



MONITORING YEAR 4 ANNUAL REPORT

Final

CROOKED CREEK #2 RESTORATION PROJECT

Union County, NC

DEQ Contract 6617

DMS Project Number 94687

USACE Permit No. SAW-2011-02201

Data Collection Period: April – November 2019

Submission Date: January 17, 2020

PREPARED FOR:



NC Department of Environmental Quality

Division of Mitigation Services

1652 Mail Service Center

Raleigh, NC 27699-1652

Mitigation Project Name Crooked Creek II Stream and Wetland Restoration Site
 DMS ID 94687
 River Basin Yadkin
 Cataloging Unit 03040105

County Union
 Date Project Instituted 12/10/2010
 Date Prepared 7/19/2019

USACE Action ID 2011-02201
 NCDWR Permit No 2012-0064

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)		3,489.600					8.400							
Potential Credits (As-Built Survey)							8.500							
Potential Credits (IRT Approved)		3,489.600					8.400							
Total Unrealized Credits (Permanent Reduction)		247.400					N/A							
Revised Potential Credits (IRT Approved)		3,242.200												
1 (Site Establishment)	N/A				N/A	N/A	N/A					N/A	N/A	N/A
2 (Year 0 / As-Built)	30%	1,046.880			2016	5/18/2016	30%	2.550				30%	2016	5/18/2016
3 (Year 1 Monitoring)	10%	348.960			2017	8/8/2017	10%	0.850				10%	2017	8/8/2017
4 (Year 2 Monitoring) - 5% Stream & Wetland Released	5%	174.480			2018	4/25/2018	5%	0.425				15%	2018	4/25/2018
IRT Adjustment - Wetland								-0.050						
4 (Year 2 Monitoring) - 5% Wetland Released							5%	0.425					2018	4/26/2019
4 (Year 2 Monitoring) - Stream - Not Released	5%	174.480			2018	No Release								
5 (Year 3 Monitoring) - 7.5% Wetland Released							7.5%	0.630				20%	2019	4/26/2019
5 (Year 3 Monitoring) - Not Released	10%	175.780			2019	No Release	7.5%	0.630						
6 (Year 4 Monitoring)	10%				2020		5%					10%	2020	
7 (Year 5 Monitoring)	15%				2021		15%					15%	2021	
8 (Year 6 Monitoring)	N/A				N/A		5%					N/A	2022	
9 (Year 7 Monitoring)	N/A				N/A		10%					N/A	2023	
Stream Bankfull Standard	15%	523.440			2018	4/25/2018	N/A					N/A		
Total Credits Released to Date		2,093.760						4.830						

NOTES:

- 4/25/2018: IRT concerned about hydrology and vegetation success concerns decided to hold 1/2 of the stream and wetland credits for Year 2 Monitoring. 5% of the stream and wetland credits was released.
- 3/15/2019: Adjustment required due to IRT concerns on how the as-built credits were calculated.
- 3/15/2019: Adjustment required due to permanent reduction of anticipated stream credits. DMS will utilize the revised potential credits to calculate the amount for future releases. The adjustment amount is needed to bring the project back in line with the revised potential credits. Total adjustment required is 148.44 stream credits. This amount is reflected in the proposed Year 3 Monitoring stream credit release.
- 7/19/2019: DMS determined the scheduled stream credits from Year 3 Monitoring and the remaining 5% from Year 2 Monitoring would not be released at this time due to concerns that assets currently at risk will ultimately be unrealized. Wetland credits approved for half of the proposed released (7.5% of Year 3 Monitoring)

CONTINGENCIES:


 Signature of Wilmington District Official Approving Credit Release

27 Sept 2019

Date

- 1 - For NCDMS, no credits are released during the first milestone
- 2 - For NCDMS 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 NCDMS 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 projects where DA permit issuance is not required
- 3 - A 15% reserve of credits is to be held back until the bankfull event performance standard has been met

PREPARED BY:



1430 South Mint Street, Suite 104
Charlotte, NC 28203

Phone: 704.332.7754
Fax: 704.332.3306



January 17, 2020

Mr. Harry Tsomides
NC Department of Environmental Quality
Division of Mitigation Services
5 Ravenscroft Dr., Suite 102
Asheville, NC 28801

RE: Crooked Creek II Mitigation Site -Year 4 Monitoring Report
Final Submittal for DMS
DMS ID 94687
DEQ Contract Number D09126S
Yadkin Pee-Dee River Basin – CU# 03040105; Union County, NC

Dear Mr. Tsomides:

Wildlands Engineering, Inc. (Wildlands) has reviewed the Division of Mitigation Services (DMS) comments and observations from the Crooked Creek II Mitigation Site Draft Year 4 Monitoring Report. The following are Wildlands responses to your comments and observations from the report noted in italics lettering.

DMS Comment; Continuous flow gauge graph for UT1 (reflecting 116 consecutive days of flow described in section 1.2.5) is missing from Appendix 5.

Wildlands Response; Wildlands has updated Appendix 5 to include flow gage for UT1.

DMS Comment; Please address digital submittal comments sent by email on 12/6/2019.

Wildlands Response; Wildlands has updated all digital submittal files based on DMS comments.

DMS Comment; Asset table footnote has a typo. Also there is no need to reference any emails relevant to the one sided stream segment it is generally recognized that one-sided stream buffers do not yield credits.

Wildlands Response; Wildlands has updated the footnote text for the Asset table.

DMS Comment; Section 1.3 – Executive summary, paragraph 5- “MY two” should read “MY2”.

Wildlands Response; Wildlands has updated this text in the executive summary.



DMS Comment; Project overview- Paragraph 1 ends with an incomplete sentence.

Wildlands Response; Wildlands has revised the sentence in the project overview.

Enclosed please find two (2) hard copies of the Year 4 Final Monitoring Report and one (1) CD with the final electronic files for DMS distribution. Please contact me at 704-941-9093 if you have any questions.

Sincerely,

A handwritten signature in black ink that reads "Kirsten Y. Gimbert".

Kirsten Y. Gimbert
Project Manager
kgimbert@wildlandseng.com

EXECUTIVE SUMMARY

Wildlands Engineering, Inc. (Wildlands) completed a design-bid-build project at the Crooked Creek #2 Mitigation Site (Site) for the North Carolina Division of Mitigation Services (DMS) to restore and enhance 5,599 linear feet (LF) of perennial streams, enhance 1.0 acre of existing wetlands, restore and create 10.5 acres of wetlands, and restore and enhance 70,936 square feet (SF) of riparian buffer in Union County, NC. The Site is expected to generate 3,242.600 stream mitigation units (SMUs), 8.4 wetland mitigation units (WMUs), and 1.24 buffer mitigation units (BMU) for the Goose Creek watershed (Table 1). The Site is located off NC Highway 218 in the northern portion of Union County, NC in the Yadkin Pee-Dee River Basin; eight-digit Cataloging Unit (CU) 03040105 and the 14-digit Hydrologic Unit Code (HUC) 03040105040010 (Figure 1). The project streams consist of two unnamed tributaries (UT) to Crooked Creek, UT1 and UT2, and two reaches of the Crooked Creek mainstem (Reach A and Reach B) (Figure 2). Crooked Creek flows into the Rocky River 4 miles northeast of the Site near Love Mill Road at the Stanly County line. The adjacent land to the streams and wetlands is primarily maintained for agricultural and residential uses.

The Site is within a Targeted Local Watershed (TLW) in the Lower Yadkin Pee-Dee River Basin Restoration Priority Plan (RBRP) (NCEEP, 2009). The Site is also located within the Goose Creek and Crooked Creek Local Watershed Plan (LWP). The final watershed management plan (WMP) for Goose Creek and Crooked Creek was completed in July 2012 (NCEEP, 2012). The stressors to watershed function identified in the WMP were sediment pollution and increases in peak stream flows resulting in impairments to aquatic habitat and aquatic life. Stream enhancement and restoration were identified as the best management opportunities to offset these impacts. Other stressors identified included nonpoint source runoff, degraded terrestrial habitat, and disconnected floodplains. Wetland enhancement and restoration was also identified as a best management opportunity to offset impacts related to these stressors. The wetland portion of the project was identified as a specific priority in the Project Atlas that accompanies the 2012 WMP.

The project goals established in the mitigation plan (Wildlands, 2013) were completed with careful consideration of goals and objectives that were described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve wetland hydrologic connectivity;
- Decrease sediment input into stream;
- Create appropriate terrestrial habitat;
- Decrease water temperature and increase dissolved oxygen concentrations; and
- Decrease nutrient and adverse chemical levels.

Overall, the Site in Monitoring Year (MY) four appears to be on track to meet the year seven requirements. Subsequent annual monitoring will be performed for seven years with an expected closeout in 2023.

MY4 assessments were completed between April and November 2019. The planted vegetation on the Site appears to be doing well with only isolated patches of invasive species present in MY4. The average planted stem density for the Site is 550 stems per acre and is on track to meet the interim year five requirement of 260 stems per acres. Following the January 2018 supplemental planting, all 12 vegetation plots exceeded the year five success criteria. The average stem height for the Site is 7.38 feet trending toward meeting the year seven 10-foot requirement. Channel dimension and profiles on UT1 appear stable and functioning as designed. Groundwater hydrologic success criteria was achieved in nine of the ten groundwater monitoring gages. Although the success criteria for bankfull for the project was met in MY2, additional bankfull events were recorded in MY4 on project streams.



CROOKED CREEK #2 RESTORATION PROJECT
Monitoring Year 4 Annual Report

TABLE OF CONTENTS

Section 1: PROJECT OVERVIEW 1-1

1.1 Project Goals and Objectives 1-1

1.2 Monitoring Year 4 Data Assessment..... 1-2

 1.2.1 Vegetation Assessment..... 1-2

 1.2.2 Vegetation Areas of Concern 1-2

 1.2.3 Stream Assessment..... 1-3

 1.2.4 Stream Areas of Concern 1-3

 1.2.5 Hydrology Assessment..... 1-3

 1.2.6 Wetland Assessment..... 1-3

 1.2.7 Wetland Areas of Concern 1-4

1.3 Monitoring Year 4 Summary 1-4

Section 2: METHODOLOGY 2-1

Section 3: REFERENCES 3-1

APPENDICES

Appendix 1	General Tables and Figures
Figure 1	Project Vicinity Map
Figure 2	Project Component/Asset Map
Table 1	Project Components and Mitigation Credits
Table 2	Project Activity and Reporting History
Table 3	Project Contact Table
Table 4	Project Information and Attributes
Table 5	Monitoring Component Summary
Appendix 2	Visual Assessment Data
Figure 3.0-3.6	Integrated Current Condition Plan View
Table 6	Visual Stream Morphology Stability Assessment Table
Table 7	Vegetation Condition Assessment Table
	Vegetation Photographs
	Stream and Wetland Photographs
Appendix 3	Vegetation Plot Data
Table 8	Vegetation Plot Criteria Attainment
Table 9	CVS Vegetation Plot Metadata
Table 10	Planted and Total Stem Counts (Species by Plot with Annual Mean)
Appendix 4	Morphological Summary Data and Plots
Table 11	Baseline Stream Data Summary
Table 12	Morphology and Hydraulic Summary (Dimensional Parameters – Cross-section)
Table 13	Monitoring Data – Stream Reach Data Summary
	Cross-section Plots
	Reachwide and Cross-section Pebble Count Plots
Appendix 5	Hydrology Summary Data and Plots
Table 14	Verification of Bankfull Events
Table 15	Wetland Gage Attainment Summary
	Groundwater Gage Plots and Stream Gage Plot
	Rainfall Plot
	Bankfull Event Photographs



Section 1: PROJECT OVERVIEW

The Crooked Creek #2 Mitigation Site (Site) is located in the Yadkin Pee-Dee River Basin; eight-digit Cataloging Unit (CU) 03040105 and the 14-digit Hydrologic Unit Code (HUC) 03040105040010 (Figure 1). The Site is located off NC Highway 218 in the northern portion of Union County, NC (Figure 1). Located in the Carolina Slate Belt of the Piedmont Physiographic Province (USGS, 1998), the project watershed includes primarily agricultural forested and developed land. The drainage area for the project Site is 24,619 acres. The project streams consist of two streams that underwent Stream Enhancement, Crooked Creek and UT2, as well as UT1 which underwent Stream Restoration.

The Site is located within a Targeted Local Watershed (TLW) in the Lower Yadkin Pee-Dee River Basin Restoration Priority Plan (RBRP) (NCEEP, 2009). The Site is also located within the Goose Creek and Crooked Creek Local Watershed Plan (LWP). The final watershed management plan (WMP) for Goose Creek and Crooked Creek was completed in July 2012 (NCEEP, 2012). The stressors to watershed function identified in the WMP were sediment pollution and increased peak stream flows resulting in impairments to aquatic habitat and aquatic life. Stream enhancement and restoration were identified as the best management opportunities to offset these impacts. Other stressors identified included nonpoint source runoff, degraded terrestrial habitat, and disconnected floodplains. Wetland enhancement and restoration was also identified as a best management opportunity to offset impacts related to these stressors. The wetland portion of the project was identified as a specific priority in the Project Atlas that accompanies the 2012 WMP.

Prior to construction activities, the streams on the Site had been channelized and the adjacent floodplain wetland areas had been cleared and ditched to provide drainage for surrounding pasture. These land use activities resulted in bank instability due to erosion and livestock access, lack of riparian buffer, and altered hydrology. Stream Incision, lateral erosion, and widening also resulted in degraded aquatic and benthic habitat, reduction in quality and acreage of riparian wetlands, and lowered dissolved oxygen levels in the stream. Table 4 in Appendix 1 and Table 11 in Appendix 4 present the post-restoration conditions in more detail.

1.1 Project Goals and Objectives

This mitigation Site is intended to provide numerous ecological benefits within the Yadkin Pee-Dee River Basin. While many of these benefits are limited to the Crooked Creek project area, others, such as pollutant removal, reduced sediment loading, and improved aquatic and terrestrial habitat, have farther-reaching effects. Expected improvements to water quality and ecological processes are outlined below as project goals and objectives.

The project goals established in the mitigation plan (Wildlands, 2013) were completed with careful consideration of goals and objectives that were described in the RBRP and to address stressors identified in the LWP. The following project goals established include:

- Improve wetland hydrologic connectivity;
- Decrease sediment input into stream;
- Create appropriate terrestrial habitat;
- Decrease water temperature and increase dissolved oxygen concentrations; and
- Decrease nutrient and adverse chemical levels.



The project objectives have been defined as follows:

- Construct stream channels that will remain relatively stable over time and adequately transport their sediment loads without significant erosion or aggradation;
- Construct stream channels that maintain riffles with coarse bed material and pools with finer bed material;
- Provide aquatic and benthic habitat diversity in the form of pools, riffles, woody debris, and in-stream structures;
- Add riffle features and structures and riparian vegetation to decrease water temperatures and increased dissolved oxygen to improve water quality;
- Construct stream reaches so that floodplains and wetlands are frequently flooded to provide energy dissipation, detain and treat flood flows, and create a more natural hydrologic regime;
- Construct fencing to keep livestock out of the streams;
- Raise local groundwater table through raising stream beds and plugging agricultural drainage features;
- Perform minor grading in wetland areas as necessary to promote wetland hydrology; and Plant native tree species to establish appropriate wetland and floodplain communities and retain existing, native trees where possible.

1.2 Monitoring Year 4 Data Assessment

Annual monitoring was conducted between April and November 2019 to assess the condition of the project. The success criteria for the Site follows the approved success criteria presented in the Crooked Creek #2 Project Mitigation Plan (Wildlands, 2013).

1.2.1 Vegetation Assessment

A total of 12 standard 10-meter by 10-meter permanent vegetation plots were established during the baseline monitoring within the project easement area. The final vegetative success criteria will be the survival of 210 planted stems per acre in the riparian corridor along restored and enhanced reaches at the end of the seven-year monitoring period (MY7). The interim measure of vegetative success for the Site will be the survival of at least 260 stems per acre at the end of the fifth-year of monitoring (MY5). In addition, planted vegetation must average 10 feet in height in each plot at the end of the seventh-year of monitoring.

The MY4 vegetation survey was completed in August 2019 resulting in an average stem density of 550 stems/acre. All 12 vegetation plots meet the year five interim requirement of 260 stems/acre, with an average of 14 stems per plot. The average stem heights per plot is greater than five feet for all plots except plot 12, which has an average stem height of 4.3 feet. The MY4 average stem height for the Site is 7.38 feet. Overall, the planted stem height appears to be trending toward meeting the 10-foot requirement. This improvement in planted stem density and height from MY2 is a result of the supplemental planting that occurred in January 2018.

In many of the plots, dense herbaceous cover and vine strangulation is affecting planted stem growth. The concern in subsequent monitoring years remains that stems growing in the plots will be choked by herbaceous cover and affect the vigor of the stems compared to those growing in less densely covered areas. Please refer to Appendix 2 for vegetation plot photographs and the vegetation condition assessment table and Appendix 3 for vegetation data tables.

1.2.2 Vegetation Areas of Concern

Generally, across the Site vegetation is doing well with only a few areas where invasive plant species persist. The invasive species Johnson grass (*Sorghum halepense*) persists in small patches throughout

the Site. The native invasive species, cattail (*Typha latifolia*) is established in UT1 and continues to colonize an area surrounding Vegetation Plot five. However, plot five is meeting criteria and does not seem to be adversely impacted by the presence of cattail. The invasive vine species, such as Chinese lantern (*Physalis spp.*), Japanese honeysuckle (*Lonicera japonica*), and morning glory (*Ipomoea sp.*) are also present on the Site. Chinese lantern and morning glory along the easement line are strangling the stems in vegetation plot 10.

There was no further easement encroachment observed since the submittal of the MY4 Site Assessment Report. The Site has responded well to treatment by Carolina Silvics that occurred throughout 2018. Large patches of Chinese privet (*Ligustrum sinense*) along Crooked Creek Reach A and B were observed with no re-sprouts during the Site walk. After invasive treatments in 2018, the percent of easement area covered in invasive species lowered from 11% in MY3 to 2% of the easement in MY4. Refer to Appendix 2 for the vegetation condition assessment table and Integrated Current Condition Plan View (CCPV).

1.2.3 Stream Assessment

The MY4 morphological survey was conducted in April 2019. Results indicate that the channel dimensions are stable and functioning as designed. In general, the cross-sections on UT1 show little to no change in the bankfull area, maximum depth ratio, or width-to-depth ratio compared to baseline. Surveyed riffle cross-sections continue to fall within the parameters defined for channels of the appropriate Rosgen stream type (Rosgen, 1996). Although the low bank height ratio for cross-section 2 decreased from 1.0 to 0.9, only minor aggradation has been observed within the channel. This is most likely related to the dense in-stream vegetation, however, UT1 continues to maintain appropriate channel dimensions and is carrying flow during high flow events. Refer to Appendix 2 for the visual stability assessment table, CCPV map, and stream photographs. Refer to Appendix 4 for the morphological summary data and plots.

1.2.4 Stream Areas of Concern

The large tree debris jams observed on Crooked Creek's main stem are still present with localized areas of bank erosion near the debris jams. Refer to Appendix 2 for the visual assessment and stream photographs.

1.2.5 Hydrology Assessment

The success criteria for stream hydrology consisting of two bankfull events occurring in separate years within the seven-year monitoring period was met during MY2. At least one bankfull event occurred on Crooked Creek, UT1, and UT2 during the MY4 data collection using either gages or visual indicators, such as wrack lines. Although stream baseflow is not part of the success criteria for the Site, UT1 is being monitored and it has recorded 116 days of consecutive baseflow. Refer to Appendix 5 for hydrologic plots and photographs of documented bankfull events.

1.2.6 Wetland Assessment

Ten groundwater monitoring gages (GWG 1-10) were installed during the baseline monitoring to provide groundwater level data throughout the wetland areas. The target performance criteria for wetland hydrology success consists of groundwater surface within 12 inches of the ground surface for 17 consecutive days (7.5 %) of the defined 227 day growing season for Union County (March 23 through November 4) under typical precipitation conditions.

The number of gages meeting success criteria increased substantially from MY3 to MY4; from four to nine gages meeting, respectively. Groundwater gage four missed meeting success criteria by one day (16 days (7.1%)). As demonstrated in the groundwater gage Table 15 and plots in Appendix 5, high

precipitation totals in the winter months most likely attributed to the increase in the number of gages that met criteria early in the MY4 growing season. Precipitation data obtained from a nearby USGS rain station indicated there was an 18% increase in rainfall for the months of January through March in MY4 (11.78 inches total) in comparison to MY3 (9.67 inches total). This increase in precipitation observed during the winter months in MY4 falls within normal precipitation conditions as illustrated on the 30-70 percentile precipitation plot in Appendix 5. It is expected that the groundwater recharge observed in MY4 will continue in subsequent monitoring years given similar patterns of precipitation occur.

Although groundwater gage four missed meeting the wetland hydrology success criteria by one day (7.5%), it is possible that this gage could meet in future monitoring years as the wetland continues to recharge and normal precipitation rates occur. Refer to Appendix 5 for the groundwater hydrology data and plots.

1.2.7 Wetland Areas of Concern

The headcut previously reported in MY3 located in the Wetland Creation Zone B area has remained stable. This area will continue to be monitored in subsequent monitoring years. There are no additional areas of concern present within the wetland areas. Refer to Appendix 2 for wetland photographs.

1.3 Monitoring Year 4 Summary

In general, the stream channel dimension and profile are stable and functioning as designed. UT1 contains vegetation over-growth but continues to carry flow during large precipitation events. The average planted stem density of 550 stems/acre and the average planted stem height of 7.38 feet is on track to meet the Site's MY7 success criteria. Nine of the ten groundwater gages met the performance criteria in MY4, which is a significant improvement from previous monitoring years. The bankfull hydrologic performance criteria was met in MY2, however, the streams are continuing to record bankfull events. Lastly, the Site has responded well to previous supplemental plantings and invasive species treatments and will continued to be monitored in subsequent years.

Summary information and data related to the 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 Mitigation Plan documents available on DMS's website. All raw data supporting the tables and figures in the appendices are available from DMS upon request.



Section 2: METHODOLOGY

Geomorphic data were collected following the standards outlined in *The Stream Channel Reference Site: An Illustrated Guide to Field Techniques* (Harrelson et al., 1994) and in the *Stream Restoration: A Natural Channel Design Handbook* (Doll et al., 2003). All Integrated Current Condition Mapping was recorded using a Trimble handheld GPS with sub-meter accuracy and processed using Pathfinder and ArcGIS. Crest gages and pressure transducers were installed in surveyed riffle cross-sections during annual Site visits. Hydrologic monitoring instrument installation and monitoring methods are in accordance with the United States Army Corps of Engineers (USACE, 2003) standards. Vegetation monitoring protocols followed the Carolina Vegetation Survey-EEP Level 2 Protocol (Lee et al., 2008).

Section 3: REFERENCES

- Doll, B.A., Grabow, G.L., Hall, K.A., Halley, J., Harman, W.A., Jennings, G.D., and Wise, D.E. 2003. Stream Restoration A Natural Channel Design Handbook.
- Harrelson, Cheryl C; Rawlins, C.L.; Potyondy, John P. 1994. *Stream Channel Reference Sites: An Illustrated Guide to Field Technique*. Gen. Tech. Rep. RM-245. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Forest and Range Experiment Station. 61 p.
- Lee, Michael T., Peet, Robert K., Steven D., Wentworth, Thomas R. 2008. CVS-EEP Protocol for Recording Vegetation Version 4.2. Retrieved from: <http://cvs.bio.unc.edu/protocol/cvs-EEP-protocol-v4.2-lev1-2.pdf>
- North Carolina Ecosystem Enhancement Program (NCEEP), 2009. Lower Yadkin Pee-Dee River Basin Restoration Priorities. Retrieved from: <http://deq.nc.gov/document/yadkin-pee-dee-rbrp-2009-final>
- North Carolina Ecosystem Enhancement Program (NCEEP), Tetra Tech, CCoG, 2012. Goose Creek and Crooked Creek Local Watershed Plan. Retrieved from: http://www.gooseandcrooked.org/documents/GooseandCrookedLWP-WMP_Final_7-2012.pdf
- North Carolina Division of Mitigation Services and Interagency Review Team Technical Workgroup. 2018. Standard Measurement of the BHR Monitoring Parameter. Raleigh, NC.
- Rosgen, D.L. 1996. Applied River Morphology. Pagosa Springs, CO: Wildland Hydrology Books.
- United States Army Corps of Engineers (USACE), 2003. Stream Mitigation Guidelines. USACE, NCDENR-DWQ, USEPA, NCWRC.
- United States Department of Agriculture (USDA), 2016. USDA Field Office Climate Data, WETS Table: Monroe, NC5771 (1971-2000).
- United States Geological Survey (USGS), 1998. North Carolina Geology. Retrieved from: <http://www.geology.enr.state.nc.us/usgs/coastalp.htm>
- United States Geological Survey (USGS), 2016. Real Time Water Data for North Carolina. Retrieved from: http://nc.water.usgs.gov/realtime/real_time_yadkin_peedee.html
- Wildlands Engineering, Inc. (2013). Crooked Creek #2 Restoration Project Final Mitigation Plan. NCEEP, Raleigh, NC.

APPENDIX 1. General Figures and Tables

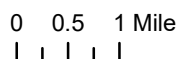
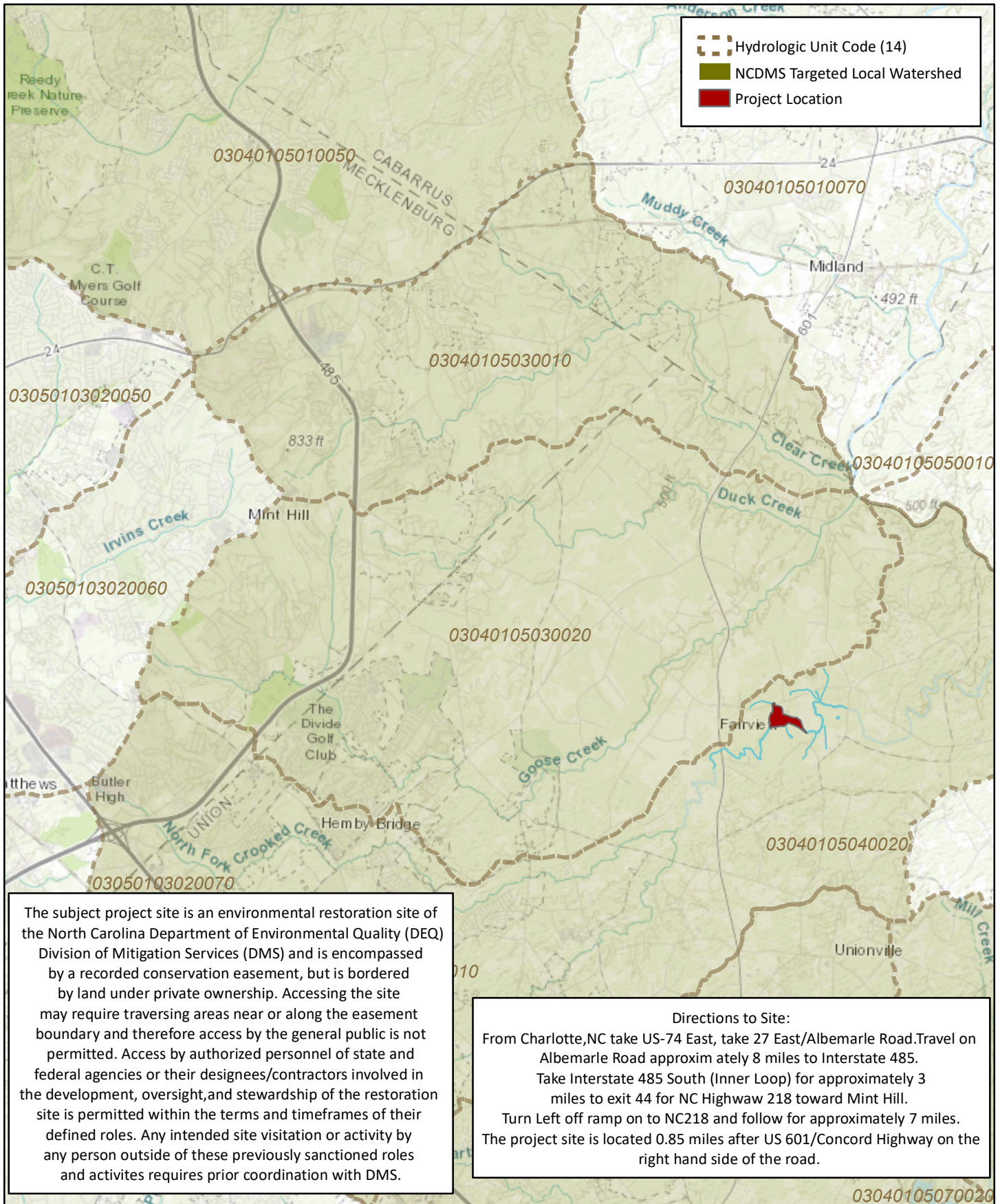
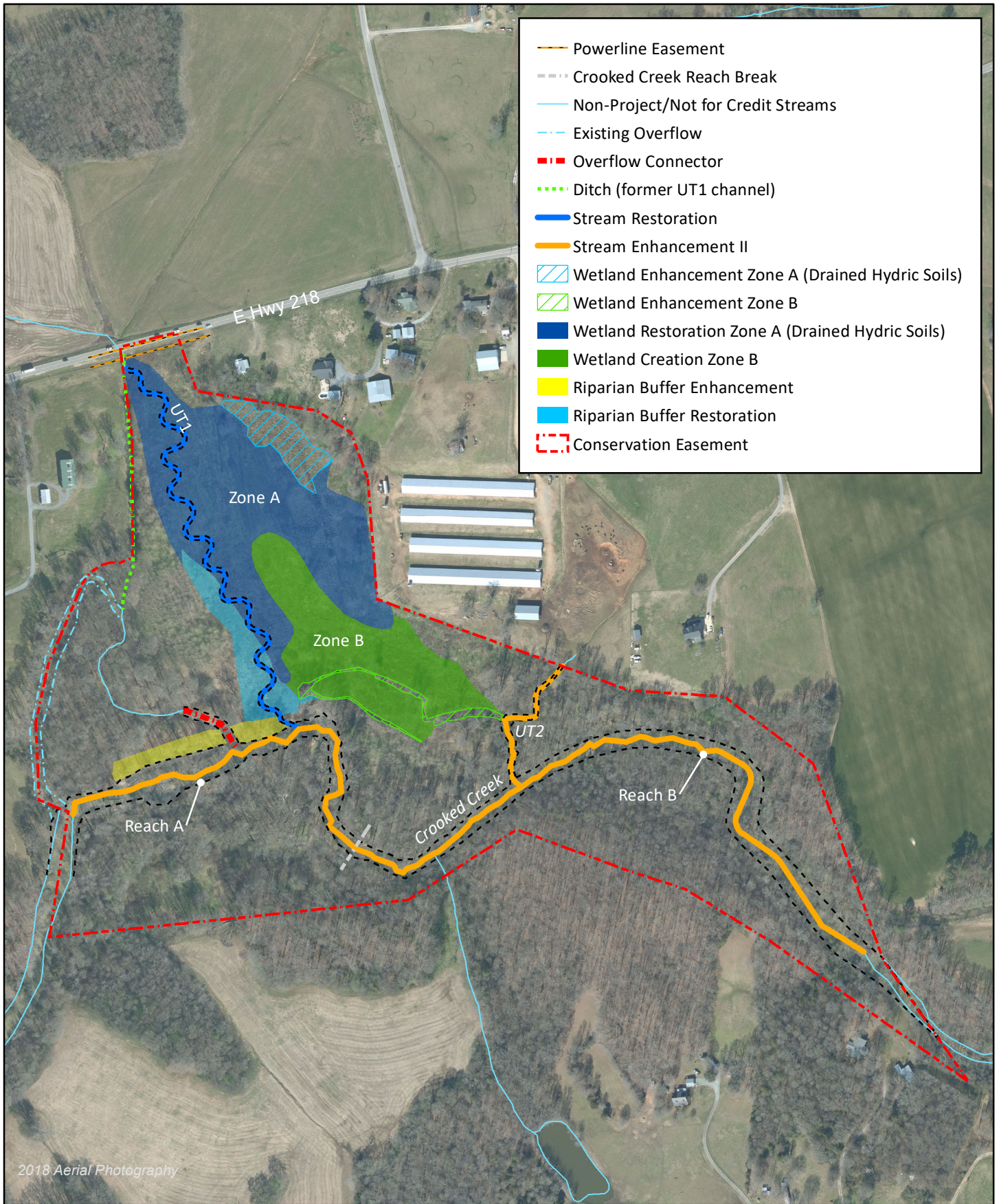


Figure 1 Project Vicinity Map
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019
 Union County, NC



0 400 Feet



Figure 2 Project Component/Asset Map
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019

Union County, NC

Table 1. Project Components and Mitigation Credits

Crooked Creek #2 Restoration Project Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Mitigation Credits									
Type	Stream		Riparian Wetland		Non-Riparian Wetland		Buffer (sqft)	Nitrogen Nutrient	Phosphorous Nutrient Offset
	R	RE	R	RE	R	RE			
Totals	3,242.2	N/A	7.900	0.500	N/A	N/A	54,135.33		N/A
Project Components									
Reach ID	As-Built Stationing/ Location	Existing Footage/ Acreage	Approach	Restoration or Restoration Equivalent	Restoration Footage/ Acreage	Mitigation Ratio	Credits ^{1,2} (SMU/ WMU)		
STREAMS									
Crooked Creek Reach A	202+20-215+55	1,555 LF	N/A	Enhancement II	1,335	2.5:1	534.000		
Crooked Creek Reach B	215+55-236+78	2,404 LF	N/A	Enhancement II	2,123	2.5:1	849.200		
UT1	100+47-117+18	1,762 LF	P1	Restoration	1,671	1:1	1,671.000		
UT2	300+52-305+60	508 LF	N/A	Enhancement II	470	2.5:1	188.000		
WETLANDS									
Zone A (Drained Hydric Soils)	N/A	0.7 AC		Enhancement	0.7	2:1	0.350		
Zone A (Drained Hydric Soils)	N/A	N/A		Restoration	6.6	1:1	6.600		
Zone B	N/A	0.3 AC		Enhancement	0.3	2:1	0.150		
Zone B	N/A	N/A		Creation	3.9	3:1	1.300		
BUFFER									
Goose Creek Buffer	N/A	25,201 sqft		Enhancement	25,201	3:1	8,400.33 sqft		
Goose Creek Buffer	N/A	N/A		Restoration	45,735	1:1	45,735 sqft		

Component Summation						
Restoration Level	Stream (LF)	Riparian Wetland (acres)		Non-Riparian (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	1,671	6.6			45,735	
Enhancement		1.0			25,201	
Enhancement I						
Enhancement II	3,928					
Creation		3.9				

1 UT1 crediting starts downstream of the powerline right-of-way along Hwy 218.
 2 UT2 crediting ends at Crooked Creek's top of bank.

Table 2. Project Activity and Reporting History
 Crooked Creek #2 Restoration Project Site
 DMS Project No. 94687
 Monitoring Year 4 - 2019

Activity or Report		Data Collection Complete	Completion or Scheduled Delivery
Mitigation Plan		June 2011	August 2013
Final Design - Construction Plans		August 2011	April 2014
Construction		January 2015 - April 2015	January 2015 - April 2015
Temporary S&E mix applied to entire project area ¹		January 2015 - March 2015	January 2015 - March 2015
Permanent seed mix applied to reach/segments		January 2015 - March 2015	January 2015 - March 2015
Bare root and live stake plantings for reach/segments		January 2016	January 2016
Baseline Monitoring Document (Year 0)		January - February 2016	May 2016
Year 1 Monitoring	Stream Survey	August 2016	November 2016
	Vegetation Survey	September 2016	
Year 2 Monitoring	Stream Survey	April 2017	November 2017
	Vegetation Survey	August 2017	
Year 3 Monitoring	Invasive Treatment	January 2018	November 2018
	Supplemental Planting		
	Stream Survey	April 2018	
	Invasive Treatment	May 2018	
		June 2018	
	Vegetation Survey	August 2019	
	Invasive Treatment	August 2018	
	October 2018		
Year 4 Monitoring	Stream Survey	April 2019	November 2019
	Vegetation Survey	August 2019	
Year 5 Monitoring	Stream Survey	2020	November 2020
	Vegetation Survey	2020	
Year 6 Monitoring	Stream Survey	2021	November 2021
	Vegetation Survey	2021	
Year 7 Monitoring	Stream Survey	2022	November 2022
	Vegetation Survey	2022	

¹Seed and mulch is added as each section of construction is completed.

Table 3. Project Contact Table
 Crooked Creek #2 Restoration Project Site
 DMS Project No. 94687
 Monitoring Year 4 - 2019

Designer Aaron Earley, PE, CFM	Wildlands Engineering, Inc. 1430 South Mint Street, Suite 104 Charlotte, NC 28203 704.332.7754
Construction Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101
Planting Contractor	Keller Environmental 7921 Haymarket Lane Raleigh, NC 27615
Supplemental Planting Contractor & Invasive Species Maintenance	Carolina Silvics 908 Indian Trail Road Edenton, NC 27932
Seeding Contractor	North State Environmental, Inc. 2889 Lowery Street Winston Salem, NC 27101
Seed Mix Sources	Green Resource, LLC
Nursery Stock Suppliers Bare Roots Live Stakes	Dykes & Son Nursery 825 Maude Etter Rd. McMinnville, TN 37110
Monitoring Performers	Wildlands Engineering, Inc.
Monitoring, POC	Kirsten Gimbart 704.941.9093

Table 4. Project Information and Attributes

Crooked Creek #2 Restoration Project Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Project Information				
Project Name	Crooked Creek #2 Restoration Project			
County	Union County			
Project Area (acres)	54.94			
Project Coordinates (latitude and longitude)	34° 58' 54.78"N, 080° 31' 25.79"W			
Project Watershed Summary Information				
Physiographic Province	Carolina Slate Belt of the Piedmont Physiographic Province			
River Basin	Yadkin			
USGS Hydrologic Unit 8-digit	03040105			
USGS Hydrologic Unit 14-digit	03040105040010			
DWR Sub-basin	03-07-12			
Project Drainage Area (acres)	24,619			
Project Drainage Area Percentage of Impervious Area	28%			
CGIA Land Use Classification	Agriculture 38%, Forested 29%, Developed 28%, Wetlands 3%, and Herbaceous Upland 2%			
Reach Summary Information				
Parameters	Crooked Creek Reach A	Crooked Creek Reach B	UT1	UT2
Length of reach (linear feet) - Post-Restoration	1,555	2,404	1,671	195 275
Drainage area (acres)	24,619		153	51
NCDWR stream identification score	52		34.5	24.5 38
NCDWR Water Quality Classification	C			
Morphological Description (stream type)	P	P	P	I P
	N/A	N/A	Stage III	Stage IV
Evolutionary trend (Simon's Model) - Pre- Restoration				
Underlying mapped soils	Chewacala silt loam 0-2% slopes (ChA)	Chewacala silt loam 0-2% slopes (ChA)	Chewacala silt loam 0-2% slopes (ChA)	Badin channery silt loam 8-15% slopes (BaC)
Drainage class	Somewhat poorly drained	Somewhat poorly drained	Somewhat poorly drained	Well drained
Soil hydric status	Type B (inclusions)	Type B (inclusions)	Type B (inclusions)	N/A
Slope	0.0022		0.0047	0.0050
FEMA classification	Zone AE	Zone AE	no regulated floodplain	no regulated floodplain
Native vegetation community	Piedmont Bottomland forest			
Percent composition exotic invasive vegetation -Post-Restoration	5%	5%	60%	5%
Regulatory Considerations				
Regulation	Applicable?	Resolved?	Supporting Documentation	
Waters of the United States - Section 404	X	X	USACE Nationwide Permit No.27 and DWQ 401 Water Quality Certification No. 3885. Action ID # 2011-02201	
Waters of the United States - Section 401	X	X		
Division of Land Quality (Erosion and Sediment Control)	X	X	NPDES Construction Stormwater General Permit NCG010000	
Endangered Species Act	X	X	Crooked Creek #2 Mitigation Plan; Wildlands determined "no effect" on Union County listed endangered species. June 21, 2011 email correspondence from USFWS indicating no listed species occur on site.	
Historic Preservation Act	X	X	No historic resources were found to be impacted (letter from SHPO dated 6/23/2011).	
Coastal Zone Management Act (CZMA)/Coastal Area Management Act (CAMA)	N/A	N/A	N/A	
FEMA Floodplain Compliance	X	X	Crooked Creek is a mapped Zone AE floodplain with defined base flood elevations. Base flood elevations have been defined and the floodway has been delineated; (FEMA Zone AE, FIRM panel 5540).	
Essential Fisheries Habitat	N/A	N/A	N/A	

Table 5. Monitoring Component Summary

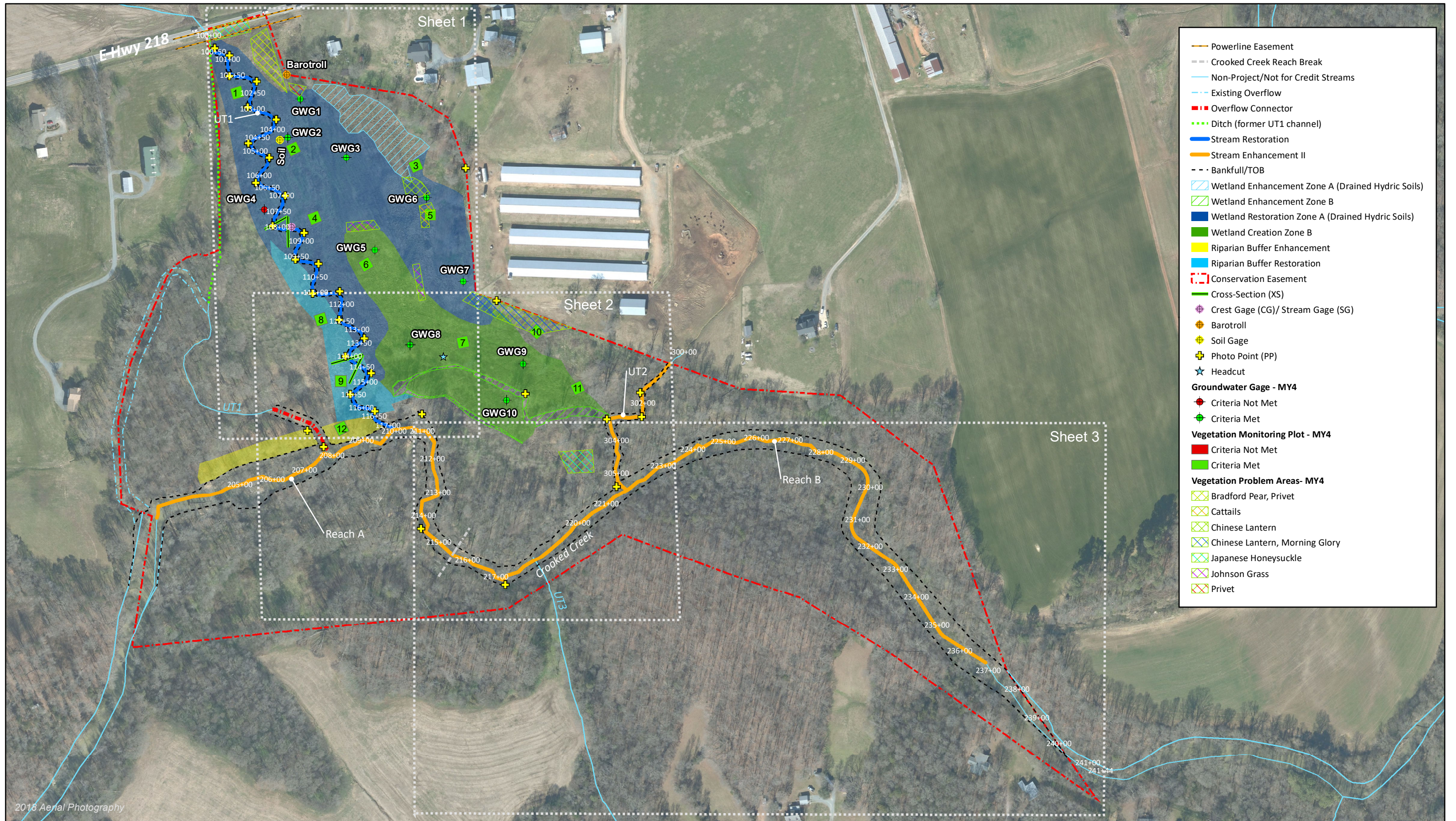
Crooked Creek #2 Restoration Project Site

DMS Project No. 94687

Monitoring Year 4 - 2019

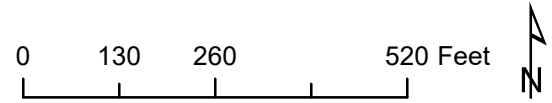
Parameter	Monitoring Feature	Quantity / Length by Reach					Frequency
		Crooked Creek Reach A	Crooked Creek Reach B	UT1	UT2	Wetlands	
Dimension	Riffle Cross-Section	N/A	N/A	2	N/A	N/A	Annual
	Pool Cross-Section	N/A	N/A	2	N/A	N/A	
Pattern	Pattern	N/A	N/A	N/A	N/A	N/A	N/A
Profile	Longitudinal Profile	N/A	N/A	N/A	N/A	N/A	Year 0
Substrate	Reach Wide (RW)/ Riffle 100 Pebble Count (RF)	N/A	N/A	1 RW / 2 RF	N/A	N/A	Annual
Hydrology	Crest Gage	1		1	1	N/A	Quarterly
Hydrology	Groundwater Gages	N/A	N/A	N/A	N/A	10	Quarterly
Vegetation	Vegetation Plots	12					Annual
Visual Assessment	All Streams	Y	Y	Y	Y	Y	Semi-Annual
Exotic and nuisance vegetation							Semi-Annual
Project Boundary							Semi-Annual
Reference Photos	Photo Points	34					Annual

APPENDIX 2. Visual Assessment Data



- Powerline Easement
- - - Crooked Creek Reach Break
- Non-Project/Not for Credit Streams
- - - Existing Overflow
- Overflow Connector
- - - Ditch (former UT1 channel)
- Stream Restoration
- Stream Enhancement II
- - - Bankfull/TOB
- ▨ Wetland Enhancement Zone A (Drained Hydric Soils)
- ▨ Wetland Enhancement Zone B
- ▨ Wetland Restoration Zone A (Drained Hydric Soils)
- ▨ Wetland Creation Zone B
- ▨ Riparian Buffer Enhancement
- ▨ Riparian Buffer Restoration
- ▨ Conservation Easement
- Cross-Section (XS)
- ⊕ Crest Gage (CG)/ Stream Gage (SG)
- ⊕ Barotroll
- ⊕ Soil Gage
- ⊕ Photo Point (PP)
- ★ Headcut
- Groundwater Gage - MY4**
- ⊕ Criteria Not Met
- ⊕ Criteria Met
- Vegetation Monitoring Plot - MY4**
- ▨ Criteria Not Met
- ▨ Criteria Met
- Vegetation Problem Areas- MY4**
- ▨ Bradford Pear, Privet
- ▨ Cattails
- ▨ Chinese Lantern
- ▨ Chinese Lantern, Morning Glory
- ▨ Japanese Honeysuckle
- ▨ Johnson Grass
- ▨ Privet

2018 Aerial Photography



Crooked Creek #2 Stream and Wetland Mitigation Site (Key)
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019
 Union County, NC

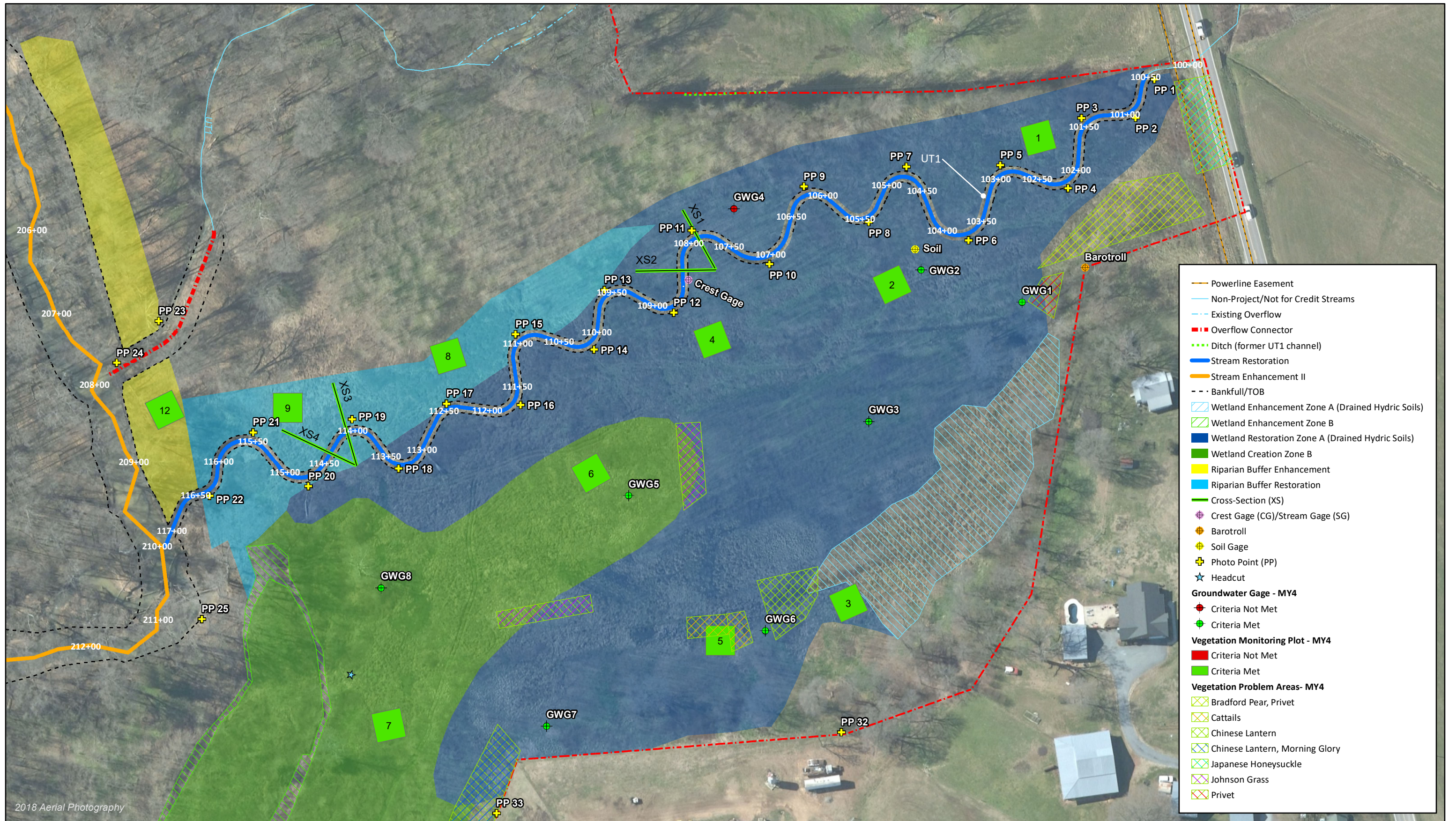


Figure 3.1 Integrated Current Condition Plan View (Sheet 1)
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019
 Union County, NC

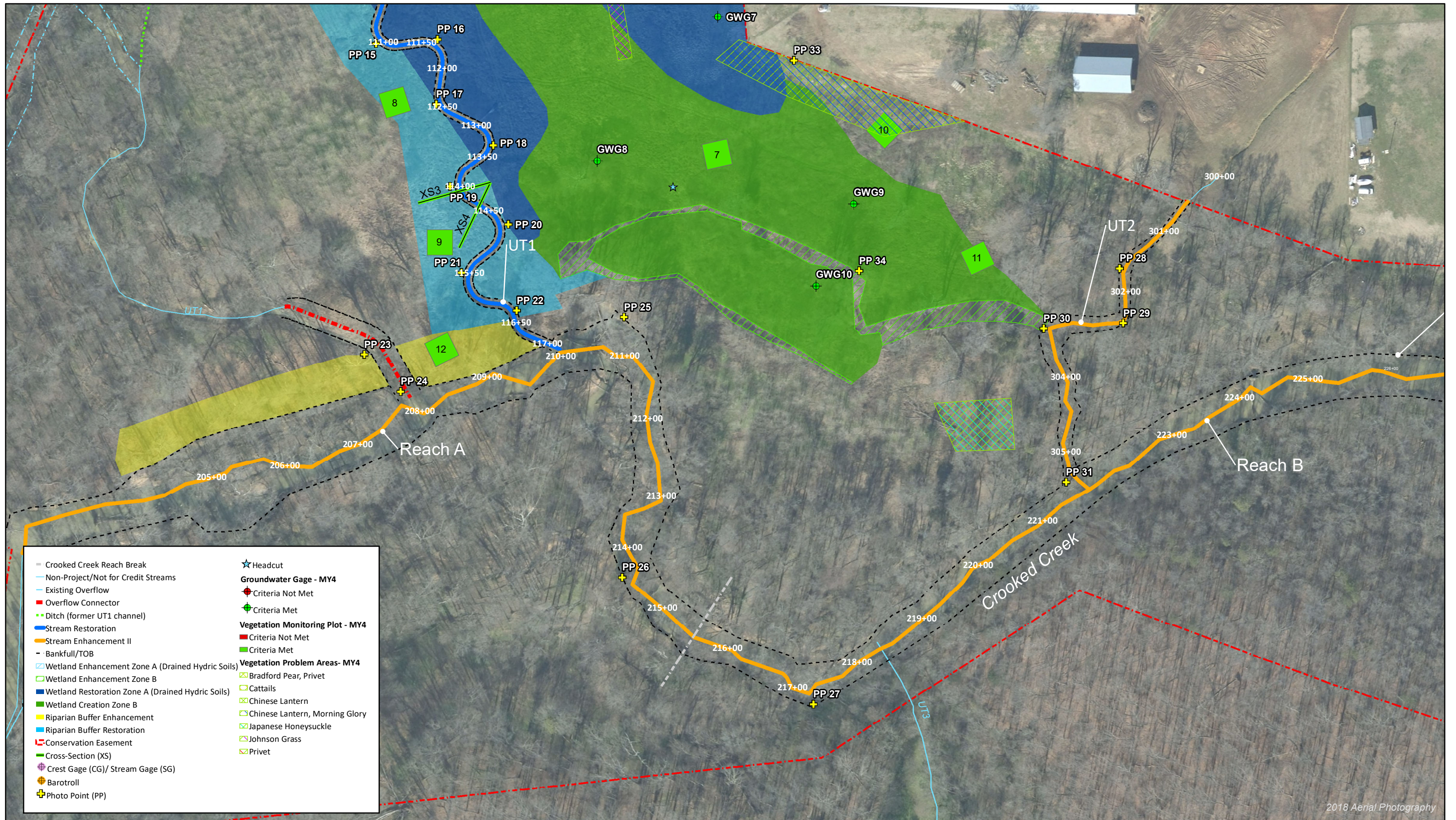


Figure 3.2 Integrated Current Condition Plan View (Sheet 2)
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019
 Union County, NC



Figure 3.3 Integrated Current Condition Plan View (Sheet 3)
 Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019
 Union County, NC

Table 6. Visual Stream Morphology Stability Assessment Table

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

UT1 (1,671 LF)

Major Channel Category	Channel Sub-Category	Metric	Number Stable, Performing as Intended	Total Number in As-Built	Number of Unstable Segments	Amount of Unstable Footage	% Stable, Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjust % for Stabilizing Woody Vegetation
1. Bed	1. Vertical Stability (Riffle and Run units)	Aggradation			0	0	100%			
		Degradation			0	0	100%			
	2. Riffle Condition	Texture/Substrate	16	16		100%				
	3. Meander Pool Condition	Depth Sufficient	20	20		100%				
		Length Appropriate	20	20		100%				
	4. Thalweg Position	Thalweg centering at upstream of meander bend (Run)	20	20		100%				
Thalweg centering at downstream of meander bend (Glide)		20	20	100%						
2. Bank	1. Scoured/Eroded	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	n/a	n/a	n/a
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat			0	0	100%	n/a	n/a	n/a
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	n/a	n/a	n/a
Totals					0	0	100%	n/a	n/a	n/a
3. Engineered Structures ¹	1. Overall Integrity	Structures physically intact with no dislodged boulders or logs.	9	9			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	4	4			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	4	4			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%.	9	9			100%			
	4. Habitat	Pool forming structures maintaining ~Max Pool Depth : Bankfull Depth ≥ 1.6 Rootwads/logs providing some cover at baseflow.	20	20			100%			

¹Excludes constructed riffles since they are evaluated in section 1.

Table 7. Vegetation Condition Assessment Table

Crooked Creek #2 Restoration Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Planted Acreage 15.0

Vegetation Category	Definitions	Mapping Threshold	Number of Polygons	Combined Acreage ¹	% of Planted Acreage
Bare Areas	Very limited cover of both woody and herbaceous material	0.1 ac	0	0.0	0%
Low Stem Density Areas ¹	Woody stem densities clearly below target levels based on MY3, 4, 5, or 7 stem count criteria.	0.1 ac	0	0.00	0.0%
			Total	0	0.0%
Areas of Poor Growth Rates or Vigor	Areas with woody stems of a size class that are obviously small given the monitoring year.	0.25	0	0.00	0.0%
			Cumulative Total	0	0.0%

Easement Acreage 54.9

Vegetation Category	Definitions	Mapping Threshold	Number of Polygons	Combined Acreage ²	% of Easement Acreage
Invasive Areas of Concern ²	Areas or points (if too small to render as polygons at map scale).	1000 SF	11	0.9	2%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	0	0	0%

¹ Acreage calculated from annual vegetation monitoring plots and plant warranty inspection plots.

² Acreage of each polygon modified by estimated percent cover of invasive population

Vegetation Photographs
Monitoring Year 4



Vegetation Plot 1 – (08/30/2019)



Vegetation Plot 2 – (08/30/2019)



Vegetation Plot 3 – (08/30/2019)



Vegetation Plot 4 – (08/29/2019)



Vegetation Plot 5 – (09/03/2019)



Vegetation Plot 6 – (08/29/2019)



Vegetation Plot 7 – (09/03/2019)



Vegetation Plot 8 – (08/30/2019)



Vegetation Plot 9 – (08/30/2019)



Vegetation Plot 10 – (09/03/2019)



Vegetation Plot 11 – (09/03/2019)



Vegetation Plot 12 – (08/30/2019)

Stream Photographs



Photo Point 1 – UT1 looking upstream (4/1/2019)



Photo Point 1 – UT1 looking downstream (4/1/2019)



Photo Point 2 – UT1 looking upstream (4/1/2019)



Photo Point 2 – UT1 looking downstream (4/1/2019)



Photo Point 3 – UT1 looking upstream (4/1/2019)



Photo Point 3 – UT1 looking downstream (4/1/2019)



Photo Point 4 – UT1 looking upstream (4/1/2019)



Photo Point 4 – UT1 looking downstream (4/1/2019)



Photo Point 5 – UT1 looking upstream (4/1/2019)



Photo Point 5 – UT1 looking downstream (4/1/2019)



Photo Point 6 – UT1 looking upstream (4/1/2019)



Photo Point 6 – UT1 looking downstream (4/1/2019)



Photo Point 7 – UT1 looking upstream (4/1/2019)



Photo Point 7 – UT1 looking downstream (4/1/2019)



Photo Point 8 – UT1 looking upstream (4/1/2019)



Photo Point 8 – UT1 looking downstream (4/1/2019)



Photo Point 9 – UT1 looking upstream (4/1/2019)



Photo Point 9 – UT1 looking downstream (4/1/2019)



Photo Point 10 – UT1 looking upstream (4/1/2019)



Photo Point 10 – UT1 looking downstream (4/1/2019)



Photo Point 11 – UT1 looking upstream (4/1/2019)



Photo Point 11 – UT1 looking downstream (4/1/2019)



Photo Point 12 – UT1 looking upstream (4/1/2019)



Photo Point 12 – UT1 looking downstream (4/1/2019)



Photo Point 13 – UT1 looking upstream (4/1/2019)



Photo Point 13 – UT1 looking downstream (4/1/2019)



Photo Point 14 – UT1 looking upstream (4/1/2019)



Photo Point 14 – UT1 looking downstream (4/1/2019)



Photo Point 15 – UT1 looking upstream (4/1/2019)



Photo Point 15 – UT1 looking downstream (4/1/2019)



Photo Point 16 – UT1 looking upstream (4/1/2019)



Photo Point 16 – UT1 looking downstream (4/1/2019)



Photo Point 17 – UT1 looking upstream (4/1/2019)



Photo Point 17 – UT1 looking downstream (4/1/2019)



Photo Point 18 – UT1 looking upstream (4/1/2019)



Photo Point 18 – UT1 looking downstream (4/1/2019)



Photo Point 19 – UT1 looking upstream (4/1/2019)



Photo Point 19 – UT1 looking downstream (4/1/2019)



Photo Point 20 – UT1 looking upstream (4/1/2019)



Photo Point 20 – UT1 looking downstream (4/1/2019)



Photo Point 21 – UT1 looking upstream (4/1/2019)



Photo Point 21 – UT1 looking downstream (4/1/2019)



Photo Point 22 – UT1 looking upstream (4/1/2019)



Photo Point 22 – UT1 looking downstream (4/1/2019)



Photo Point 23 – UT1 looking upstream (4/1/2019)



Photo Point 23 – UT1 looking downstream (4/1/2019)



Photo Point 24 – Crooked Creek looking upstream (4/1/2019)



Photo Point 24 – Crooked Creek looking downstream (4/1/2019)



Photo Point 25 – Crooked Creek looking upstream (4/1/2019)



Photo Point 25 – Crooked Creek looking downstream (4/1/2019)



Photo Point 26 – Crooked Creek looking upstream (4/1/2019)



Photo Point 26 – Crooked Creek looking downstream (4/1/2019)



Photo Point 27 – Crooked Creek looking upstream (4/1/2019)



Photo Point 27 – Crooked Creek looking downstream (4/1/2019)



Photo Point 28 – UT2 looking upstream (4/1/2019)



Photo Point 28 – UT2 looking downstream (4/1/2019)



Photo Point 29 – UT2 looking upstream (4/1/2019)



Photo Point 29 – UT2 looking downstream (4/1/2019)



Photo Point 30 – UT2 looking downstream to UT2 (4/1/2019)



**Photo Point 31 – UT2 looking upstream Crooked Creek
(4/1/2019)**



**Photo Point 31 – UT2 looking downstream Crooked Creek
(4/1/2019)**



Photo Point 31 – UT2 looking upstream UT2 (4/1/2019)

Wetland Photographs

Monitoring Year 4



Photo Point 30 –Wetland CC outlet facing West (8/29/2019)



Photo Point 30 –Wetland CC outlet facing East (8/29/2019)



Photo Point 32 –Wetland AA facing West (4/1/2019)



Photo Point 32 – Wetland Zone A facing South (4/1/2019)



Photo Point 33 – Wetland Zone A & B facing West (4/1/2019)



Photo Point 33 - Wetland B facing South (4/1/2019)



Photo Point 34 –Wetland CC facing Northwest (4/1/2019)



Photo Point 34 –Wetland CC facing South (4/1/2019)

APPENDIX 3. Vegetation Plot Data

Table 8. Vegetation Plot Criteria Attainment

Crooked Creek #2 Restoration Project Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Plot	MY2 Success Criteria Met (Y/N)	Tract Mean
1	Y	100%
2	Y	
3	Y	
4	Y	
5	Y	
6	Y	
7	Y	
8	Y	
9	Y	
10	Y	
11	Y	
12	Y	

Table 9. CVS Vegetation Plot Metadata

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Report Prepared By	Ella Wickliff
Date Prepared	9/25/2019 14:34
Database Name	cvs-eep-entrytool-v2.3.0_Crooked Creek_MY4.mdb
Database Location	Q:\ActiveProjects\005-02156 Crooked Creek Monitoring\Monitoring\Monitoring Year 4 (2019)\Vegetation Assessment
Computer Name	ELLA-PC
File Size	46698496
DESCRIPTION OF WORKSHEETS IN THIS DOCUMENT-----	
Metadata	Description of database file, the report worksheets, and a summary of project(s) and project data.
Project planted	Each project is listed with its PLANTED stems per acre, for each year. This excludes live stakes.
Project 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	94687
Project Name	Crooked Creek #2 Restoration Project
Description	Crooked Creek #2 Restoration Project
Required Plots (calculated)	12
Sampled Plots	12

Table 10. Planted and Total Stem Counts

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Scientific Name	Common Name	Species Type	Current Plot Data (MY4 2019)																								
			94687-WEI-0001			94687-WEI-0002			94687-WEI-0003			94687-WEI-0004			94687-WEI-0005			94687-WEI-0006			94687-WEI-0007			94687-WEI-0008			
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	
Acer negundo	Box Elder	Tree			2																		4				
Acer rubrum	Red Maple	Tree	1	1	1							2	2	2										3	3	6	
Betula nigra	River Birch	Tree				1	1	1	1	1	1	1	1	1	1	1	1	1	6	6	6	1	1	1	2	2	2
Carpinus caroliniana	Ironwood	Shrub Tree																2	2	2							
Celtis laevigata	Sugarberry	Shrub Tree	2	2	2				1	1	1													1	1	1	
Cornus florida	Flowering Dogwood	Shrub Tree																									
Diospyros virginiana	American Persimmon	Tree	2	2	2	1	1	1	1	1	1													5	5	5	
Fraxinus pennsylvanica	Green Ash	Tree			18			1			9			2			34						20			3	
Juglans nigra	Black Walnut	Tree																									
Liquidambar styraciflua	Sweet Gum	Tree						1															7				
Liriodendron tulipifera	Tulip Poplar	Tree																									
Nyssa sylvatica	Black Gum	Tree																									
Platanus occidentalis	Sycamore	Tree	6	6	6	6	6	6	1	1	2	3	3	3	1	1	1	4	4	17	2	2	2	2	2	2	
Quercus	Oak sp.	Shrub Tree																									
Quercus lyrata	Overcup Oak	Tree																									
Quercus nigra	Water Oak	Tree																			3	3	3	1	1	1	
Quercus phellos	Willow Oak	Tree	1	1	2	1	1	1				1	1	1				2	2	2	3	3	3				
Salix nigra	Black Willow	Tree																									
Taxodium distichum	Bald-cypress	Tree	4	4	4	4	4	4	7	7	7	4	4	4	9	9	10	2	2	2	1	1	1	1	1	1	
Ulmus alata	Winged Elm	Tree																2	2	6	4	4	4				
Ulmus americana	American Elm	Tree																									
Stem count			16	16	37	13	13	15	11	11	21	11	11	13	11	11	46	18	18	35	14	14	45	15	15	21	
size (ares)			1			1			1			1			1			1			1			1			
size (ACRES)			0.02			0.02			0.02			0.02			0.02			0.02			0.02			0.02			
Species count			6	6	8	5	5	7	5	5	6	5	5	6	3	3	4	6	6	6	6	6	9	7	7	8	
Stems per ACRE			647	647	1497	526	526	607	445	445	850	445	445	526	445	445	1862	728	728	1416	567	567	1821	607	607	850	

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%

PnoLS: Number of planted stems excluding live stakes

P-all: Number of planted stems including live stakes

T: Total stems

Table 10. Planted and Total Stem Counts

Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019

Scientific Name	Common Name	Species Type	Current Plot Data (MY4 2019)												Annual Means														
			94687-WEI-0009			94687-WEI-0010			94687-WEI-0011			94687-WEI-0012			MY4 (8/2019)			MY3 (8/2018)			MY2 (8/2017)			MY1 (9/2016)			MY0 (2/2016)		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	Box Elder	Tree			5			12						23		49		43		18			17						
Acer rubrum	Red Maple	Tree	6	6	6									12	12	15	13	13	14	11	11	11	13	13	13	14	14	14	
Betula nigra	River Birch	Tree	4	4	4	2	2	2	4	4	4	4	4	5	27	27	28	26	26	26	12	12	14	14	14	15	18	18	18
Carpinus caroliniana	Ironwood	Shrub Tree												2	2	2											2		
Celtis laevigata	Sugarberry	Shrub Tree				2	2	2						6	6	6	9	9	14			4			1				
Cornus florida	Flowering Dogwood	Shrub Tree									2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	6	6	6	
Diospyros virginiana	American Persimmon	Tree	2	2	2						1	1	1	12	12	12	13	13	16	7	7	7	10	10	13	27	27	27	
Fraxinus pennsylvanica	Green Ash	Tree						30			10					127		41			25			26			45		
Juglans nigra	Black Walnut	Tree																3			4						1		
Liquidambar styraciflua	Sweet Gum	Tree						20			10			1		39		6			7			7			4		
Liriodendron tulipifera	Tulip Poplar	Tree											1		1						1			1			2		
Nyssa sylvatica	Black Gum	Tree				1	1	1				1	1	1	2	2	2	2	2	3	2	2	2	3	3	3	7	7	7
Platanus occidentalis	Sycamore	Tree	1	1	1							1	1	1	27	27	41	28	28	50	12	12	44	13	13	26	15	15	16
Quercus	Oak sp.	Shrub Tree															2	2	2	1	1	1	13	13	13	53	53	53	
Quercus lyrata	Overcup Oak	Tree				1	1	1	3	3	3	2	2	2	6	6	6	8	8	8	8	8	8	8	7	7	7		
Quercus nigra	Water Oak	Tree				1	1	1	6	6	6	1	1	1	12	12	12	12	12	12	11	11	11	4	4	4			
Quercus phellos	Willow Oak	Tree				1	1	1							9	9	10	6	6	6	6	6	6	3	3	3			
Salix nigra	Black Willow	Tree																	2										
Taxodium distichum	Bald-cypress	Tree				4	4	4				4	4	4	40	40	41	41	41	41	12	12	12	13	13	13	16	16	16
Ulmus alata	Winged Elm	Tree													6	6	10	6	6	12			5					1	
Ulmus americana	American Elm	Tree																						7					
Stem count			13	13	13	12	12	67	13	13	45	16	16	19	163	163	377	168	168	307	84	84	207	95	95	172	156	156	229
size (ares)			1			1			1			1			12			12			12			12			12		
size (ACRES)			0.02			0.02			0.02			0.02			0.30			0.30			0.30			0.30			0.30		
Species count			4	4	4	7	7	10	3	3	6	8	8	10	13	13	17	13	13	18	11	11	18	11	11	17	8	8	15
Stems per ACRE			526	526	526	486	486	2711	526	526	1821	647	647	769	550	550	1271	567	567	1035	283	283	698	320	320	580	526	526	772

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%

PnoLS: Number of planted stems excluding live stakes
 P-all: Number of planted stems including live stakes
 T: Total stems

APPENDIX 4. Morphological Summary Data and Plots

Table 11. Baseline Stream Data Summary

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

UT1

Parameter	Gage	Pre-Restoration Condition				Reference Reach Data				Design		As-Built/Baseline	
		UT1 Reach 1		UT1 Reach 2		UT to Lyle Creek		Spencer Creek 1		UT1		UT1	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Shallow													
Bankfull Width (ft)	N/A	17.7		10.9		7.0 8.6		8.7		12.0		11.7 12.6	
Floodprone Width (ft)		500		539		45 49		229		44+		200+	
Bankfull Mean Depth		0.5		0.7		0.5		1.2		0.7		0.6	
Bankfull Max Depth		1.3		1.0		1.0 1.1		1.9		1.0		1.1	
Bankfull Cross-sectional Area (ft ²)		8.6		7.8		3.5 4.1		10.6		8.7		7.3 7.5	
Width/Depth Ratio		36.4		15.3		14.9 18.3		7.3		16.6		18.9 21.1	
Entrenchment Ratio		28.2		49.3		5.7 6.4		26.3		2.2+		2.2+	
Bank Height Ratio		1.4		2.9		0.6 0.9		1.0		1.0		1.0	
D50 (mm)		3.1		---								0.3 35.9	
Riffle Length (ft)		N/A	*		*		0.0055 0.0597		0.0100 0.0670		0.0045 0.0080		12 50
Riffle Slope (ft/ft)											0.0004 0.0193		
Pool Length (ft)					---		---		---		17.8 65.4		
Pool Max Depth (ft)	0.76 1.27		0.76 1.27		1.3		2.5		1.5 2.1		1.1 3.0		
Pool Spacing (ft)	20		74		15 28		13 47		42 84		36 99		
Pool Volume (ft ³)													
Pattern													
Channel Beltwidth (ft)	N/A	---		115 543		21		24 52		30 72		30 72	
Radius of Curvature (ft)		61.2 170.6		61.2 170.6		19 32		5 22		22 48		22 48	
Rc:Bankfull Width (ft/ft)		3.5 9.6		3.5 9.6		2.7 3.7		0.6 2.5		1.8 4.0		1.8 4.0	
Meander Length (ft)		---		163 400		39 44		54 196		72 132		102 135	
Meander Width Ratio		---		10.5 49.7		2.4 3		2.8 6.0		2.5 6.0		2.5 6.0	
Substrate, Bed and Transport Parameters													
Ri%/Ru%/P%/G%/S%	N/A												
SC%/Sa%/G%/C%/B%/Be%													
d16/d35/d50/d84/d95/d100		-/3.1/8.6/11.0/16.0		---		-/0.1/0.2/0.5/4.0/8.0		0.1/3.0/8.8/77/180/-				SC/SC/0.1/19/90/256	
Reach Shear Stress (Competency) lb/ft ²		---		---						0.012		0.11 0.12	
Max part size (mm) mobilized at bankfull													
Stream Power (Capacity) W/m ²													
Additional Reach Parameters													
Drainage Area (SM)	N/A	0.24		N/A		0.25		0.50		0.24		0.24	
Watershed Impervious Cover Estimate (%)		<1%		<1%		---		---		<1%		<1%	
Rosgen Classification		N/A ¹		N/A ¹		C5/6		E4/C4		C4		C4	
Bankfull Velocity (fps)		3.5		4.1		4.7		---		3.4		2.2	
Bankfull Discharge (cfs)		30		N/A ²		18		---		30		16	
Q-NFF regression (2-yr)		50		N/A ²									
Q-USGS extrapolation (1.2-yr)		17 40		N/A ²									
Q-Mannings		24		N/A ²									
Valley Length (ft)		---		---		---		---		1,353		1,353	
Channel Thalweg Length (ft)				1,789		---		---		1,718		1,718	
Sinuosity		1.0		1.5		1.1		1.1		1.3		1.3	
Water Surface Slope (ft/ft) ²		0.0071		0.0034		0.004		0.0132		0.0032		0.0034	
Bankfull Slope (ft/ft)		0.0066		0.0058		0.009		0.0139		0.0041		0.0036	

SC: Silt/Clay <0.062 mm diameter particles

(---): Data was not provided

N/A: Not Applicable

N/A¹: The Rosgen classification system is for natural streams. These channels have been heavily manipulated by man and therefore the Rosgen classification system is not applicable

N/A²: Downstream of the confluence with overflow channel, hydraulic regime not applied

*: Channel was dry during survey, slope was calculated using channel thalweg

Table 12. Morphology and Hydraulic Summary (Dimensional Parameters - Cross-Section)

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Dimension and Substrate ¹	Cross-Section 1, UT1 (Pool)					Cross-Section 2, UT1 (Riffle)					Cross-Section 3, UT1 (Pool)					Cross-Section 4, UT1 (Riffle)								
	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5	Base	MY1	MY2	MY3	MY4	MY5
Bankfull elevation	541.8	541.9	541.8	541.8	541.8		542.1	542.0	542.1	542.1	542.0		539.7	539.7	539.7	539.6	539.7		539.8	539.8	539.8	539.7	539.9	
Low Bank Elevation	541.8	541.9	541.8	541.8	541.8		542.1	542.0	542.1	542.1	542.0		539.7	539.7	539.7	539.6	539.7		539.8	539.8	539.8	539.7	539.9	
Bankfull Width (ft)	13.3	12.7	13.6	13.3	10.2		11.7	11.1	11.4	15.6	10.9		12.6	12.3	12.2	15.4	13.6		12.6	11.9	12.0	13.1	13.1	
Floodprone Width (ft)	---	---	---	---	---		200+	200+	200+	89.0	89.0		---	---	---	---	---		200+	200+	200+	83.0	83.0	
Bankfull Mean Depth (ft)	0.7	0.7	0.6	0.7	0.8		0.6	0.5	0.6	0.5	0.6		1.0	0.9	1.0	0.8	1.0		0.6	0.7	0.6	0.6	0.6	
Bankfull Max Depth (ft)	1.5	1.4	1.4	1.5	1.5		1.1	0.9	1.0	1.1	1.0		2.4	2.2	2.1	2.2	2.2		1.1	1.0	1.2	1.1	1.1	
Bankfull Cross-Sectional Area (ft ²)	8.7	8.5	8.3	8.7	8.4		7.3	5.9	6.5	7.9	6.3		12.6	11.4	12.3	12.6	13.3		7.5	7.8	7.6	7.6	7.4	
Bankfull Width/Depth Ratio	20.4	18.9	22.4	20.4	12.5		18.9	20.8	20.1	30.7	18.8		12.7	13.4	12.1	18.9	13.8		21.1	18.0	18.9	22.7	23.2	
Bankfull Entrenchment Ratio	---	---	---	---	---		2.2+	2.2+	2.2+	2.2+	2.2+		---	---	---	---	---		2.2+	2.2+	2.2+	2.2+	2.2+	
Bankfull Bank Height Ratio	---	---	---	---	---		1.0	1.0	1.0	1.0	0.9		---	---	---	---	---		1.0	1.0	1.0	1.0	1.0	

¹ In MY3- MY5 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current year's low bank height.

Table 13. Monitoring Data - Stream Reach Data Summary

Crooked Creek #2 Restoration Project
 DMS Project No. 94687
 Monitoring Year 4 - 2019

UT1

Parameter	As-Built/Baseline		MY-1		MY-2		MY-3		MY-4		MY-5	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle¹												
Bankfull Width (ft)	11.7	12.6	11.1	11.9	11.4	12.0	13.0	15.6	10.9	19.5		
Floodprone Width (ft)	200+		200+		200+		89+		89+			
Bankfull Mean Depth	0.6		0.5	0.7	0.6		0.5	0.6	0.6			
Bankfull Max Depth	1.1		0.9	1.0	1.0	1.2	1.1		1.0	1.1		
Bankfull Cross-sectional Area (ft ²)	7.3	7.5	5.9	7.8	6.5	7.6	7.6	7.9	6.3	7.4		
Width/Depth Ratio	18.9	21.1	18.0	20.8	18.9	20.1	22.7	30.7	18.8	23.2		
Entrenchment Ratio	2.2+		2.2+		2.2+		2.2+		2.2+			
Bank Height Ratio	1.0		1.0		1.0		1.0		0.9	1.0		
D50 (mm)	0.3	35.9	SC	65.6	SC	66.2	SC	52.8	SC	46.0		
Profile												
Riffle Length (ft)	12	50										
Riffle Slope (ft/ft)	0.0004	0.0193										
Pool Length (ft)	18	65										
Pool Max Depth (ft)	1.1	3.0										
Pool Spacing (ft)	36	99										
Pool Volume (ft ³)												
Pattern												
Channel Beltwidth (ft)	30	72										
Radius of Curvature (ft)	22	48										
Rc:Bankfull Width (ft/ft)	1.8	4.0										
Meander Wave Length (ft)	102	135										
Meander Width Ratio	2.5	6.0										
Additional Reach Parameters												
Rosgen Classification	C4											
Channel Thalweg Length (ft)	1,718											
Sinuosity (ft)	1.3											
Water Surface Slope (ft/ft)	0.0034											
Bankfull Slope (ft/ft)	0.004											
Ri%/Ru%/P%/G%/S%												
SC%/Sa%/G%/C%/B%/Be%												
d16/d35/d50/d84/d95/d100	SC/SC/0.1/19/90/256											
% of Reach with Eroding Banks												

¹ In MY3- MY5 Bank Height Ratio is calculated based on the As-built (MY0) cross-sectional area as described in the Standard Measurement of the BHR Monitoring Parameter document provided by the NCIRT and NCDMS (9/2018). The remainder of the cross-section dimension parameters were calculated based on the current year's low bank height.

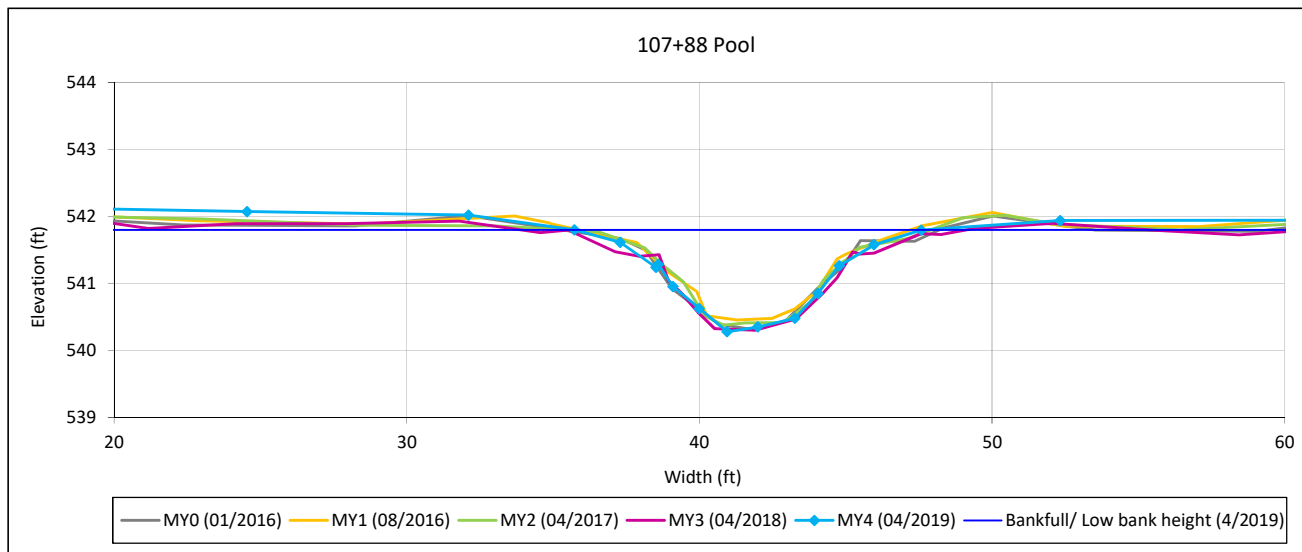
Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Cross-Section 1-UT1



Bankfull Dimensions

- 8.4 x-section area (ft.sq.)
- 10.2 width (ft)
- 0.8 mean depth (ft)
- 1.5 max depth (ft)
- 10.8 wetted perimeter (ft)
- 0.8 hydraulic radius (ft)
- 12.5 width-depth ratio

Survey Date: 4/2019

Field Crew: Wildlands Engineering



View Downstream

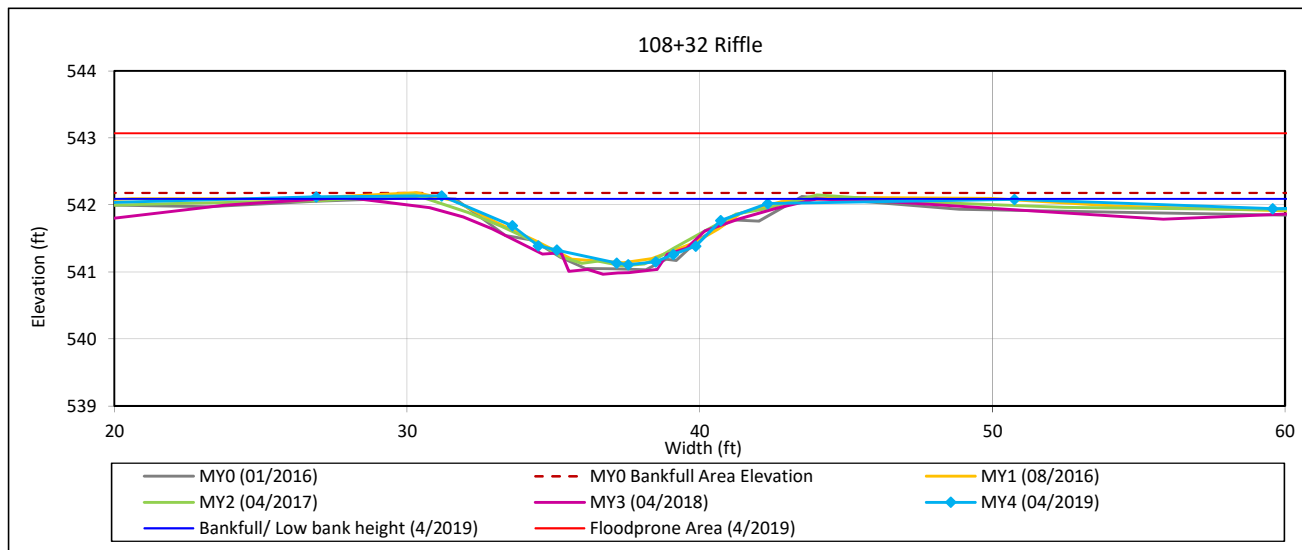
Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Cross-Section 2-UT1



Bankfull Dimensions

- 6.3 x-section area (ft.sq.)
- 10.9 width (ft)
- 0.6 mean depth (ft)
- 1.0 max depth (ft)
- 11.1 wetted perimeter (ft)
- 0.6 hydraulic radius (ft)
- 18.8 width-depth ratio
- 89.3 W flood prone area (ft)
- 8.2 entrenchment ratio
- 0.9 low bank height ratio

Survey Date: 4/2019

Field Crew: Wildlands Engineering



View Downstream

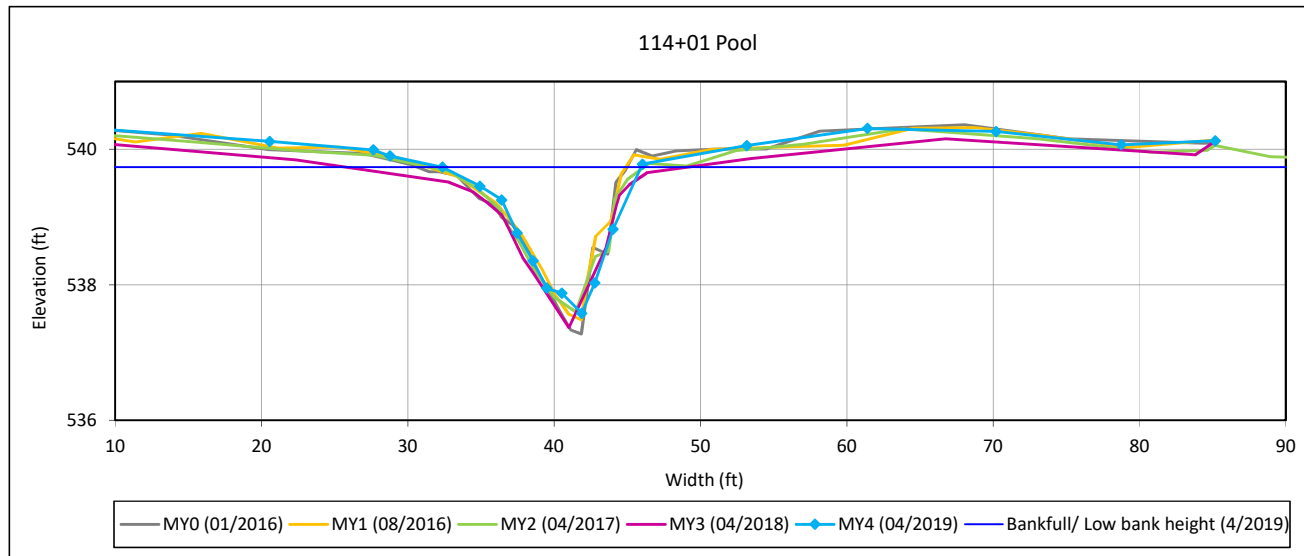
Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Cross-Section 3-UT1



Bankfull Dimensions

- 13.3 x-section area (ft.sq.)
- 13.6 width (ft)
- 1.0 mean depth (ft)
- 2.2 max depth (ft)
- 14.4 wetted perimeter (ft)
- 0.9 hydraulic radius (ft)
- 13.8 width-depth ratio

Survey Date: 4/2019
Field Crew: Wildlands Engineering



View Downstream

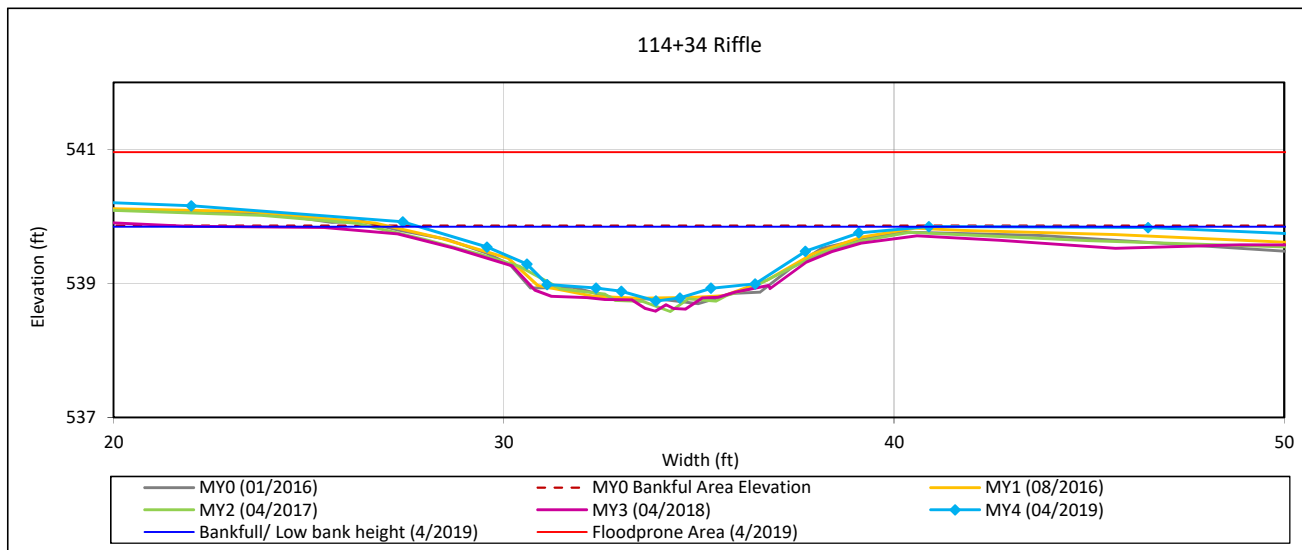
Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

DMS Project No. 94687

Monitoring Year 4 - 2019

Cross-Section 4-UT1



Bankfull Dimensions

- 7.4 x-section area (ft.sq.)
- 13.1 width (ft)
- 0.6 mean depth (ft)
- 1.1 max depth (ft)
- 13.4 wetted perimeter (ft)
- 0.6 hydraulic radius (ft)
- 23.2 width-depth ratio
- 83.0 W flood prone area (ft)
- 6.3 entrenchment ratio
- 1.0 low bank height ratio

Survey Date: 4/2019

Field Crew: Wildlands Engineering



View Downstream

Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

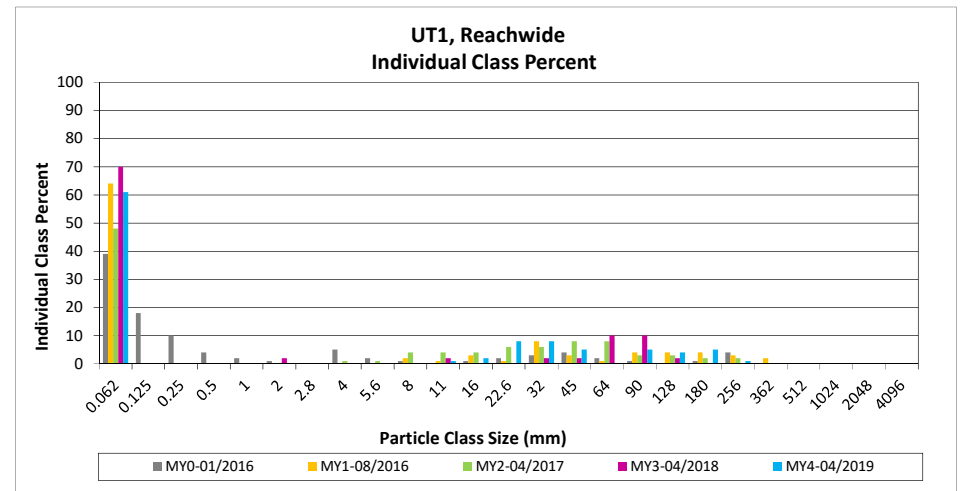
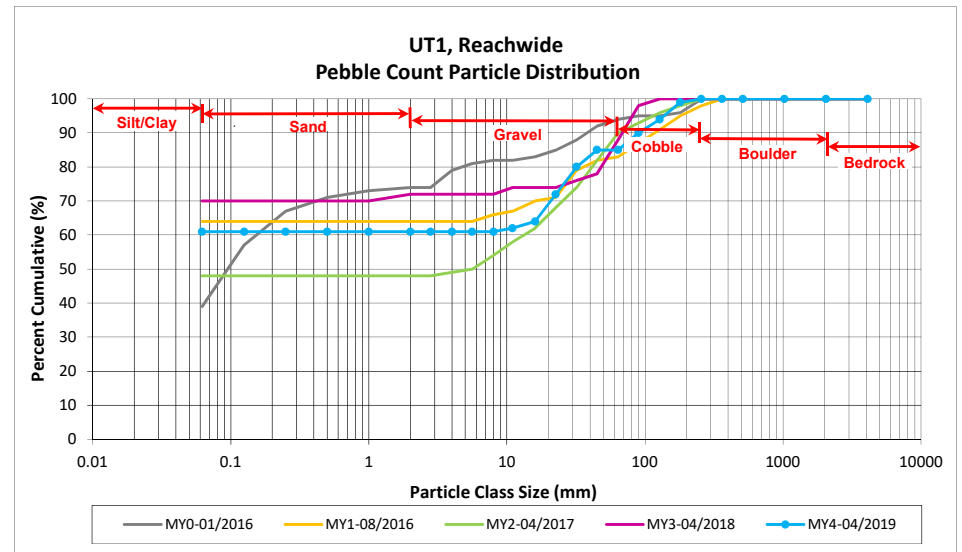
DMS Project No. 94687

Monitoring Year 4 - 2019.

UT1, Reachwide

Particle Class		Diameter (mm)		Particle Count			Reach Summary	
		min	max	Riffle	Pool	Total	Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	11	50	61	61	61
SAND	Very fine	0.062	0.125					61
	Fine	0.125	0.250					61
	Medium	0.25	0.50					61
	Coarse	0.5	1.0					61
	Very Coarse	1.0	2.0					61
GRAVEL	Very Fine	2.0	2.8					61
	Very Fine	2.8	4.0					61
	Fine	4.0	5.6					61
	Fine	5.6	8.0					61
	Medium	8.0	11.0	1		1	1	62
	Medium	11.0	16.0	2		2	2	64
	Coarse	16.0	22.6	8		8	8	72
	Coarse	22.6	32	8		8	8	80
	Very Coarse	32	45	5		5	5	85
	Very Coarse	45	64					85
COBBLE	Small	64	90	5		5	5	90
	Small	90	128	4		4	4	94
	Large	128	180	5		5	5	99
	Large	180	256	1		1	1	100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
BEDROCK	Large/Very Large	1024	2048					100
	Bedrock	2048	>2048					100
Total				50	50	100	100	100

Reachwide Channel materials (mm)	
D ₁₆ =	Silt/Clay
D ₃₅ =	Silt/Clay
D ₅₀ =	Silt/Clay
D ₈₄ =	42.0
D ₉₅ =	137.0
D ₁₀₀ =	256.0



Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

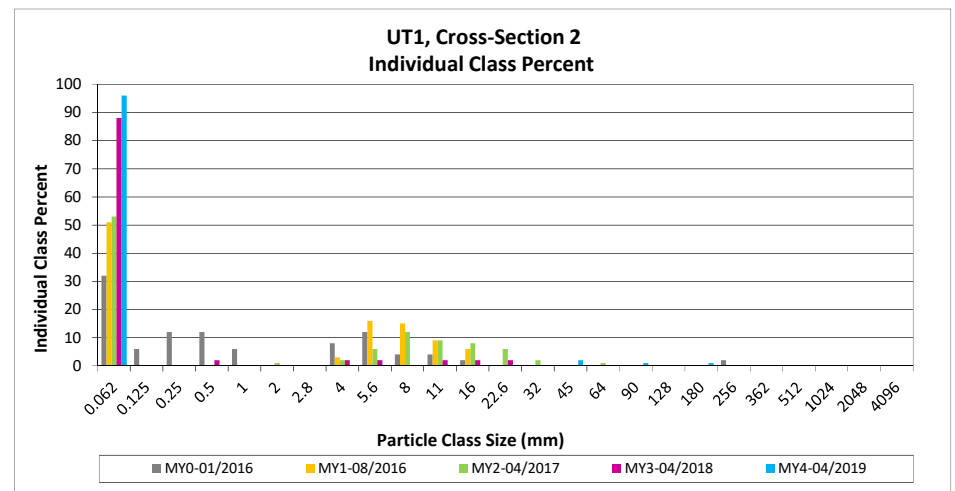
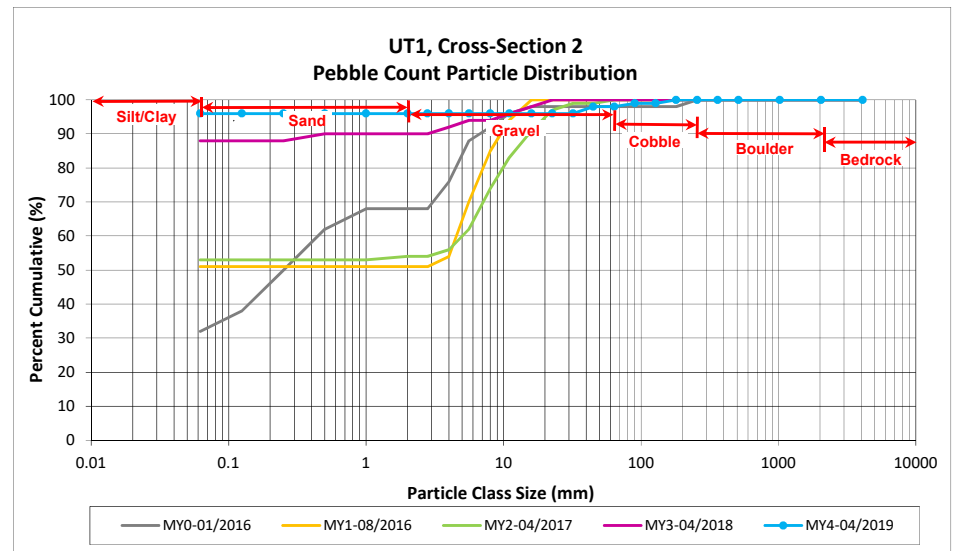
DMS Project No. 94687

Monitoring Year 4 - 2019.

UT1, Cross-Section 2

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
<i>SILT/CLAY</i>	Silt/Clay	0.000	0.062	96	96	96
SAND	Very fine	0.062	0.125			96
	Fine	0.125	0.250			96
	Medium	0.25	0.50			96
	Coarse	0.5	1.0			96
	Very Coarse	1.0	2.0			96
GRAVEL	Very Fine	2.0	2.8			96
	Very Fine	2.8	4.0			96
	Fine	4.0	5.6			96
	Fine	5.6	8.0			96
	Medium	8.0	11.0			96
	Medium	11.0	16.0			96
	Coarse	16.0	22.6			96
	Coarse	22.6	32			96
	Very Coarse	32	45	2	2	98
	Very Coarse	45	64			98
COBBLE	Small	64	90	1	1	99
	Small	90	128			99
	Large	128	180	1	1	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
BEDROCK	Large/Very Large	1024	2048			100
	Bedrock	2048	>2048			100
Total				100	100	100

Cross-Section 2	
Channel materials (mm)	
D ₁₆ =	Silt/Clay
D ₃₅ =	Silt/Clay
D ₅₀ =	Silt/Clay
D ₈₄ =	#N/A
D ₉₅ =	#N/A
D ₁₀₀ =	180.0



Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

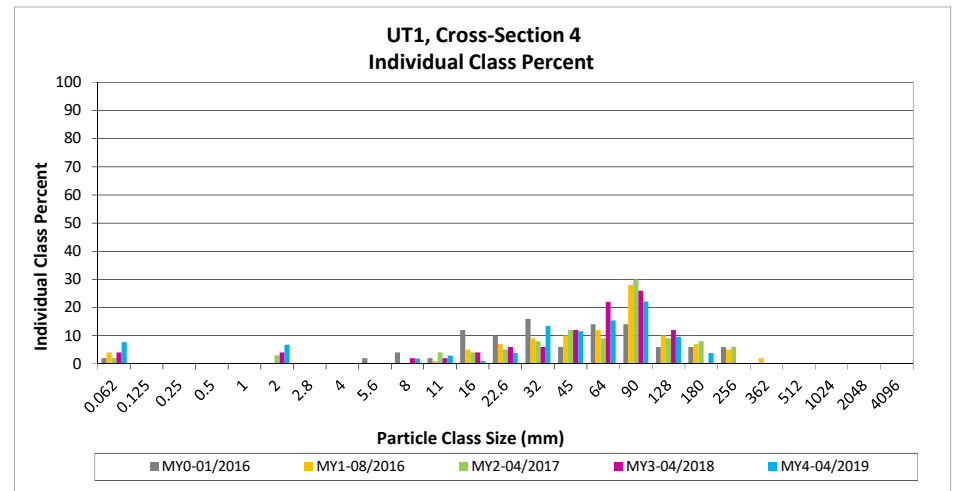
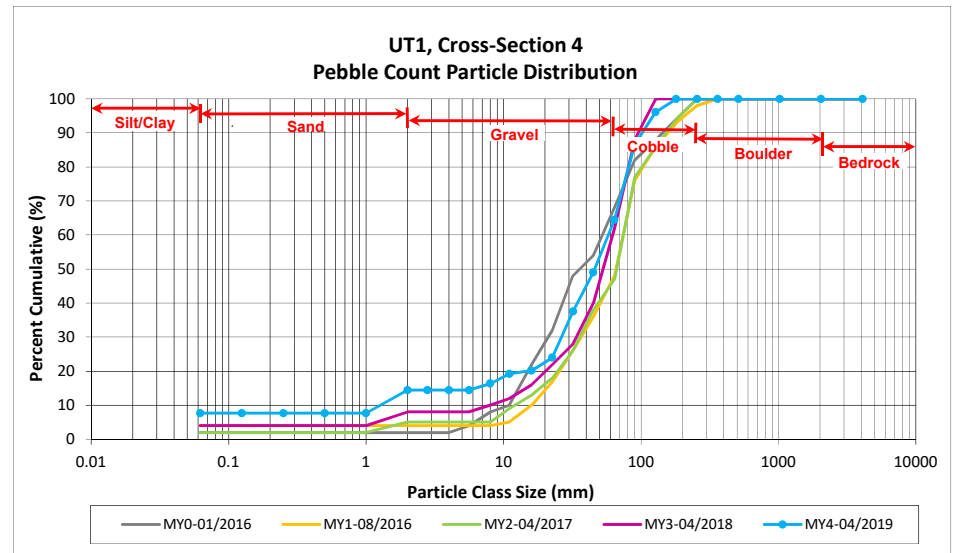
DMS Project No. 94687

Monitoring Year 4 - 2019.

UT1, Cross-Section 4

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
<i>SILT/CLAY</i>	Silt/Clay	0.000	0.062	8	8	8
<i>SAND</i>	Very fine	0.062	0.125			8
	Fine	0.125	0.250			8
	Medium	0.25	0.50			8
	Coarse	0.5	1.0			8
	Very Coarse	1.0	2.0	7	7	14
<i>GRAVEL</i>	Very Fine	2.0	2.8			14
	Very Fine	2.8	4.0			14
	Fine	4.0	5.6			14
	Fine	5.6	8.0	2	2	16
	Medium	8.0	11.0	3	3	19
	Medium	11.0	16.0	1	1	20
	Coarse	16.0	22.6	4	4	24
	Coarse	22.6	32	14	13	38
	Very Coarse	32	45	12	12	49
	Very Coarse	45	64	16	15	64
<i>COBBLE</i>	Small	64	90	23	22	87
	Small	90	128	10	10	96
	Large	128	180	4	4	100
	Large	180	256			100
<i>BOULDER</i>	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
<i>BEDROCK</i>	Large/Very Large	1024	2048			100
	Bedrock	2048	>2048			100
Total				104	100	100

Cross-Section 4 Channel materials (mm)	
D ₁₆ =	7.50
D ₃₅ =	30.00
D ₅₀ =	46.0
D ₈₄ =	86.5
D ₉₅ =	122.7
D ₁₀₀ =	180.0



APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Reach	MY of Occurrence	Date of Occurrence (Approximate)	Method
UT1	MY1	7/11/2016	Crest Gage
	MY2	6/20/2017	Crest Gage/Stream Gage
	MY3	9/17/2018	Stream Gage
		10/12/2018	
		10/27/2018	
		11/5/2018	
MY4	4/5/2019		
UT2	MY1	7/11/2016	Crest Gage
		10/8/2016	
	MY2	6/20/2017	
	MY3	11/5/2018	Wrack Line
MY4	4/5/2019	Bankfull Flow Photo	
Crooked Creek	MY1	7/11/2016	Crest Gage
		10/8/2016	
	MY2	6/20/2017	Crest Gage
	MY3	11/5/2018	Wrack Line
	MY4	4/5/2019	Bankfull Flow Photo
Unknown		Wrack Line	

Table 15. Wetland Gage Attainment Summary

Crooked Creek #2 Restoration Project

DMS Project No. 964687

Monitoring Year 4 - 2019

Summary of Groundwater Gage Results for Monitoring Years 1 through 7							
Gage	Success Criteria Achieved/Max Consecutive Days During Growing Season (Percentage)						
	Year 1 (2016)	Year 2 (2017)	Year 3 (2018)	Year 4 (2019)	Year 5 (2020)	Year 6 (2021)	Year 7 (2022)
1	No/0 Days (0%)	No/7 Days (3%)	No/12 Days (5%)	Yes/22 Days (9.7%)			
2	No/2 Days (0.9%)	No/8 Days (4%)	No/13 Days (6%)	Yes/21 Days (9.3%)			
3	No/1 Days (0.4%)	No/9 Days (4%)	Yes/29 Days (13%)	Yes/34 Days (15%)			
4	No/0 Days (0%)	No/6 Days (3%)	No/10 Days (4%)	No/16 Days (7.1%)			
5	No/1 Days (0.4%)	No/7 Days (3%)	No/12 Days (5%)	Yes/22 Days (9.7%)			
6	Yes/26 Days (11.5%)	Yes/75 Days (33%)	Yes/88 Days (39%)	Yes/67 Days (29.6%)			
7	Yes/18 Days (8%)	Yes/47 Days (21%)	Yes/45 Days (20%)	Yes/56 Days (24.8%)			
8	No/14 Days (6.2%)	Yes/31 Days (14%)	Yes/45 Days (20%)	Yes/35 Days (15.5%)			
9	No/1 Days (0.4%)	No/7 Days (3%)	No/13 Days (6%)	Yes/23 Days (10.2%)			
10	No/2 Days (0.9%)	No/11 Days (5%)	No/10 Days (4%)	Yes/23 Days (10.2%)			

Growing season 3/23/2019- 11/4/2019

Success Criteria is 17 consecutive days

Gages meeting criteria: MY1 = 2/10, MY2 = 3/10, MY3 = 4/10, MY4= 9/10.

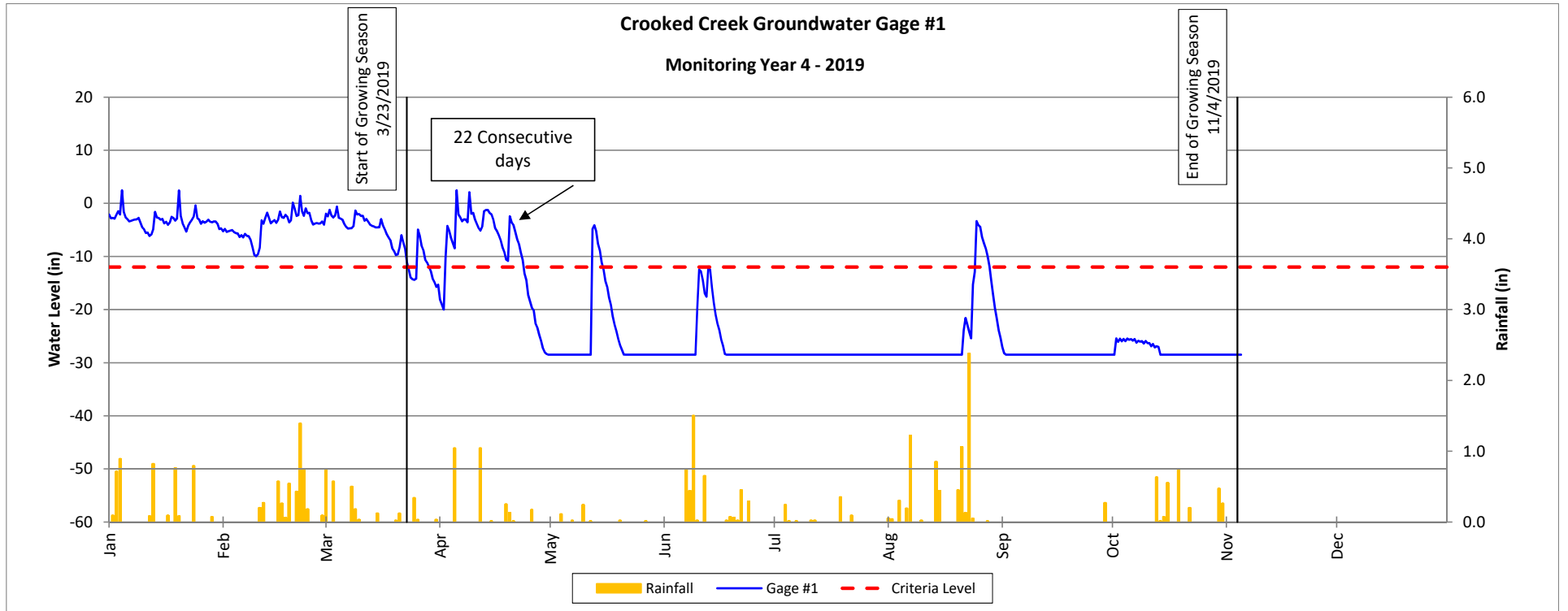
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



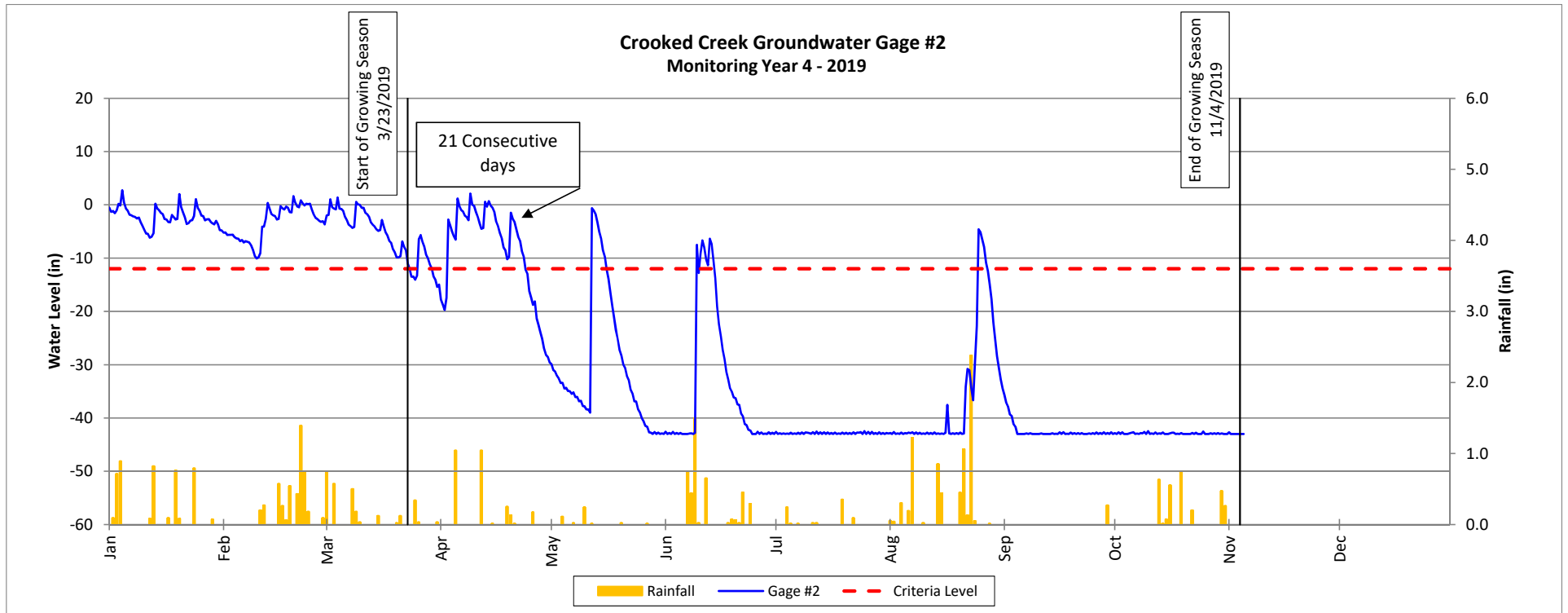
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



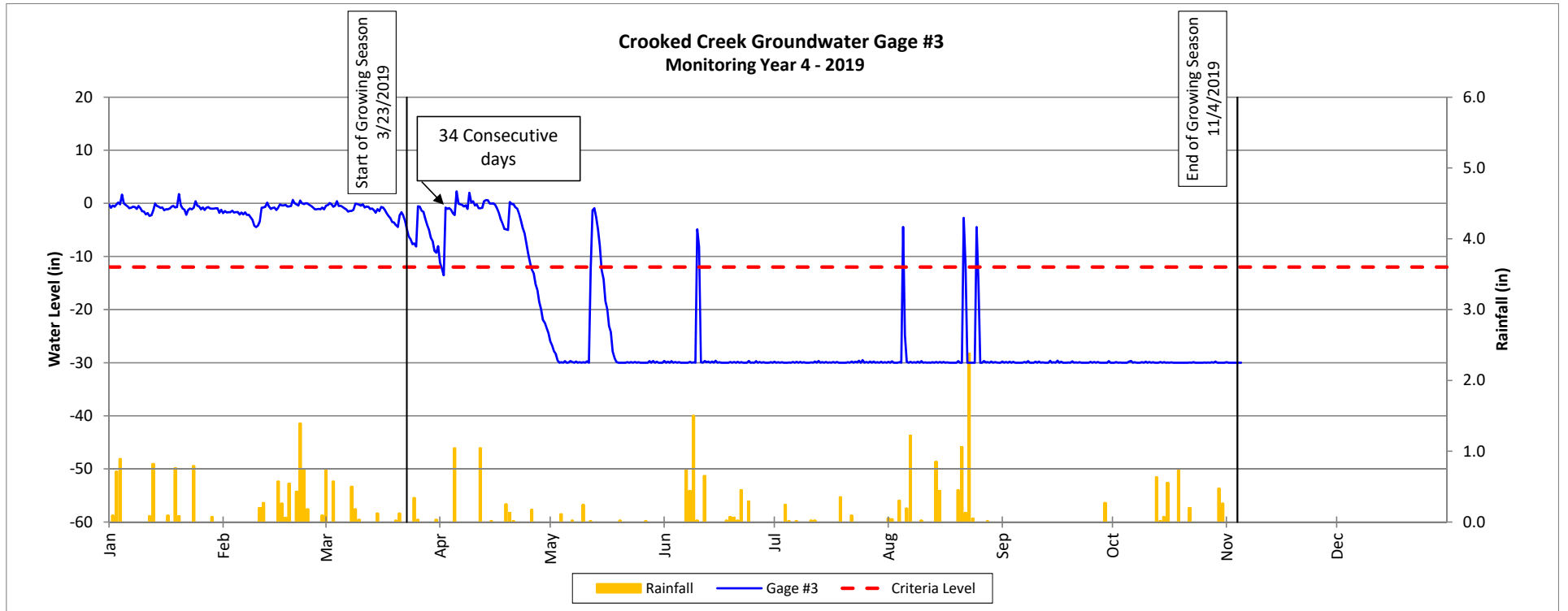
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



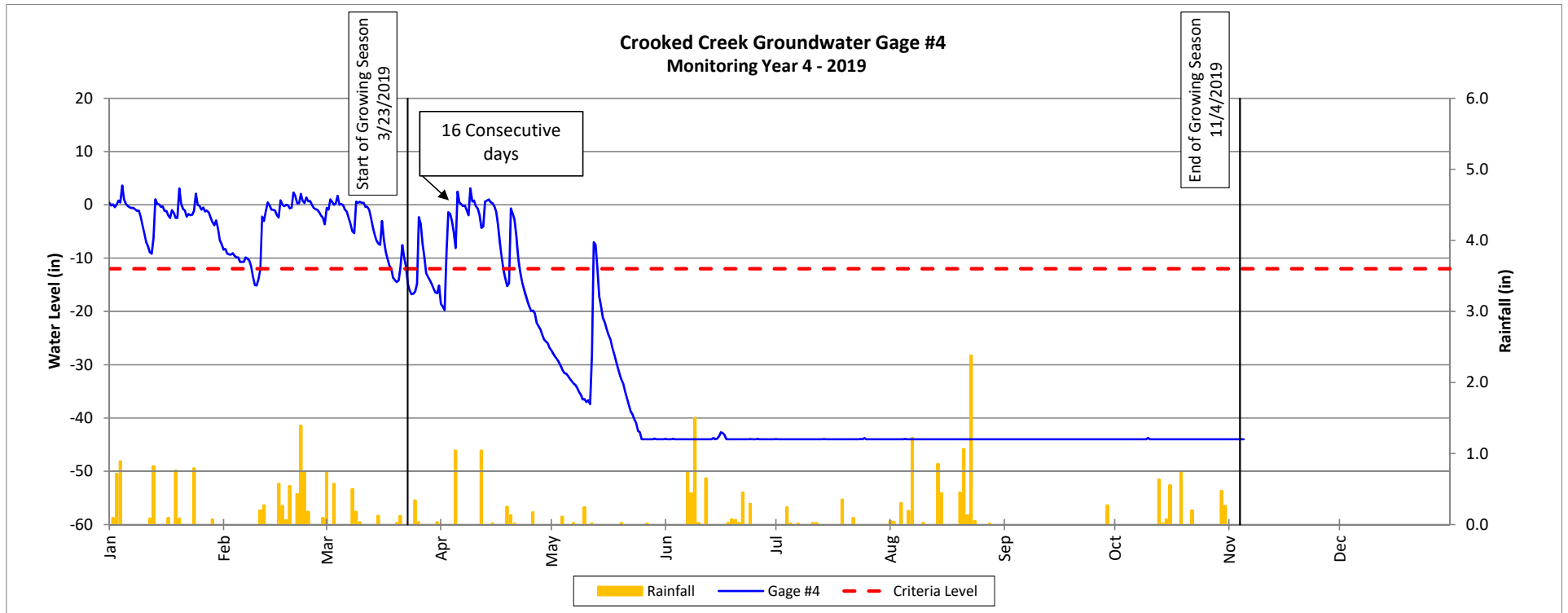
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



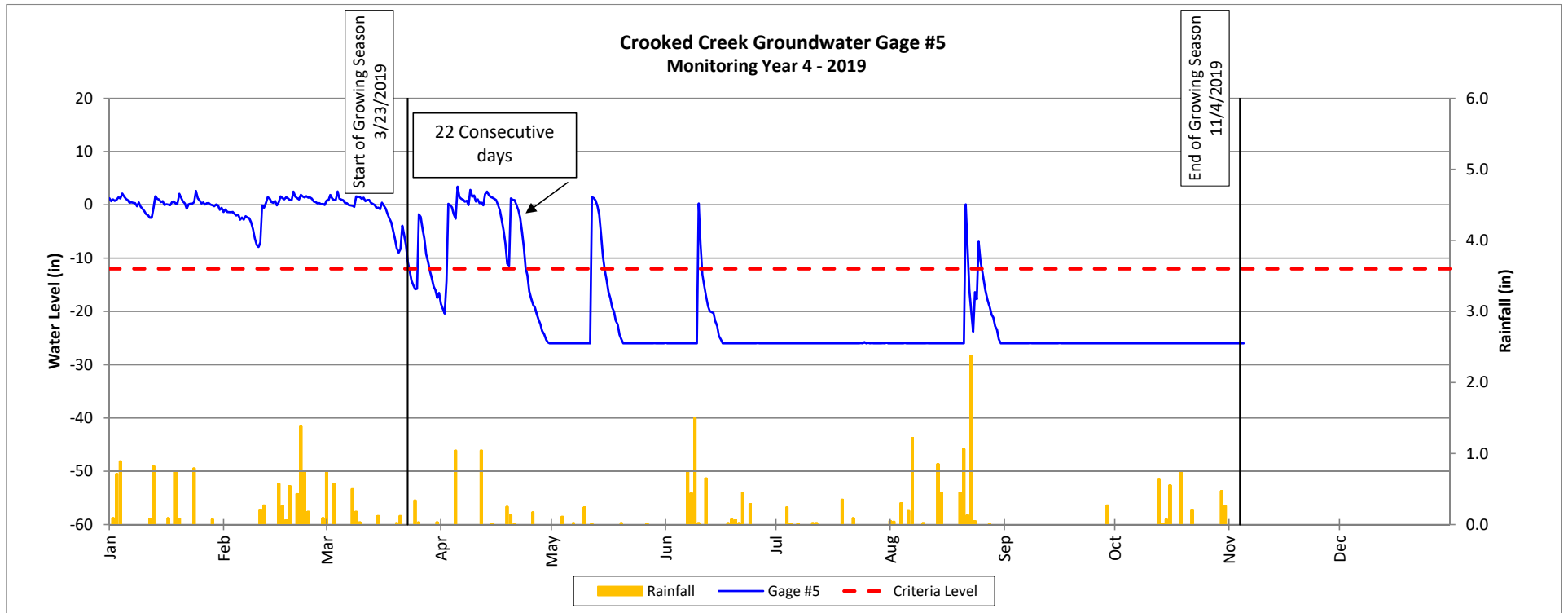
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



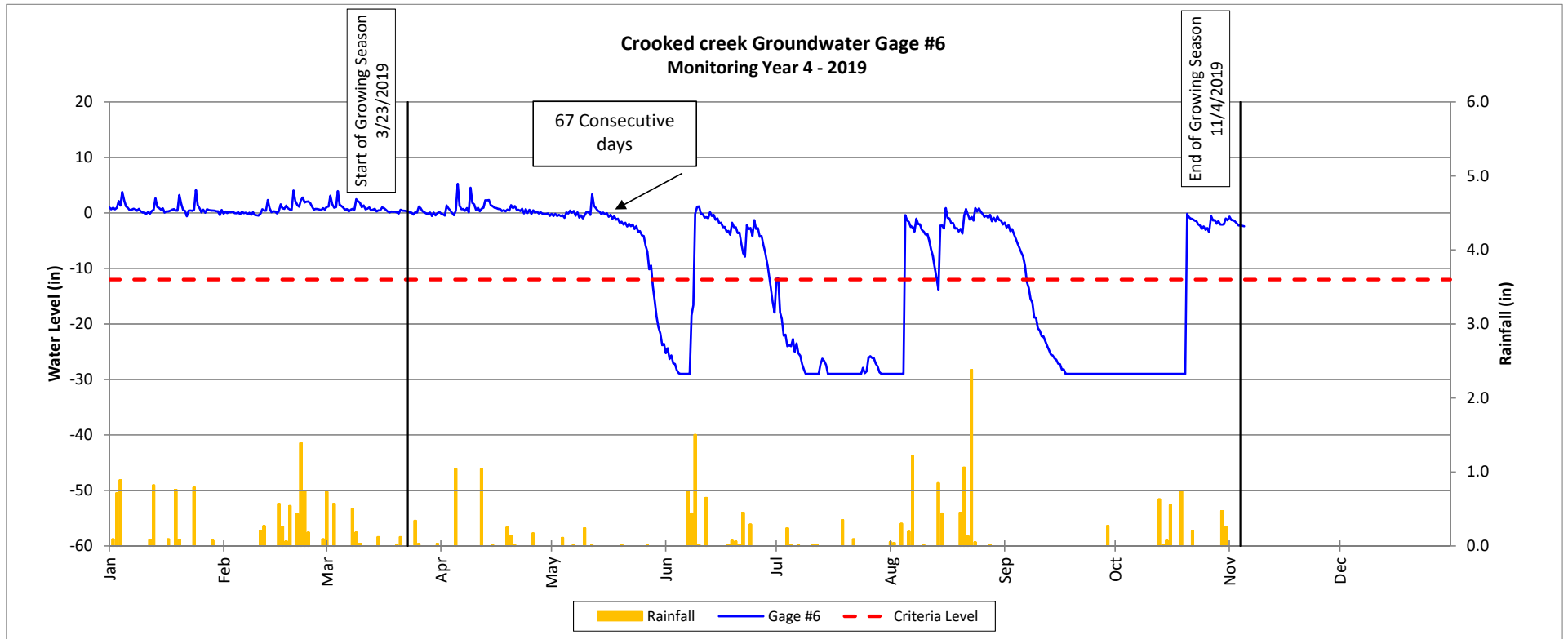
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



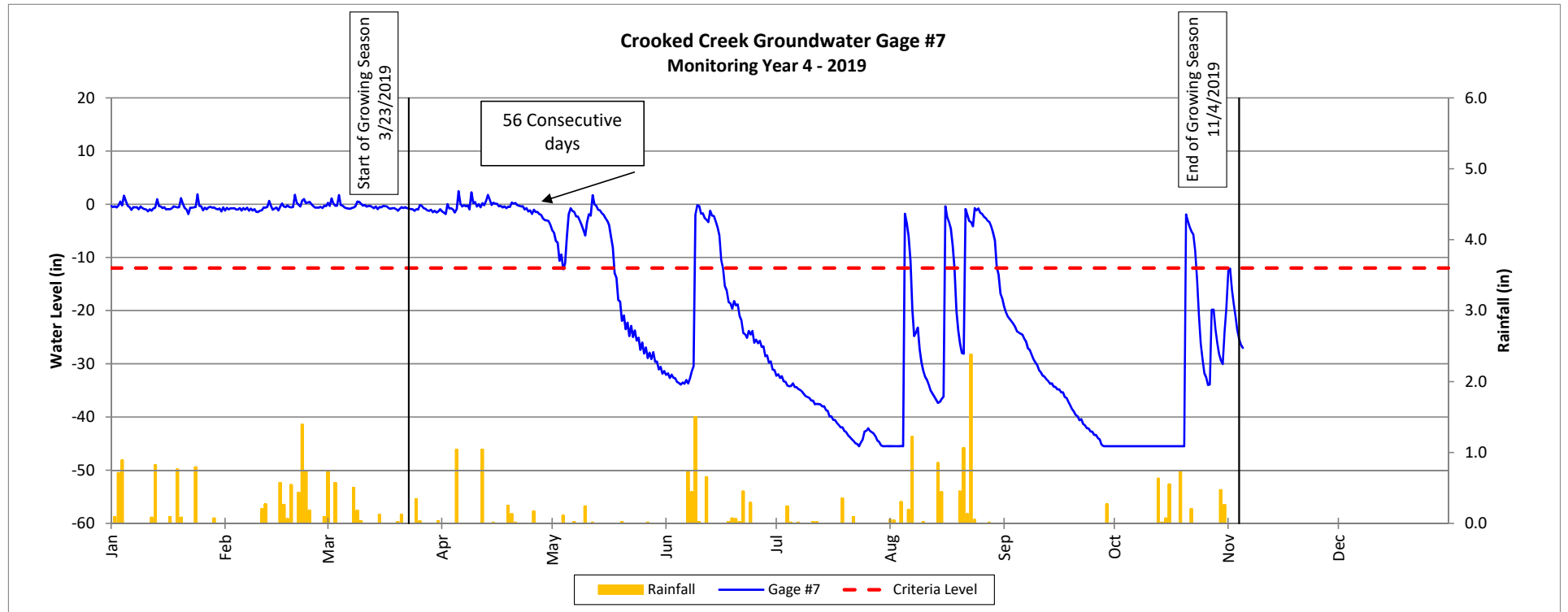
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



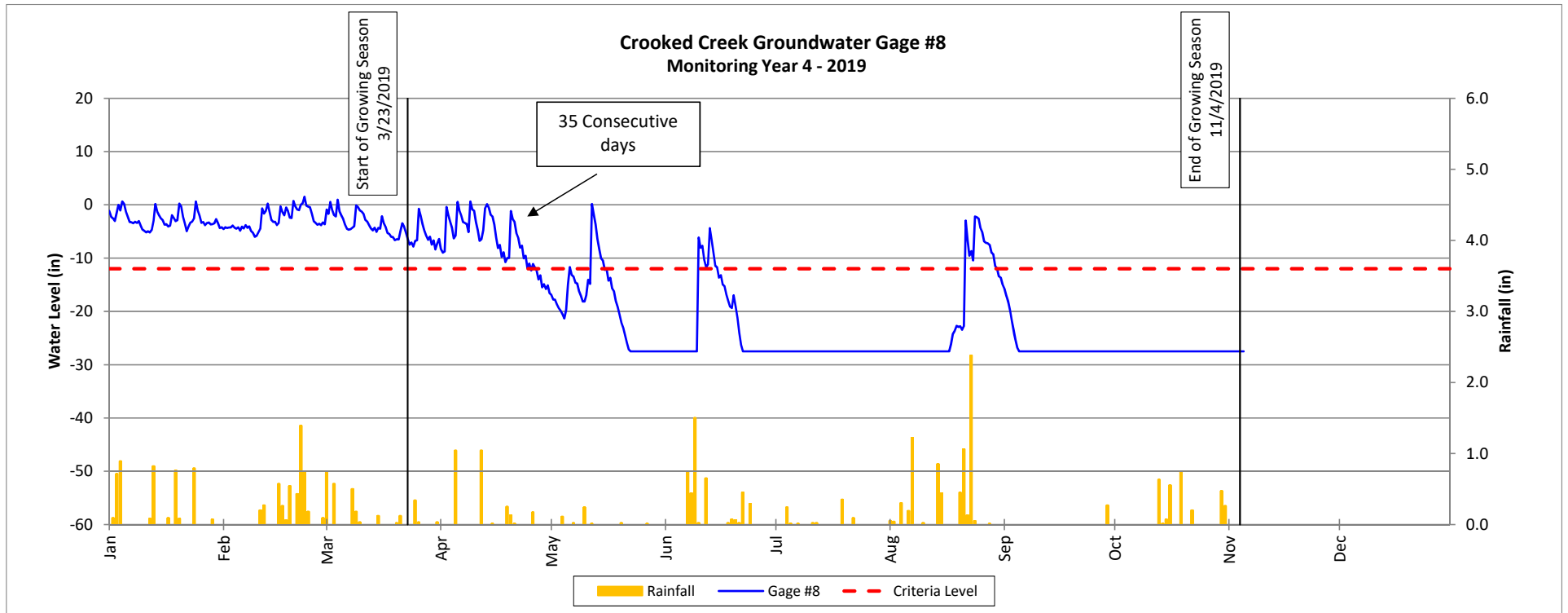
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



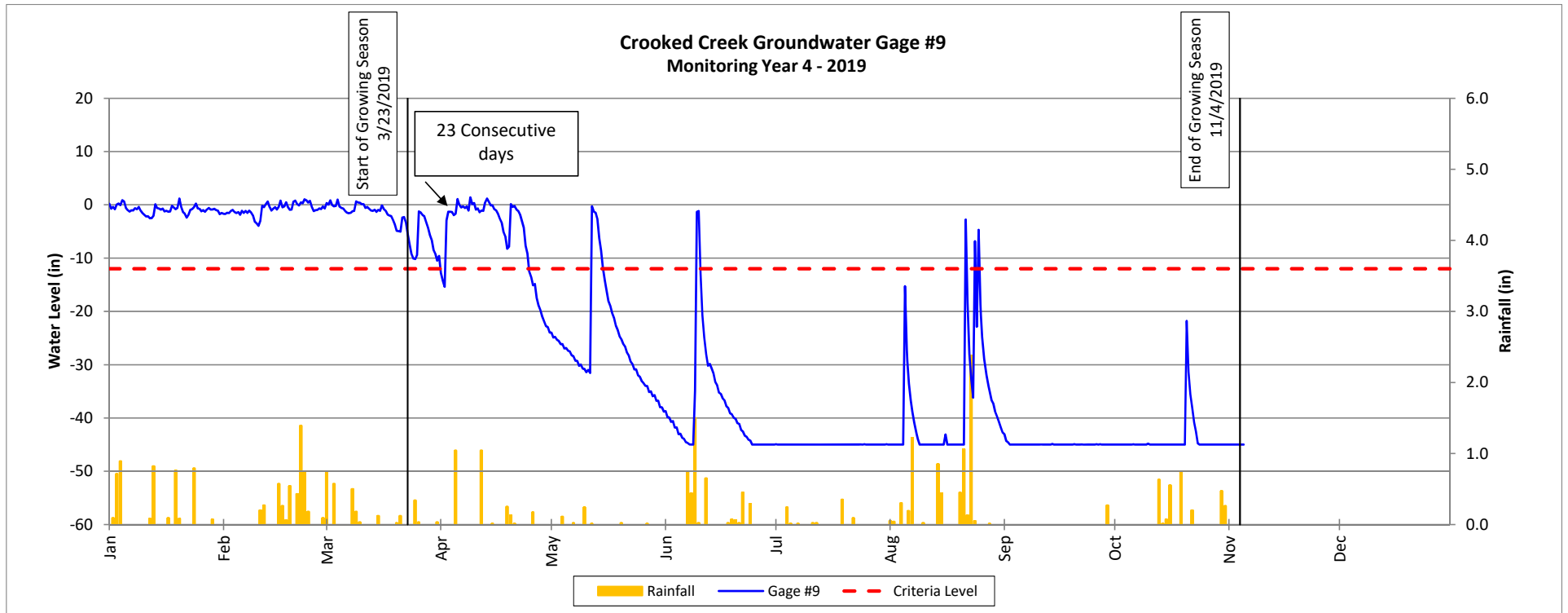
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



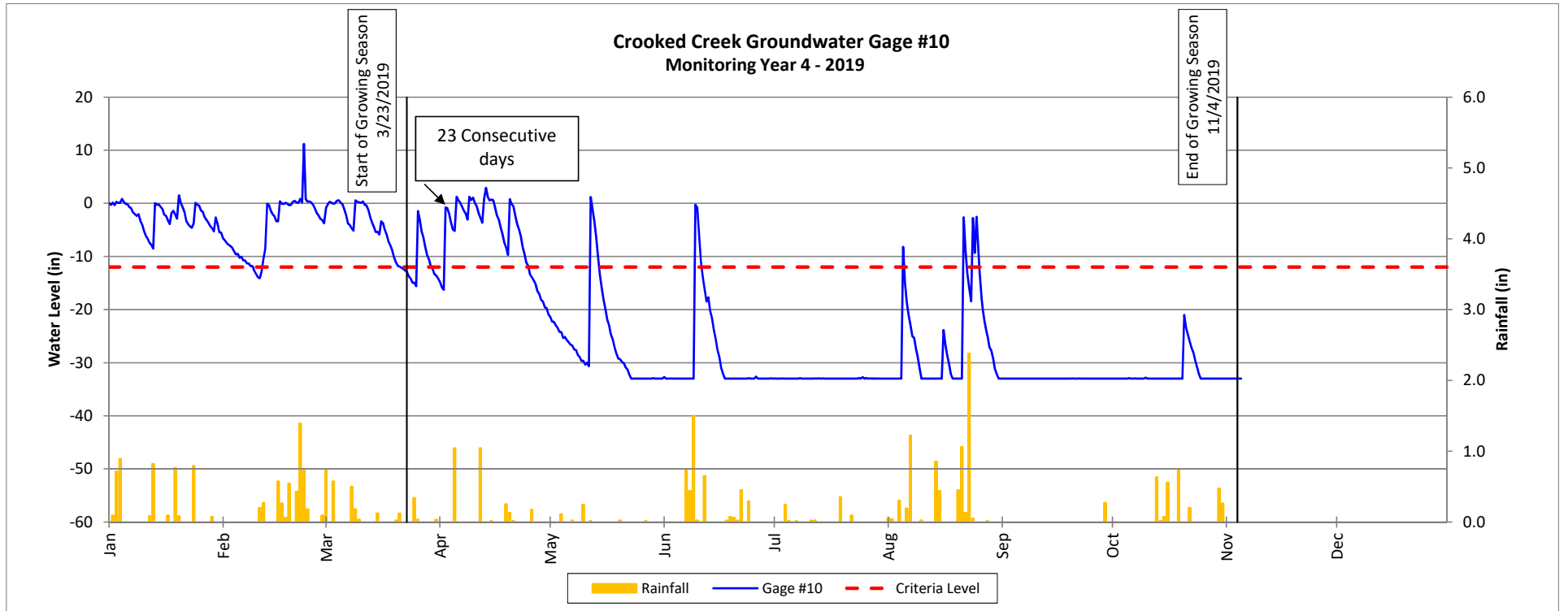
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

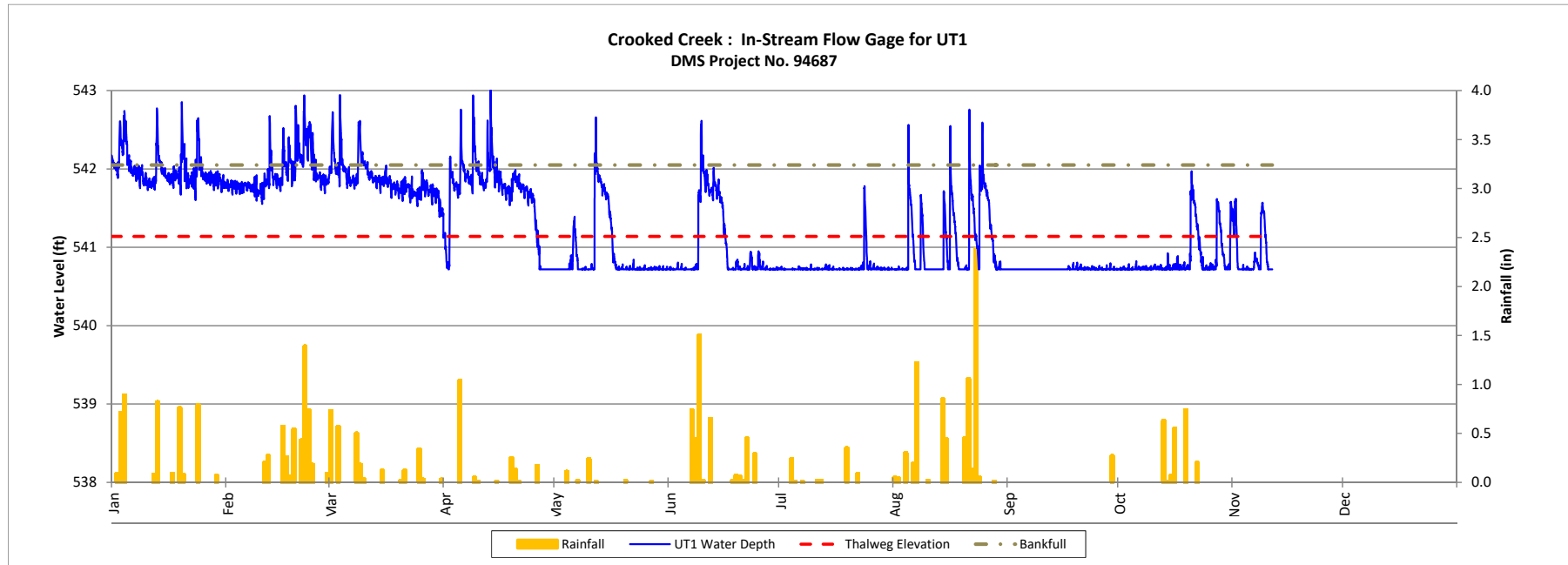
DMS Project No. 94687

Monitoring Year 4 - 2019

Wetland Restoration



Recorded In-stream Flow Events
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 4 - 2019

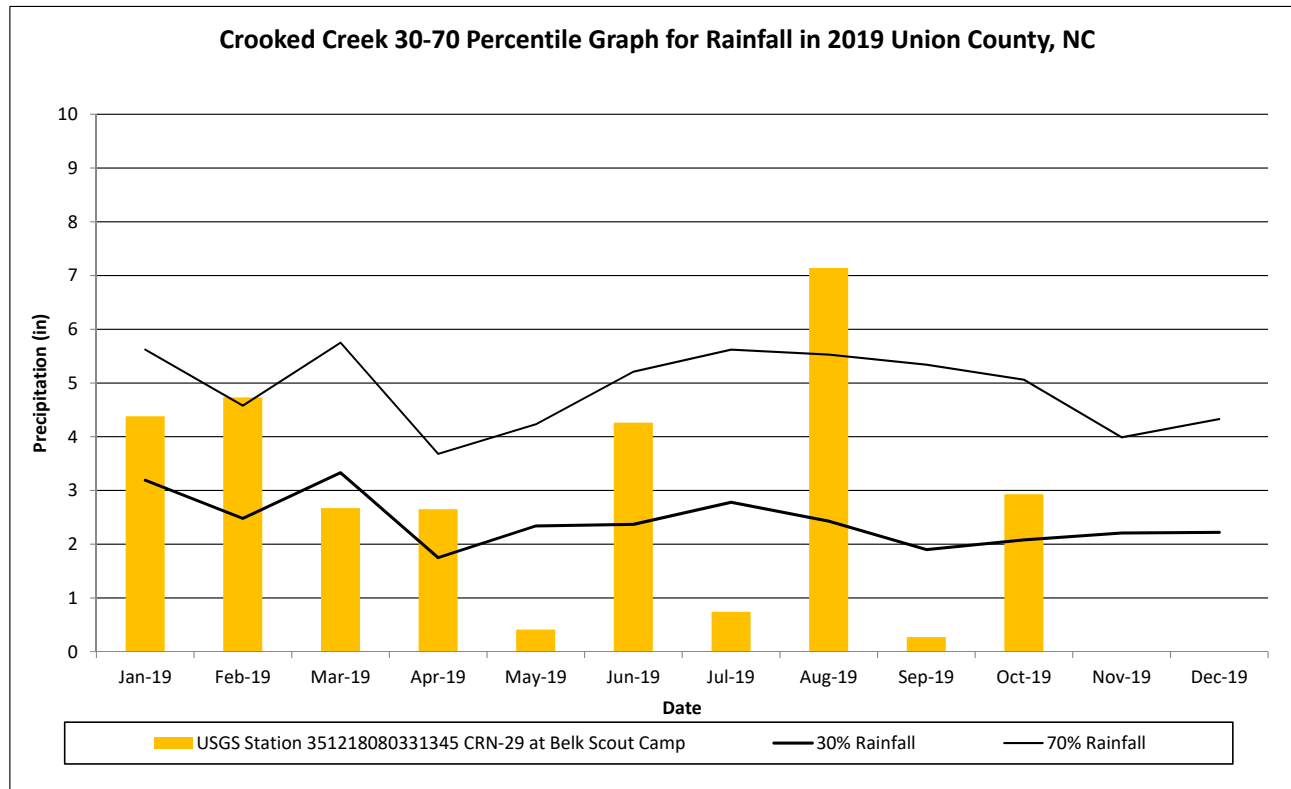


Monthly Rainfall Data

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 4 - 2019



¹ 30th and 70th percentile rainfall data generated from WETS Table: Monroe, NCS771 (1971-2000). (USDA Field Office Climate Data, 2016)

Bankfull Photographs

Monitoring Year 4



Bankfull Flow – Crooked Creek (4/5/2019)



Wrack Line – Crooked Creek (8/28/2019)



Bankfull Flow – UT1 (4/5/2019)