| | | | | | |
|---|---|---|---|---|---|
| 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 | 8/27/2018 | | |
| Cataloging Unit | 03020001 | | | | |

| 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 | | | 30% | | 2013 | 3/21/2014 |
| 3 (Year 1 Monitoring) | 10% | 400.600 | | | 2014 | 4/23/2015 | 10% | 0.400 | | | 10% | | 2014 | 4/23/2015 |
| 4 (Year 2 Monitoring) | 10% | 400.600 | | | 2015 | 4/27/2016 | 10% | 0.400 | | | 15% | | 2015 | 4/27/2016 |
| 5 (Year 3 Monitoring) | 10% | 390.900 | | | 2016 | 10/20/2017 | 5% | 0.200 | | | 20% | | 2018 | 10/20/2017 |
| IRT Adjustment* | | -58.200 | | | | 10/20/2017 | | | | | | | | |
| Unreleased wetland credits from Year 3 Monitoring | | | | | | | 5% | 0.200 | | | | | 2018 | 8/27/2018 |
| 6 (Year 4 Monitoring) | 5% | 195.450 | | | 2017 | 8/27/2018 | 10% | 0.400 | | | 10% | | 2017 | 8/27/2018 |
| 7 (Year 5 Monitoring) | 10% | | | | 2018 | | 10% | | | | 15% | | 2018 | |
| 8 (Year 6 Monitoring) | 5% | | | | 2019 | | 10% | | | | N/A | | 2018 | |
| 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 Data | | 2,831.750 | | | | | | 2.800 | | | | | | |

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

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 Enhancement 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 | 75.000% | 75.000% | | | 70.000% | | | | | | | | | | | |
| Released Amounts (feet / acres) | 2,631.750 | 450.000 | | | 2.800 | | | | | | | | | | | |
| Released Amounts (credits) | 2,631.750 | 300.000 | | | 2.800 | | | | | | | | | | | |

| NCDWR Permit | USACE Action ID | Project Name | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2010-0306 | 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 | 2010-01707 | Hangar P683/P687 & 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 | 2010-01707 | Hangar P683/P687 & 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 | 180.000 | | | | | | | | | | | | | | |
| 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 | | | | | 0.160 | | | | | | | | | | |
| 2007-0245 | 2007-00266-067 | Marine Corps Special Operations Command 2nd phase | 16.000 | | | | | | | | | | | | | | |
| 2010-0306 | 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 | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | |
| Remaining Amounts (feet / acres) | | | 0.000 | 0.000 | | | 1.020 | | | | | | | | | | |
| Remaining Amounts (credits) | | | 0.000 | 0.000 | | | 1.020 | | | | | | | | | | |

Contingencies (if any): None

Signature of Wilmington District Official Approving Credit Release

9/6/18
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) Receipt 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

Michael Baker
INTERNATIONAL

*Innovation Done Right...We Make a Difference*

January 16, 2019

Jeff Schaffer
Eastern Supervisor, Project Management
NCDEQ Division of Mitigation Services
1652 Mail Service Center
Raleigh, NC 27699-1652

Subject: Task 11: Response Letter to DMS review comments regarding the Draft Year 5 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

Dear Mr. Schaffer,

Please find enclosed three hardcopies of the Final Year 5 Monitoring Report and our responses to your review comments received on December 19, 2018 regarding the UT to Mill Swamp Restoration Project located in Onslow County, NC. As requested, we have also provided a CD containing a pdf version of the final report along with the revised GIS shapefiles in response to the review comments below:

1. Digital drawings:
   a. Digital files for each asset listed in Table 1 were not formatted or attributed as required in the EEP/DMS digital drawing guidance. The stream centerlines for example were submitted as a highly segmented polyline and were devoid of attributes such as reach ID and linear footage. DMS would prefer to receive shapefiles for all of the features in the digital drawings requirements, but at a minimum, each asset (as listed in table 1 of the monitoring report) and each monitoring feature must be provided as a discreet, properly attributed polyline/polygon as required by contract and stated in table 2 of DMS's Format, Data Requirements, and Content Guidance for Electronic Drawings Submitted to EEP version 1.0 (03/27/08).
   **Response:** For the draft e-submittal, older shapefiles were erroneously included. The revised shapefiles (made last year from similar DMS comments) are included with the final e-submittal with our apologies for the confusion.

   b. During the review, DMS received a pop-up warning that the spatial reference is missing for the As- Built_Streams_UTMillSwamp, Crossings_UTMillSwamp, FlowGauges_UTMillSwamp, TopOfBank_UTMillSwamp, UTMillSwamp_CrestGauge shapefiles.
   **Response:** As stated above, older shapefiles were erroneously included the draft e-submission and have been replaced with the revised shapefiles in the final e-submission with our apologies for the confusion.

2. Cover Page: Change the word "Permits:" to USACE Action ID.
   **Response:** Change made as advised.

3. Section 1:
   a. Page 3, paragraph 7: the report states that gauge MSAW10 "unexpectedly and permanently failed during the summer of 2018." Please address if this gauge is to be replaced and if not, explain why.
   **Response:** Wetland gauge MSAW10 has never passed the hydrology success criteria of consecutive days within 12" of ground surface for 12% of the growing season in any monitoring year, with 0.0%, 0.6%, 5.3%, 2.1%, 4.9%, and now 5.3%. Given that this was one of the wetter years on record and it still failed to meet success criteria, it seems highly unlikely that it ever will. As such, it will not be replaced. The report has been amended to offer more explanation about this well.

   b. Page 3, paragraph 8: the report states that "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." Please address if this gauge is to be replaced and if not, explain why.
   **Response:** We do not intend to replace flow gauge MSFL2 at this stage of the project. The mitigation plan states that the success criteria for this reach (UT1b) is the documentation of two separate flow events within a 5-year monitoring period consisting of a minimum of 30 consecutive days each. Gauge MSFL2 has easily passed each previous monitoring year 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. Also consider that this reach does have a second flow gauge installed within the upper section which has also already met the success criteria five consecutive times and will continue to record flow data for the reach for the remaining two years of project monitoring. The report has been amended to offer more explanation about this gauge.

4. Section 2.2.2: Even though the groundwater gauges are discussed in this section, explain why there is no section to specifically discuss the wetland assessment. Section 2.2.2 appears as if it should be more associated with the stream portion of this project.
   **Response:** A new Section 2.3 (Wetlands Assessment) was added to methodology portion of report as a location for the wetlands-specific discussion.

5. Appendix D, Table 11: During our review of the Bank Height Ratios (BHR) in Table 11, DMS staff performs a visual comparison of the MY5 data to As-Built/Baseline cross-sections. DMS noted/realized that by displaying the As-built Bankfull Cross-Sectional Area alone, the calculation for the BHR can be difficult to reconcile. We noted possible discrepancies in the BHR calculations for cross-sections 1 and 5 given this disconnect. Using the new BHR calculation methodology where the As-Built Bankfull Area is held constant, please display the Year 5 bankfull elevation as another data series just for the sake of clarity between the BHR calculation and the overlay. It appears that the BHR calculations were done correctly, but just please add the MY5 bankfull data series with its elevation for the sake of clarity to the reader.
   **Response:** An additional data series was added to each cross-section figure showing the MY5 bankfull line (generated using the as-built bankfull area as per the recent DMS memo) as requested. The BHR calculations for the listed cross-sections were re-checked again and were all confirmed as correct. With the new bankfull line shown, a visual comparison between it and the MY5 cross-section data certainly makes the BHR value appear to make intuitive sense.

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

# UT to Mill Swamp Restoration Project
# Sixth Monitoring Measurement
# Fifth Year of Credit Release - FINAL

**Onslow County, North Carolina**

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

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

| | |
|---|---|
| Project Info: | Credit Release Year: 5 of 7 (Sixth site measurement since construction)<br>Year of Data Collection: 2018<br>Year of Completed Construction: 2013<br>Submission Date: December 2019 |
| Submitted To: | NCDEQ – Division of Mitigation Services<br>1652 Mail Service Center<br>Raleigh, NC 27699-1652 |

# UT to Mill Swamp Restoration Project
# Sixth Monitoring Measurement
# Fifth Year of Credit Release - FINAL

**Onslow County, North Carolina**

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

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

Report Prepared and Submitted by Michael Baker Engineering, Inc.

NC Professional Engineering License # F-1084

Michael Baker
INTERNATIONAL

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## APPENDICES

# 1.0 EXECUTIVE SUMMARY

Michael Baker Engineering (Baker) restored 3,606 linear feet of perennial stream, 6.62 acres of riparian wetlands, and enhanced 600 linear feet 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 (NCDMS) 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 (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 Priorities or RBRP (NCDMS 2010) 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

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*.

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

The Year 5 monitoring survey data of the eight permanent cross-sections indicate 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. There are no Stream Problem Areas (SPA) to report.

During Year 5 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 average density of total planted stems, based on the data collected from the six monitoring plots in October 2018 was 459 stems/acre. Thus, the Year 5 vegetation data demonstrates that the Site has met the minimum success interim criteria of 260 stems/acre by the end of Year 5.

Previously during Year 4 monitoring, the area around Veg Plot 3 totaling approximately 0.20 acres was supplementally planted in March of 2017 with additional stems of bald cypress (*Taxodium distichum*) from bare root, and water tupelo (*Nyssa aquatica*) planted from tubelings. This area was inspected again in October of 2018 and the stems appear to be alive and doing well, with numerous healthy-looking stems readily identifiable.

Invasive species areas of concern were observed and documented during Year 5 monitoring. One area of Chinese privet (*Ligustrum sinense*) re-sprouts totaling 0.53 acres was discovered along the left floodplain of the middle section of Reach UT1c. This area is identified as a Vegetation Problem Area (VPA) and will be treated in Monitoring Year 6. These resprouts overlap with a 0.55 acre area that had previously been treated for privet in February of 2018. The CCPV found in Appendix B shows the locations of each of these areas.

Additionally, scattered loblolly pine (*Pinus taeda*) and sweetgum (*Liquidambar styraciflua*) saplings were observed growing in the floodplain of UT1c and lower UT1b. They were subsequently heavily thinned during Monitoring Year 5.

At this time, no other areas of concern regarding the Site vegetation were observed along UT1a, UT1b or UT1c. The complete Year 5 vegetation assessment information and photographs are provided in Appendix B and C.

During Year 5 monitoring, groundwater monitoring demonstrated that fifteen 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 demonstrated consecutive hydroperiods of 12% or greater, ranging from 12.3 to 100% of the growing season (see Figure 4 and Table 12 in Appendix E). The one gauge that did not meet success criteria with only 5.3% was MSAW10, which unexpectedly and permanently failed during the summer of 2018. Gauge MSAW10 has never passed the hydroperiod success criteria of consecutive days within 12" of ground surface for 12% of the growing season in any monitoring year, with 0.0%, 0.6%, 5.3%, 2.1%, 4.9%, and now 5.3%. Given that this was one of the wetter years on record and it still failed to meet success criteria during the typical early-spring timeframe, it seems highly unlikely that it ever will. As such, it will not be replaced.

Additionally, during an IRT field visit on 5/1/18, it was suggested that wells MSAW3 and MSAW7 could be relocated to better help confirm restored wetland areas elsewhere in the floodplain. These wells had previously been located either directly on the wetland boundary, or outside it in the adjacent uplands, and it was felt they would be more useful collecting data in other, more relevant areas. As such, in June 2018 these two wells were relocated to the suggested areas as shown in the CCPV found in Appendix B. Graphs for all the groundwater data collected from each well during Year 5 monitoring are located in Appendix E.

Year 5 flow monitoring on Reach UT1b demonstrated that flow gauge MSFL1 (on upper UT1b) met the stated success criteria of 30 days or more of consecutive flow through upper UT1b with 65 days of consecutive flow and 247 days of total cumulative flow. The gauge demonstrated similar patterns relative to rainfall events observed in the vicinity of the Site. 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 previous monitoring year 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 two project monitoring years from gauge MSFL1 alone. Flow data collected during Year 5 monitoring are located in Appendix E.

The Site was also found to have had at least two above-bankfull events based on the crest gauge readings during Year 5 monitoring. The highest recorded reading was measured to be 3.41 feet and was associated with Hurricane Florence on September 15, 2018. Crest gauge reading data are presented in Appendix E and gauge photographs are presented in Appendix B.

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 November 7, 2011 (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 Year 5 vegetation plot data and all visual site assessment data were collected in October 2018. The cross-section survey data were collected in November 2018, while the final monitoring gauge data were collected in December 2018.

## 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, the use of water level monitoring gauges to document both groundwater and flooding functions.

### 2.1.1 Hydrology

Two automated groundwater well 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. Graphs of the groundwater data collected for these gauges during Year 5 monitoring are located in Appendix E.

Additionally, two in-stream 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 MSFL1 (on UT1a) met this success criteria with 65 consecutive days of recorded flow, and a cumulative total of 247 days of flow. The gauge demonstrated similar patterns relative to rainfall events observed in the vicinity of the Site. Flow gauge MSFL2 (on 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 collected during Year 5 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. Site photographs for UT1a and UT1b were taken at established photo-point stations and can be 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 NCDMS.

Survey data from the eight permanent project cross-sections were collected and classified using the Rosgen Stream Classification System, and all monitored cross-sections fall within the quantitative parameters defined for channels of the design stream type (Rosgen 1994). The Year 5 monitoring survey data for the cross-sections indicates that the Site is geomorphically stable and performing at 100 percent for all the parameters evaluated. The data collected are within the lateral/vertical stability and in-stream structure performance categories. Morphological survey data are presented in Appendix D.

Please note, as per NCDMS/IRT request the bank height ratios for MY5 have been calculated using the as-built bankfull area to determine low bank height and the max depth based on the current-year channel profile. All other values were calculated using the as-built bankfull elevation, as was done for all previous monitoring reports.

### 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 MY5, two above-bankfull events associated with storm events were documented by the crest gauge. The highest recorded reading was measured to be 3.41 feet and was associated with Hurricane Florence on September 15, 2018. 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 MY5 for Reach UT1c were taken at the previously established photo-point stations located along the enhanced and restored stream sections of UT1c and are presented in Appendix B. Additionally, reference photograph transects were taken at each permanent cross-section in November of 2018. 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.

### 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 evaluated. During Year 5 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 5 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 has never once 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 5 monitoring are found in Appendix E.

During Year 5 monitoring, groundwater monitoring demonstrated that fifteen 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 demonstrated consecutive hydroperiods of 12% or greater, ranging from 12.3 to 100% of the growing season (see Table 12 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 2017 through November 2018 was 74.2 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 an exceeded the 70% probable by 13.7 inches. However, much of that additional rainfall came in September 2018, and in particular from Hurricane Florence, which dropped approximately 13 inches of rainfall on the site on September 15th alone. The remainder of the fall of 2018 has been fairly dry, with monthly rainfall totals below their historic 30% probables in October and November.

## 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-NCDMS Protocol for Recording Vegetation, Version 4.1 (Lee 2007) using the CVS-DMS Data Entry Tool v. 2.3.1 (CVS 2012). 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.

During Year 5 monitoring, the planted acreage performance categories were functioning well with no bare areas to report. The average density of total planted stems, based on the data collected from the six monitoring plots in October 2018 was 459 stems/acre. Thus, the Year 5 vegetation data demonstrates that the Site has met the minimum success interim criteria of 260 stems/acre by the end of Year 5.

# 3.0 REFERENCES


Carolina Vegetation Survey (CVS) and NC Division of Mitigation Services (NCDMS). CVS-DMS Data Entry Tool v. 2.3.1. University of North Carolina, Raleigh, NC. 2012.

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.

North Carolina Division of Mitigation Services (NCDMS). 2010. White Oak River Basin Restoration Priorities.

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

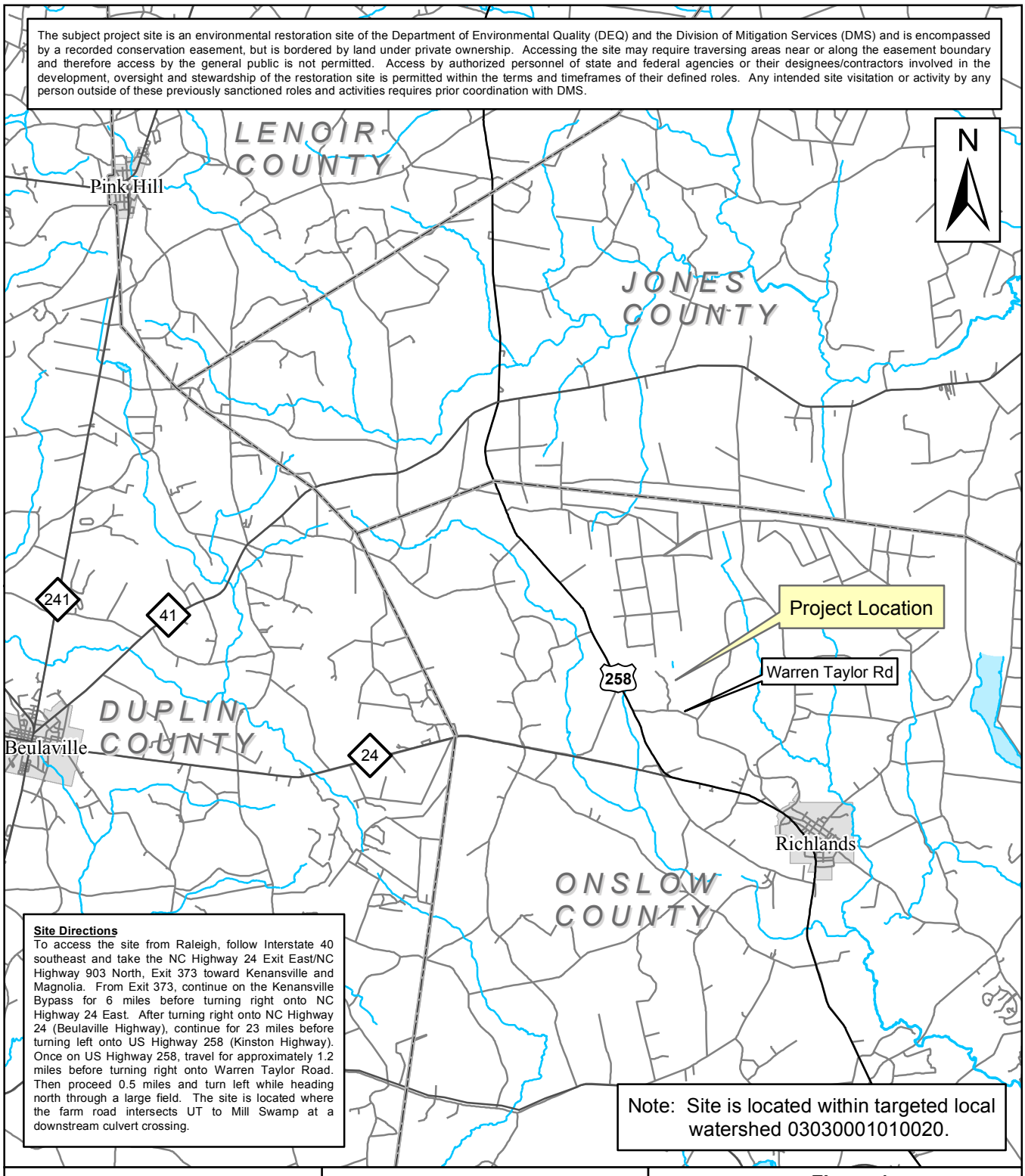
Schafale, M. P., and A. S. Weakley. 1990. Classification of the natural communities of North Carolina, third approximation. North Carolina Natural Heritage Program. Division of Parks and Recreation, NCDENR. Raleigh, NC.

United States Army Corps of Engineers (USACE). 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.

# 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**

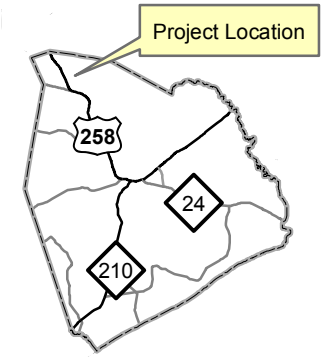



**Figure 1**
**Project Vicinity Map**
**UT to Mill Swamp Site**

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 | N/A | N/A |
| 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 (2018) will be considered Year 5. All references to Year 5 included in this report will indicate monitoring activities conducted during 2018. Data collected during 2014 that was previously considered monitoring Year 2 is labeled as Year 2*

| Table 3. Project Contacts<br>UT to Mill Swamp Restoration Project: DMS Project ID No. 95019 | |
|---|---|
| **Designer** | |
| Michael Baker Engineering, Inc. | 8000 Regency Parkway, Suite 600<br>Cary, NC 27518<br>Contact:<br>Katie Mckeithan, Tel. (919) 481-5703 |
| **Construction Contractor** | |
| River Works, Inc. | 114 W. Main St.<br>Clayton, NC 27520<br>Contact:<br>Bill Wright, Telephone: 919-590-5193 |
| **Planting Contractor** | |
| River Works, Inc. | 114 W. Main St.<br>Clayton, NC 27520<br>Contact:<br>Bill Wright, Telephone: 919-590-5193 |
| **Seeding Contractor** | |
| River Works, Inc. | 114 W. Main St.<br>Clayton, NC 27520<br>Contact:<br>Bill Wright, Telephone: 919-590-5193 |
| Seed Mix Sources<br>Nursery Stock Suppliers | Green Resources, Tel. 336-855-6363<br>Mellow Marsh Farm, 919-742-1200<br>ArborGen, 843-528-3204<br>Superior Tree, 850-971-5159 |
| **Monitoring Performers** | |
| Michael Baker Engineering, Inc. | 8000 Regency Parkway, Suite 600<br>Cary, NC 27518<br>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 |

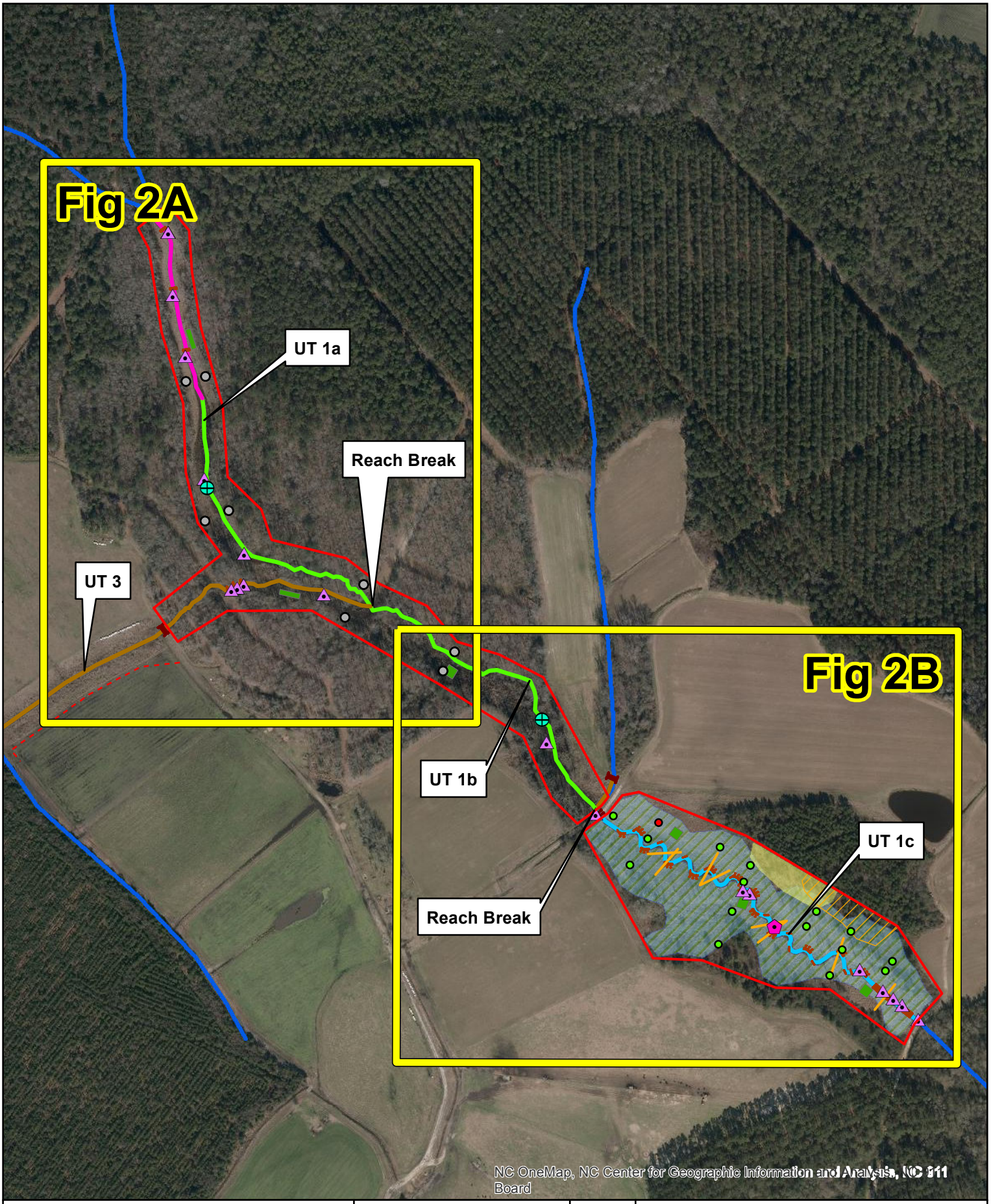
**Table 4. Project Attributes**
**UT to Mill Swamp Restoration Project: DMS Project ID No. 95019**

| **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%)<br>Agriculture (44%)<br>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<br>(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



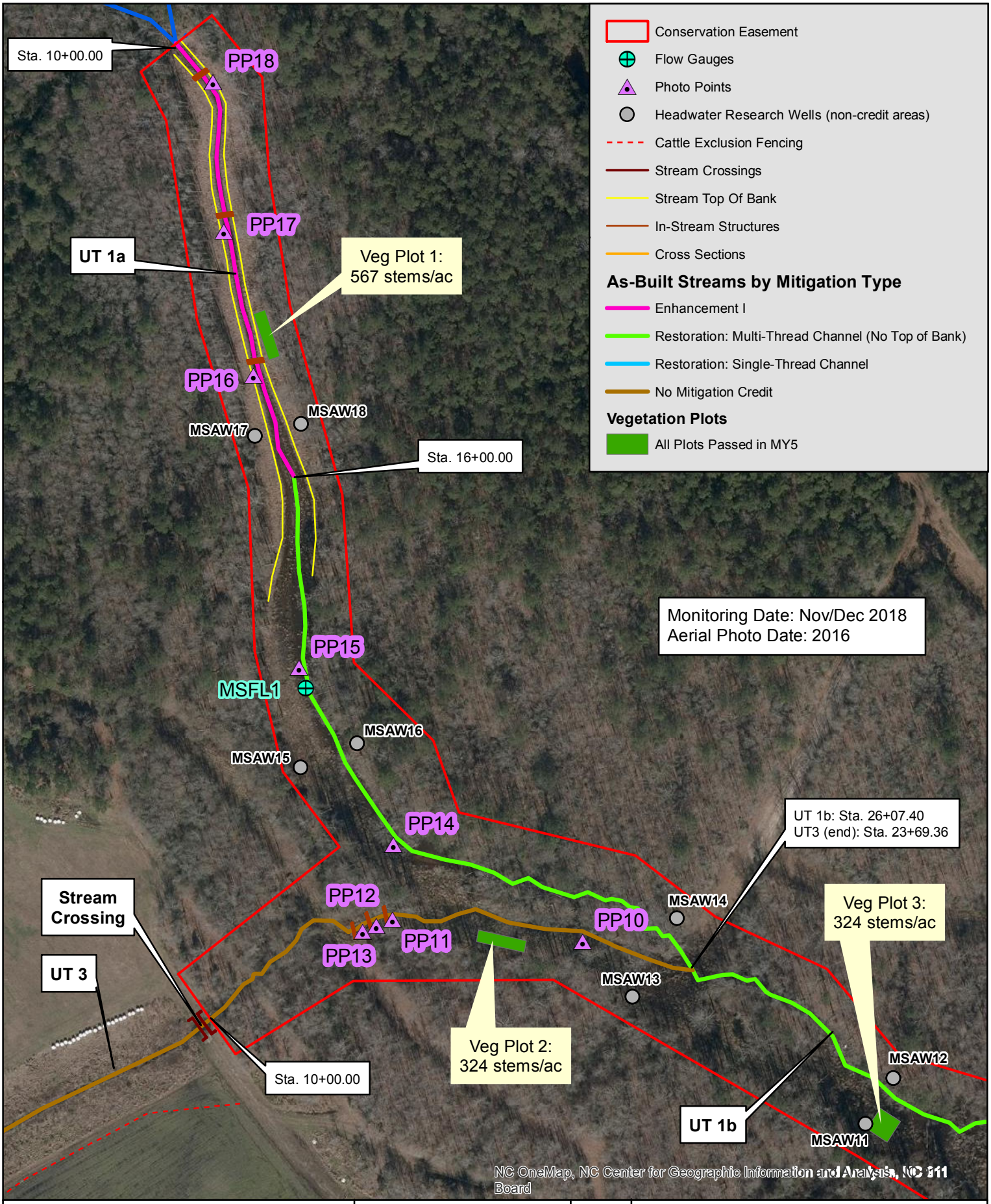

Michael Baker INTERNATIONAL

0 250 500 Feet

N

DMS Project # 95019

**Figure 2 Index Map**
**Current Condition Plan View**
**Monitoring Year 5**
**UT to Mill Swamp Site**



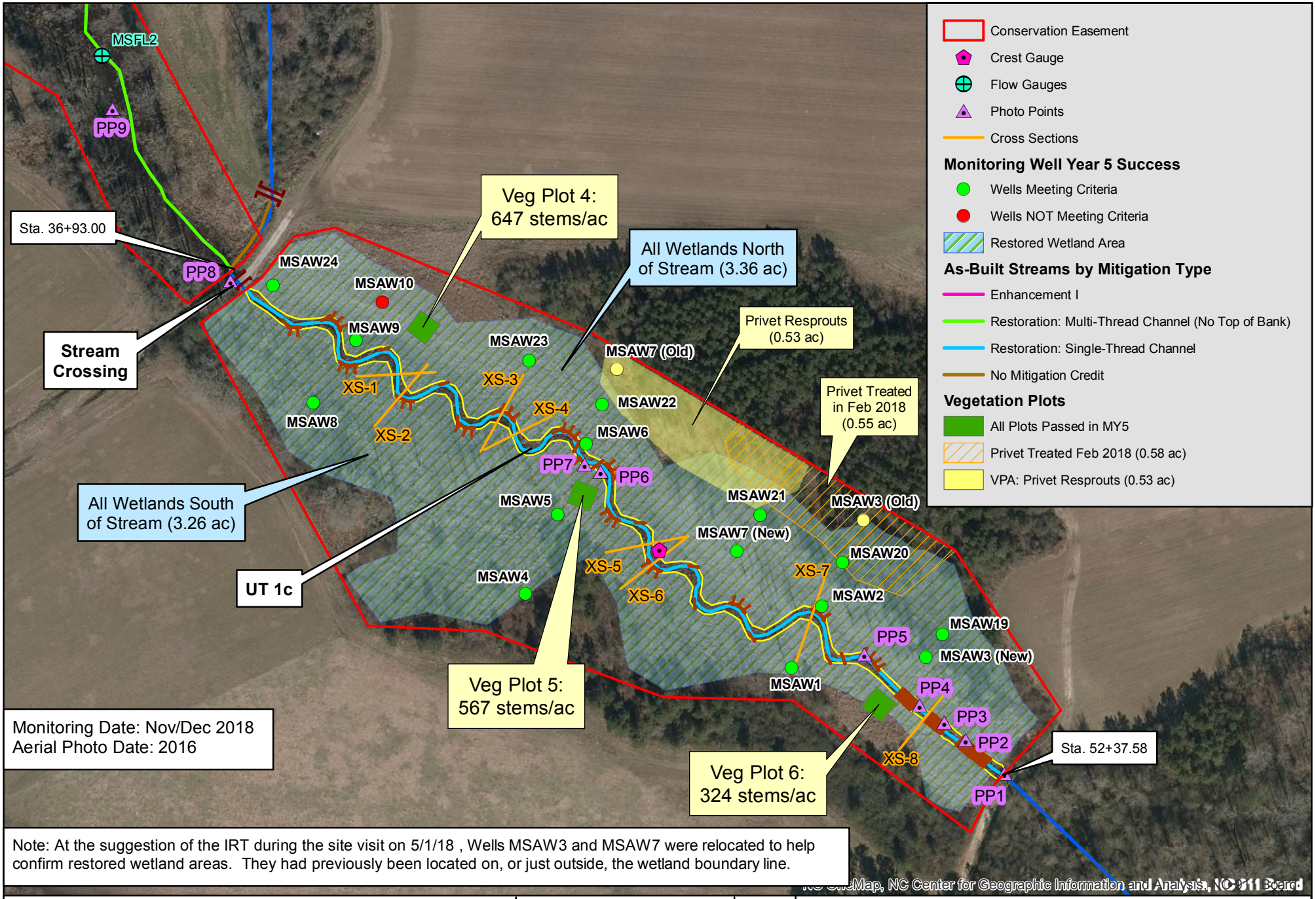

Michael Baker INTERNATIONAL

0 100 200 Feet

N

DMS Project # 95019

**Figure 2A**
**Current Condition Plan View**
**Monitoring Year 5**
**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.

NC OneMap, NC Center for Geographic Information and Analysis, NC 911 Board

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0 100 200 Feet

N

DMS Project # 95019

**Figure 2B**
**Current Condition Plan View**
**Monitoring Year 5**
**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)<br>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<br>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 | 1 | 0.53 | 2.7% |
| 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* ) | Station 43+75 to 46+50 (along the outermost portion of the left bank). See CCPV for exact location | Re-sprouts | See Appendix B |

UT to Mill Swamp: Stream Station Photographs

Photo Point 1 – Upstream 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

UT to Mill Swamp: Stream Station Photographs

Photo Point 7 – Log Weir

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

Photo Point 13 – UT3 Log Weir

Photo Point 14 – UT1b view upstream

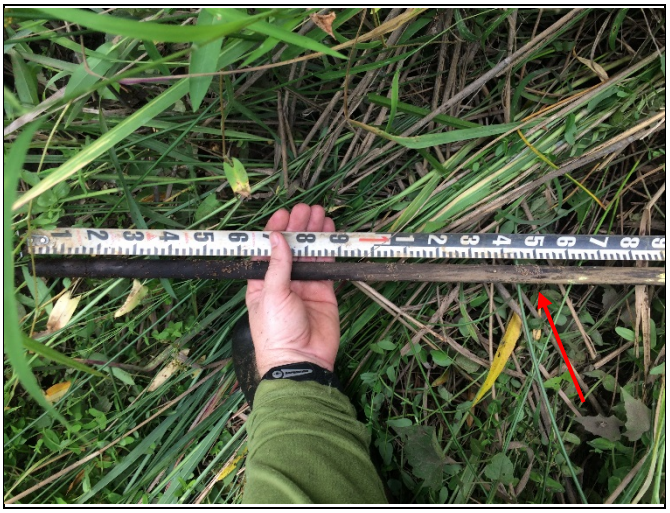
Photo Point 15 – UT1b view upstream

Photo Point 16 – Log Weir

Photo Point 17 – Log Weir

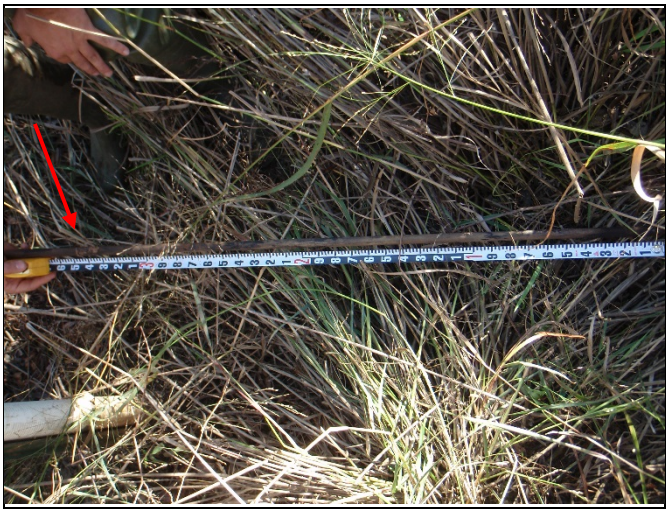
Photo Point 18 – Log Weir

UT to Mill Swamp: Crest Gauge and Flow Camera Photographs



Crest gauge reading: 1.50 ft from 5/31/18 storm

Crest gauge reading: 1.50 ft from 5/31/18 storm



Crest gauge reading: 3.41 ft from 9/15/18
(Hurricane Florence)

Crest gauge reading: 3.41 ft from 9/15/18
(Hurricane Florence)

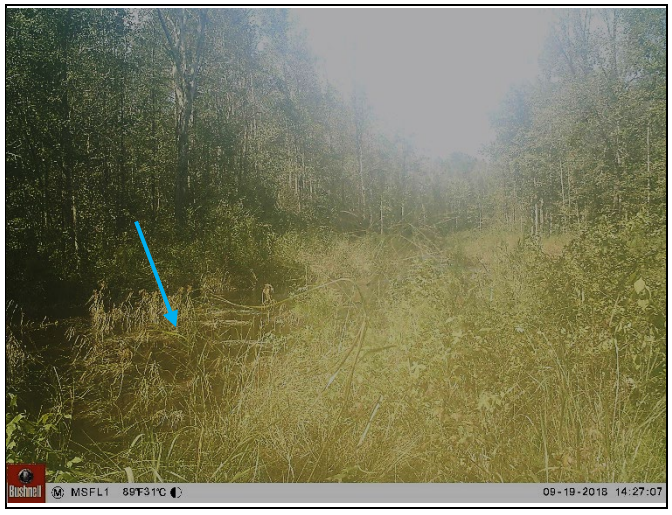
Debris wrack line on floodplain of UT-1c

Debris wrack line outside channel on UT-1b

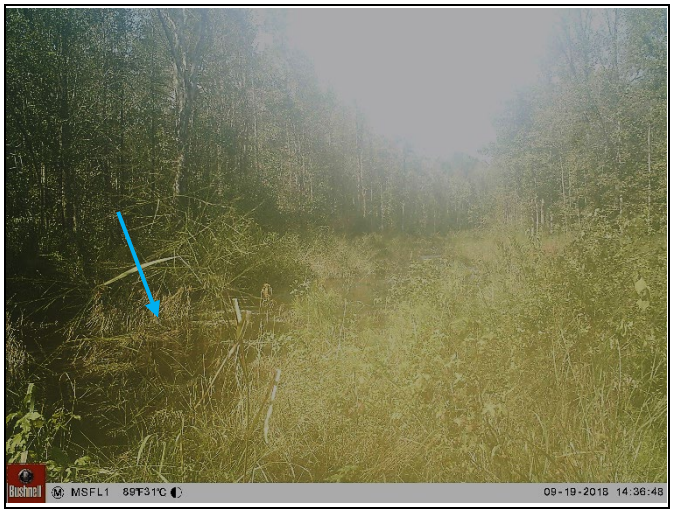
UT to Mill Swamp: Crest Gauge and Flow Camera Photographs


Flow Camera #1 on 1/14/18 (flow in channel)


Flow Camera #1 on 3/8/18 (flow in channel)




Flow Camera #1 on 9/19/18 (post-Hurricane Florence) with flow in channel




Flow Camera #1 on 9/19/18 (post-Hurricane Florence) with flow in channel

Flow looking upstream on Reach UT1b at Station 19+00 on 2/28/18

Flow looking downstream on Reach UT1b at Station 19+00 on 2/28/18

UT to Mill Swamp: Vegetation Plot Photographs

Vegetation Plot 1

Vegetation Plot 2

Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Vegetation Plot 6

UT to Mill Swamp: Vegetation Problem Area Photographs

VPA (*Ligustrum sinense* resprouts) 10/30/18

VPA (*Ligustrum sinense* resprouts) 10/30/18

VPA (*Ligustrum sinense* resprouts) 12/04/18

*Ligustrum sinense* (treated in Feb 2018)

*Ligustrum sinense* (treated in Feb 2018)

*Ligustrum sinense* (treated in Feb 2018)

# 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? | MY5 Planted Density / As-built Planted Stem Density* | 2018 Tract Mean |
|---|---|---|---|
| 1 | Y | 567/1052 | 459 |
| 2 | Y | 324/931 | |
| 3 | Y | 324/1012 | |
| 4 | Y | 647/931 | |
| 5 | Y | 567/809 | |
| 6 | Y | 324/728 | |

Note: *Planted /As-Built Planted Stem Count reflects the changes in stem density for each monitoring year as compared to their initial as built planting density. These stem counts reflect the changes in the *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** | Scott King |
| **Date Prepared** | 11/29/2018 12:01 |
| **database name** | MichaelBaker_UTMillSwamp.mdb |
| **database location** | \\CARYFS1.bkr.mbakercorp.com\PROJECTS\124578\Monitoring\Post-Restoration\Veg Plots |
| **computer name** | CARYLAPOWERS1 |
| **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**

| Species | Species Type | Common Name | Total Planted Stems | # plots | avg# stems | plot 95019-01-0001-year:5 | plot 95019-01-0002-year:5 | plot 95019-01-0003-year:5 | plot 95019-01-0004-year:5 | plot 95019-01-0005-year:5 | plot 95019-01-0006-year:5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| *Carpinus caroliniana* | Shrub/Tree | American hornbeam | 4 | 3 | 1.3 | | | | 2 | 1 | 1 |
| *Fraxinus pennsylvanica* | Tree | green ash | 1 | 1 | 1.0 | 1 | | | | | |
| *Liriodendron tulipifera* | Tree | tuliptree | 3 | 1 | 3.0 | 3 | | | | | |
| *Nyssa biflora* | Tree | swamp tupelo | 5 | 4 | 1.3 | 1 | 1 | 1 | 2 | | |
| *Persea palustris* | Tree | swamp bay | 3 | 3 | 1.0 | 1 | | | | 1 | 1 |
| *Quercus laurifolia* | Tree | laurel oak | 2 | 2 | 1.0 | | | | | 1 | 1 |
| *Quercus lyrata* | Tree | overcup oak | 7 | 4 | 1.8 | 3 | 1 | | | 2 | 1 |
| *Quercus michauxii* | Tree | swamp chestnut oak | 12 | 5 | 2.4 | 3 | 1 | 3 | 1 | 4 | |
| *Quercus nigra* | Tree | water oak | 2 | 2 | 1.0 | 1 | | | 1 | | |
| *Quercus pagoda* | Tree | cherrybark oak | 17 | 6 | 2.8 | 1 | 4 | 1 | 5 | 4 | 2 |
| *Quercus phellos* | Tree | willow oak | 7 | 4 | 1.8 | | 1 | 1 | 4 | 1 | |
| *Taxodium distichum* | Tree | bald cypress | 2 | 1 | 2.0 | | | 2 | | | |
| *Ulmus americana* | Tree | American elm | 3 | 2 | 1.5 | | | | 1 | | 2 |
| | | | **68** | **38** | | **14** | **8** | **8** | **16** | **14** | **8** |

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

| Species Latin Name | Common Name | Plots | | | | | | Year 5 Totals | Yearly Average Planted stems/acre |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 | 2 | 3 | 4 | 5 | 6 | | |
| *Carpinus caroliniana* | American hornbeam | | | | 2 | 1 | 1 | 4 | |
| *Fraxinus pennsylvanica* | green ash | 1 | | | | | | 1 | |
| *Liriodendron tulipifera* | tuliptree | 3 | | | | | | 3 | |
| *Nyssa biflora* | swamp tupelo | 1 | 1 | 1 | 2 | | | 5 | |
| *Persea palustris* | swamp bay | 1 | | | | 1 | 1 | 3 | |
| *Quercus laurifolia* | laurel oak | | | | | 1 | 1 | 2 | |
| *Quercus lyrata* | overcup oak | 3 | 1 | | | 2 | 1 | 7 | |
| *Quercus michauxii* | swamp chestnut oak | 3 | 1 | 3 | 1 | 4 | | 12 | |
| *Quercus nigra* | water oak | 1 | | | 1 | | | 2 | |
| *Quercus pagoda* | cherrybark oak | 1 | 4 | 1 | 5 | 4 | 2 | 17 | |
| *Quercus phellos* | willow oak | | 1 | 1 | 4 | 1 | | 7 | |
| *Taxodium distichum* | bald cypress | | | 2 | | | | 2 | |
| *Ulmus americana* | American elm | | | | 1 | | 2 | 3 | |
| ***Number of Planted Stems Per Plot** | | 14 | 8 | 8 | 16 | 14 | 8 | 68 | |
| **Stems/acre Year 5 (Fall 2018)** | | 567 | 324 | 324 | 648 | 567 | 324 | | 459 |
| **Stems/acre Year 4 (Fall 2017)**** | | - | - | - | - | - | - | | - |
| **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 |

**Notes:**

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

**Supplemental planting in and around the vicinity of Vegetation Plot 3 was completed on March 20, 2017. Monitoring year 4 did not require vegetation plot monitoring.

**Table 9c. CVS Density Per Plot**

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

**Current Plot Data (MY5 2018)**

| 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 | | | | | | | | | | | | | | | | | | |
| *Callicarpa americana* | American beautyberry | Shrub | | 3 | 3 | | 1 | 1 | | | | | | | | | | | | |
| *Carpinus caroliniana* | American hornbeam | Tree | | | | | | | | | | 2 | | 2 | 1 | | 1 | 1 | | 1 |
| *Clethra alnifolia* | coastal sweetpepperbush | Shrub | | 1 | 1 | | | | | | | | | | | | | | | |
| *Fraxinus pennsylvanica* | green ash | Tree | 1 | | 1 | | | | | | | | | | | | | | | |
| *Itea virginica* | Virginia sweetspire | Shrub | | | | | | | | | | | | | | | | | | |
| *Liriodendron tulipifera* | tuliptree | Tree | 3 | | 3 | | | | | 1 | 1 | | | | | | | | | |
| *Nyssa biflora* | swamp tupelo | Tree | 1 | | 1 | 1 | | 1 | 1 | | 1 | 2 | | 2 | | | | | | |
| *Persea palustris* | swamp bay | tree | 1 | 2 | 3 | | | | | | | | | | 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 | 1 | | 1 | 3 | | 3 | 1 | | 1 | 4 | | 4 | | | |
| *Quercus nigra* | water oak | Tree | 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 | | | |
| *Salix nigra* | black willow | Tree | | | | | | | | 1 | 1 | | 1 | 1 | | 10 | 10 | | | |
| *Taxodium distichum* | bald cypress | Tree | | | | | | | 2 | | 2 | | | | | | | | | |
| *Ulmus americana* | American elm | Tree | | | | | | | | | | 1 | | 1 | | | | 2 | | 2 |
| *Acer Rubrum* | Red Maple | Shrub or Tree | | | | | | | | 1 | 1 | | | | | | | | | |
| | | **Stem count** | 14 | 6 | 20 | 8 | 1 | 9 | 8 | 3 | 11 | 16 | 1 | 17 | 14 | 10 | 24 | 8 | 0 | 8 |
| | | **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 | 3 | 10 | 5 | 1 | 6 | 5 | 3 | 8 | 7 | 1 | 8 | 7 | 1 | 8 | 6 | 0 | 6 |
| | | **Stems per ACRE** | 566.56 | 242.81 | 809.37 | 323.75 | 40.47 | 364.22 | 323.75 | 121.41 | 445.15 | 647.50 | 40.47 | 687.97 | 566.56 | 404.69 | 971.25 | 323.75 | 0 | 323.75 |

**Annual Means**

| Scientific Name | Common Name | Species Type | MY5 (2018) | | | MY4 (2016) | | | MY3 (2015) | | | MY2 (2014) | | | MY1 (2013) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | P | V | T | P | V | T | P | V | T | P | V | T | P | V | T |
| *Betula nigra* | river birch | Tree | | | | | | | | | | 1 | 1 | 1 | | | |
| *Callicarpa americana* | American beautyberry | Shrub | | 4 | 4 | | | | | | | | | | | | |
| *Carpinus caroliniana* | American hornbeam | Tree | 4 | | 4 | 4 | | 4 | 4 | | 4 | 3 | | 3 | 5 | | 5 |
| *Clethra alnifolia* | coastal sweetpepperbush | Shrub | | 1 | 1 | | | | | | | | | | | | |
| *Fraxinus pennsylvanica* | green ash | Tree | 1 | | 1 | 1 | | 1 | | | | | | | | | |
| *Itea virginica* | Virginia sweetspire | Shrub | | | | | | | 1 | | 1 | 2 | | 2 | 2 | | 2 |
| *Liriodendron tulipifera* | tuliptree | Tree | 3 | 1 | 4 | 3 | 3 | 6 | 3 | | 3 | 6 | | 6 | 7 | | 7 |
| *Nyssa biflora* | swamp tupelo | Tree | 5 | | 5 | 7 | | 7 | 7 | | 7 | 9 | | 9 | 12 | | 12 |
| *Persea palustris* | swamp bay | tree | 3 | 2 | 5 | 3 | | 3 | 3 | | 3 | 2 | | 2 | 6 | | 6 |
| *Quercus laurifolia* | laurel oak | Tree | 2 | | 2 | 2 | | 2 | 2 | | 2 | | | | | | |
| *Quercus lyrata* | overcup oak | Tree | 7 | | 7 | 7 | | 7 | 9 | | 9 | 9 | | 9 | 9 | | 9 |
| *Quercus michauxii* | swamp chestnut oak | Tree | 12 | | 12 | 13 | | 13 | 15 | | 15 | 20 | | 20 | 21 | | 21 |
| *Quercus nigra* | water oak | Tree | 2 | | 2 | 3 | | 3 | 2 | | 2 | 3 | | 3 | 6 | | 6 |
| *Quercus pagoda* | cherrybark oak | Tree | 17 | | 17 | 17 | | 17 | 14 | | 14 | 14 | | 14 | 12 | | 12 |
| *Quercus phellos* | willow oak | Tree | 7 | | 7 | 7 | | 7 | 7 | | 7 | 9 | | 9 | 10 | | 10 |
| *Salix nigra* | black willow | Tree | | 12 | 12 | | | | | | | | | | | | |
| *Taxodium distichum* | bald cypress | Tree | 2 | | 2 | | | | | | | | | | | | |
| *Ulmus americana* | American elm | Tree | 3 | | 3 | 3 | | 3 | 2 | | 2 | 4 | | 4 | 4 | | 4 |
| *Acer Rubrum* | Red Maple | Shrub or Tree | | 1 | 1 | | | | | | | | | | 2 | | 2 |
| **Stem count** | | | 68 | 21 | 89 | 70 | 3 | 73 | 69 | 0 | 69 | 82 | 1 | 82 | 96 | 0 | 96 |
| **size (ares)** | | | | 6 | | | 6 | | | 6 | | | 6 | | | 6 | |
| **size (ACRES)** | | | | 0.15 | | | 0.15 | | | 0.15 | | | 0.15 | | | 0.15 | |
| **Species count** | | | 13 | 6 | 17 | 12 | 1 | 12 | 12 | 0 | 12 | 12 | 1 | 12 | 12 | 0 | 12 |
| **Stems per ACRE** | | | 458.64 | 141.64 | 600.28 | 472.13 | 20.23 | 492.37 | 465.39 | 0 | 465.39 | 553.07 | 6.74 | 553.07 | 647.50 | 0 | 647.50 |

**Color for Density**

| | |
|---|---|
| Exceeds requirements by 10% | |
| Exceeds requirements, but by less than 10% | |
| Fails to meet requirements, by less than 10% | |
| Fails to meet requirements by more than 10% | |
| Volunteers | |

**P** Planted
**V** Volunteers
**T** Total

**Table 9d. Vegetation Plot Summary Information**
**UT to Mill Swamp Restoration Project: DMS Project ID No. 95019**

## UT to Mill Swamp (#95019)

**Year 5 (30-Oct-2018)**

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 | 6 | **20** | 0 |
| **2** | n/a | 8 | 0 | 0 | 1 | **9** | 0 |
| **3** | n/a | 8 | 0 | 0 | 2 | **11** | 0 |
| **4** | n/a | 16 | 0 | 0 | 1 | **17** | 0 |
| **5** | n/a | 14 | 0 | 0 | 10 | **24** | 0 |
| **6** | n/a | 8 | 0 | 0 | 0 | **8** | 0 |

## Wetland/Stream Vegetation Totals

(per acre)

| Plot # | Stream/ Wetland Stems[2] | Volunteers[3] | Total[4] | Success Criteria Met? |
|---|---|---|---|---|
| **1** | 567 | 243 | 809 | Yes |
| **2** | 324 | 40 | 364 | Yes |
| **3** | 324 | 121 | 445 | Yes |
| **4** | 647 | 40 | 688 | Yes |
| **5** | 567 | 405 | 971 | Yes |
| **6** | 324 | 0 | 324 | Yes |
| **Project Avg** | **459** | **148** | **594** | **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%

# Appendix D

## Stream Survey Data

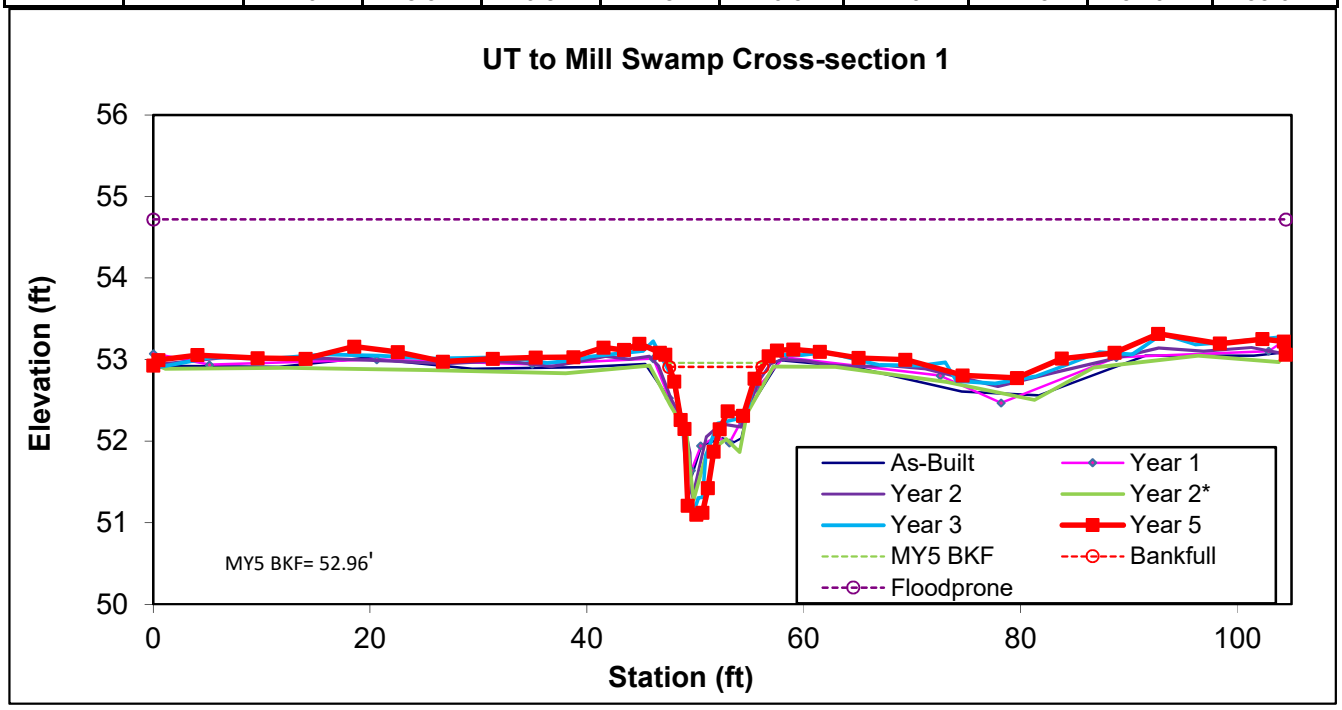
## Figure 3. Cross-sections with Annual Overlays.

### Permanent Cross-section 1

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | E | 7.0 | 8.5 | 0.8 | 1.8 | 10.3 | 1.0 | 12.3 | 52.91 | 53.04 |



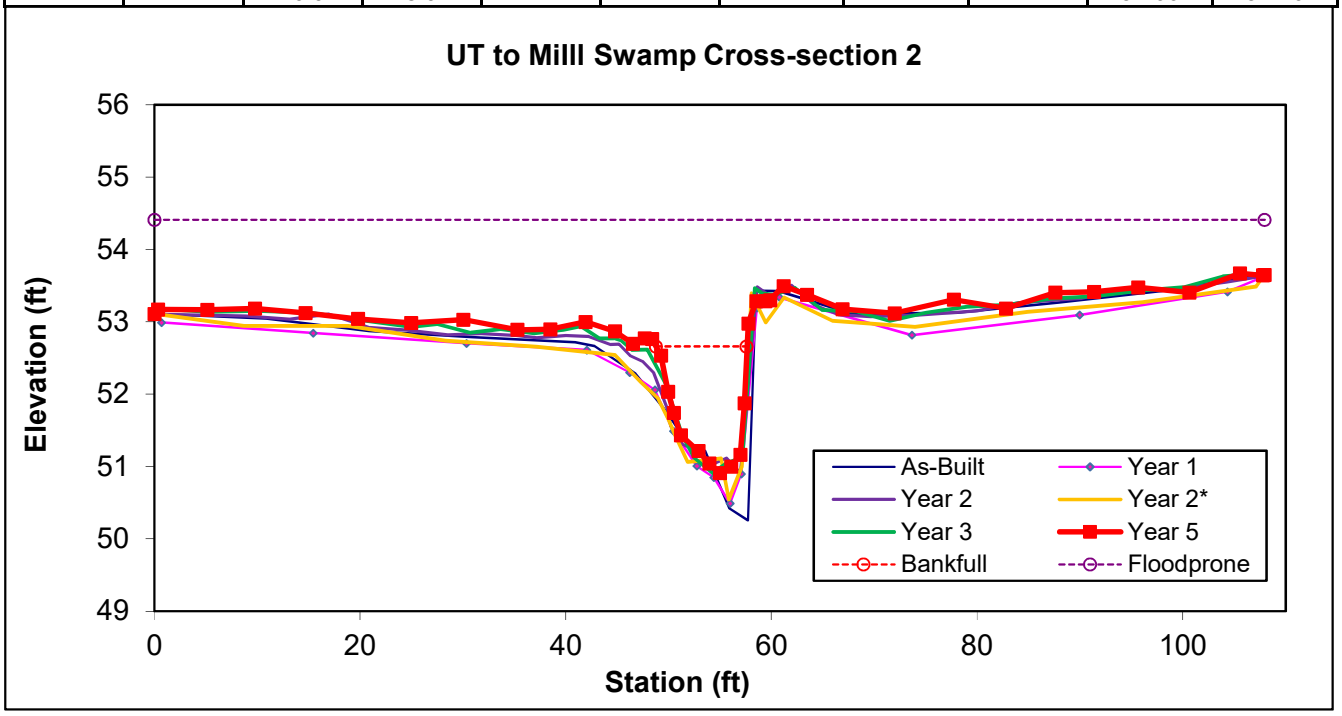

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 2

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | - | 10.9 | 8.9 | 1.2 | 1.7 | 7.2 | - | - | 52.66 | 52.76 |



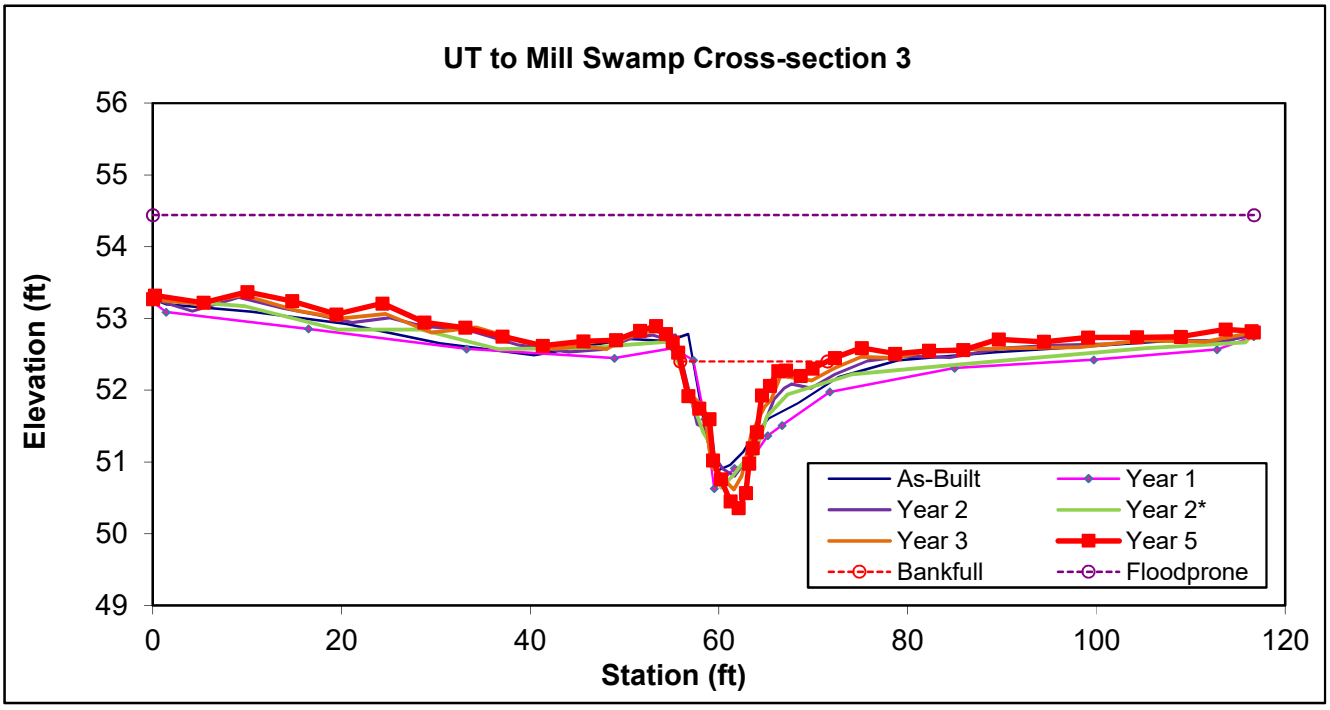

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 3

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | - | 11.4 | 15.6 | 0.7 | 2.0 | 21.2 | - | - | 52.40 | 52.27 |



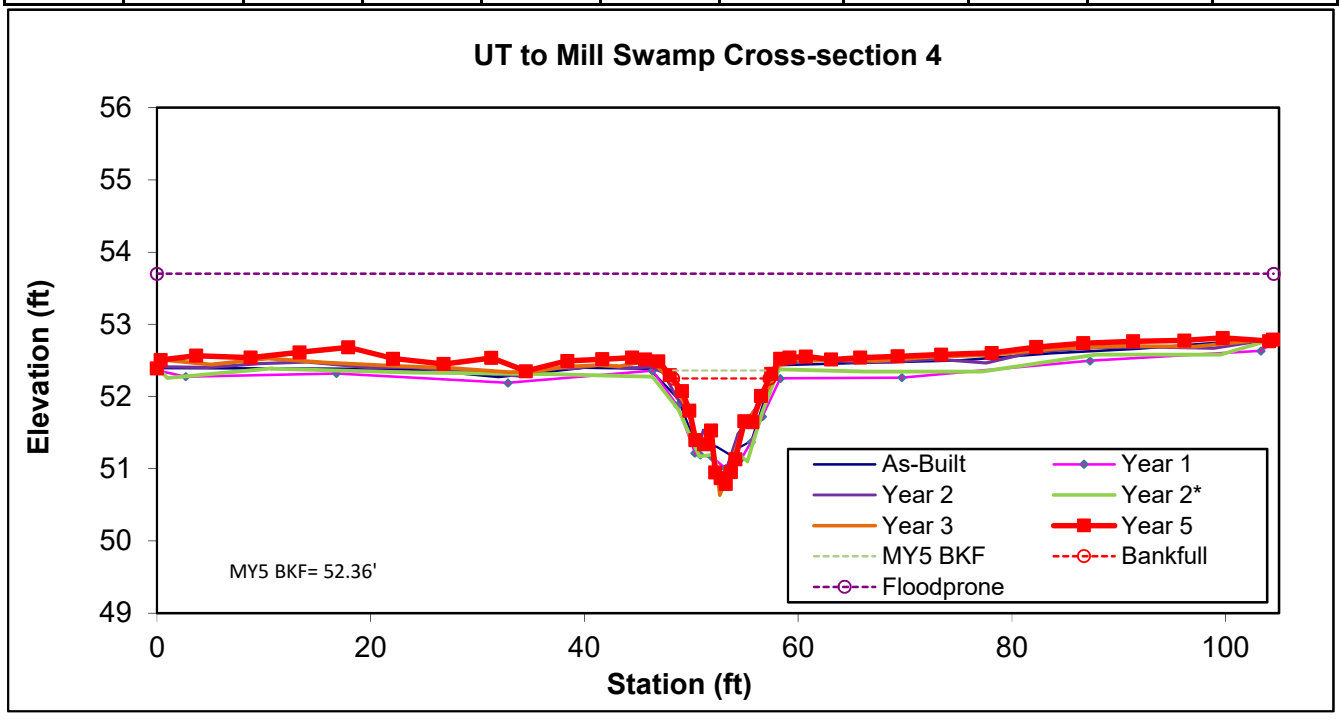

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 4

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 6.4 | 9.0 | 0.7 | 1.5 | 12.7 | 1.1 | 11.6 | 52.25 | 52.49 |



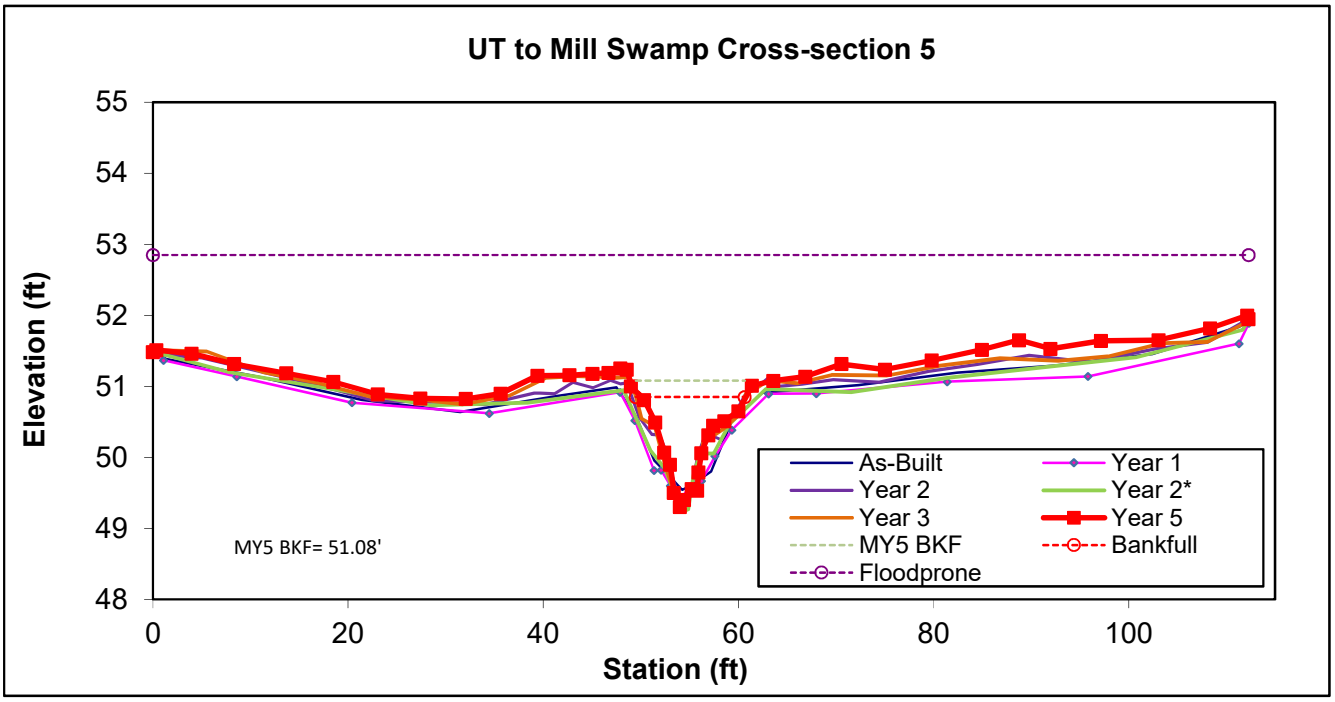

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 5

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | C | 7.1 | 10.7 | 0.7 | 1.5 | 16.2 | 1.0 | 10.5 | 50.85 | 50.45 |



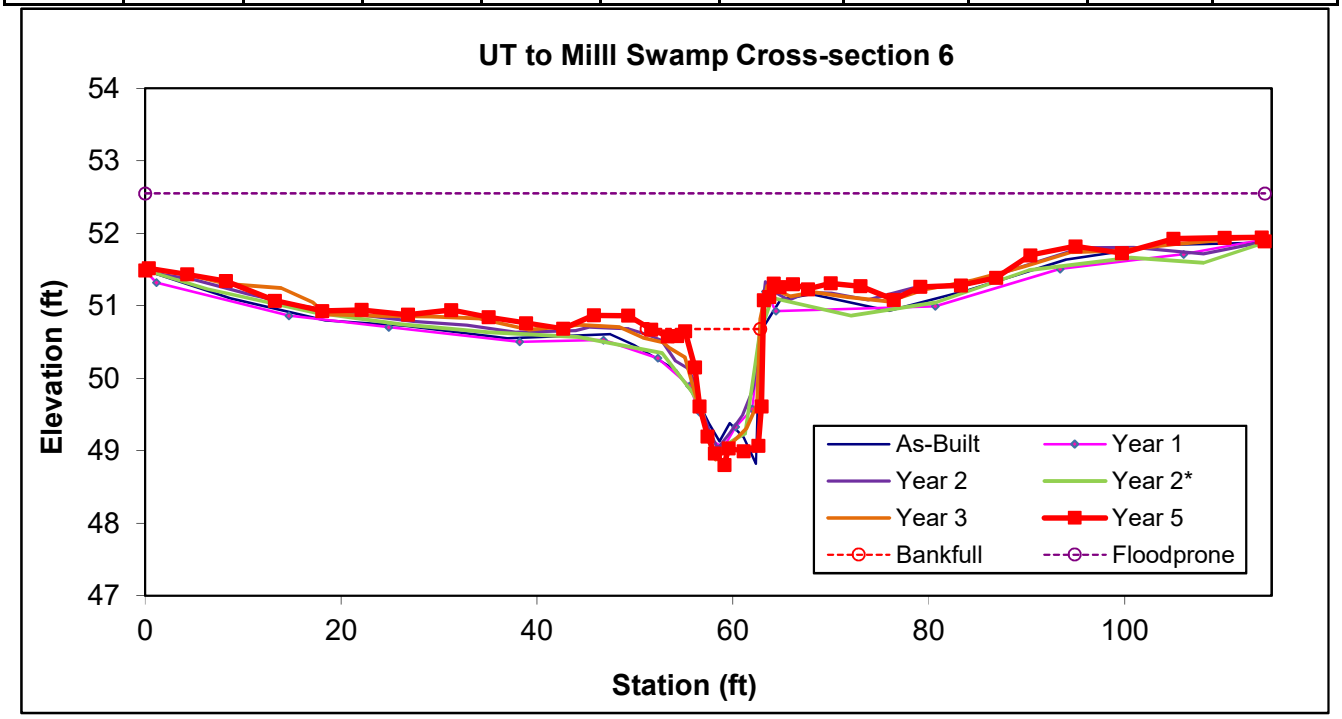

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 6

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | - | 11.2 | 11.5 | 1.0 | 1.9 | 11.8 | - | - | 50.68 | 50.65 |



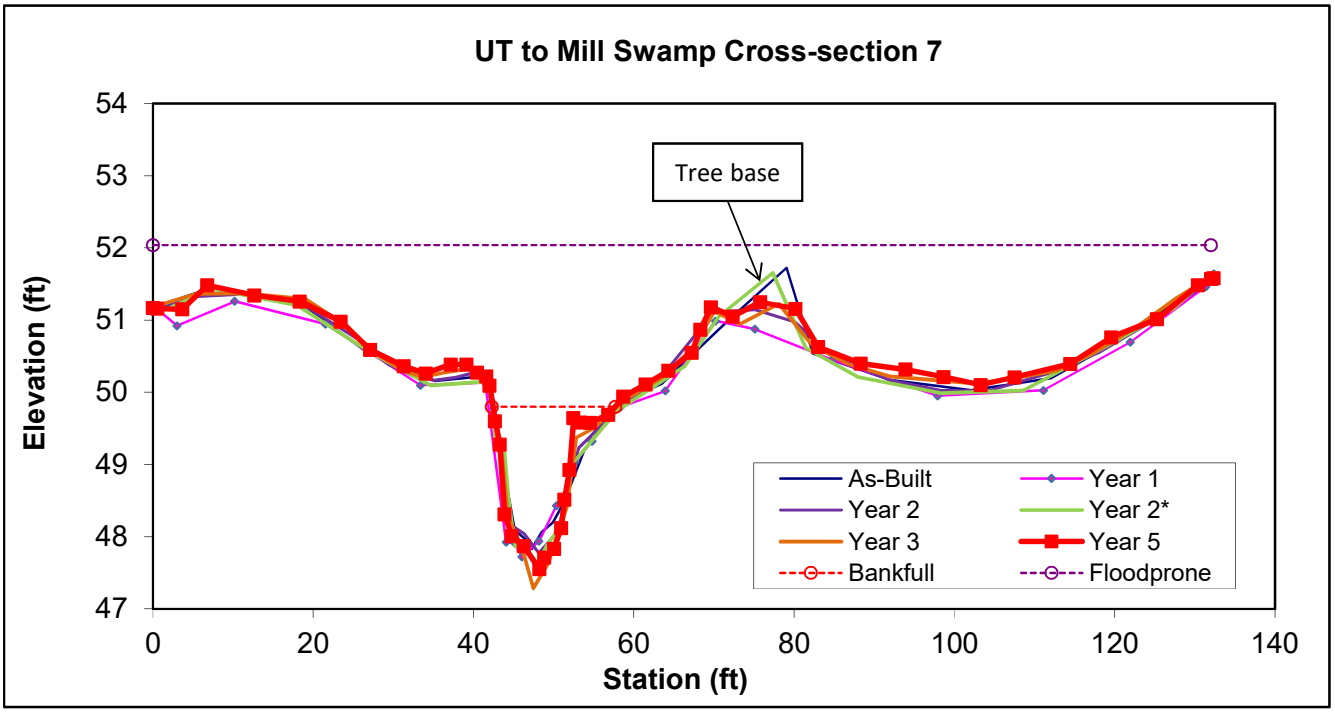

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 7

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Pool | - | 17.0 | 15.2 | 1.1 | 2.2 | 13.6 | - | - | 49.80 | 49.65 |



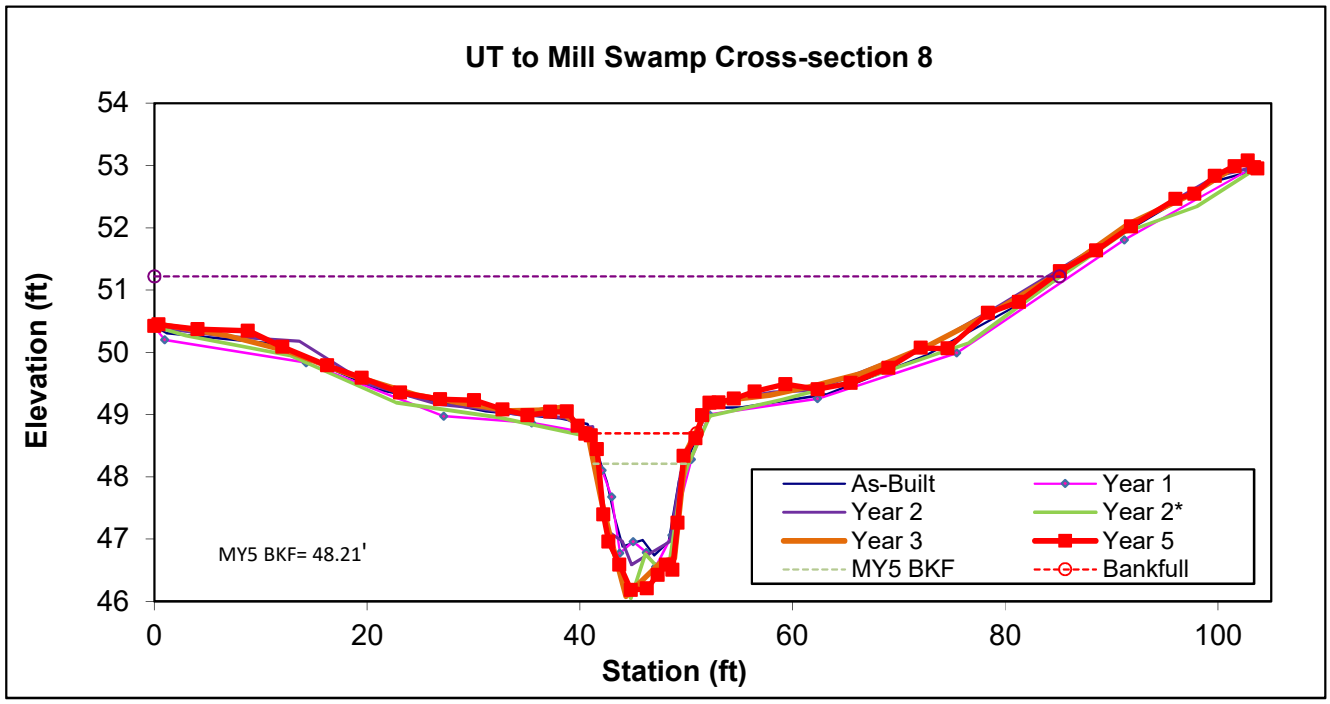

Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

# Permanent Cross-section 8

(Year 5 Data - Collected November 2018)



| Feature | Stream Type | BKF Area | BKF Width | BKF Depth | Max BKF Depth | W/D | BH Ratio | ER | BKF Elev | TOB Elev |
|---|---|---|---|---|---|---|---|---|---|---|
| Riffle | E | 16.6 | 10.5 | 1.6 | 2.5 | 6.7 | 1.2 | 8.0 | 48.70 | 48.66 |




Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

**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) $lb/ft^2$ | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |
| 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) $lb/ft^2$ | ----- | 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 | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- | ----- |

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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 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ |
| **Based on fixed baseline bankfull elevation** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BF Width (ft) | 11.9 | 11.1 | 11.3 | 10.1 | 8.8 | -- | 8.5 | | 15.4 | 22.5 | 21.3 | 12.7 | 11.9 | -- | 8.9 | | 21.3 | 39.2 | 33.5 | 19.6 | 18.1 | -- | 15.6 | | 11.2 | 11.5 | 11.3 | 9.6 | 9.7 | -- | 9.0 | |
| BF Mean Depth (ft) | 0.6 | 0.6 | 0.7 | 0.6 | 0.8 | -- | 0.8 | | 1.1 | 0.7 | 0.7 | 1.0 | 1.0 | -- | 1.2 | | 0.6 | 0.5 | 0.5 | 0.7 | 0.7 | -- | 0.7 | | 0.7 | 0.7 | 0.8 | 0.7 | 0.7 | -- | 0.7 | |
| Width/Depth Ratio | 18.9 | 17.7 | 16.1 | 15.9 | 11.7 | -- | 10.3 | | 14.4 | 31.2 | 30.1 | 12.6 | 12.0 | -- | 7.2 | | 33.9 | 82.4 | 72.8 | 29.6 | 27.8 | -- | 21.2 | | 16.5 | 15.4 | 14.7 | 14.6 | 14.3 | -- | 12.7 | |
| BF Cross-sectional Area (ft²) | 7.5 | 6.9 | 8.0 | 6.4 | 6.6 | -- | 7.0 | | 16.6 | 16.2 | 15.0 | 12.8 | 11.9 | -- | 10.9 | | 13.4 | 18.7 | 15.4 | 12.9 | 11.7 | -- | 11.4 | | 7.5 | 8.5 | 8.7 | 6.3 | 6.6 | -- | 6.4 | |
| BF Max Depth (ft) | 1.4 | 1.3 | 1.6 | 1.6 | 1.7 | -- | 1.8 | | 2.4 | 2.2 | 2.1 | 1.8 | 1.8 | -- | 1.7 | | 1.5 | 1.8 | 1.8 | 1.6 | 1.8 | -- | 2.0 | | 1.1 | 1.3 | 1.5 | 1.5 | 1.6 | -- | 1.5 | |
| Width of Floodprone Area (ft) | 104 | 104 | 104 | 104 | 104 | -- | 104 | | 108 | 108 | 108 | 108 | 108 | -- | 108 | | 117 | 117 | 117 | 117 | 117 | -- | 117 | | 104 | 105 | 104 | 104 | 104 | -- | 105 | |
| Entrenchment Ratio | 8.8 | 9.4 | 9.2 | 10.3 | 11.9 | -- | 12.3 | | - | - | - | - | - | -- | - | | - | - | - | - | - | -- | - | | 9.4 | 9.1 | 9.2 | 10.8 | 10.8 | -- | 11.6 | |
| Bank Height Ratio | 1.0 | 1.1 | 1.0 | 1.0 | 1.1 | -- | 1.0 | | - | - | - | - | - | -- | - | | - | - | - | - | - | -- | - | | 1.1 | 1.0 | 1.0 | 1.1 | 1.2 | -- | 1.1 | |
| Wetted Perimeter (ft) | 13.2 | 12.3 | 12.7 | 11.4 | 10.3 | -- | 9.9 | | 17.6 | 23.9 | 22.7 | 14.7 | 13.9 | -- | 10.2 | | 22.5 | 40.2 | 34.4 | 20.9 | 19.4 | -- | 16.7 | | 12.5 | 12.9 | 12.9 | 11.0 | 11.0 | -- | 9.9 | |
| Hydraulic Radius (ft) | 0.6 | 0.6 | 0.6 | 0.6 | 0.6 | -- | 0.7 | | 0.9 | 0.7 | 0.7 | 0.9 | 0.9 | -- | 1.1 | | 0.6 | 0.5 | 0.4 | 0.6 | 0.6 | -- | 0.7 | | 0.6 | 0.7 | 0.7 | 0.6 | 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 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ | Base | MY1 | MY2* | MY2 | MY3 | [1]MY4 | MY5 | MY+ |
| **Based on fixed baseline bankfull elevation** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| BF Width (ft) | 13.8 | 14.6 | 13.4 | 11.5 | 11.2 | -- | 10.7 | | 15.1 | 31.0 | 22.9 | 13.3 | 13.9 | -- | 11.5 | | 15.5 | 16.6 | 16.3 | 15.8 | 15.6 | -- | 15.2 | | 10.1 | 10.7 | 12.2 | 9.6 | 10.2 | -- | 10.5 | |
| BF Mean Depth (ft) | 0.7 | 0.7 | 0.7 | 0.7 | 0.7 | -- | 0.7 | | 0.8 | 0.4 | 0.5 | 0.7 | 0.8 | -- | 1.0 | | 1.1 | 1.1 | 1.1 | 1.1 | 1.2 | -- | 1.1 | | 1.2 | 1.3 | 1.3 | 1.4 | 1.6 | -- | 1.6 | |
| Width/Depth Ratio | 19.4 | 19.8 | 19.0 | 17.3 | 15.5 | -- | 16.2 | | 20.1 | 78.8 | 46.4 | 18.4 | 17.5 | -- | 11.8 | | 14.5 | 14.9 | 15.0 | 14.7 | 13.4 | -- | 13.6 | | 8.3 | 8.4 | 9.1 | 6.8 | 6.2 | -- | 6.7 | |
| BF Cross-sectional Area (ft²) | 9.9 | 10.8 | 9.5 | 7.6 | 8.0 | -- | 7.1 | | 11.3 | 12.2 | 11.3 | 9.7 | 11.1 | -- | 11.2 | | 16.7 | 18.4 | 17.7 | 17.0 | 18.2 | -- | 17.0 | | 12.3 | 13.6 | 16.3 | 13.7 | 16.7 | -- | 16.6 | |
| BF Max Depth (ft) | 1.3 | 1.4 | 1.6 | 1.5 | 1.6 | -- | 1.5 | | 1.8 | 1.6 | 1.7 | 1.7 | 1.8 | -- | 1.9 | | 2.0 | 2.1 | 2.2 | 2.0 | 2.5 | -- | 2.2 | | 2.0 | 2.2 | 2.7 | 2.1 | 2.6 | -- | 2.5 | |
| Width of Floodprone Area (ft) | 112 | 112 | 112 | 112 | 112 | -- | 112 | | 114 | 114 | 114 | 114 | 114 | -- | 114 | | 132 | 132 | 132 | 132 | 132 | -- | 132 | | 80 | 83 | 86 | 80 | 85 | -- | 85 | |
| Entrenchment Ratio | 8.1 | 7.7 | 8.4 | 9.8 | 10.1 | -- | 10.5 | | - | - | - | - | - | -- | - | | - | - | - | - | - | -- | - | | 7.9 | 7.8 | 7.1 | 8.3 | 8.4 | -- | 8.0 | |
| Bank Height Ratio | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 | -- | 1.0 | | - | - | - | - | - | -- | - | | - | - | - | - | - | -- | - | | 1.1 | 1.0 | 1.0 | 1.0 | 1.2 | -- | 1.2 | |
| Wetted Perimeter (ft) | 15.3 | 16.1 | 14.9 | 12.8 | 12.6 | -- | 11.5 | | 16.6 | 31.8 | 23.9 | 14.8 | 15.5 | -- | 13.3 | | 17.7 | 18.8 | 18.5 | 17.9 | 17.9 | -- | 16.7 | | 12.5 | 13.2 | 14.8 | 12.5 | 13.4 | -- | 12.6 | |
| Hydraulic Radius (ft) | 0.6 | 0.7 | 0.6 | 0.6 | 0.6 | -- | 0.6 | | 0.7 | 0.4 | 0.5 | 0.7 | 0.7 | -- | 11.8 | | 0.9 | 1.0 | 1.0 | 0.9 | 1.0 | -- | 1.0 | | 1.0 | 1.0 | 1.1 | 1.1 | 1.2 | -- | 1.3 | |
| **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) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

**Notes:**
* 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 (2017) will be considered Year 4. All references to Year 4 included in this report will indicate monitoring activities conducted during 2017. Data collected during 2014 that was previously considered monitoring Year 2 is labeled as Year 2*

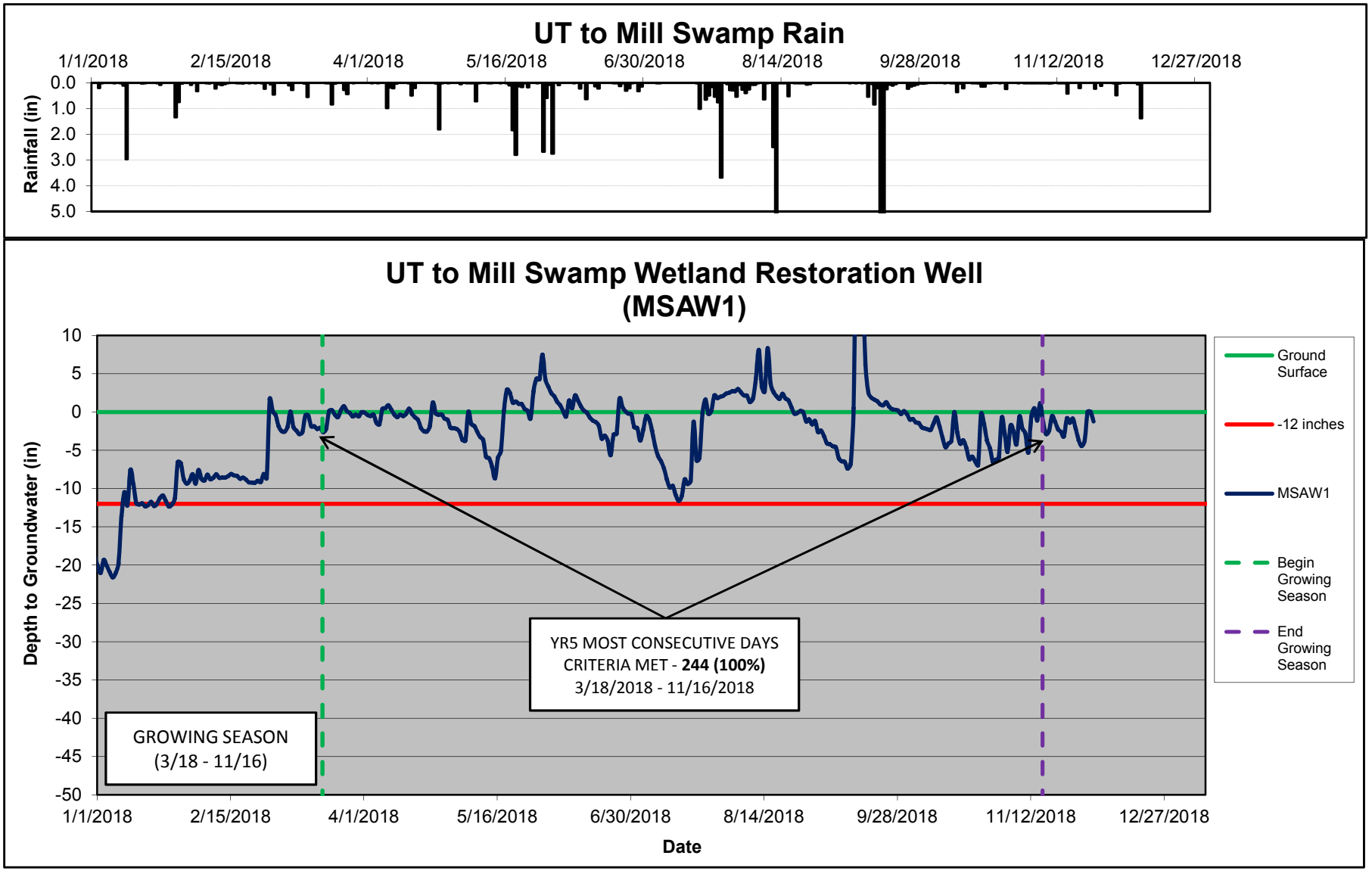
[1] UT to Mill Swamp Restoration Site does not require Year 4 and 6 monitoring cross-sectional surveys per Site Mitigation Plan

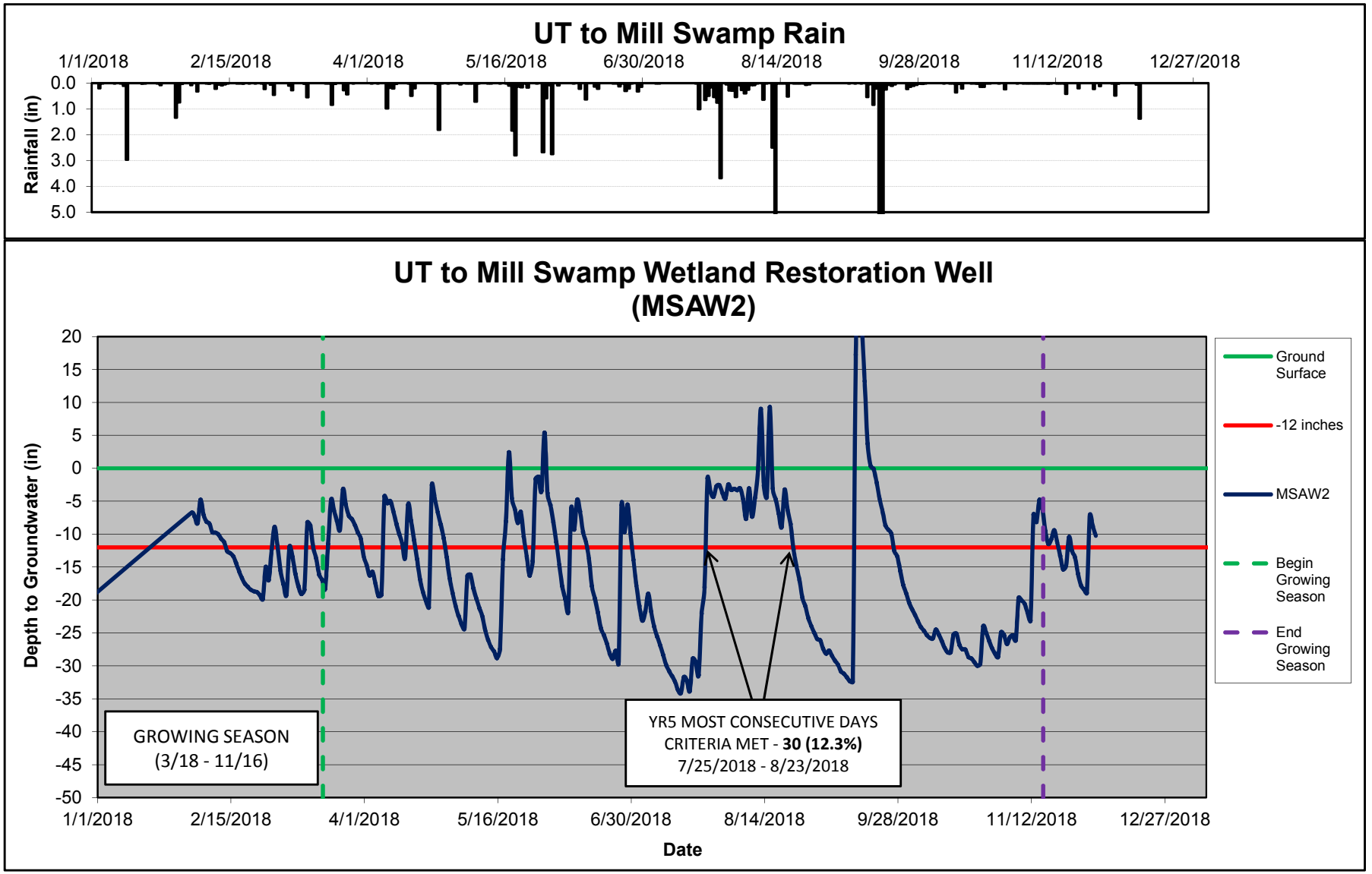
Note: Per DMS/IRT request, bank height ratio for MY5 has been calculated using the as-built bankfull area. All other values were calculated using the as-built bankfull elevation, as was done for previous monitoring reports.

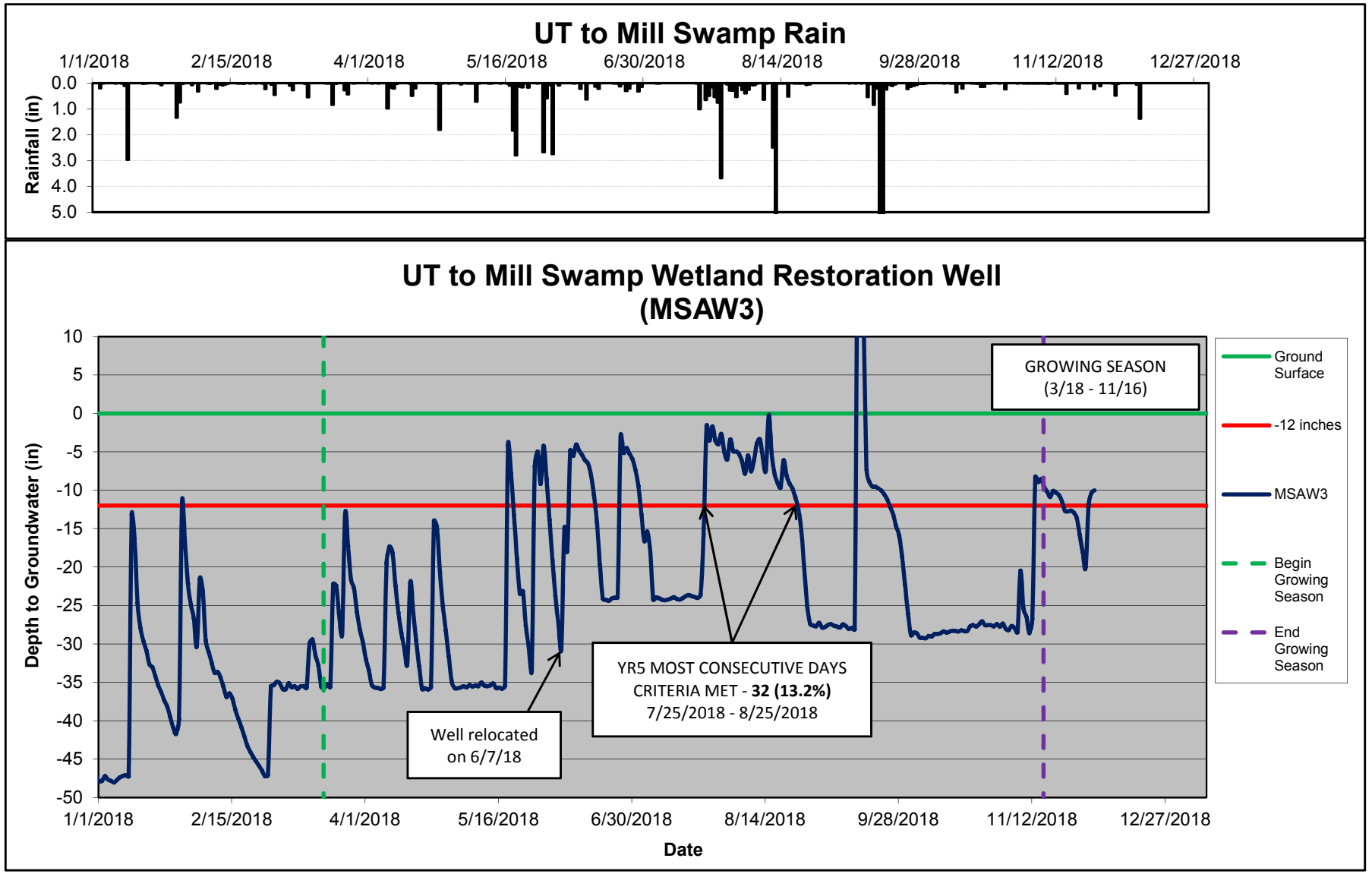
# Appendix E

## Hydrologic Data

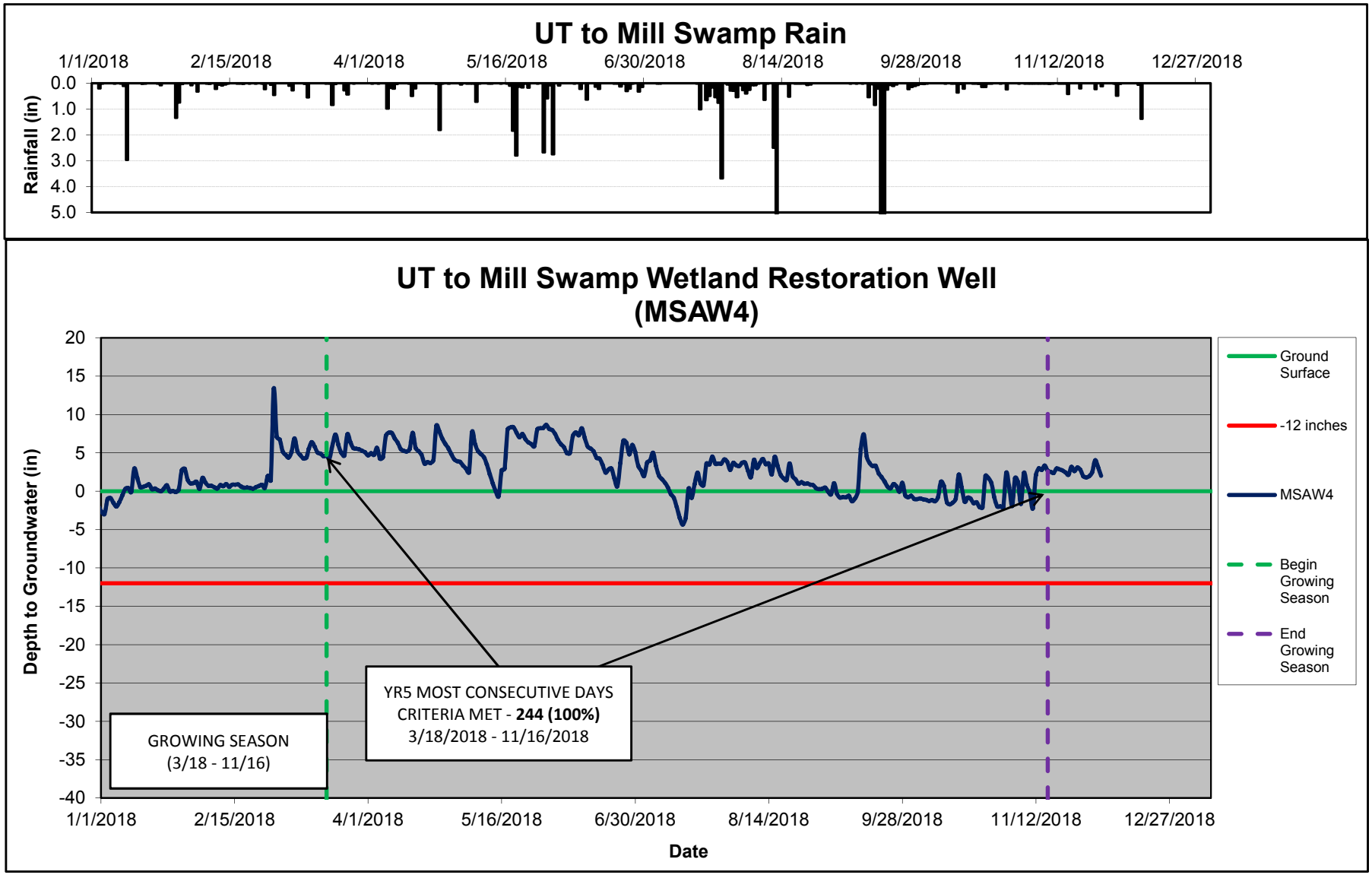
## Figure 4. Wetland Gauge Graphs

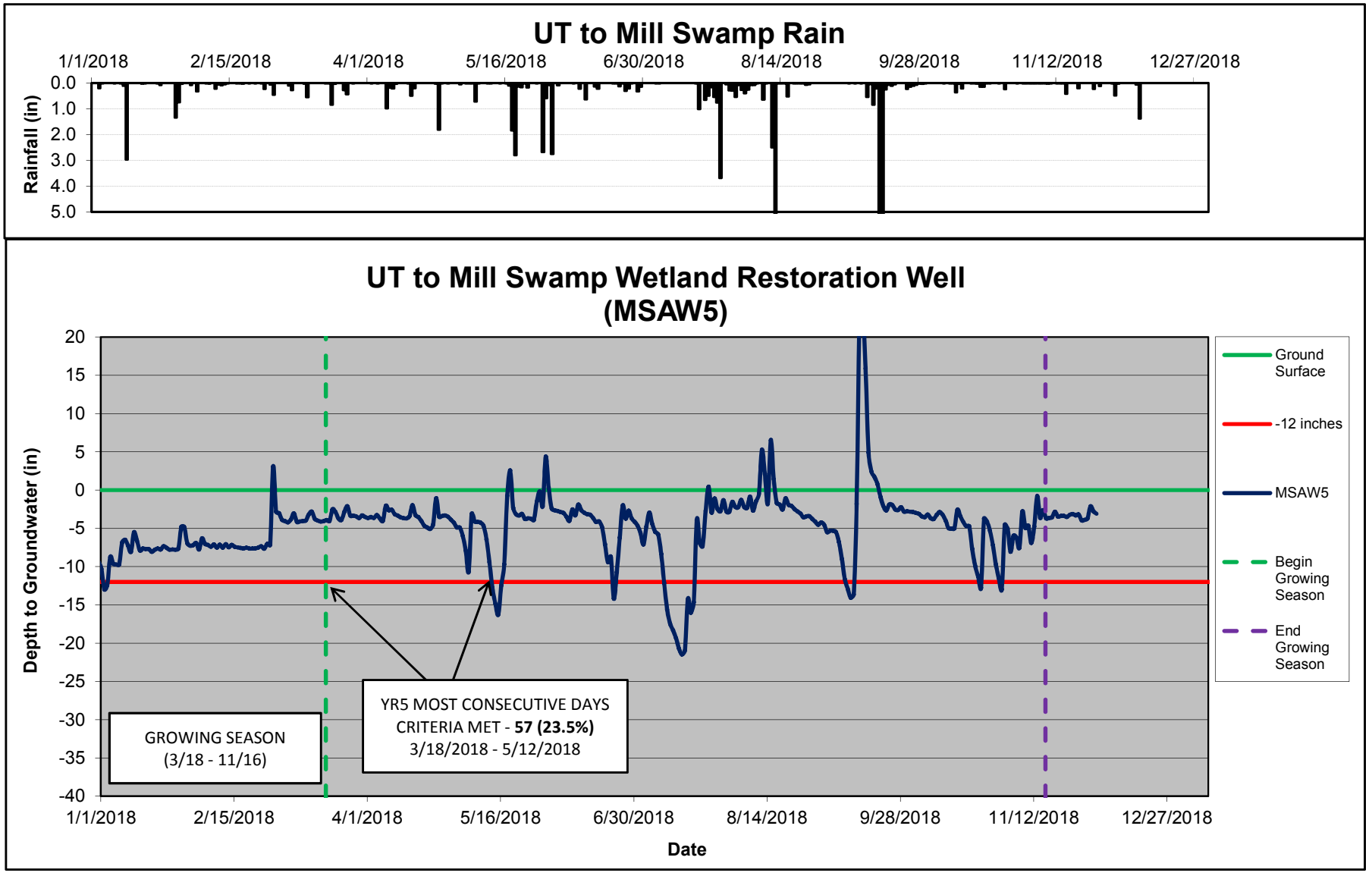


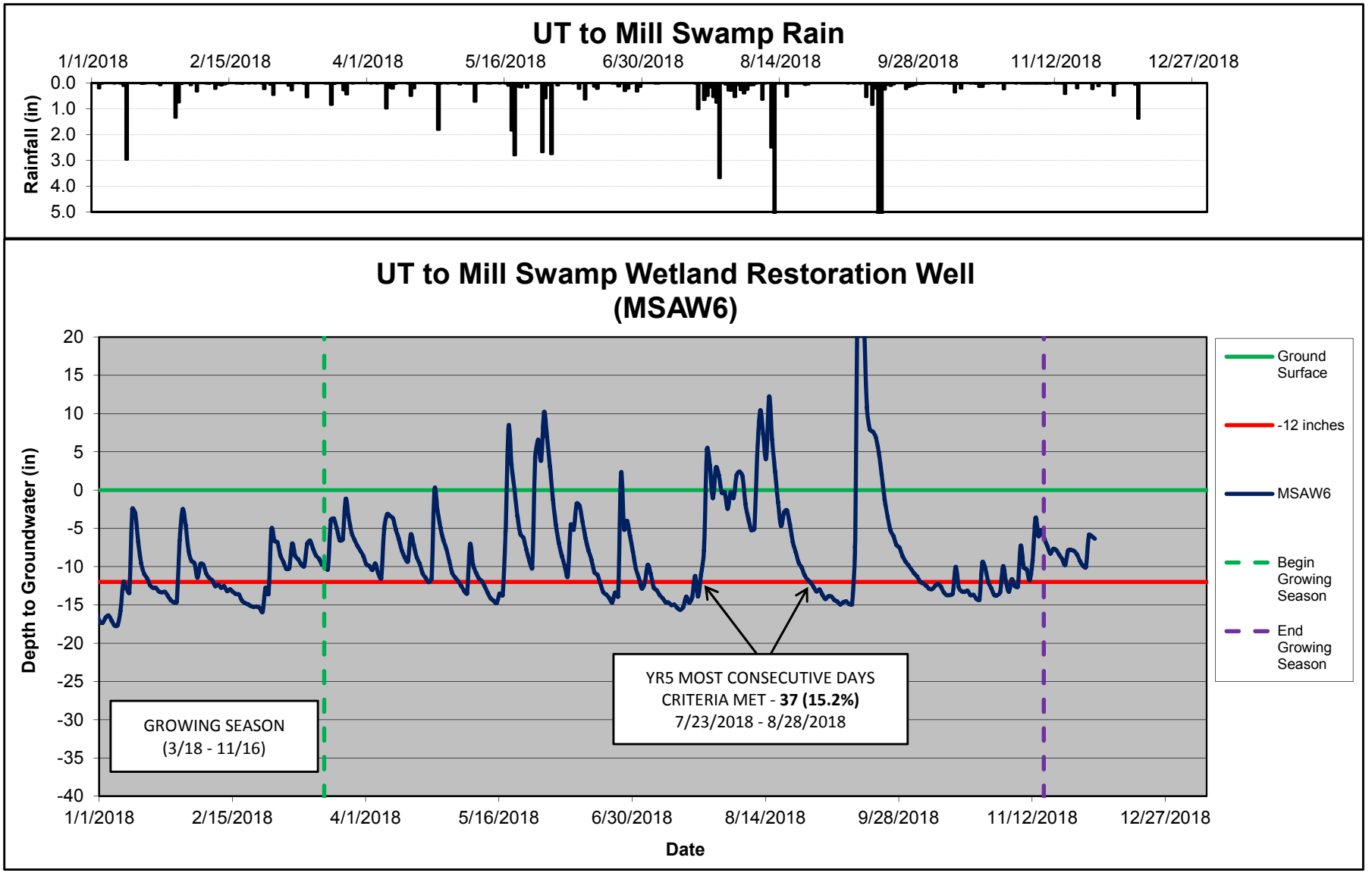

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW2)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW2
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 30 (12.3%)
7/25/2018 - 8/23/2018
Date

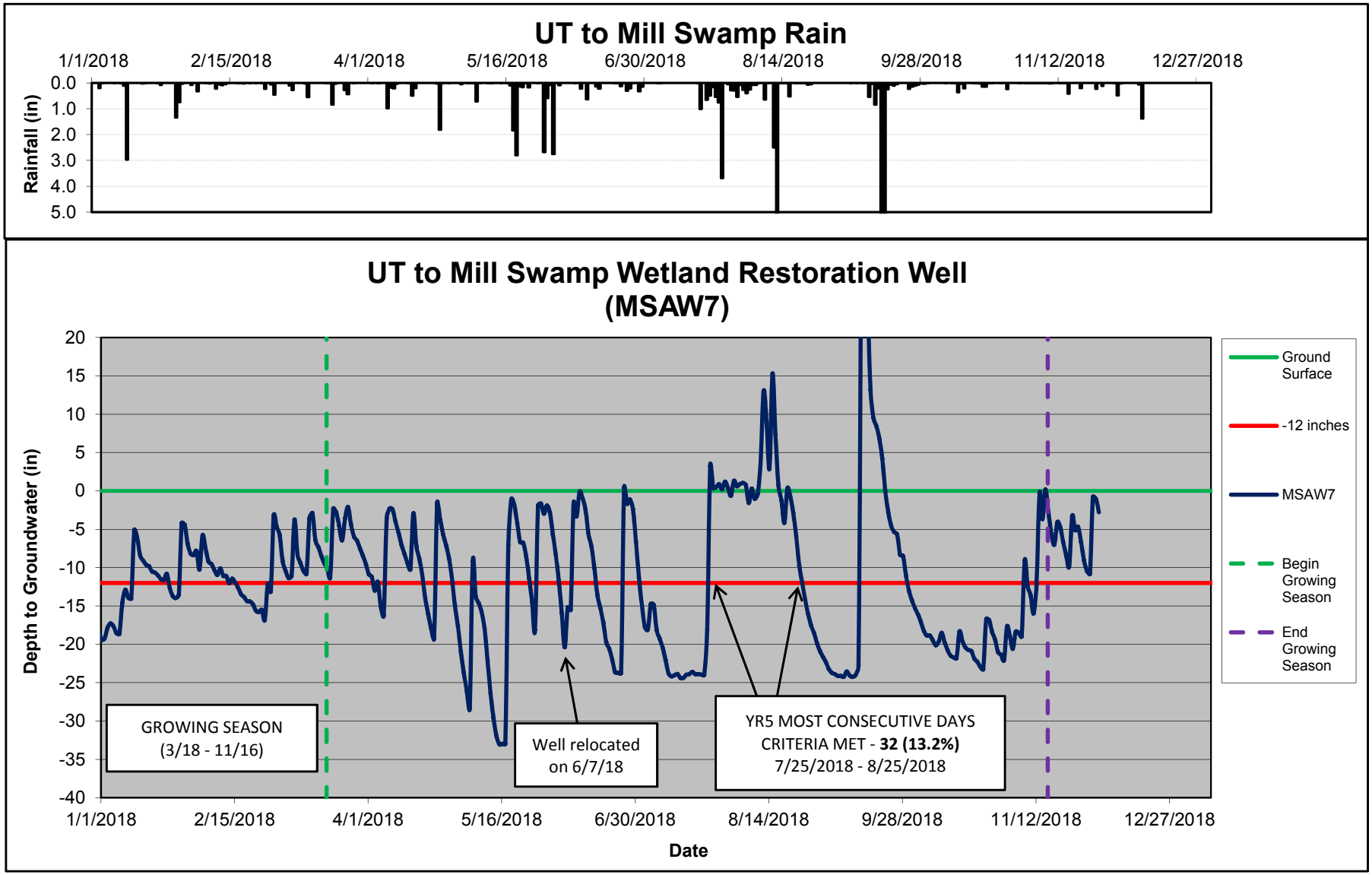



**Note: Well MSAW3 was relocated by IRT suggestion on 6/7/18 as shown on the CCPV in Appendix B.**

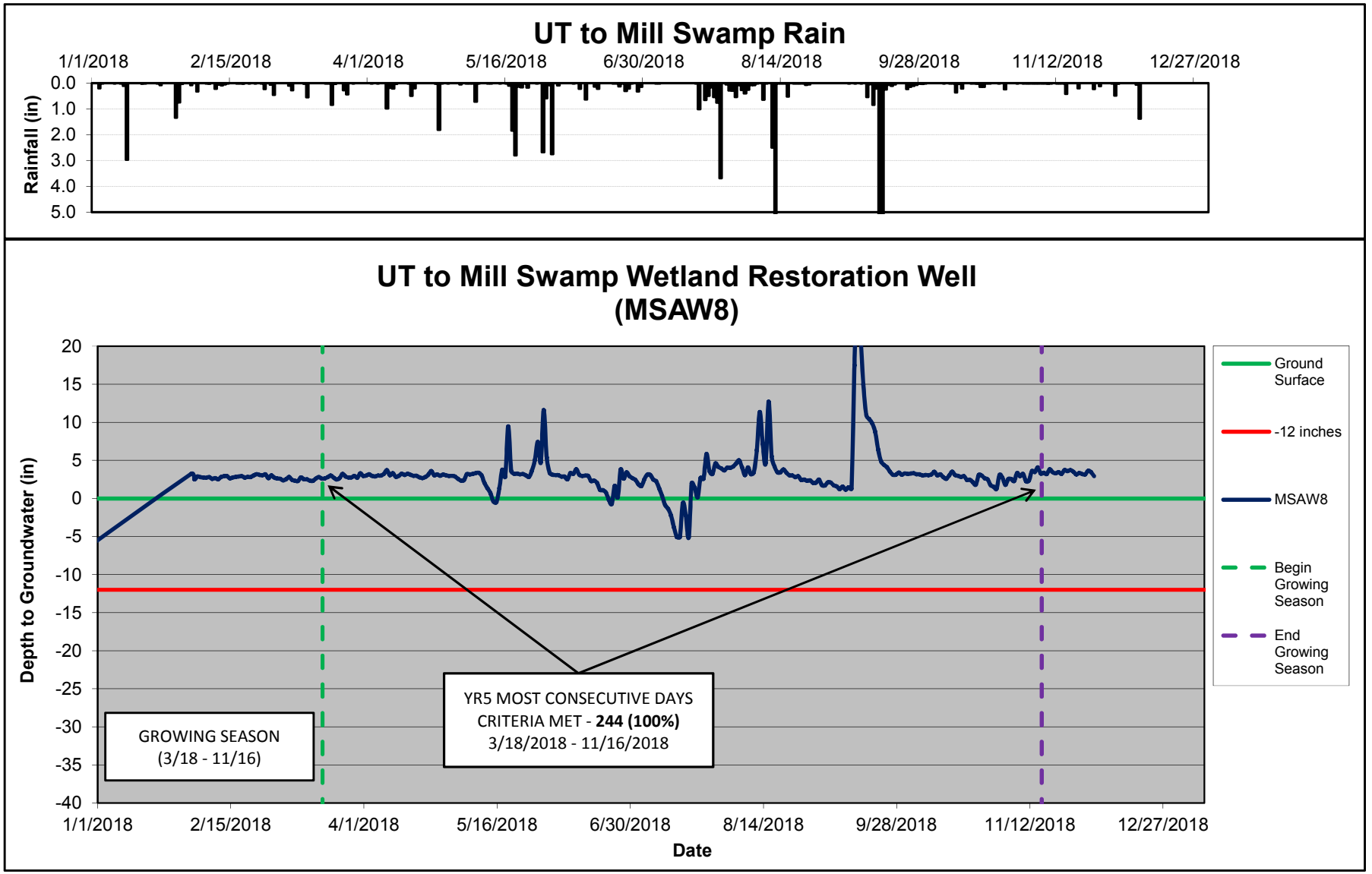

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW4)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 244 (100%)
3/18/2018 - 11/16/2018
Ground Surface
-12 inches
MSAW4
Begin Growing Season
End Growing Season
Date

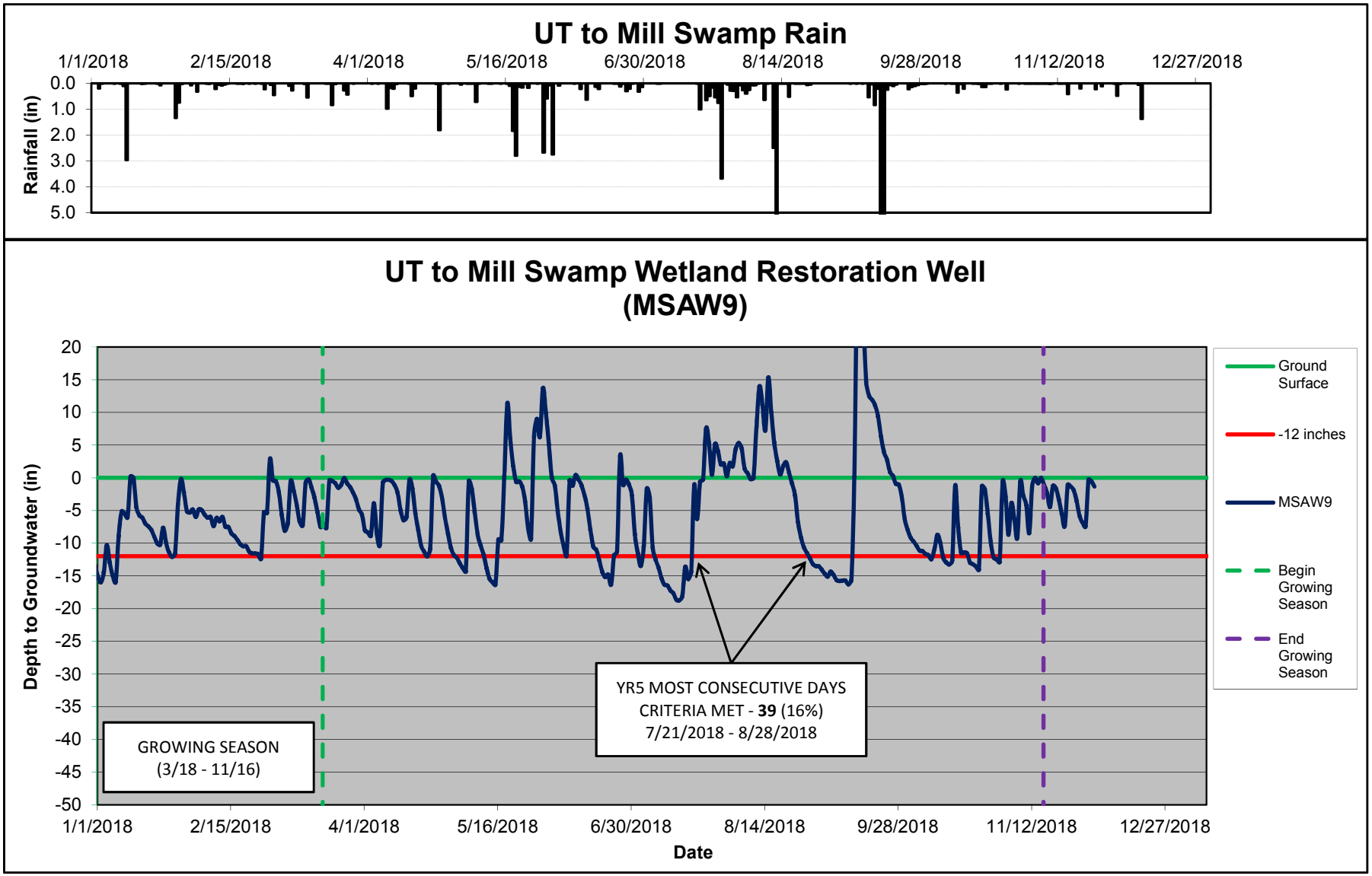

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW5)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW5
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 57 (23.5%)
3/18/2018 - 5/12/2018
Date

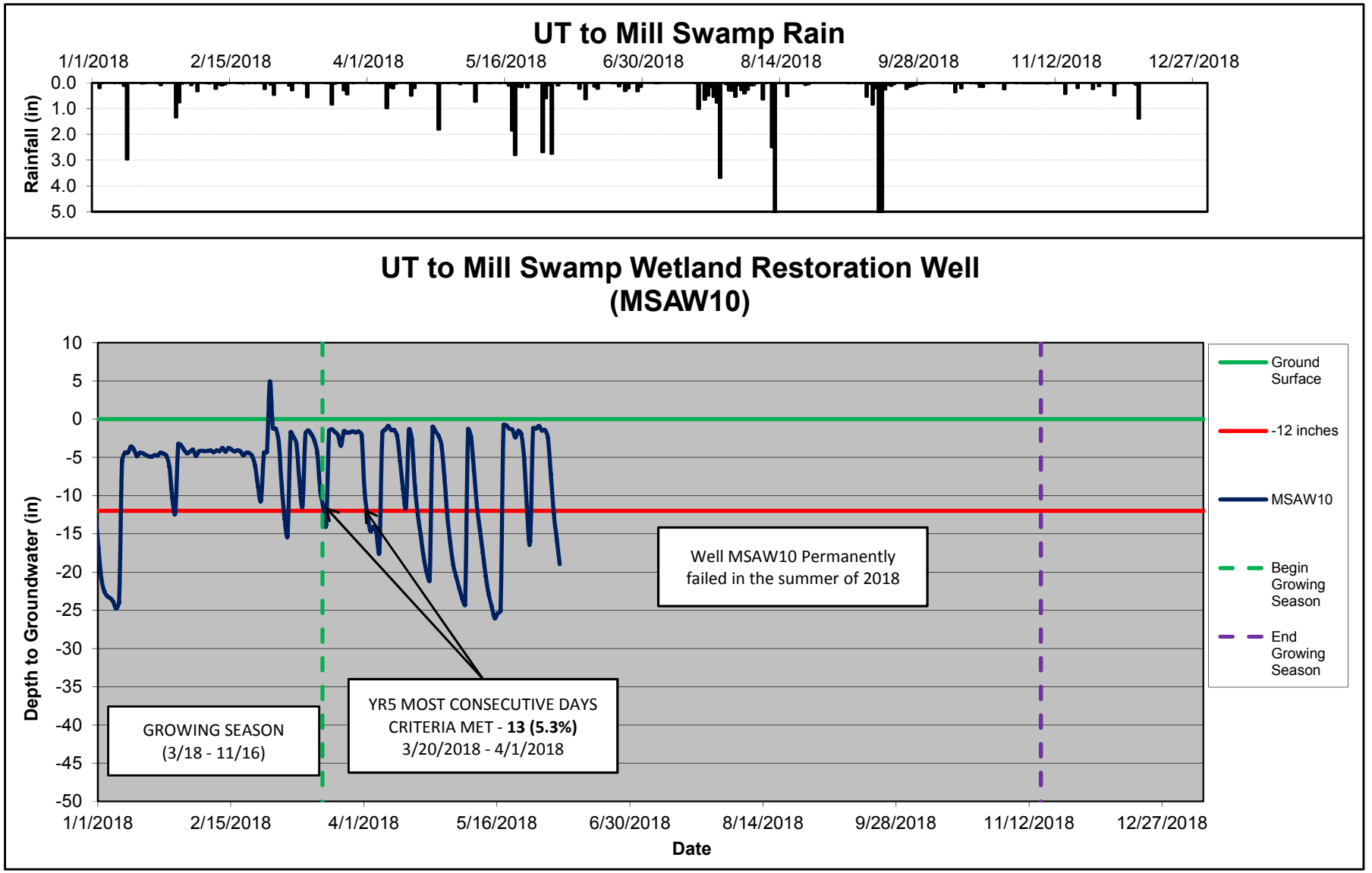

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW6)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 37 (15.2%)
7/23/2018 - 8/28/2018
Ground Surface
-12 inches
MSAW6
Begin Growing Season
End Growing Season
Date

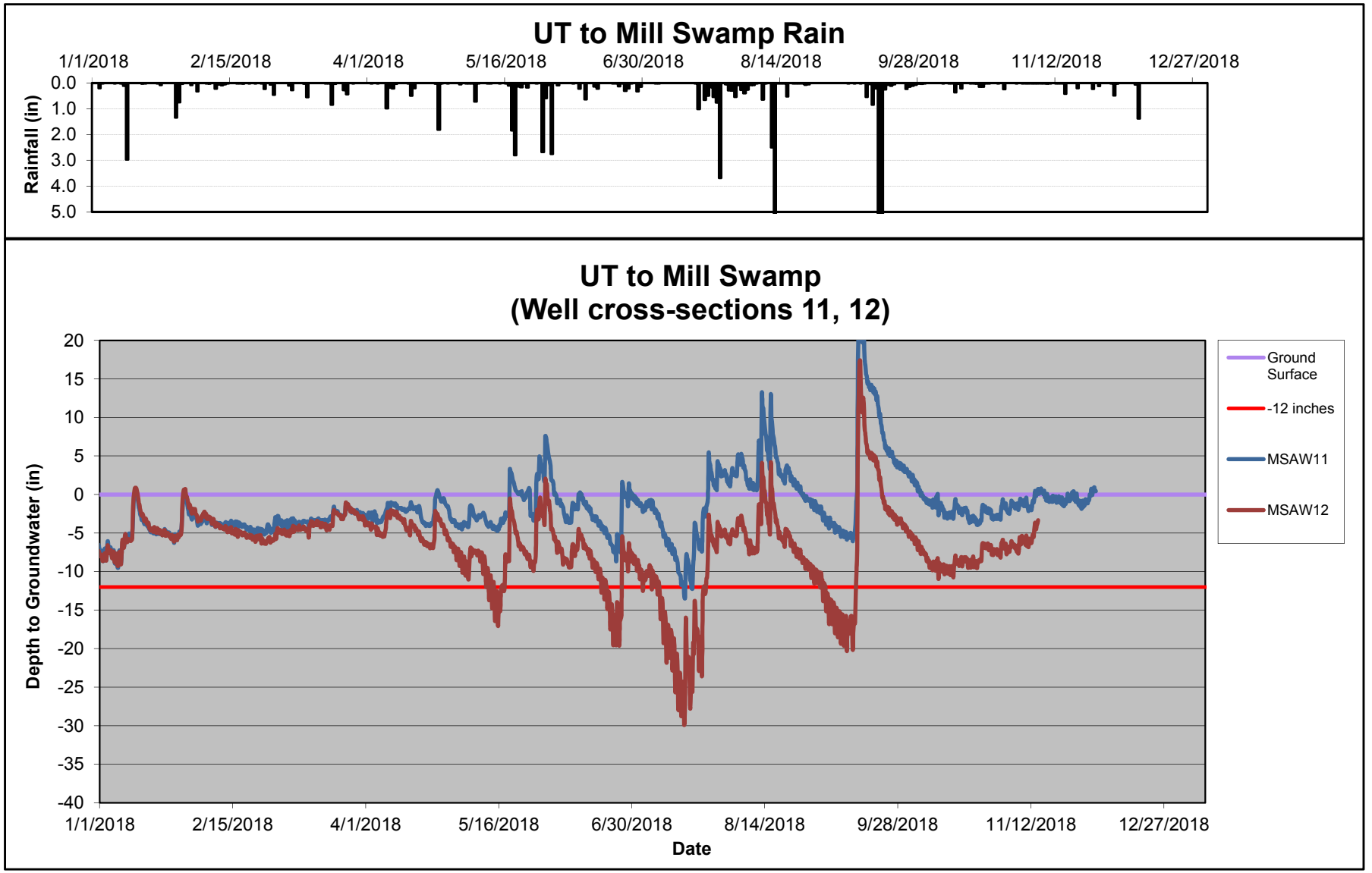


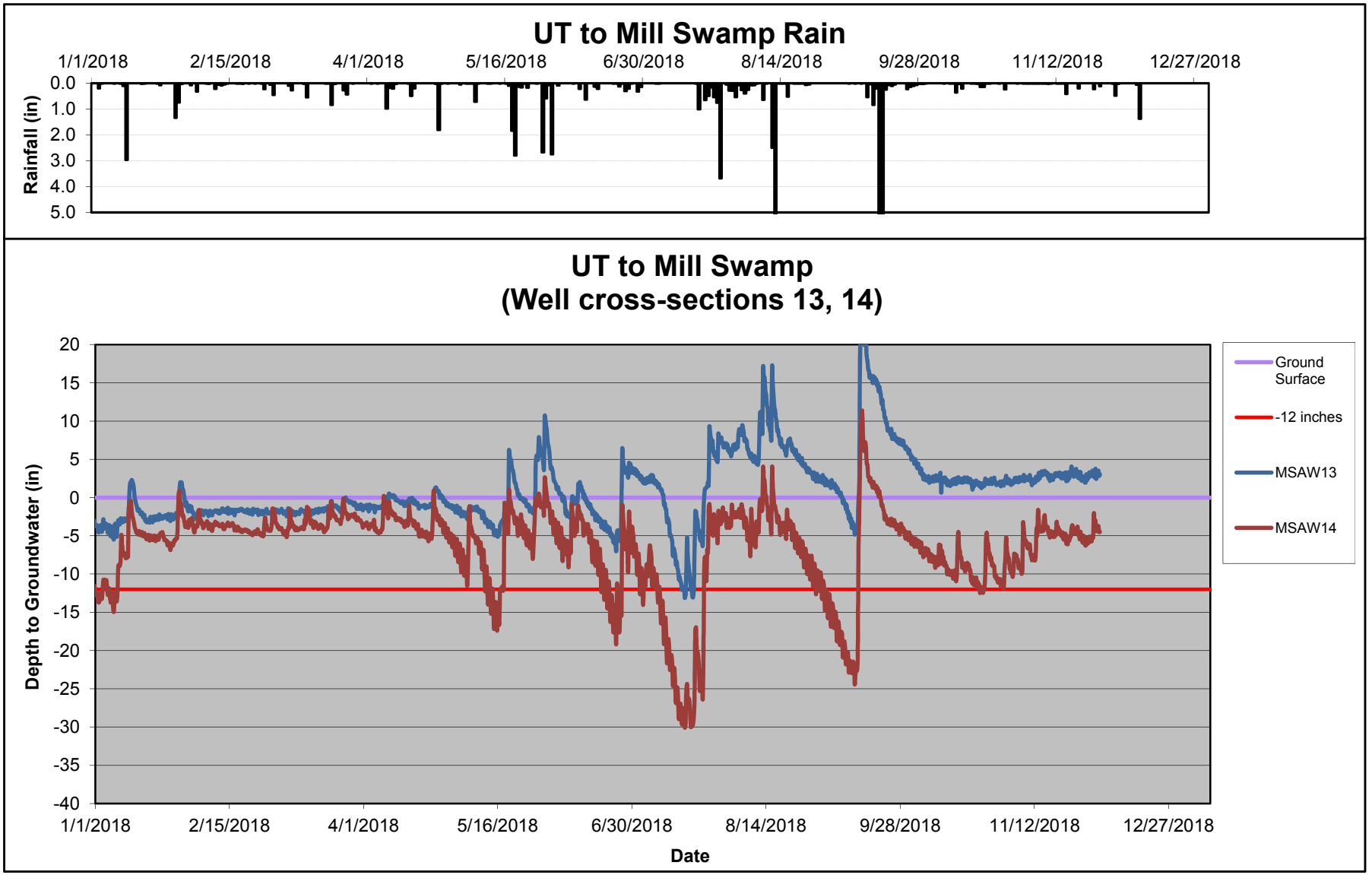

**Note: Well MSAW7 was relocated by IRT suggestion on 6/7/18 as shown on the CCPV in Appendix B.**

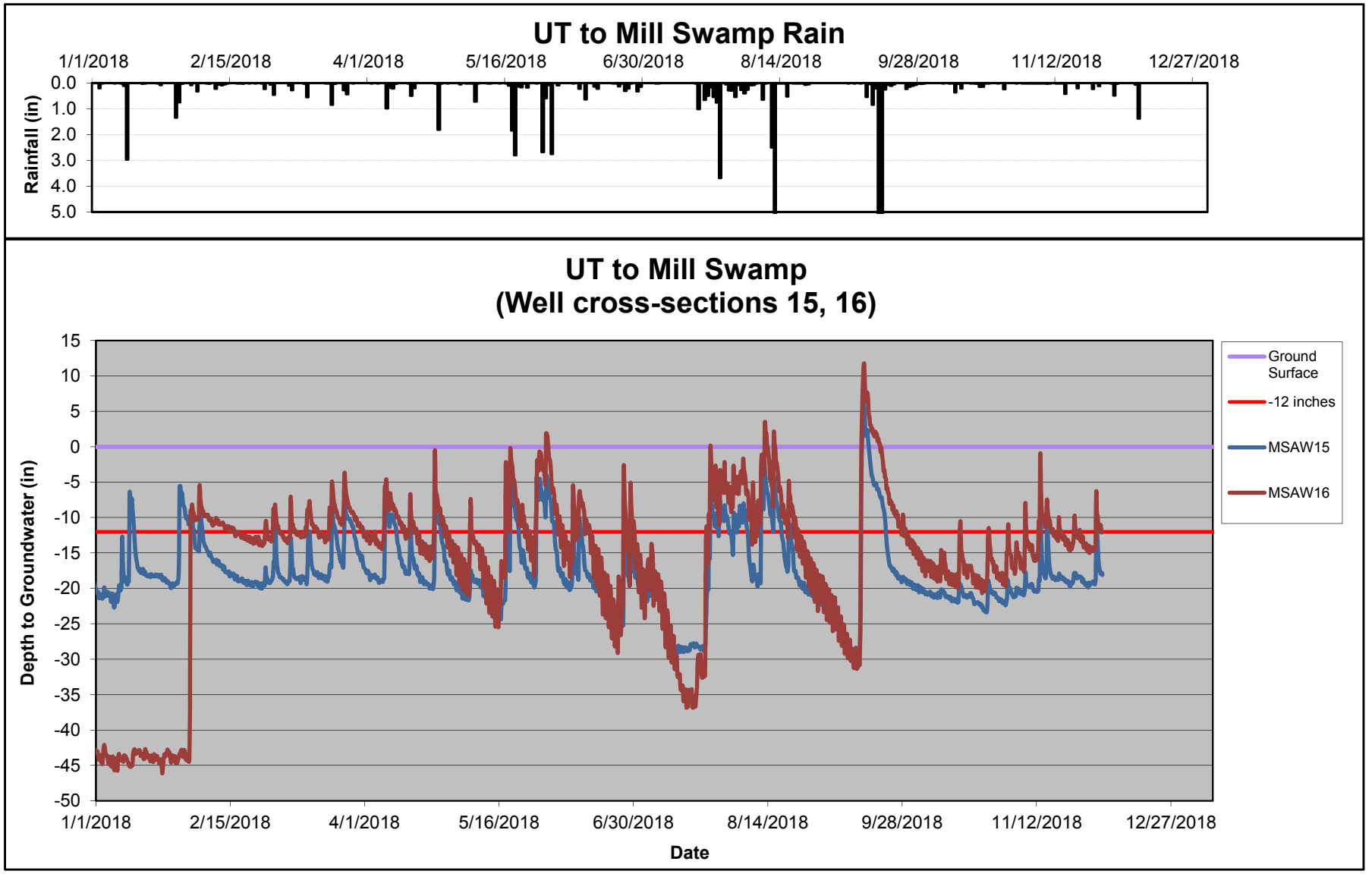

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW8)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW8
Begin Growing Season
End Growing Season
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 244 (100%)
3/18/2018 - 11/16/2018
Date

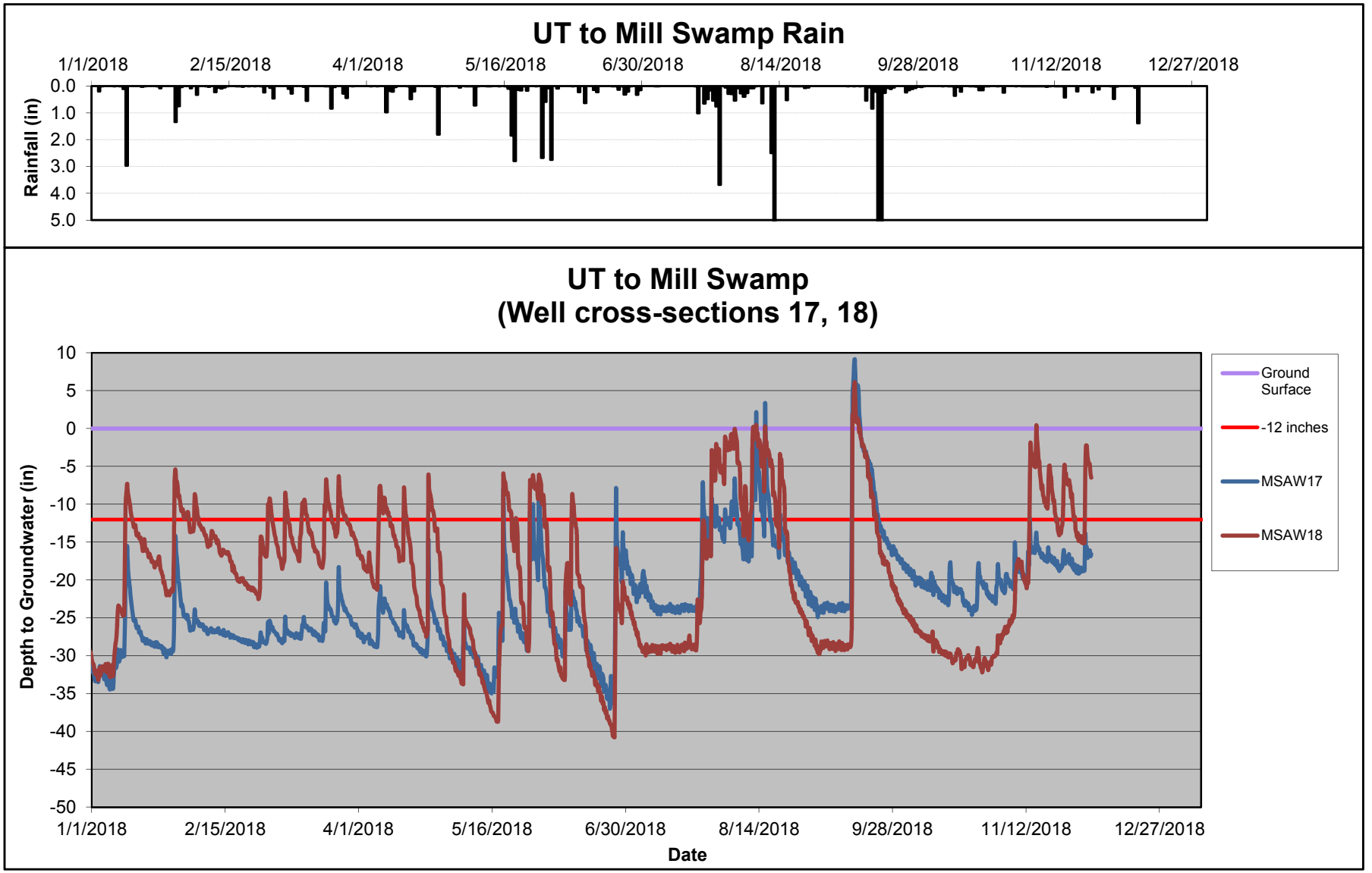

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW9)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 39 (16%)
7/21/2018 - 8/28/2018
Ground Surface
-12 inches
MSAW9
Begin Growing Season
End Growing Season
Date

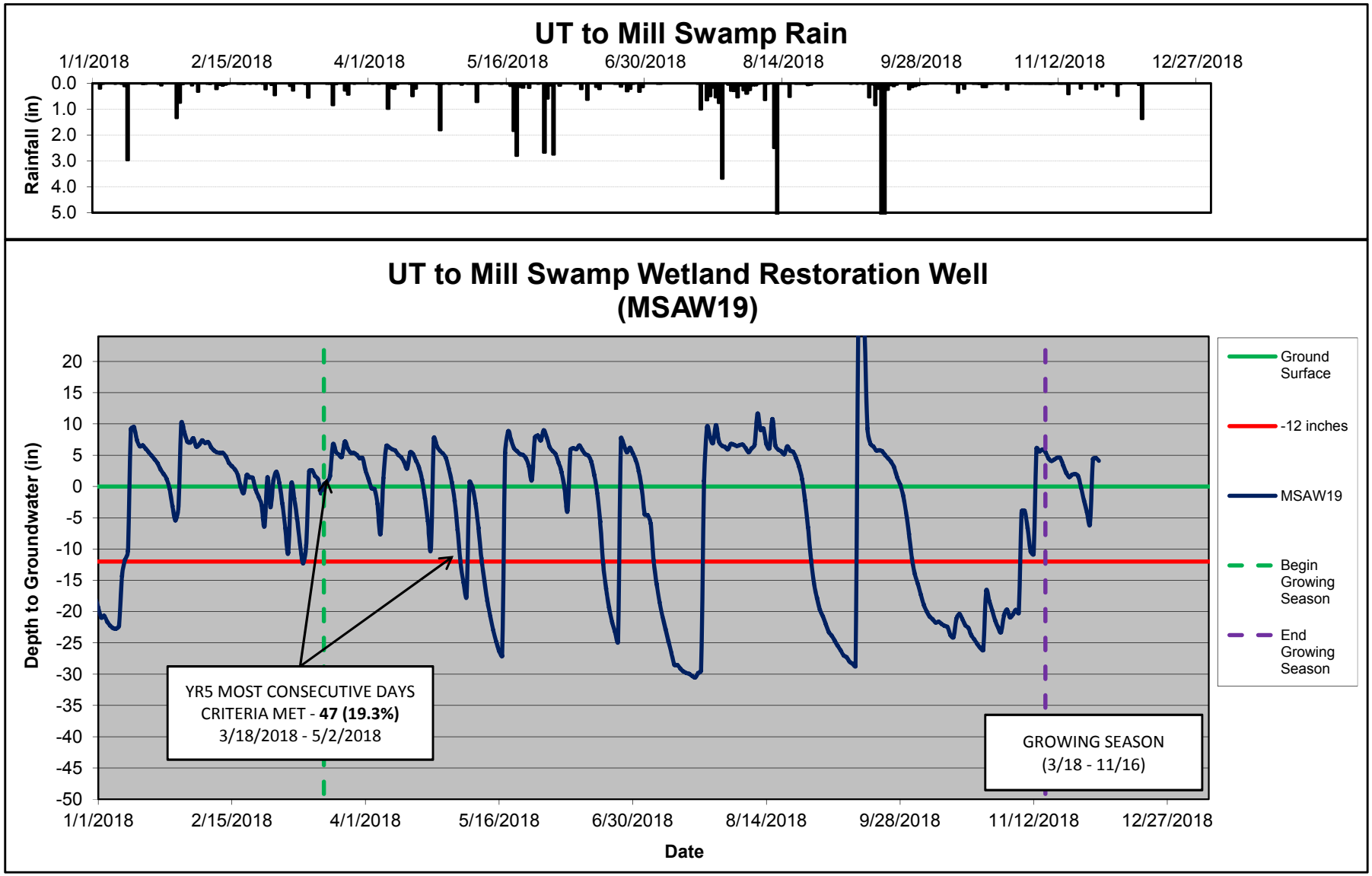

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW10)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW10
Begin Growing Season
End Growing Season
Well MSAW10 Permanently failed in the summer of 2018
GROWING SEASON (3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS CRITERIA MET - 13 (5.3%) 3/20/2018 - 4/1/2018
Date

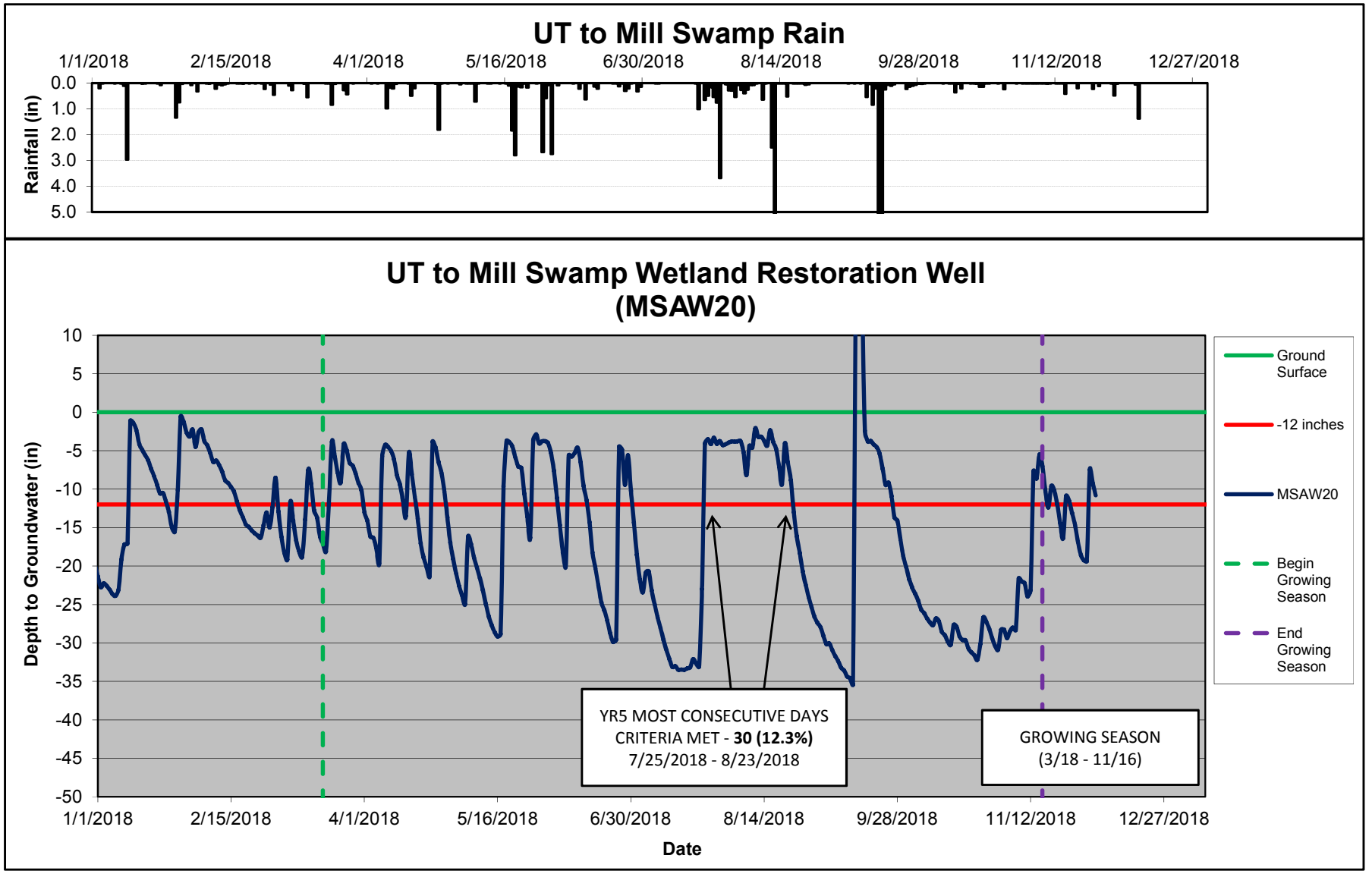

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp
(Well cross-sections 11, 12)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Date
Ground Surface
-12 inches
MSAW11
MSAW12

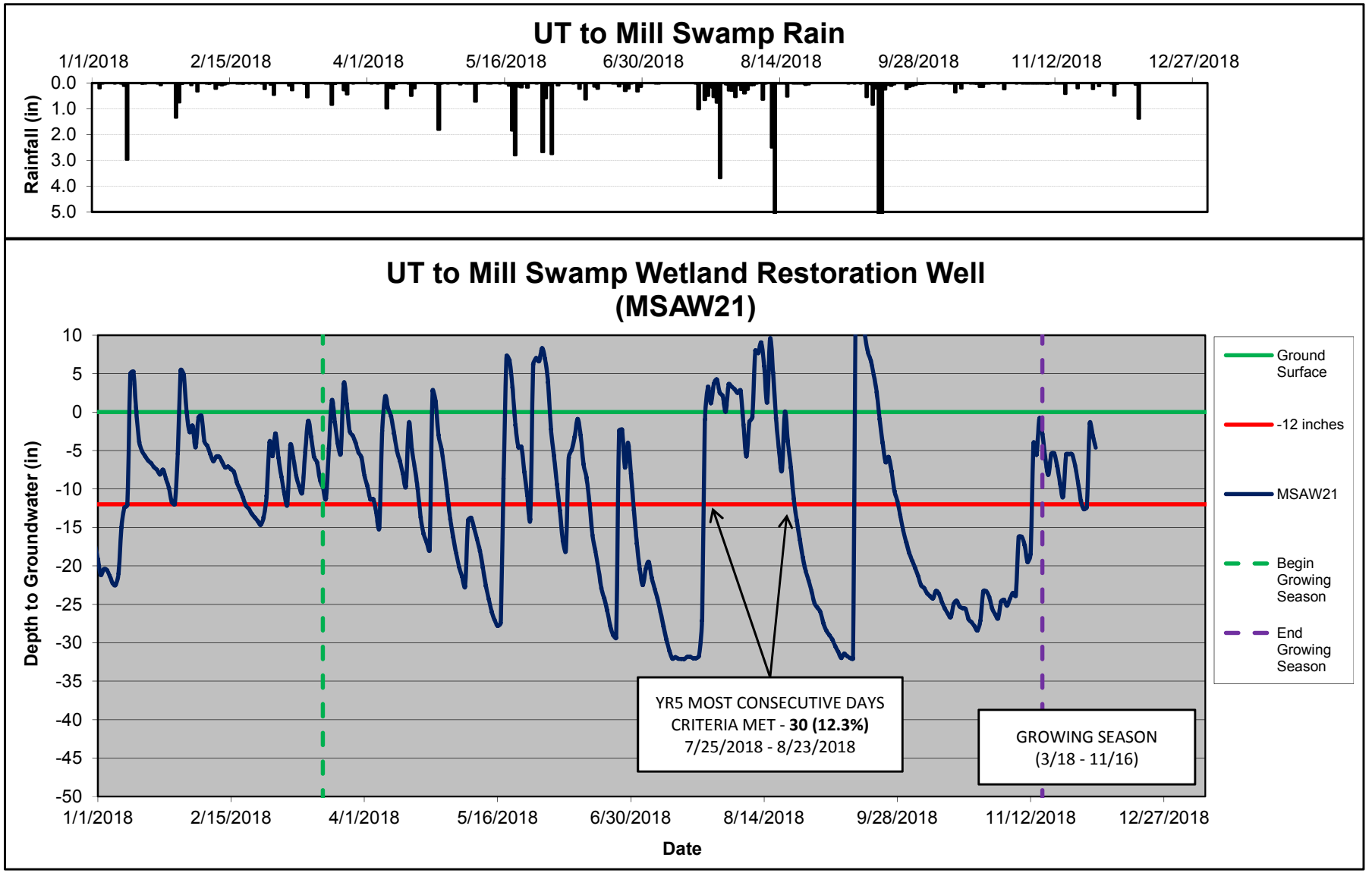

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp
(Well cross-sections 13, 14)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Date
Ground Surface
-12 inches
MSAW13
MSAW14

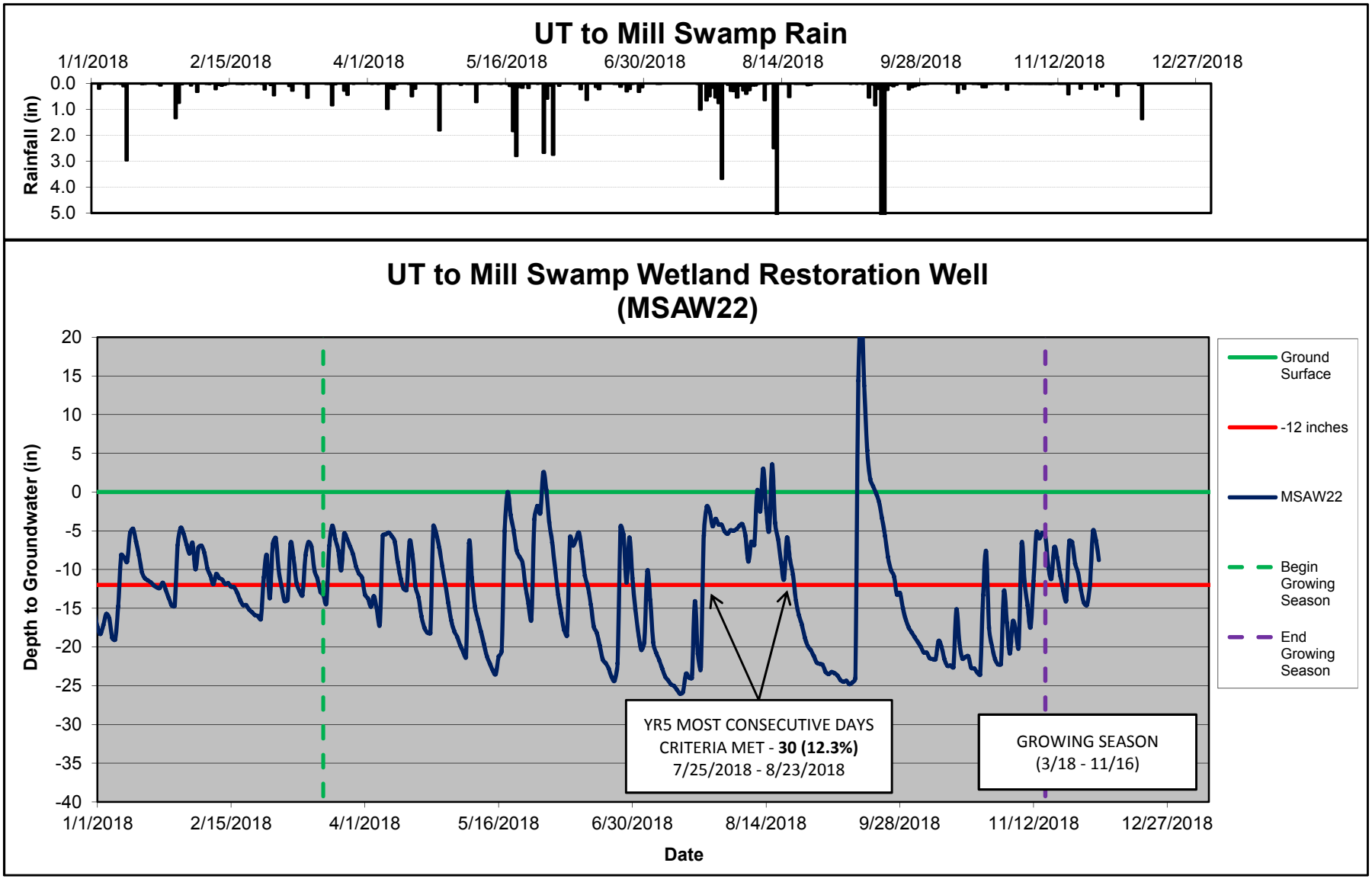

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp
(Well cross-sections 15, 16)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW15
MSAW16
Date

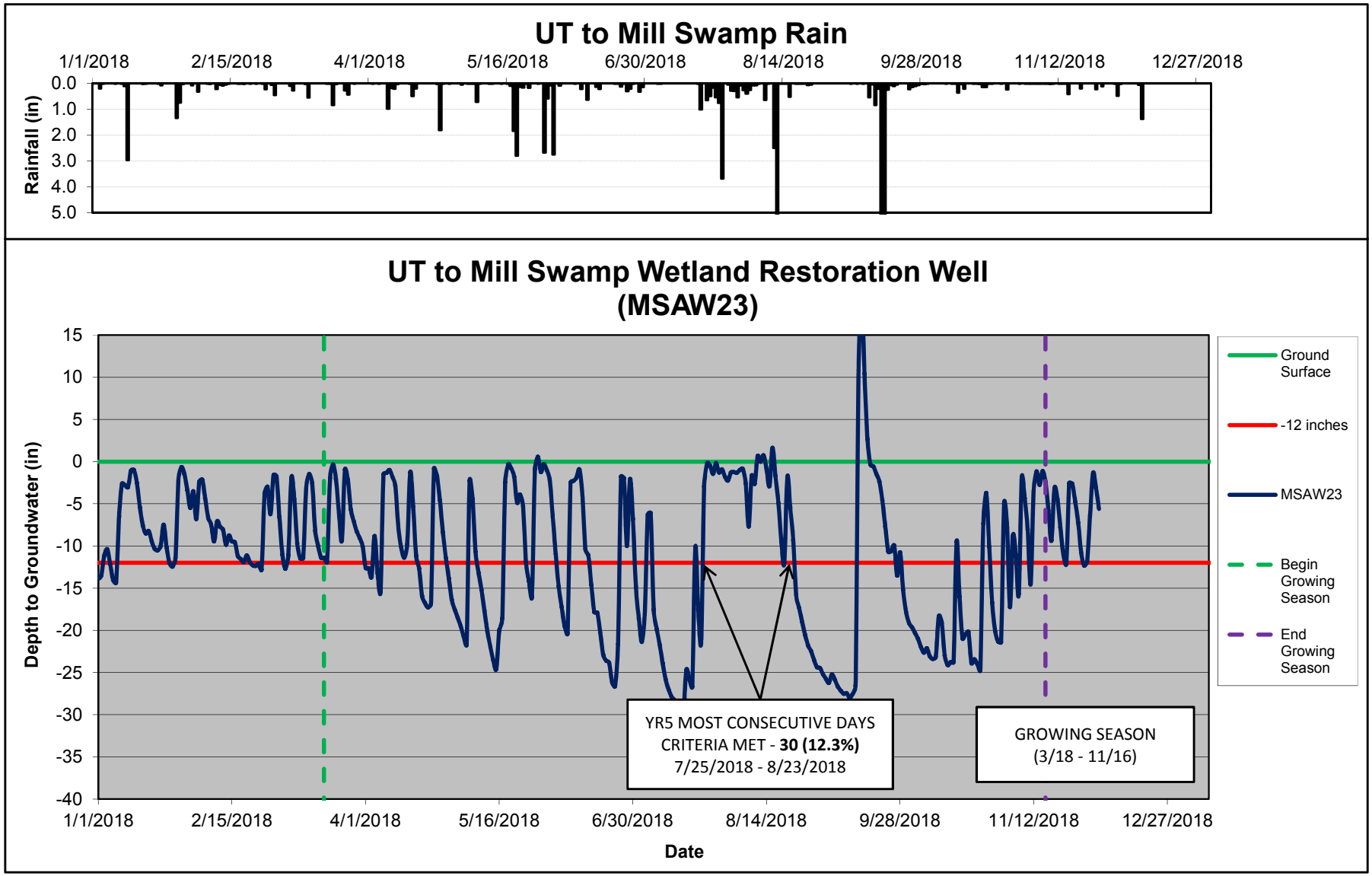

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp
(Well cross-sections 17, 18)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW17
MSAW18
Date

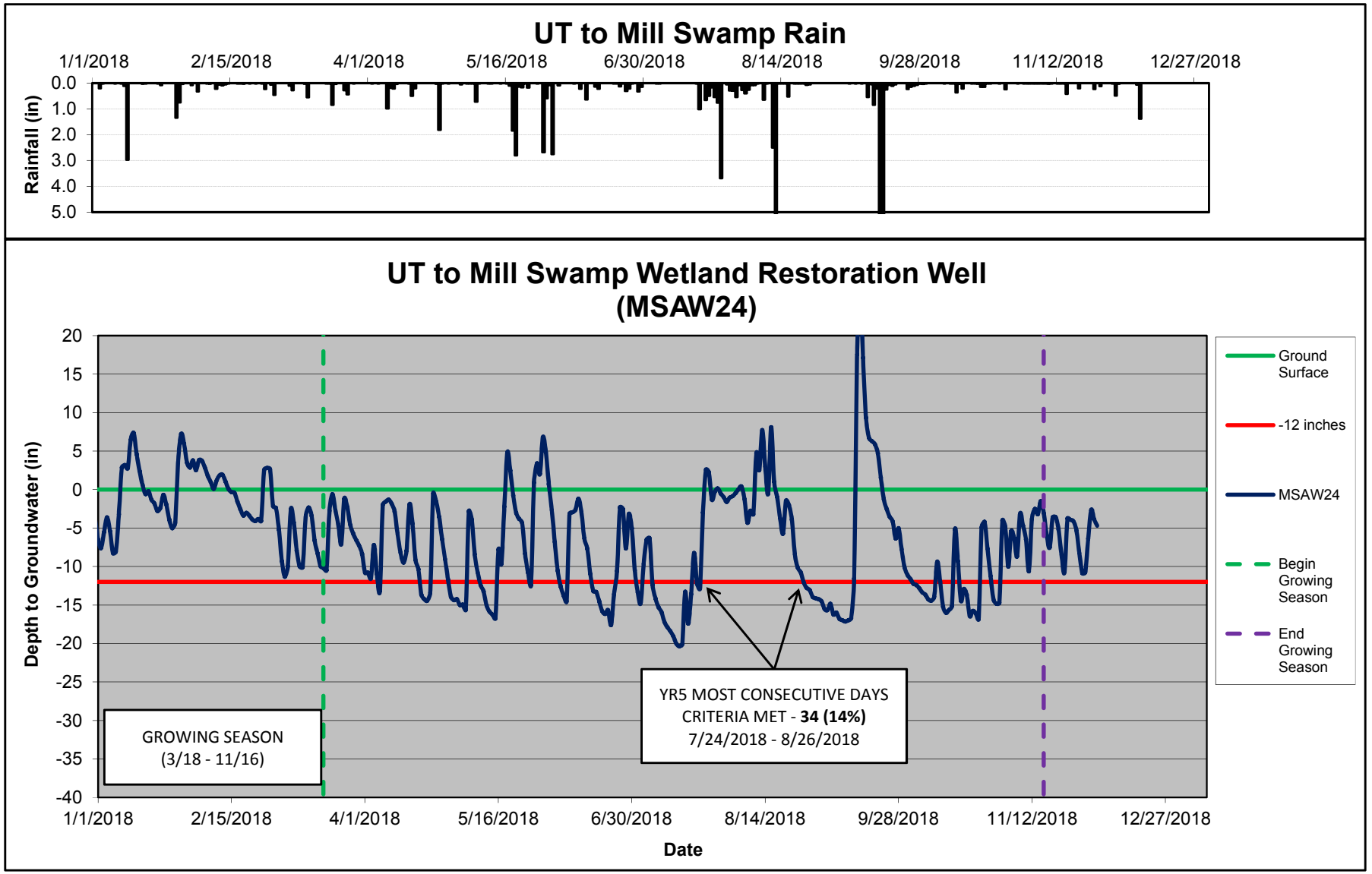

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW19)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 47 (19.3%)
3/18/2018 - 5/2/2018
GROWING SEASON
(3/18 - 11/16)
Ground Surface
-12 inches
MSAW19
Begin Growing Season
End Growing Season
Date


UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
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
YR5 MOST CONSECUTIVE DAYS CRITERIA MET - 30 (12.3%)
7/25/2018 - 8/23/2018
GROWING SEASON
(3/18 - 11/16)
Date

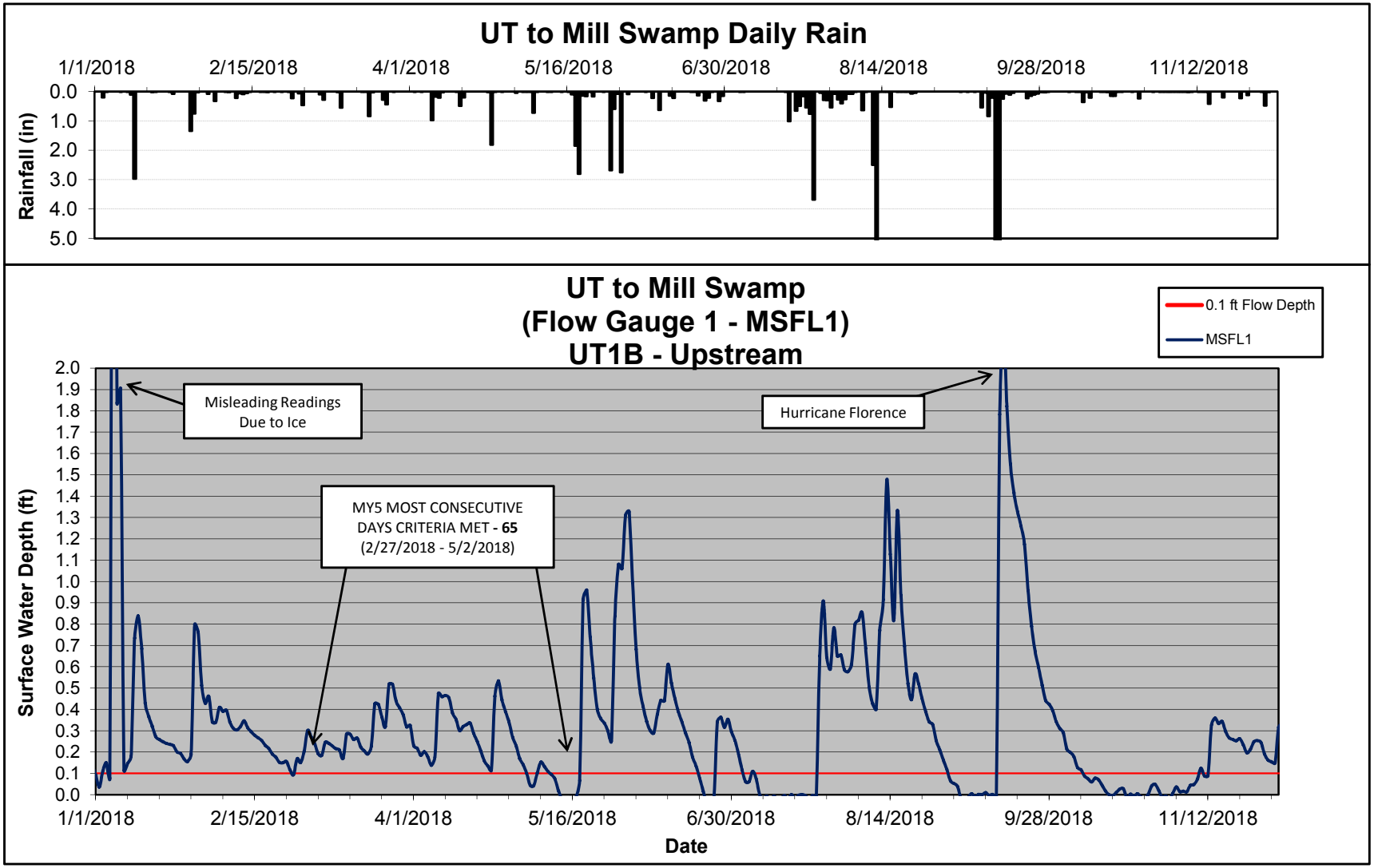

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW21)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
-45
-50
Ground Surface
-12 inches
MSAW21
Begin Growing Season
End Growing Season
YR5 MOST CONSECUTIVE DAYS CRITERIA MET - 30 (12.3%)
7/25/2018 - 8/23/2018
GROWING SEASON
(3/18 - 11/16)
Date


UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
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
YR5 MOST CONSECUTIVE DAYS CRITERIA MET - 30 (12.3%)
7/25/2018 - 8/23/2018
GROWING SEASON
(3/18 - 11/16)
Date


UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW23)
Depth to Groundwater (in)
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
Ground Surface
-12 inches
MSAW23
Begin Growing Season
End Growing Season
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 30 (12.3%)
7/25/2018 - 8/23/2018
GROWING SEASON
(3/18 - 11/16)
Date

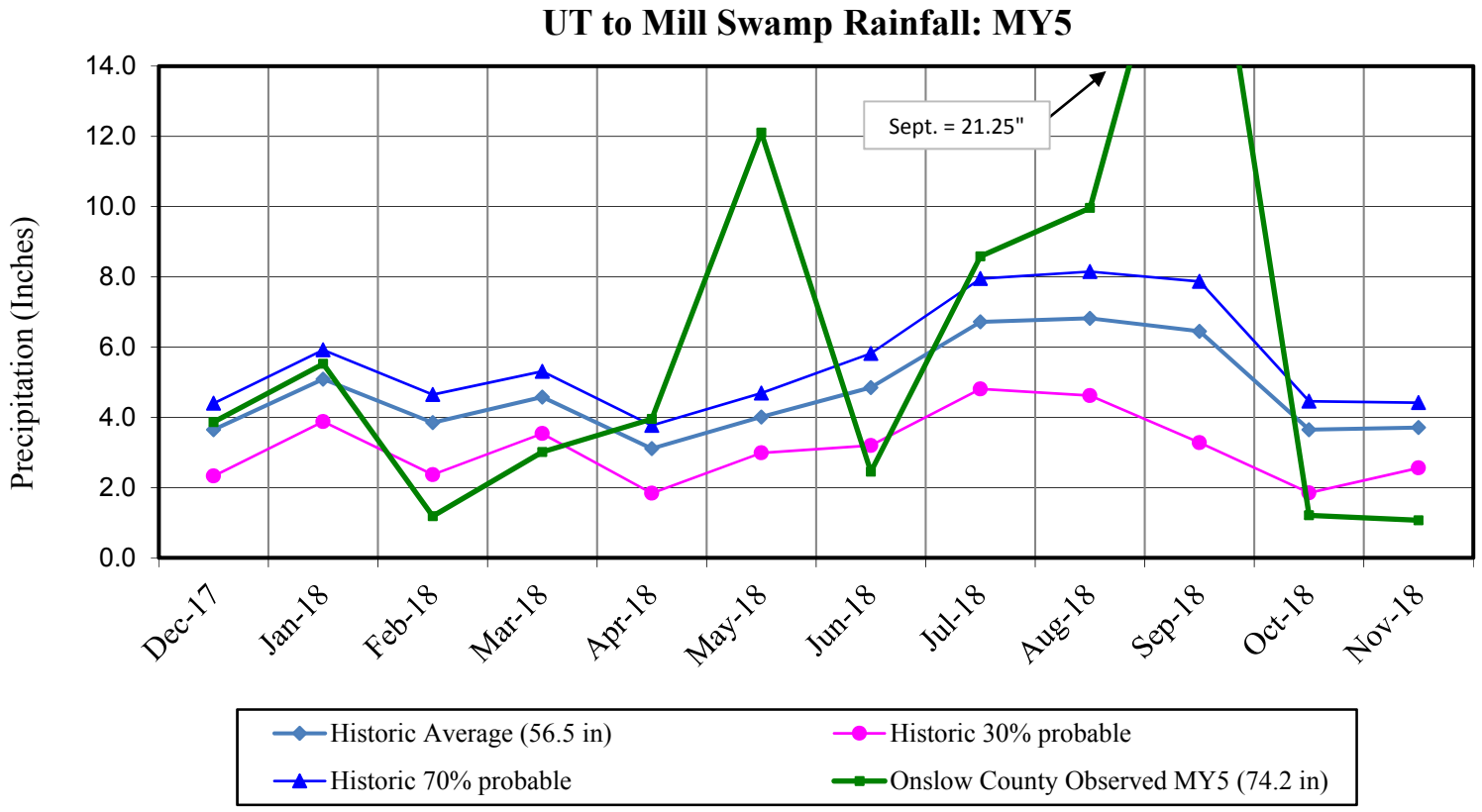

UT to Mill Swamp Rain
1/1/2018
2/15/2018
4/1/2018
5/16/2018
6/30/2018
8/14/2018
9/28/2018
11/12/2018
12/27/2018
Rainfall (in)
0.0
1.0
2.0
3.0
4.0
5.0
UT to Mill Swamp Wetland Restoration Well
(MSAW24)
Depth to Groundwater (in)
20
15
10
5
0
-5
-10
-15
-20
-25
-30
-35
-40
GROWING SEASON
(3/18 - 11/16)
YR5 MOST CONSECUTIVE DAYS
CRITERIA MET - 34 (14%)
7/24/2018 - 8/26/2018
Ground Surface
-12 inches
MSAW24
Begin Growing Season
End Growing Season
Date

## 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.

**Figure 6. Observed Rainfall versus Historic Average**




Note: Data from nearest NC-CRONOS station KOAJ

**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 1 (2013) | Year 2* (2014) | Year 2 (2015) | Year 3 (2016) | Year 4 (2017) | Year 5 (2018) | Year 1 (2013) | Year 2* (2014) | Year 2 (2015) | Year 3 (2016) | Year 4 (2017) | Year 5 (2018) | Year 1 (2013) | Year 2* (2014) | Year 2 (2015) | Year 3 (2016) | Year 4 (2017) | Year 5 (2018) |
| **UT1c Cross-Sectional Well Arrays (Installed July 2013)** | | | | | | | | | | | | | | | | | | | | | | | | |
| MSAW1 | 4.4 | 29.1 | 20.8 | 24.6 | 14.8 | 100.0 | 11 | 71 | 51 | 60 | 36 | 244 | 53.5 | 56.8 | 52.1 | 66.5 | 37.4 | 100.0 | 130 | 138 | 127 | 162 | 91 | 244 |
| MSAW2 | 0.7 | 3.3 | 6.5 | 4.0 | 2.5 | 12.3 | 2 | 8 | 16 | 10 | 6 | 30 | 3.5 | 20.2 | 26.3 | 19.8 | 22.2 | 40.2 | 9 | 49 | 64 | 48 | 54 | 98 |
| MSAW3† | 0.0 | 0.3 | 0.6 | 0.6 | 0.4 | 13.1 | 0 | 1 | 2 | 2 | 1 | 32 | 0.0 | 1.0 | 2.1 | 0.8 | 0.4 | 27.9 | 0 | 3 | 5 | 2 | 1 | 68 |
| MSAW4 | 10.3 | 27.8 | 36.4 | 31.2 | 46.1 | 100.0 | 25 | 68 | 89 | 76 | 112 | 244 | 97.0 | 74.2 | 61.0 | 83.4 | 80.2 | 100.0 | 236 | 180 | 148 | 203 | 195 | 244 |
| MSAW5 | 3.3 | 21.2 | 19.7 | 31.1 | 25.1 | 23.4 | 8 | 52 | 48 | 76 | 61 | 57 | 40.5 | 51.9 | 51.6 | 58.3 | 52.7 | 91.4 | 98 | 126 | 126 | 142 | 128 | 223 |
| MSAW6 | 1.1 | 3.8 | 7.0 | 4.2 | 10.7 | 15.2 | 3 | 9 | 17 | 10 | 26 | 37 | 9.5 | 23.3 | 28.3 | 19.7 | 24.3 | 67.6 | 23 | 57 | 69 | 48 | 59 | 165 |
| MSAW7† | 0.2 | 3.7 | 2.7 | 2.1 | 1.6 | 13.1 | 1 | 9 | 7 | 5 | 4 | 32 | 0.3 | 10.9 | 14.6 | 7.1 | 6.6 | 49.2 | 1 | 27 | 36 | 17 | 16 | 120 |
| MSAW8 | 14.1 | 47.3 | 37.7 | 31.1 | 36.2 | 100.0 | 34 | 115 | 92 | 76 | 88 | 244 | 96.8 | 73.9 | 66.3 | 83.0 | 79.4 | 100.0 | 235 | 180 | 161 | 202 | 193 | 244 |
| MSAW9 | 2.5 | 4.5 | 8.6 | 5.7 | 5.3 | 16.0 | 6 | 11 | 21 | 14 | 13 | 39 | 44.5 | 33.0 | 28.6 | 41.7 | 39.1 | 77.5 | 108 | 80 | 70 | 101 | 95 | 189 |
| 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 | -- | -- | -- | 21 | 31 | 47 | -- | -- | -- | 43.8 | 42.4 | 66.0 | -- | -- | -- | 107 | 103 | 161 |
| **MSAW20 | -- | -- | -- | 3.7 | 3.7 | 12.3 | -- | -- | -- | 9 | 9 | 30 | -- | -- | -- | 10.1 | 19.3 | 42.2 | -- | -- | -- | 25 | 47 | 103 |
| **MSAW21 | -- | -- | -- | 3.7 | 10.7 | 12.7 | -- | -- | -- | 9 | 26 | 31 | -- | -- | -- | 12.7 | 17.7 | 48.4 | -- | -- | -- | 31 | 43 | 118 |
| **MSAW22 | -- | -- | -- | 2.8 | 3.3 | 12.7 | -- | -- | -- | 7 | 8 | 31 | -- | -- | -- | 14.0 | 23.0 | 43.4 | -- | -- | -- | 34 | 56 | 106 |
| **MSAW23 | -- | -- | -- | 3.1 | 9.5 | 12.7 | -- | -- | -- | 8 | 23 | 31 | -- | -- | -- | 23.7 | 32.5 | 52.0 | -- | -- | -- | 58 | 79 | 127 |
| **MSAW24 | -- | -- | -- | 31.2 | 26.3 | 13.9 | -- | -- | -- | 76 | 64 | 34 | -- | -- | -- | 72.1 | 83.1 | 64.8 | -- | -- | -- | 175 | 202 | 158 |
| **Headwater Research Cross-Sectional Well Arrays on UT1a and UT1b (Installed July 2013)** | | | | | | | | | | | | | | | | | | | | | | | | |
| MSAW11 | 4.7 | 21.2 | 32.3 | 40.1 | 36.0 | 49.8 | 12 | 52 | 79 | 98 | 88 | 122 | 38.5 | 72.4 | 76.7 | 84.9 | 68.3 | 99.6 | 94 | 176 | 187 | 206 | 166 | 243 |
| MSAW12 | 0.7 | 15.4 | 10.1 | 7.6 | 14.5 | 25.3 | 2 | 38 | 25 | 19 | 35 | 62 | 7.0 | 19.1 | 24.9 | 27.4 | 15.1 | 84.0 | 17 | 47 | 61 | 67 | 37 | 205 |
| MSAW13 | 6.5 | 46.5 | 40.0 | 40.0 | 36.0 | 50.0 | 16 | 113 | 97 | 97 | 88 | 122 | 81.5 | 80.0 | 82.2 | 84.8 | 66.0 | 99.3 | 198 | 195 | 200 | 206 | 161 | 242 |
| MSAW14 | 0.6 | 39.1 | 18.3 | 17.9 | 25.6 | 23.5 | 2 | 95 | 45 | 44 | 62 | 57 | 4.0 | 31.0 | 46.7 | 61.6 | 32.7 | 84.6 | 10 | 75 | 114 | 150 | 80 | 207 |
| MSAW15 | 0.8 | 0.9 | 2.4 | 1.6 | 1.1 | 3.6 | 2 | 2 | 6 | 4 | 3 | 9 | 4.0 | 3.9 | 5.1 | 6.7 | 2.0 | 20.0 | 10 | 10 | 13 | 16 | 5 | 49 |
| MSAW16 | 2.4 | 2.8 | 2.3 | 2.1 | 1.2 | 13.6 | 6 | 7 | 6 | 5 | 3 | 33 | 14.5 | 13.0 | 11.5 | 7.1 | 2.2 | 40.2 | 35 | 32 | 28 | 17 | 5 | 98 |
| MSAW17 | 0.0 | 0.1 | 0.7 | 0.3 | 0.2 | 3.7 | 0 | 0 | 2 | 1 | 1 | 9 | 0.0 | 0.1 | 1.3 | 0.5 | 0.2 | 9.3 | 0 | 0 | 3 | 1 | 1 | 23 |
| MSAW18 | 3.8 | 10.2 | 7.4 | 2.2 | 1.2 | 5.0 | 9 | 25 | 18 | 5 | 3 | 12 | 18.5 | 15.3 | 20.8 | 10.7 | 3.6 | 23.1 | 45 | 37 | 51 | 26 | 9 | 56 |

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 5 wetland monitoring, only one of sixteen wells did not exhibit hyrdroperiods greater than 12% during the 2018 growing season. That well is MSAW10 and it 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.

**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 | - | - | 34 | 242 | 137 | 187 | 213 | 247 | - | - |
| MSFL2 | 35 | 131 | 152 | 105 | 164 | N/A[3] | - | - | 79 | 327 | 186 | 231 | 243 | 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.

**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)** | | | |
| 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 |
| **Year 4 (2017)** | | | |
| 3/20/2017 | 1/2/2017 | Crest Gauge | 1.18 |
| 6/2/2017 | 4/25/2017 | Crest Gauge | 1.20 |
| **Year 5 (2018)** | | | |
| 6/7/2018 | 5/31/2018 | Crest Gauge* | 1.50 |
| 10/30/2018 | 9/15/2018 (Hurricane Florence) | Crest Gauge* | 3.41 |

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