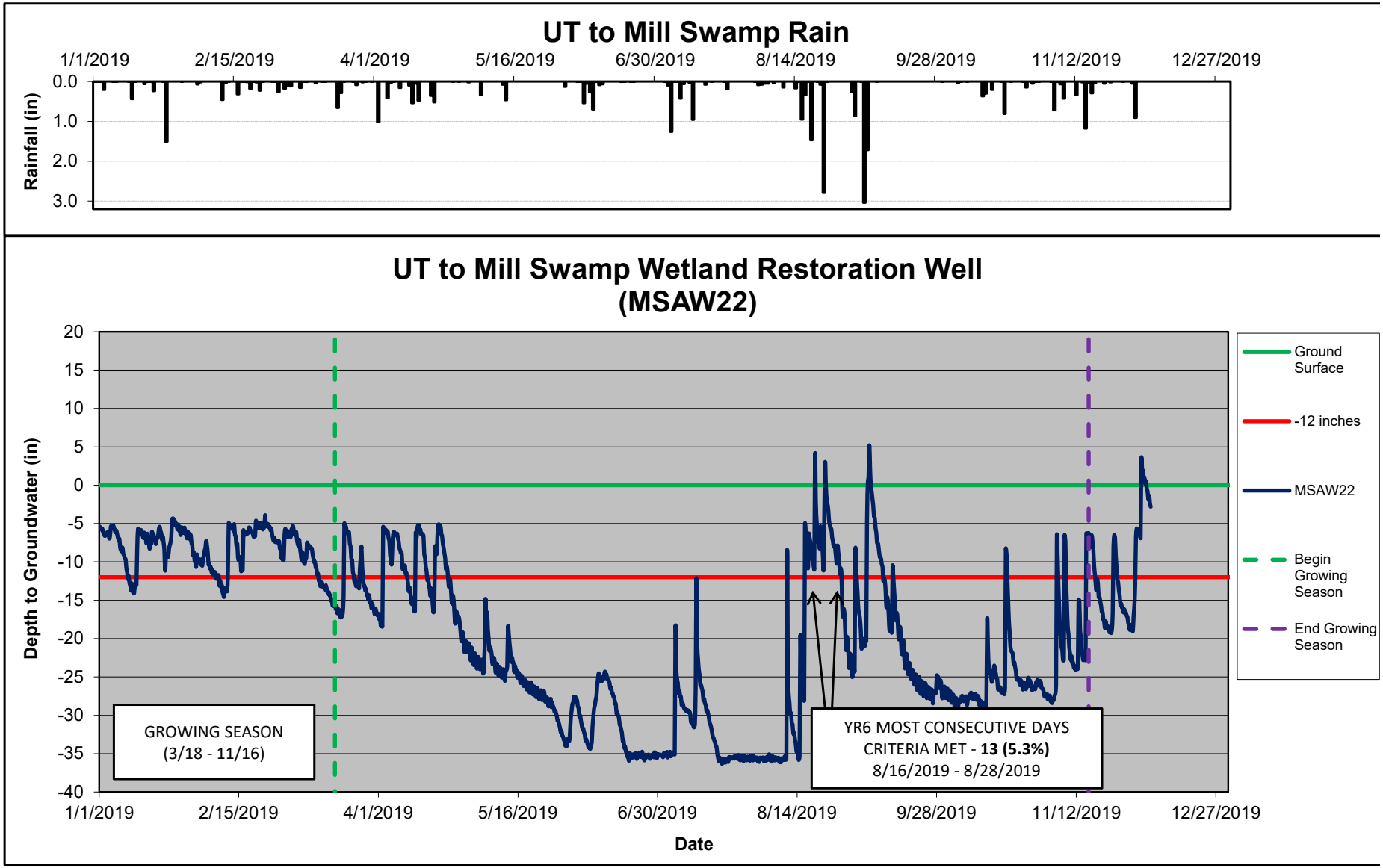

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp
(Well Cross-Sections 15 and 16)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW15
MSAW16
Date

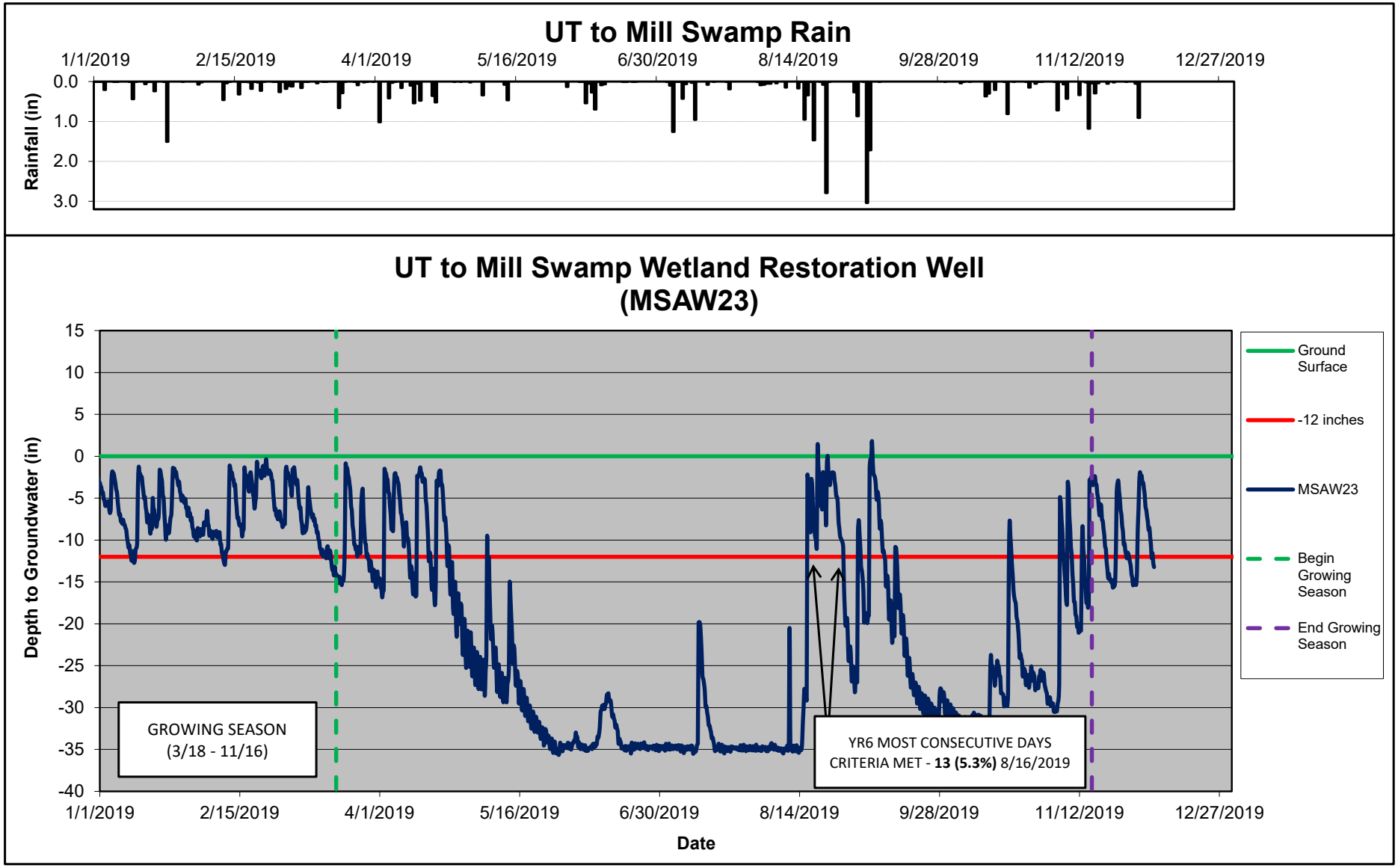

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp
(Well Cross-Sections 17 and 18)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Well MSAW-18 permanently failed on 4/3/2019
Ground Surface
-12 inches
MSAW17
MSAW18
Date


UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
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
Ground Surface
-12 inches
MSAW19
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 34 (13.9%)
8/16/2019 - 9/18/2019
Date


UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
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
YR6 MOST CONSECUTIVE DAYS CRITERIA MET - 11 (4.5%)
8/19/2019 - 8/29/2019
GROWING SEASON
(3/18 - 11/16)
Date


UT to Mill Swamp Rain
Rainfall (in)
0.0
1.0
2.0
3.0
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
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
YR6 MOST CONSECUTIVE DAYS CRITERIA MET - 17 (7.0%) 4/2/2019 - 4/18/2019
GROWING SEASON (3/18 - 11/16)
Ground Surface
-12 inches
MSAW21
Begin Growing Season
End Growing Season
Date


UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW22)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW22
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 13 (5.3%)
8/16/2019 - 8/28/2019
Date


UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW23)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 13 (5.3%) 8/16/2019
Ground Surface
-12 inches
MSAW23
Begin Growing Season
End Growing Season
Date

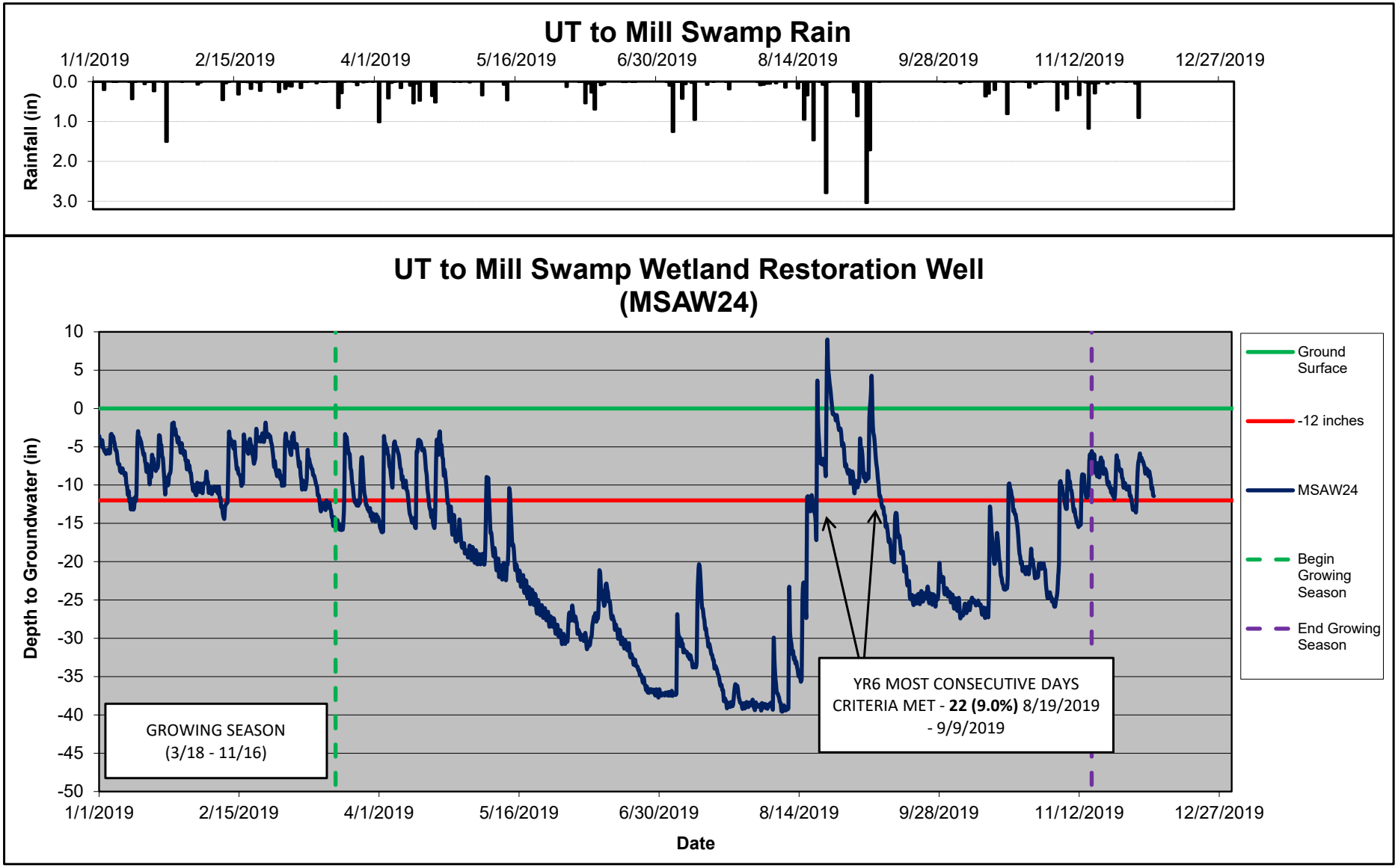

UT to Mill Swamp Rain
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
UT to Mill Swamp Wetland Restoration Well
(MSAW24)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW24
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR6 MOST CONSECUTIVE DAYS
CRITERIA MET - 22 (9.0%) 8/19/2019
- 9/9/2019
Date

Table 13. Flow Gauge Success
UT to Mill Swamp Restoration Project: DMS Project ID No. 95019

Flow Gauge ID	Most Consecutive Days Meeting Criteria[1]								Cumulative Days Meeting Criteria[2]							
	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)	Year 7 (2020)	Year 1 (2013)	Year 2* (2014)	Year 2 (2015)	Year 3 (2016)	Year 4 (2017)	Year 5 (2018)	Year 6 (2019)	Year 7 (2020)
Flow Gauges (Installed September 27, 2013)																
MSFL1	9	31	51	59	139	65	78	-	34	242	137	187	213	247	170	-
MSFL2	35	131	152	105	164	N/A	N/A[3]	-	79	327	186	231	243	N/A	N/A[3]	-

Notes:

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

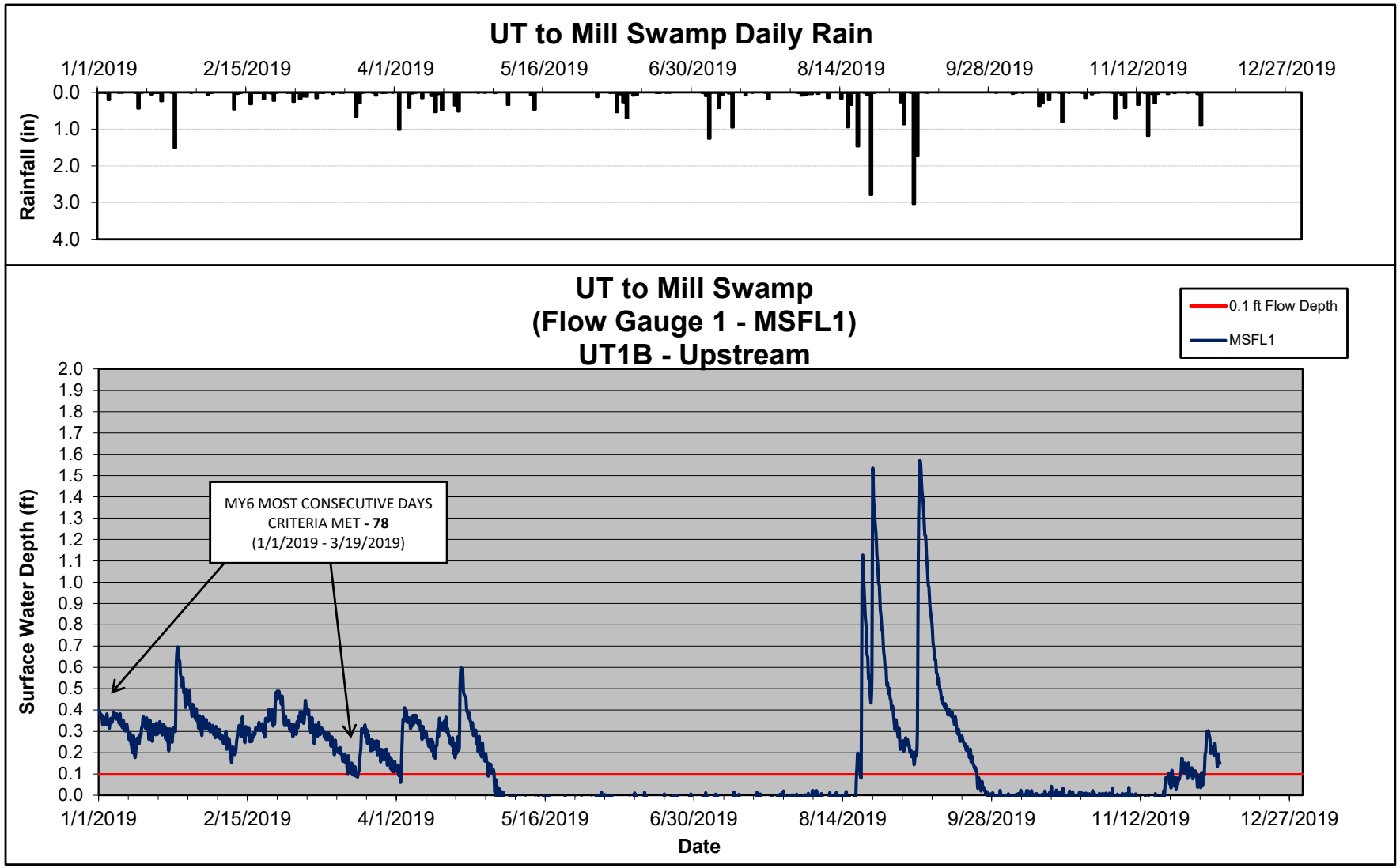
[2]Indicates the total number of days within the monitoring year where flow was measured.

[3]The pressure transducer for MSFL2 permanently failed over the winter of 2017/2018 and was not replaced as it had already met the required project success criteria in each previous year.

Success Criteria per UT to Mill Swamp Mitigation Plan: A surface water flow event will be considered perennial when the recorded flow duration occurs for a **minimum of 30 consecutive days during the monitoring year**. Two surface water flow events must be documented within a five-year monitoring period; otherwise, monitoring will continue for seven years or until two flow events have been documented in separate years.

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

Figure 5. Flow Gauge Graph



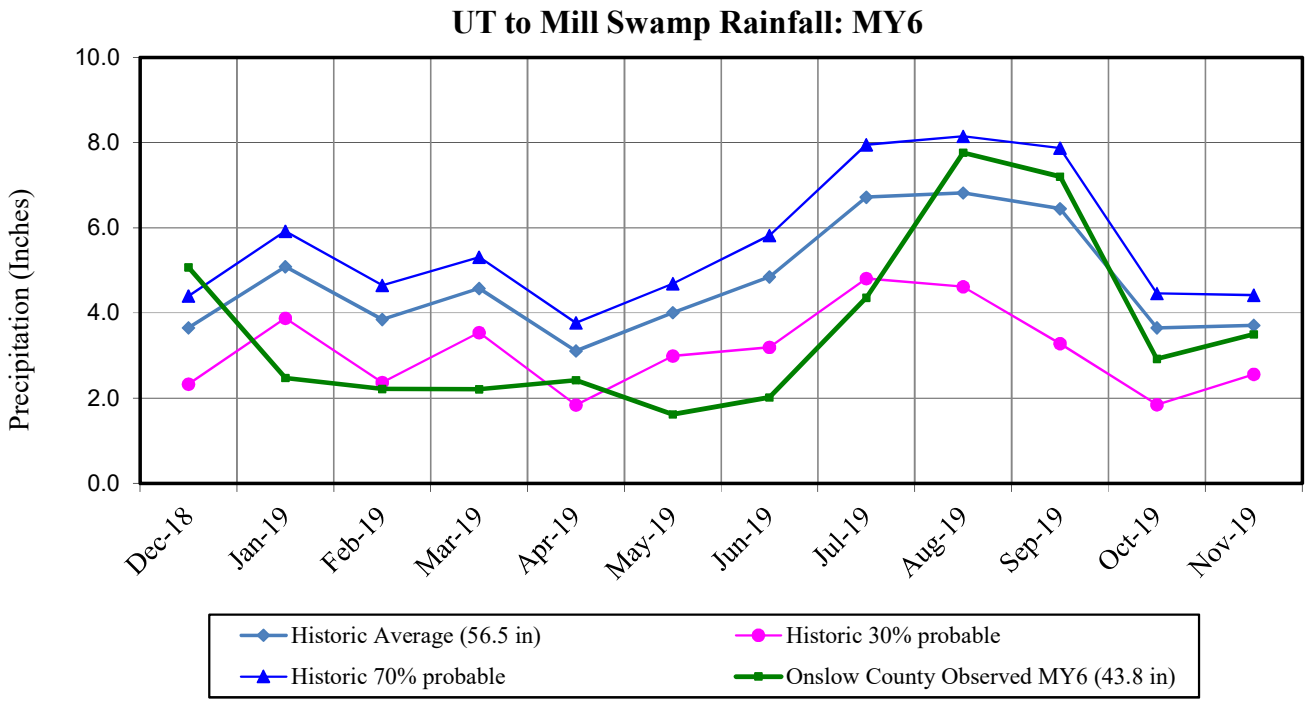
* Surface water flow is estimated to have occurred when the pressure transducer reading is equal to or above 0.1 feet in depth.

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

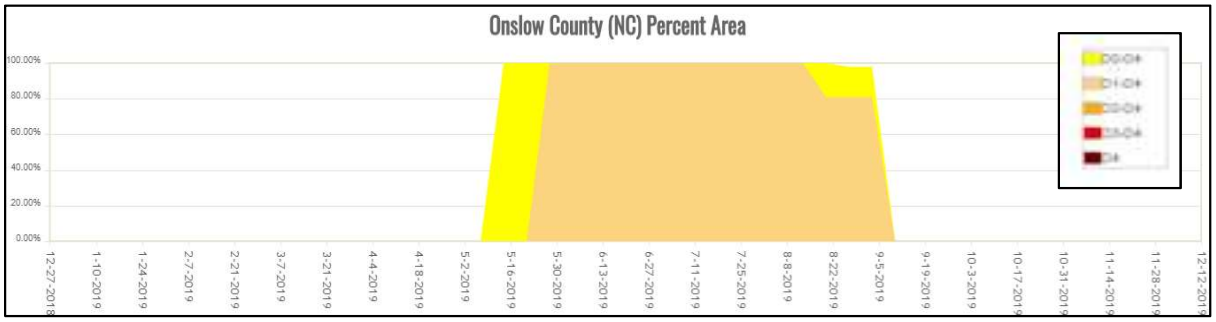
Date of Data Collection	Estimated Occurrence of Bankfull Event	Method of Data Collection	Gauge Reading (feet)
Year 1 (2013)			
10/16/2013	10/11/2013	Crest Gauge	0.17
12/24/2013	12/15/2013	Crest Gauge	0.19
Year 2* (2014)			
03/27/2014	03/07/2014	Crest Gauge	0.32
10/14/2014	08/04/2014	Crest Gauge	0.56
12/19/2014	11/26/2014	Crest Gauge	0.27
Year 2 (2015)			
01/24/2015	01/24/2015	Crest Gauge	0.59
04/27/2015	02/26/2015	Crest Gauge	1.07
06/23/2015	05/11/2015	Crest Gauge	1.61
11/12/2015	10/03/2015	Crest Gauge	1.54
Year 3 (2016)			
03/10/2016	02/05/2016	Crest Gauge	1.44
11/22/2016	10/8/2016 (Hurricane Matthew)	Crest Gauge	2.32
Year 4 (2017)			
03/20/2017	01/02/2017	Crest Gauge	1.18
06/02/2017	04/25/2017	Crest Gauge	1.20
Year 5 (2018)			
06/07/2018	05/31/2018	Crest Gauge	1.50
10/30/2018	9/15/2018 (Hurricane Florence)	Crest Gauge	3.41
Year 6 (2019)			
12/06/2019	09/05/2019	Crest Gauge*	2.10

* Note: Crest gauge readings can be correlated with spikes in flow gauge measurements (see graph in Appendix E)

Figure 6. Observed Rainfall versus Historic Average



Note: Total Rainfall for MY6 was just 43.8", a deficit of 12.7" from the historic average of 56.5"



Note: The drought monitor for Onslow County reveals that the entire county was under D1 Moderate Drought conditions from May through August 2019.

https://droughtmonitor.unl.edu/Data/Timeseries.aspx