


MONITORING YEAR 6 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 2021
Submission Date: December 16, 2021

PREPARED FOR:

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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 created with careful consideration of the goals and objectives described in the RBRP and 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) six appears to be on track to meet the year seven requirements, with the exception of a few wetland areas. The planted vegetation on the Site appears to be doing well with isolated patches of invasive species that were treated in 2021. The average planted stem density for the Site is 513 stems per acre and is on track to meet the year seven requirement of 210 stems per acres. All 12 vegetation plots individually met the year seven success criteria. The planted buffer is establishing well on the Site and tree growth accelerated by 47% in MY6 with an average stem height of 14 feet. Invasives treatments occurred in March and September 2021 and have been effective, significantly controlling the invasive species previously identified within the Site, although the areas have remained on the CCPV maps to monitor for re-sprouts in MY7. Channel dimension and profiles on UT1 appear stable and functioning as designed with only minor fluctuations. Groundwater hydrologic success criteria was achieved in four of the eleven groundwater monitoring gages. Although the success criteria for bankfull for the project was met in MY2, additional bankfull events were recorded in MY6 on

project streams. Annual monitoring will continue to be conducted through MY7 with an expected closeout in 2023.

CROOKED CREEK #2 RESTORATION PROJECT
Monitoring Year 6 Annual Report

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APPENDICES

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 (Crooked Creek and UT2) that underwent Stream Enhancement as well as one stream (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 created with careful consideration of the goals and objectives described in the RBRP and 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 6 Data Assessment

The following sections present the MY6 data collected between April and November 2021 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 are the survival of 210 planted stems per acre with an average height of 10 feet in each plot in the riparian corridor along restored and enhanced reaches at the end of the seven-year monitoring period (MY7).

The MY6 vegetation survey was completed in September 2021 resulting in an average stem density of 513 stems per acre. All 12 vegetation plots individually met the year seven requirement of 210 stems/acre, with an average of 13 stems per plot. The MY6 average stem height for the Site is 14 feet, increasing from 10 feet in MY5. All plots except for plots 6, 9, and 12 have individually met the 10-foot requirement. Plot 6 contains herbaceous vegetation, which is competing with the stems, but has shown improvement from MY5 to MY6 with an average stem height of 9 feet. Plots 9 and 12 are located within the Crooked Creek riparian corridor and are largely shaded by mature canopy with average stem heights of 7 and 6 feet respectively. The planted stem height appears to be trending toward meeting the 10-foot requirement in each plot, with an overall increase in height of 47% from MY5 to MY6 and all individual plots exceeding the MY7 stem density requirement.

The vegetation across the site is performing well and the site has responded well to the invasive species treatment that DMS has contracted throughout the 2020 and 2021 growing seasons; refer to section 1.2.2 for further details. Supplemental plantings that occurred in January 2018 are established and have survived multiple growing seasons. Overall, strong tree growth across the Site and the shrub/herbaceous species colonization of the wetter portions of the site have created a healthy riparian buffer.

Please refer to Appendix 2 for vegetation plot photographs and the overall vegetation condition assessment table. The vegetation data tables are located in Appendix 3. Please refer to Appendix 6 for the Invasive Species Treatment Logs.

1.2.2 Vegetation Areas of Concern

Generally, the vegetation within the Site is healthy with a few areas of invasive plant species present. Invasive species noted on the site include cattail (*Typha latifolia*), Japanese honeysuckle (*Lonicera japonica*), Chinese privet (*Ligustrum sinense*), and balloon vine (*Cardiospermum halicacabum*). The native invasive species, cattail (*Typha latifolia*) continues to surround vegetation plot 5, but it is not adversely affecting tree growth in the plot. The colony is established but has not expanded beyond the area adjacent to vegetation plot 5.

The percent of easement area covered in invasive species remains at 3% of the easement area in MY6 and is consistent with the MY5 percentage. Treated invasive areas have remained on the MY6 CCPV maps to monitor for re-sprouts in MY7. If treatments are successful in MY7 and treated areas are removed from the CCPV maps, then the remaining mapped invasive species area would account for only 0.4% of the easement area. After the September 2021 treatment, very few privet, tree of heaven, or honeysuckle resprouts were observed during the Q3 and Q4 Site walks. DMS will continue to treat these invasive species as needed through closeout.

Additionally, mowing within the easement during MY5 continued into MY6. There was evidence of mowing along the easement line in the left floodplain of Crooked Creek during the April 2021 site visit. DMS installed additional easement signs and a clear marker line connecting the easement signs with white tape to deter further mowing. No additional easement encroachments have been observed since. Wildlands will continue to monitor these areas for any evidence of future encroachment or further advancement of the previously noted areas of concern. Refer to Appendix 2 for the vegetation condition assessment table and the CCPV maps for MY6 vegetation areas of concern, and Appendix 6 for the invasive species treatment log.

1.2.3 Stream Assessment

The MY6 morphological survey conducted in April 2021 indicated that UT1 channel dimensions appear stable and functioning as designed. In general, the cross-sections show only minor changes in the bankfull area, maximum depth ratio, or width-to-depth ratio compared to the baseline survey. Surveyed riffle cross-sections continue to fall within the parameters defined for channels of the appropriate Rosgen stream type (Rosgen, 1996). Cross-section 2 continued to fine in MY6 but may wash through the channel with a large storm event. Cross-sections 3 and 4 have maintained designed dimensions since removal of the beaver dam. 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

There were no stream areas of concern for UT1 or UT2 recorded for MY6.

1.2.5 Hydrology Assessment

The stream hydrology success criteria require two bankfull events must occur in separate years within the seven-year monitoring period. Although, the stream hydrology success criteria were met in MY2, bankfull events continue to be recorded on Crooked Creek, UT1, and UT2. Events were verified with stream gages or visual indicators, such as wrack lines. During MY6 there were 6 bankfull events recorded on UT1. In addition to bankfull assessments, stream baseflow is being monitored on UT1 to demonstrate stream flow regimes are sufficient to establish an ordinary high water mark. UT1 recorded 92 days of consecutive baseflow in MY6. Refer to Appendix 5 for hydrologic plots and photographs of documented bankfull events.

1.2.6 Wetland Assessment

At total of 11 groundwater gages (GWG) have been installed throughout the wetland areas to provide groundwater level data and one soil temperature probe was installed near GWG2. The target success criteria for wetland hydrology success consists of a groundwater surface within 12 inches of the ground surface for 17 consecutive days (7.5 %) of the defined 226 day growing season for Union County (March 23 through November 4) under typical precipitation conditions.

Fewer GWGs met the success criteria in MY6 compared to previous monitoring years, with 4/11 gages meeting. Generally, the gages that met were located in Wetland Restoration Zone A away from the left floodplain of UT1: GWG3 (18 days,7.9%), GWG6 (25 days, 11%), GWG7 (30 days, 13.2%), and GWG8 (26 days, 11. 5%). GWGs 6, 7, and 8 have consistently met the success criteria each monitoring year and GWG3 has met success criteria each monitoring year except MY1.

Within the group of groundwater gages not meeting success criteria in MY6 (GWGs 1, 2, 4, 5, 9, 10, and 11), GWG2, and GWG5 met in both MY4 and MY5, missing the success criteria by 3 days in MY6. GWG1, GWG9, and GWG10 are all located on the wetland edges and have not consistently met throughout the monitoring period, including MY6. These three only met in MY4, which is most likely due to the substantial rainfall that occurred in the later winter and early spring, enabling the wetlands to retain high groundwater surface levels. GWG4 has yet to meet criteria and GWG11 has not met since it was installed in March 2020. However, as detailed in the MY5 report, there is evidence from both the vegetation and the developing soils in the areas surrounding both gages that the floodplain may be saturated during a period of the year.

In MY6, total rainfall from January to October was 24.58 inches, which is 45% less than MY5 rainfall of 45.15 inches. The rainfall in 2021 in Union County has been isolated, very dry, and less than the 30% annual average according to the USGS Station 351218080331345 at Belk Scout Camp, located about 5 miles away from the Site. A 30-day rolling precipitation total was added to the GWG plots in MY6 along with the 30th and 70th percentile rainfall data for each month for Union County. The additional data helps explain changes in the groundwater surface level recorded by the gages throughout the year by totaling the rainfall within the previous thirty days. The plots show that the precipitation in later winter/ early spring was average, and the water table level remained above criteria level for all GWGs in the period of the year with average rainfall. However, an exceptionally dry spring resulted in a greatly reduced groundwater surface that was not able to recharge from the precipitation deficit, even with average precipitation amounts in the late summer and fall. DMS will conduct a soil study in Winter 2022-2023 to determine which wetland assets would potentially be removed at closeout.

Soil temperature data has indicated that the ground temperature starts to rise in early March and remains above the 41-degree Fahrenheit threshold throughout the growing season. Supplemental soil temperature data has been collected since 2019, however no bud burst, or leaf drop data has been gathered to verify the growing season dates with the soil probe data. Please refer to Appendix 7 for supplemental soils temperature and adjusted groundwater gage data.

Please refer to Appendix 5 for the groundwater hydrology data, plots, and rainfall data.

1.2.7 Wetland Areas of Concern

Currently, there are no areas of concern within the wetland areas. Repair work completed on the headcut near Wetland Creation Zone B, previously reported in MY3, has not retreated further. There is some evidence that water has continued to move through this area where vegetation has not fully established. However, the headcut is not threatening the stability of the Site or the riparian buffer. The headcut area will continue to be monitored in MY7. Refer to Appendix 2 for wetland photographs.

1.3 Monitoring Year 6 Summary

In general, the dimensions and profiles of the restored and enhanced stream channels appear stable and are functioning as designed. UT1 retains the ability to transport sediment and maintain channel form during bankfull events. The Site has withstood several bankfull events and has met success criteria for the project. The average planted stem density of 513 stems per acre and the average planted stem height of 14 feet across the Site indicates that the riparian buffer is establishing within the site. The Site has responded well to previous supplemental plantings and invasive species treatments. Due in part to below average rainfall, 4/11 groundwater gages met success criteria in MY6. The area of Wetland Restoration Zone A to the left of UT1, represented by GWGS 4 and 11, may be at risk of failing to meet success criteria during the seven-year monitoring period.

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

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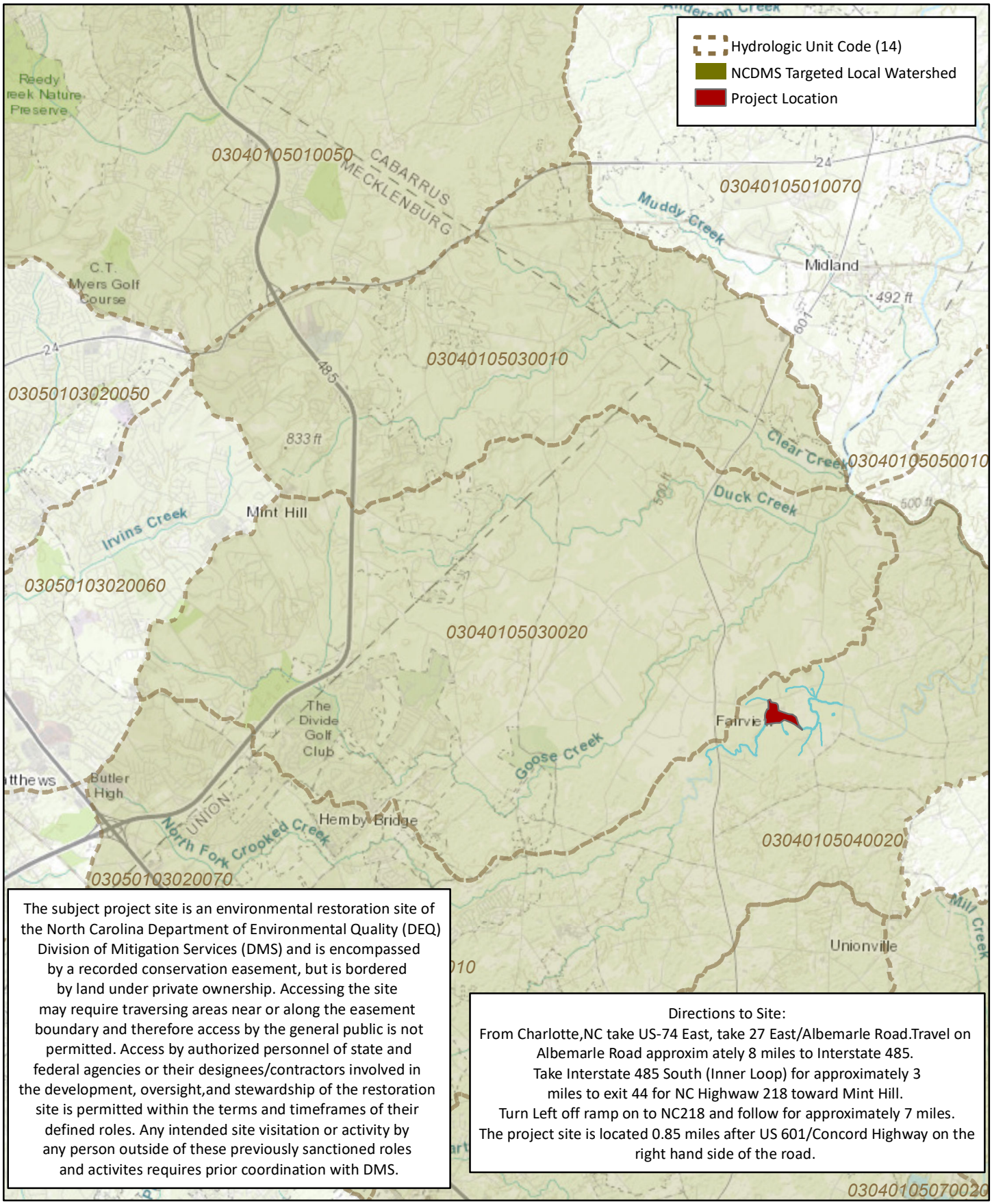
United States Geological Survey (USGS), 2016. Real Time Water Data for North Carolina. Retrieved from: http://nc.water.usgs.gov/realtime/real_time_yadkin_peedee.html

Wildlands Engineering, Inc. (2013). Crooked Creek #2 Restoration Project Final Mitigation Plan. NCEEP, Raleigh, NC.

APPENDIX 1. General Figures and Tables



The subject project site is an environmental restoration site of the North Carolina Department of Environmental Quality (DEQ) 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 activites requires prior coordination with DMS.

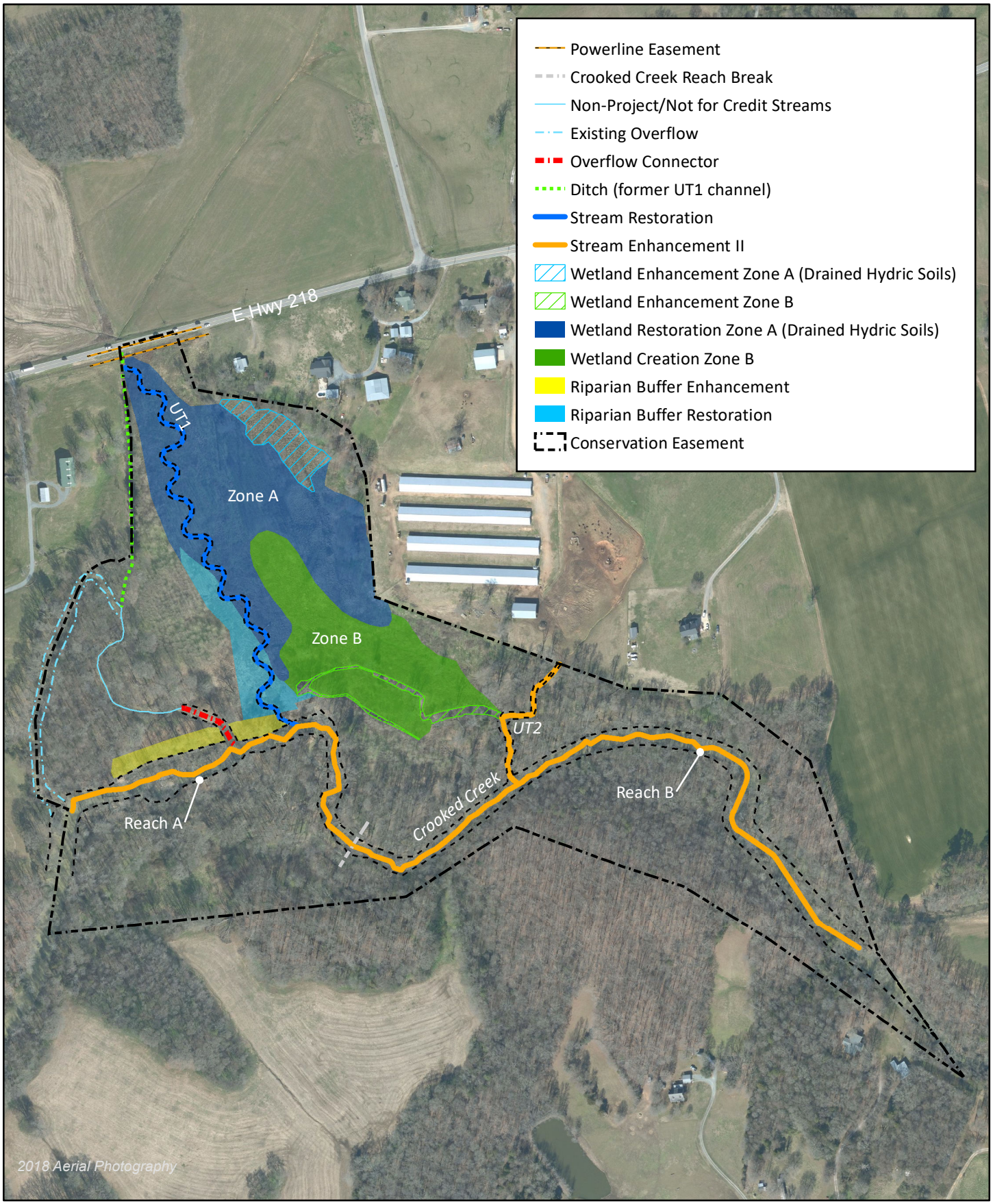
Directions to Site:
From Charlotte,NC take US-74 East, take 27 East/Albemarle Road.Travel on Albemarle Road approxim ately 8 miles to Interstate 485.
Take Interstate 485 South (Inner Loop) for approximately 3 miles to exit 44 for NC Highwaw 218 toward Mint Hill.
Turn Left off ramp on to NC218 and follow for approximately 7 miles.
The project site is located 0.85 miles after US 601/Concord Highway on the right hand side of the road.

WILDLANDS ENGINEERING

0 0.5 1 Mile

N

Figure 1 Project Vicinity Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021
Union County, NC



WILDLANDS ENGINEERING

0 400 Feet

N

Figure 2 Project Component/Asset Map
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6- 2021
Union County, NC

Table 1. Project Components and Mitigation Credits
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 6 - 2021

Mitigation Credits									
	Stream		Riparian Wetland		Non-Riparian Wetland		Buffer (sqft)	Nitrogen Nutrient	Phosphorous Nutrient Offset
Type	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] (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+00-305+60	470 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 sqft	3:1	8,400.33 sqft
Goose Creek Buffer	N/A	N/A		Restoration	45,735 sqft	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 No credit generated where only one side of stream is buffered per email from Harry Tsomides dated October 15, 2018.

2 UT1 rediting starts at the outer edge of the powerline right-of-way along Hwy 218; Crooked Creek assets have been reduced to account for one-side easement sections at upstream and downstream ends.

Table 2. Project Activity and Reporting History
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 6 - 2021

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	March 2020	November 2020
	Vegetation Survey	September 2020	
	Invasive Treatment	October 2020	
Year 6 Monitoring	Stream Survey	April 2021	November 2021
	Vegetation Survey	September 2021	
	Invasive Treatment	March 2021	
		Septmber 2021	
Year 7 Monitoring	Stream Survey	2022	November 2022
	Vegetation Survey	2022	

[1]Seed 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 6 - 2021

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 Gimbert 704.941.9093

Table 4. Project Information and Attributes
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 6 - 2021

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 Drainiage 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%

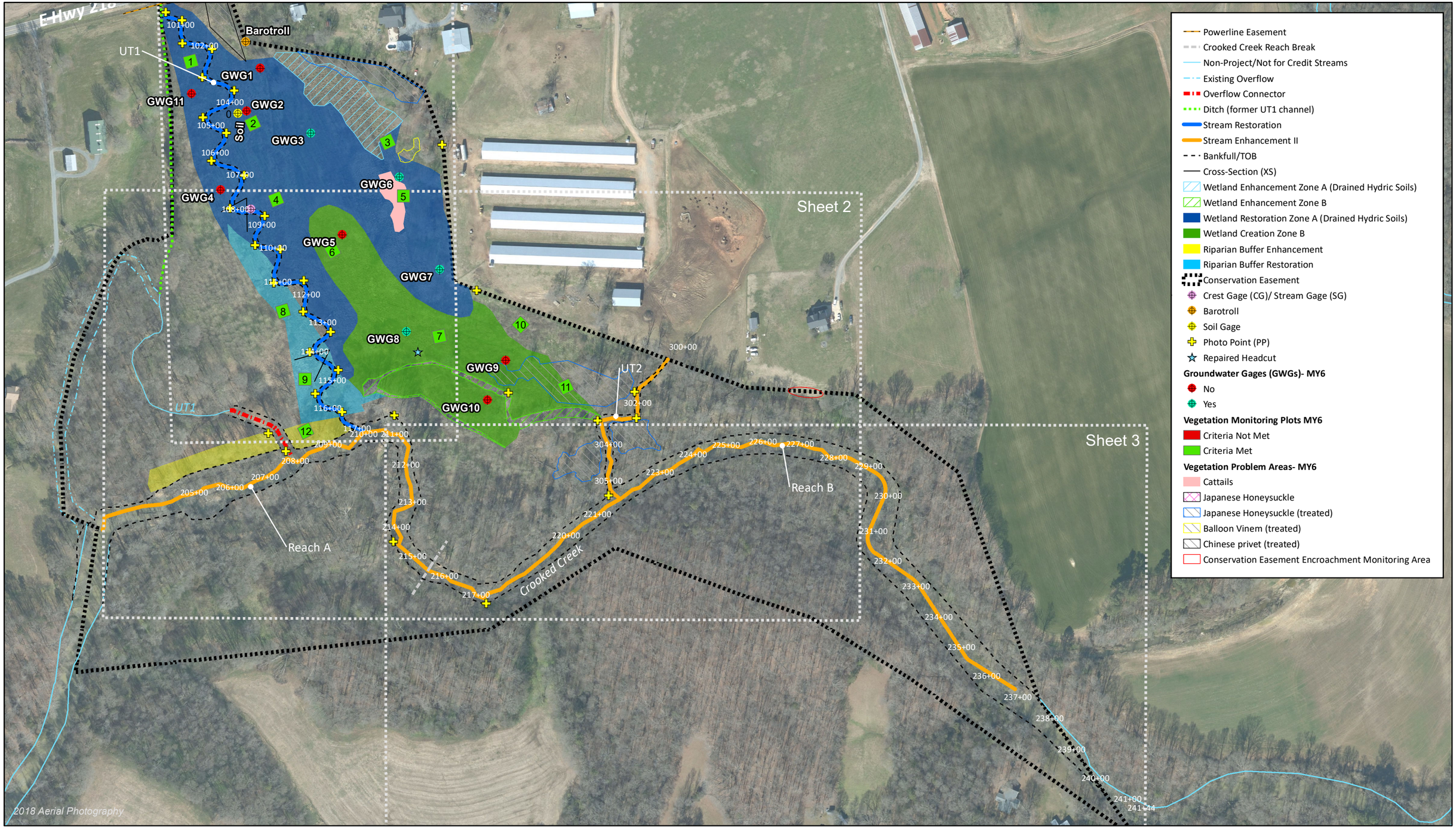
Reach Summary Information					
Parameters	**Crooked Creek Reach A**	**Crooked Creek Reach B**	**UT1**	**UT2**	
Length of reach (linear feet) - Post-Restoration	1,555	2,404	1,671	195	275
Drainage area (acres)	24,619		153	51	
NCDWR stream identification score	52		34.5	24.5	38
NCDWR Water Quality Classification	C				
Morphological Desription (stream type)	P	P	P	I	P
Evolutionary trend (Simon's Model) - Pre- Restoration	N/A	N/A	Stage III	Stage IV	
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 6 - 2021

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	11	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



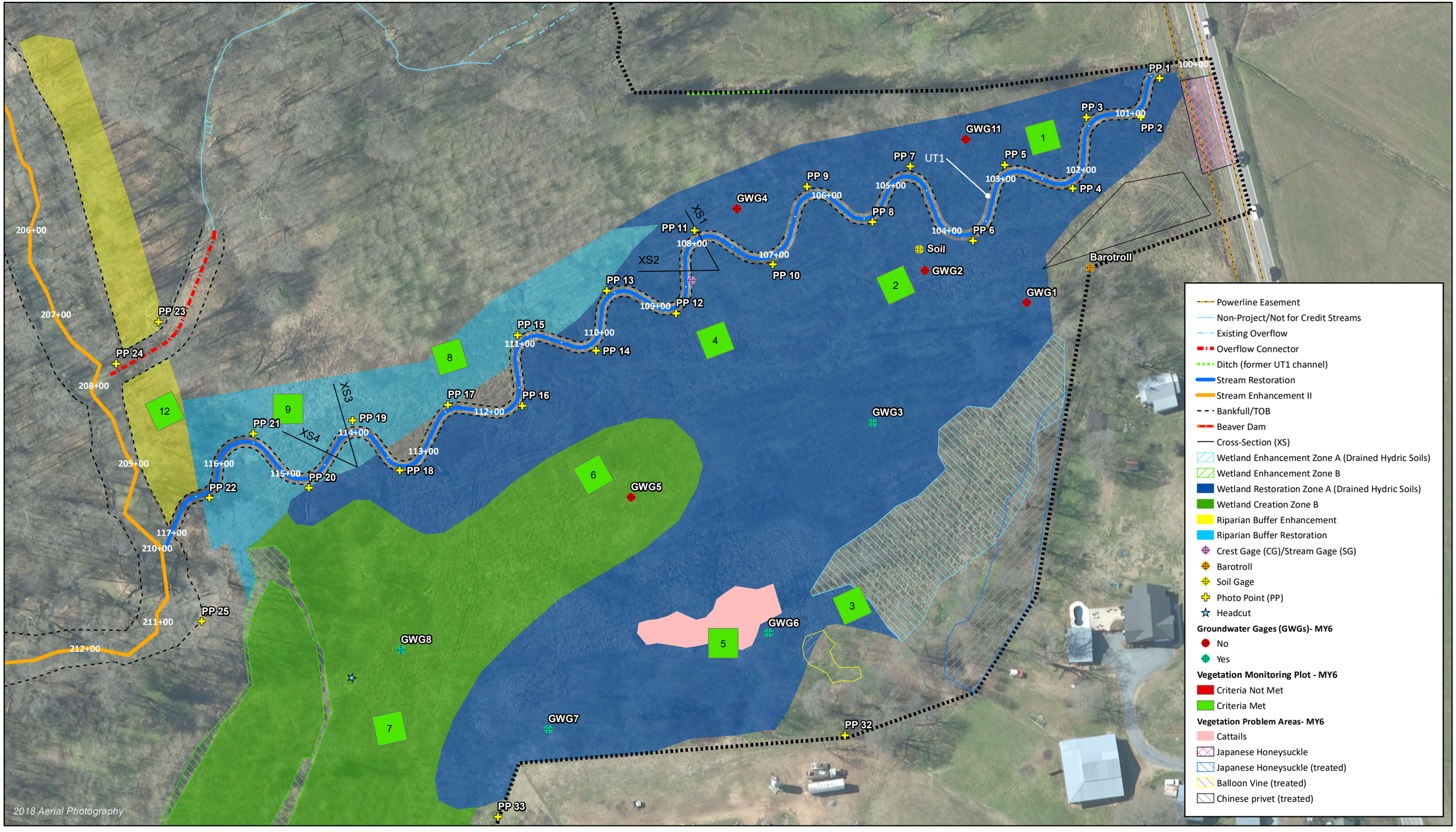
WILDLANDS ENGINEERING

0 130 260 520 Feet

N

Figure 3.0 Inegrated Current Condition Plan View (Key)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6- 2021

Union County, NC



WILDLANDS ENGINEERING

0 50 100 200 Feet

Figure 3.1 Integrated Current Condition Plan View (Sheet 1)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

Union County, NC

Stream Restoration
Stream Enhancement II
Riparian Buffer Restoration
Riparian Buffer Enhancement
Crooked Creek Reach Break
Non-Project/Not for Credit Streams
Existing Overflow
Overflow Connector
Ditch (former UT1 channel)
Bankfull/TOB
Cross-Section (XS)
Conservation Easement
Wetland Enhancement Zone A (Drained Hydric Soils)
Wetland Enhancement Zone B
Wetland Restoration Zone A (Drained Hydric Soils)
Wetland Creation Zone B
Crest Gage (CG)/ Stream Gage (SG)
Barotroll
Photo Point (PP)
Headcut

Groundwater Gages (GWGs)- MY6
No
Yes

Vegetation Monitoring Plot - MY6
Criteria Not Met
Criteria Met

Vegetation Problem Areas- MY6
Cattails
Japanese Honeysuckle
Japanese Honeysuckle (treated)
Balloon Vine (treated)
Chinese privet (treated)
Conservation Easement Mowing

GWG4 GWG5 GWG7 GWG8 GWG9 GWG10
PP 11 PP 12 PP 13 PP 14 PP 15 PP 16 PP 17 PP 18 PP 19 PP 20 PP 21 PP 22 PP 23 PP 24 PP 25 PP 26 PP 27 PP 28 PP 29 PP 30 PP 31 PP 33 PP 34
XS1 XS2 XS3 XS4
108+00 109+00 110+00 111+00 112+00 113+00 114+00 115+00 117+00 205+00 206+00 207+00 208+00 209+00 210+00 211+00 212+00 213+00 214+00 215+00 216+00 217+00 218+00 219+00 220+00 221+00 223+00 224+00 225+00 226+00 227+00 228+00 300+00 301+00 302+00 304+00 305+00
4 5 6 7 8 9 10 11 12
UT1 UT2
Reach A Reach B
Crooked Creek
2018 Aerial Photography

WILDLANDS ENGINEERING

0 62.5 125 250 Feet

N

Figure 3.2 Integrated Current Condition Plan View (Sheet 2)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

Union County, NC

WILDLANDS ENGINEERING

0 62.5 125 250 Feet

N

Figure 3.3 Integrated Current Condition Plan View (Sheet 3)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

Union County, NC

Table 6. Visual Stream Morphology Stability Assessment Table
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6- 2021

UT1 (1,671 LF) / Assessment Date 11/8/2021

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%			

[1]Excludes 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 6- 2021

Planted Acreage **15.0** **Assessment Date 9/1/2021**

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	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	**0.00**	**0.00**	**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**	**0.00**	**0.00**

Easement Acreage **54.9**

Vegetation Category	Definitions	Mapping Threshold	Number of Polygons	Combined Acreage[2]	% of Easement Acreage
Invasive Areas of Concern[1]	Areas or points (if too small to render as polygons at map scale).	1000 SF	9	1.75	3%
Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale).	none	1	0.04	0.1%

1. Treated October 2020, November 2020, March 2021, and September 2021.

Vegetation Photographs
Monitoring Year 6

Vegetation Plot 1 – (9/1/2021)

Vegetation Plot 2 – (9/1/2021)

Vegetation Plot 3 – (9/1/2021)

Vegetation Plot 4 – (9/1/2021)

Vegetation Plot 5 – (9/1/2021)

Vegetation Plot 6 – (9/1/2021)

	
Vegetation Plot 7 – (9/1/2021)	**Vegetation Plot 8** – (9/1/2021)
	
Vegetation Plot 9 – (9/1/2021)	**Vegetation Plot 10** – (9/1/2021)
	
Vegetation Plot 11 – (9/1/2021)	**Vegetation Plot 12** – (9/1/2021)

Stream Photographs

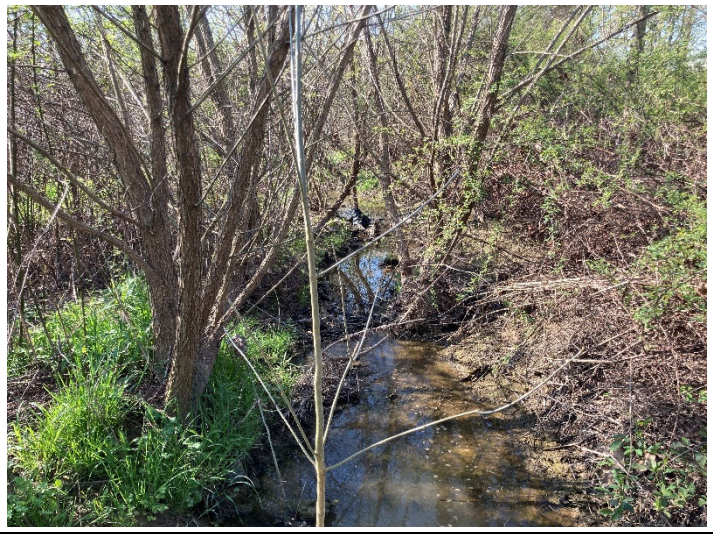
	
Photo Point 1 – UT1 looking upstream (4/5/2021)	**Photo Point 1** – UT1 looking downstream (4/5/2021)
	
Photo Point 2 – UT1 looking upstream (4/5/2021)	**Photo Point 2** – UT1 looking downstream (4/5/2021)
	
Photo Point 3 – UT1 looking upstream (4/5/2021)	**Photo Point 3** – UT1 looking downstream (4/5/2021)

	
Photo Point 4 – UT1 looking upstream (4/5/2021)	**Photo Point 4** – UT1 looking downstream (4/5/2021)
	
Photo Point 5 – UT1 looking upstream (4/5/2021)	**Photo Point 5** – UT1 looking downstream (4/5/2021)
	
Photo Point 6 – UT1 looking upstream (4/5/2021)	**Photo Point 6** – UT1 looking downstream (4/5/2021)

	
Photo Point 7 – UT1 looking upstream (4/5/2021)	**Photo Point 7** – UT1 looking downstream (4/5/2021)
	
Photo Point 8 – UT1 looking upstream (4/5/2021)	**Photo Point 8** – UT1 looking downstream (4/5/2021)
	
Photo Point 9 – UT1 looking upstream (4/5/2021)	**Photo Point 9** – UT1 looking downstream (4/5/2021)

	
Photo Point 10 – UT1 looking upstream (4/5/2021)	**Photo Point 10** – UT1 looking downstream (4/5/2021)
	
Photo Point 11 – UT1 looking upstream (4/5/2021)	**Photo Point 11** – UT1 looking downstream (4/5/2021)
	
Photo Point 12 – UT1 looking upstream (4/5/2021)	**Photo Point 12** – UT1 looking downstream (4/5/2021)

	
Photo Point 13 – UT1 looking upstream (4/5/2021)	**Photo Point 13** – UT1 looking downstream (4/5/2021)
	
Photo Point 14 – UT1 looking upstream (4/5/2021)	**Photo Point 14** – UT1 looking downstream (4/5/2021)
	
Photo Point 15 – UT1 looking upstream (4/5/2021)	**Photo Point 15** – UT1 looking downstream (4/5/2021)

	
Photo Point 16 – UT1 looking upstream (4/5/2021)	**Photo Point 16** – UT1 looking downstream (4/5/2021)
	
Photo Point 17 – UT1 looking upstream (4/5/2021)	**Photo Point 17** – UT1 looking downstream (4/5/2021)
	
Photo Point 18 – UT1 looking upstream (4/5/2021)	**Photo Point 18** – UT1 looking downstream (4/5/2021)

	
Photo Point 19 – UT1 looking upstream (4/5/2021)	**Photo Point 19** – UT1 looking downstream (4/5/2021)
	
Photo Point 20 – UT1 looking upstream (4/5/2021)	**Photo Point 20** – UT1 looking downstream (4/5/2021)
	
Photo Point 21 – UT1 looking upstream (4/5/2021)	**Photo Point 21** – UT1 looking downstream (4/5/2021)

	
Photo Point 22 – UT1 looking upstream (4/5/2021)	**Photo Point 22** – UT1 looking downstream (4/5/2021)
	
Photo Point 23 – UT1 looking upstream (4/5/2021)	**Photo Point 23** – UT1 looking downstream (4/5/2021)
	
Photo Point 24 – Crooked Creek looking upstream (4/5/2021)	**Photo Point 24** – Crooked Creek looking downstream (4/5/2021)

	
Photo Point 25 – Crooked Creek looking upstream (4/5/2021)	**Photo Point 25** – Crooked Creek looking downstream (4/5/2021)
	
Photo Point 26 – Crooked Creek looking upstream (4/5/2021)	**Photo Point 26** – Crooked Creek looking downstream (4/5/2021)
	
Photo Point 27 – Crooked Creek looking upstream (4/5/2021)	**Photo Point 27** – Crooked Creek looking downstream (4/5/2021)

Photo Point 28 – UT2 looking upstream (4/5/2021)

Photo Point 28 – UT2 looking downstream (4/5/2021)

Photo Point 29 – UT2 looking upstream (4/5/2021)

Photo Point 29 – UT2 looking downstream (4/5/2021)

Photo Point 30 – UT2 looking downstream to UT2 (4/5/2021)

Photo Point 31 – UT2 looking upstream Crooked Creek (4/5/2021)

Photo Point 31 – UT2 looking downstream Crooked Creek (4/5/2021)

Photo Point 31 – UT2 looking upstream UT2 (4/5/2021)

Wetland Photographs

	
Photo Point 30 –Wetland CC outlet facing West (4/5/2021)	**Photo Point 30** –Wetland CC outlet facing East (4/5/2021)
	
Photo Point 32 –Wetland AA facing West (4/5/2021)	**Photo Point 32** – Wetland Zone A facing South (4/5/2021)
	
Photo Point 33 – Wetland Zone A & B facing West (4/5/2021)	**Photo Point 33** - Wetland B facing South (4/5/2021)

	
Photo Point 34 –Wetland CC facing Northwest (4/5/2021)	**Photo Point 34** –Wetland CC facing South (4/5/2021)

Area of Concern Photographs
Monitoring Year 6

Mowing easement encroachment spring (4/05/2021)

Mowing easement encroachment addressed (9/01/2021)

Mowing easement encroachment addressed (11/01/2021)

Treated honeysuckle (9/01/2021)

Treated privet (9/01/2021)

APPENDIX 3. Vegetation Plot Data

Table 8. Vegetation Plot Criteria Attainment
Crooked Creek #2 Restoration Project Site
DMS Project No. 94687
Monitoring Year 6 - 2021

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 6 - 2021

Report Prepared By	Ella Wickliff
Date Prepared	10/2/2021 14:01
Database Name	cvs-eep-entrytool-v2.3.0_Crooked Creek_MY6.mdb
Database Location	Q:\ActiveProjects\005-02156 Crooked Creek Monitoring\Monitoring\Monitoring Year 4 (2019)\Vegetation Assessment
Computer Name	ELLA-PC
File Size	46927872
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 10a. Planted and Total Stem Counts
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

			Current Plot Data (MY6 2021)																																				
			VP1			VP2			VP3			VP4			VP5			VP6			VP7			VP8			VP9			VP10			VP11			VP12		
Scientific Name	**Common Name**	**Species Type**	**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**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**	**PnoLS**	**P-all**	**T**
Acer negundo	Box Elder	Tree																					3			18			4			6			10			10
Acer rubrum	Red Maple	Tree	1	1	1							2	2	2										3	3	3	6	6	6										
Betula nigra	River Birch	Tree							1	1	1	1	1	1	1	1	1	5	5	5	1	1	1	1	1	1	3	3	3	2	2	2	4	4	4	4	4	4
Carpinus caroliniana	Ironwood	Shrub Tree																1	1	1																			
Celtis laevigata	Sugarberry	Shrub Tree	2	2	2				1	1	1																			2	2	2							
Cornus florida	Flowering Dogwood	Shrub Tree																																		1	1	1
Diospyros virginiana	American Persimmon	Tree	2	2	2	1	1	1	1	1	1													5	5	5	2	2	4							1	1	1
Fraxinus pennsylvanica	Green Ash	Tree			10						4			3									3			3			4			8			7			
Juglans nigra	Black Walnut	Tree																																				
Liquidambar styraciflua	Sweet Gum	Tree																					13									3			10			3
Liriodendron tulipifera	Tulip Poplar	Tree																																				
Nyssa sylvatica	Black Gum	Tree																												1	1	1						
Platanus occidentalis	Sycamore	Tree	6	6	6	6	6	6	1	1	1	2	2	2	1	1	1	4	4	19	2	2	2	3	3	3										1	1	1
Quercus	Oak sp.	Shrub Tree																																				
Quercus lyrata	Overcup Oak	Tree																1	1	1				1	1	1				1	1	1	3	3	3	2	2	2
Quercus nigra	Water Oak	Tree																			3	3	3	1	1	1				1	1	1	6	6	6	1	1	1
Quercus phellos	Willow Oak	Tree	1	1	1	1	1	1				1	1	1				1	1	1	3	3	3							1	1	1							
Salix nigra	Black Willow	Tree																																				
Salix sericea	Silky Willow	Shrub Tree			1																																	
Taxodium distichum	Bald-cypress	Tree	3	3	3	4	4	4	7	7	7	4	4	4	9	9	11	2	2	2	1	1	1	1	1	1	1	1	1	2	2	2				4	4	4
Ulmus alata	Winged Elm	Tree																2	2	7	3	3	3									1						5
Ulmus americana	American Elm	Tree																																				
Stem count			15	15	26	12	12	12	11	11	15	10	10	13	11	11	13	16	16	36	13	13	32	15	15	36	12	12	22	10	10	28	13	13	40	14	14	32
size (ares)			1			1			1			1			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			0.02			0.02			0.02			0.02		
Species count			6	6	8	4	4	4	5	5	6	5	5	6	3	3	3	7	7	7	6	6	9	7	7	9	4	4	6	7	7	11	3	3	6	7	7	10
Stems per ACRE			607	607	1052	486	486	486	445	445	607	405	405	526	445	445	526	647	647	1457	526	526	1295	607	607	1457	486	486	890	405	405	1133	526	526	1619	567	567	1295

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 included in total

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

Table 10b. Planted and Total Stem Annual Means

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

			Annual Means																				
			MY6 (9/2021)			MY5 (9/2020)			MY4 (8/2019)			MY3 (8/2018)			MY2 (8/2017)			MY1 (9/2016)			MY0 (2/2016)		
Scientific Name	**Common Name**	**Species Type**	**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			51			11			23			49			43			18			17
Acer rubrum	Red Maple	Tree	12	12	12	12	12	12	12	12	15	13	13	14	11	11	11	13	13	13	14	14	14
Betula nigra	River Birch	Tree	23	23	23	22	22	24	27	27	28	26	26	26	12	12	14	14	14	15	18	18	18
Carpinus caroliniana	Ironwood	Shrub Tree	1	1	1	2	2	2	2	2	2												2
Celtis laevigata	Sugarberry	Shrub Tree	5	5	5	6	6	6	6	6	6	9	9	14			4			1			
Cornus florida	Flowering Dogwood	Shrub Tree	1	1	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	6	6	6
Diospyros virginiana	American Persimmon	Tree	12	12	14	12	12	13	12	12	12	13	13	16	7	7	7	10	10	13	27	27	27
Fraxinus pennsylvanica	Green Ash	Tree			42			55			127			41			25			26			45
Juglans nigra	Black Walnut	Tree												3			4						1
Liquidambar styraciflua	Sweet Gum	Tree			29			22			39			6			7			7			4
Liriodendron tulipifera	Tulip Poplar	Tree									1						1			1			2
Nyssa sylvatica	Black Gum	Tree	1	1	1	2	2	2	2	2	2	2	2	3	2	2	2	3	3	3	7	7	7
Platanus occidentalis	Sycamore	Tree	26	26	41	27	27	54	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	8	8	8	8	8	8	6	6	6	8	8	8	8	8	8	7	7	7			
Quercus nigra	Water Oak	Tree	12	12	12	12	12	12	12	12	12	12	12	12	11	11	11	4	4	4			
Quercus phellos	Willow Oak	Tree	8	8	8	8	8	8	9	9	10	6	6	6	6	6	6	3	3	3			
Salix nigra	Black Willow	Tree												2									
Salix sericea	Silky Willow	Shrub Tree			1																		
Taxodium distichum	Bald-cypress	Tree	38	38	40	39	39	45	40	40	41	41	41	41	12	12	12	13	13	13	16	16	16
Ulmus alata	Winged Elm	Tree	5	5	16	5	5	5	6	6	10	6	6	12			5						1
Ulmus americana	American Elm	Tree						14												7			
Stem count			152	152	305	156	156	294	163	163	377	168	168	307	84	84	207	95	95	172	156	156	229
size (ares)			12			12			12			12			12			12			12		
size (ACRES)			0.30			0.30			0.30			0.30			0.30			0.30			0.30		
Species count			13	13	17	13	13	17	13	13	17	13	13	18	11	11	18	11	11	17	8	8	15
Stems per ACRE			513	513	1029	526	526	991	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%

Volunteers included in total

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 6 - 2021

UT1

		Pre-Restoration Condition				Reference Reach Data				Design		As-Built/Baseline	
Parameter	**Gage**	**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					---		---		---		12	50
Riffle Slope (ft/ft)		*		*		0.0055	0.0597	0.0100	0.0670	0.0045	0.0080	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	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/A[1]: 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/A[2]: Donstream 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 Hydrauloc Summary (Dimensional Parameters- Cross-Section)
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

	Cross-Section 1, UT1 (Pool)							Cross-Section 2, UT1 (Riffle)						
Dimension and Substrate[1]	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**
Bankfull elevation	541.8	541.9	541.8	541.8	541.8	541.8	541.9	542.1	542.0	542.1	542.1	542.0	542.1	542.2
Low Bank Elevation	541.8	541.9	541.8	541.8	541.8	541.8	541.9	542.1	542.0	542.1	542.1	542.0	542.1	542.1
Bankfull Width (ft)	13.3	12.7	13.6	13.3	10.2	12.1	12.2	11.7	11.1	11.4	15.6	10.9	11.2	10.7
Floodprone Width (ft)	---	---	---	---	---	---	---	200+	200+	200+	89.0	89.0	89.0	89.3
Bankfull Mean Depth (ft)	0.7	0.7	0.6	0.7	0.8	0.7	0.7	0.6	0.5	0.6	0.5	0.6	0.6	0.5
Bankfull Max Depth (ft)	1.5	1.4	1.4	1.5	1.5	1.4	1.4	1.1	0.9	1.0	1.1	1.0	1.0	1.0
Bankfull Cross-Sectional Area (ft^2)	8.7	8.5	8.3	8.7	8.4	8.3	8.5	7.3	5.9	6.5	7.9	6.3	6.4	5.9
Bankfull Width/Depth Ratio	20.4	18.9	22.4	20.4	12.5	17.5	17.6	18.9	20.8	20.1	30.7	18.8	19.8	19.4
Bankfull Entrenchment Ratio	---	---	---	---	---	---	---	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	0.9	0.9
	Cross-Section 3, UT1 (Pool)							**Cross-Section 4, UT1 (Riffle)**						
Dimension and Substrate[1]	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**	**Base**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY6**
Bankfull elevation	539.7	539.7	539.7	539.6	539.7	539.7	539.7	539.8	539.8	539.8	539.7	539.9	539.8	539.8
Low Bank Elevation	539.7	539.7	539.7	539.6	539.7	539.7	539.7	539.8	539.8	539.8	539.7	539.9	539.8	539.8
Bankfull Width (ft)	12.6	12.3	12.2	15.4	13.6	14.2	12.8	12.6	11.9	12.0	13.1	13.1	12.3	11.8
Floodprone Width (ft)	---	---	---	---	---	---	---	200+	200+	200+	83.0	83.0	83.0	83.0
Bankfull Mean Depth (ft)	1.0	0.9	1.0	0.8	1.0	1.0	1.1	0.6	0.7	0.6	0.6	0.6	0.6	0.6
Bankfull Max Depth (ft)	2.4	2.2	2.1	2.2	2.2	2.1	2.2	1.1	1.0	1.2	1.1	1.1	1.0	1.4
Bankfull Cross-Sectional Area (ft^2)	12.6	11.4	12.3	12.6	13.3	13.9	14.6	7.5	7.8	7.6	7.6	7.4	7.1	7.6
Bankfull Width/Depth Ratio	12.7	13.4	12.1	18.9	13.8	14.6	11.2	21.1	18.0	18.9	22.7	23.2	21.2	18.3
Bankfull Entrenchment Ratio	---	---	---	---	---	---	---	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	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 6 - 2021

UT1

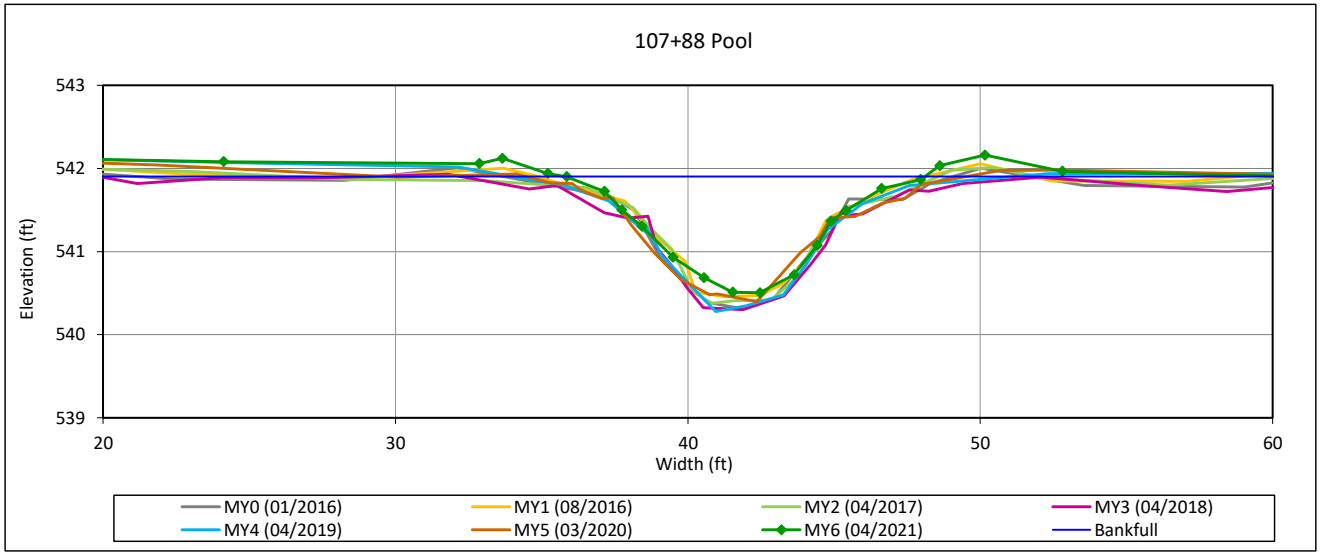
Parameter	As-Built/Baseline		MY-1		MY-2		MY-3		MY-4		MY-5		MY-6	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Dimension and Substrate - Riffle[1]														
Bankfull Width (ft)	11.7	12.6	11.1	11.9	11.4	12.0	13.0	15.6	10.9	19.5	11.2	12.3	10.7	11.8
Floodprone Width (ft)	200+		200+		200+		89+		89+		83	89	83	89
Bankfull Mean Depth	0.6		0.5	0.7	0.6		0.5	0.6	0.6		0.6		0.5	0.6
Bankfull Max Depth	1.1		0.9	1.0	1.0	1.2	1.1		1.0	1.1	1.0		1.0	1.4
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	6.4	7.1	5.9	7.6
Width/Depth Ratio	18.9	21.1	18.0	20.8	18.9	20.1	22.7	30.7	18.8	23.2	19.8	21.2	18.3	19.4
Entrenchment Ratio	2.2+		2.2+		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	0.9	1.0	0.9	1.0
D50 (mm)	0.3	35.9	SC	65.6	SC	66.2	SC	52.8	SC	46.0	0.3	16.0	SC	46.7
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 6 - 2021

Cross Section 1-UT1



Bankfull Dimensions	
8.5	x-section area (ft.sq.)
12.2	width (ft)
0.7	mean depth (ft)
1.4	max depth (ft)
12.7	wetted perimeter (ft)
0.7	hydraulic radius (ft)
17.6	width-depth ratio

Survey Date: 04/2021
Field Crew: Wildlands Engineering

View Downstream

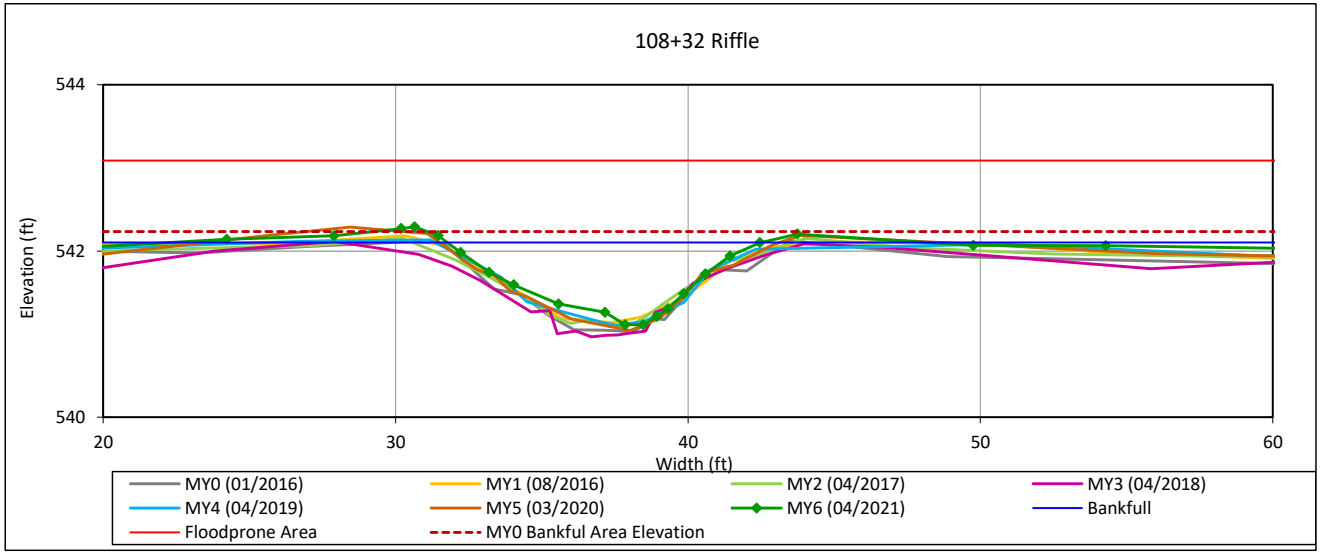
Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

DMS Project No. 94687

Monitoring Year 6 - 2020

Cross Section 2-UT1



Bankfull Dimensions	
5.9	x-section area (ft.sq.)
10.7	width (ft)
0.5	mean depth (ft)
1.0	max depth (ft)
10.9	wetted perimeter (ft)
0.5	hydraulic radius (ft)
19.4	width-depth ratio
89.3	W flood prone area (ft)
8.4	entrenchment ratio
0.9	low bank height ratio

Survey Date: 04/2021

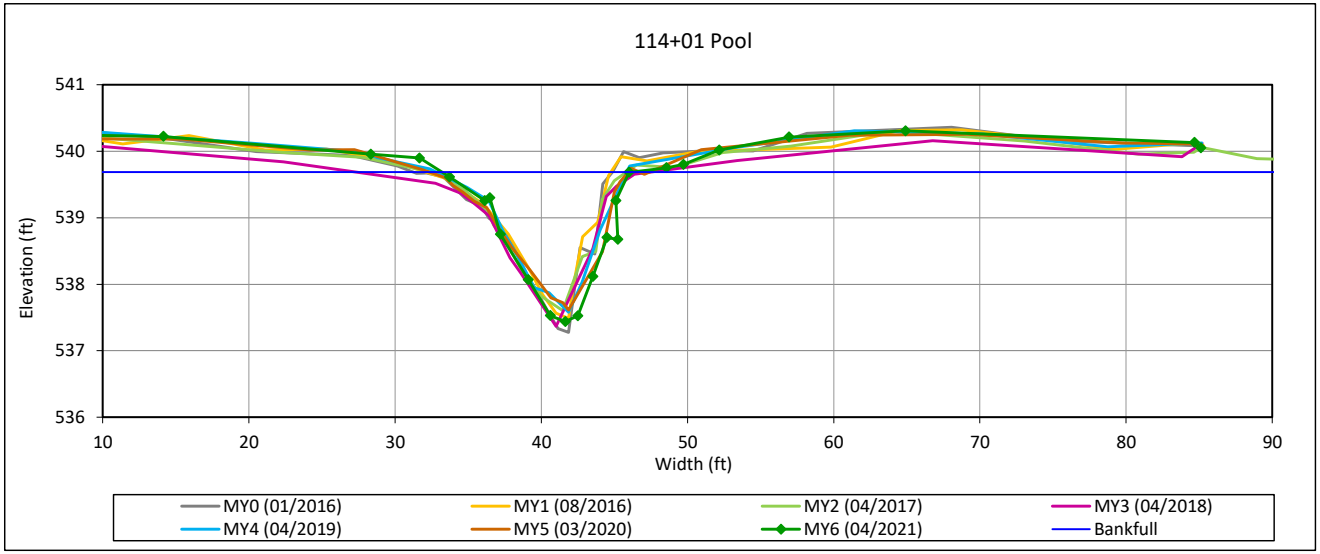
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 6 - 2021

Cross Section 3-UT1



Bankfull Dimensions	
14.6	x-section area (ft.sq.)
12.8	width (ft)
1.1	mean depth (ft)
2.2	max depth (ft)
14.4	wetted perimeter (ft)
1.0	hydraulic radius (ft)
11.2	width-depth ratio

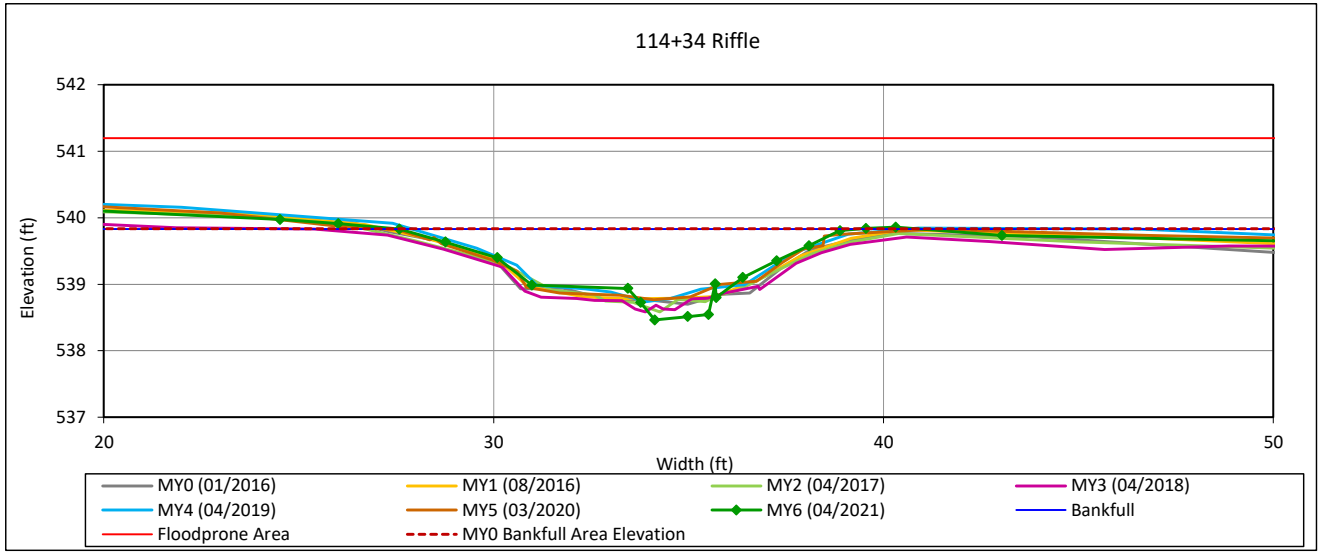
Survey Date: 04/2021
Field Crew: Wildlands Engineering

View Downstream

Cross-Section Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 6 - 2020

Cross Section 4-UT1



Bankfull Dimensions	
7.6	x-section area (ft.sq.)
11.8	width (ft)
0.6	mean depth (ft)
1.4	max depth (ft)
12.7	wetted perimeter (ft)
0.6	hydraulic radius (ft)
18.3	width-depth ratio
83.0	W flood prone area (ft)
7.1	entrenchment ratio
1.0	low bank height ratio

Survey Date: 04/2021
Field Crew: Wildlands Engineering

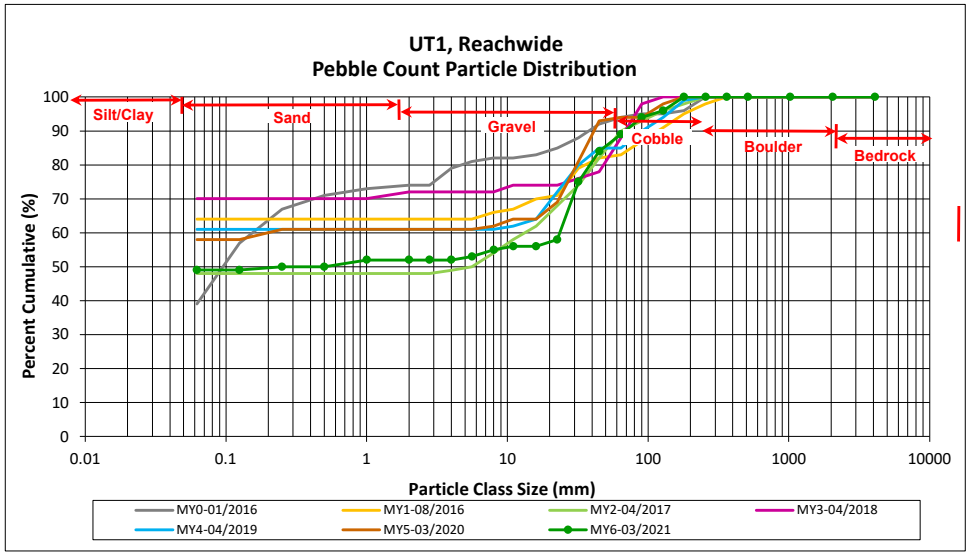
View Downstream

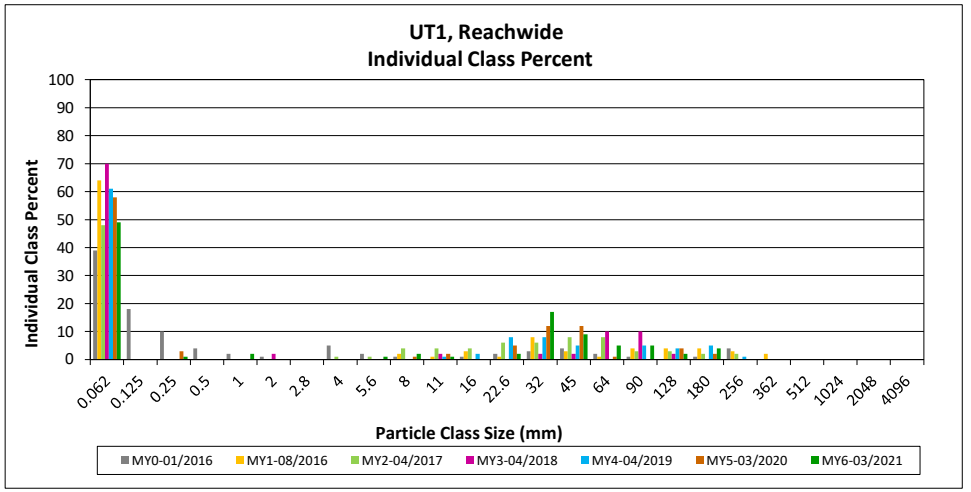
Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 6 - 2021
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	4	45	49	49	49
SAND	Very fine	0.062	0.125					49
	Fine	0.125	0.250		1	1	1	50
	Medium	0.25	0.50					50
	Coarse	0.5	1.0		2	2	2	52
	Very Coarse	1.0	2.0					52
GRAVEL	Very Fine	2.0	2.8					52
	Very Fine	2.8	4.0					52
	Fine	4.0	5.6	1		1	1	53
	Fine	5.6	8.0	1	1	2	2	55
	Medium	8.0	11.0		1	1	1	56
	Medium	11.0	16.0					56
	Coarse	16.0	22.6	2		2	2	58
	Coarse	22.6	32	17		17	17	75
	Very Coarse	32	45	9		9	9	84
	Very Coarse	45	64	5		5	5	89
COBBLE	Small	64	90	5		5	5	94
	Small	90	128	2		2	2	96
	Large	128	180	4		4	4	100
	Large	180	256					100
BOULDER	Small	256	362					100
	Small	362	512					100
	Medium	512	1024					100
	Large/Very Large	1024	2048					100
BEDROCK	Bedrock	2048	>2048					100
			Total	**50**	**50**	**100**	**100**	**100**

Reachwide	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	0.3
D_{84} =	45.0
D_{95} =	107.3
D_{100} =	180.0





Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site

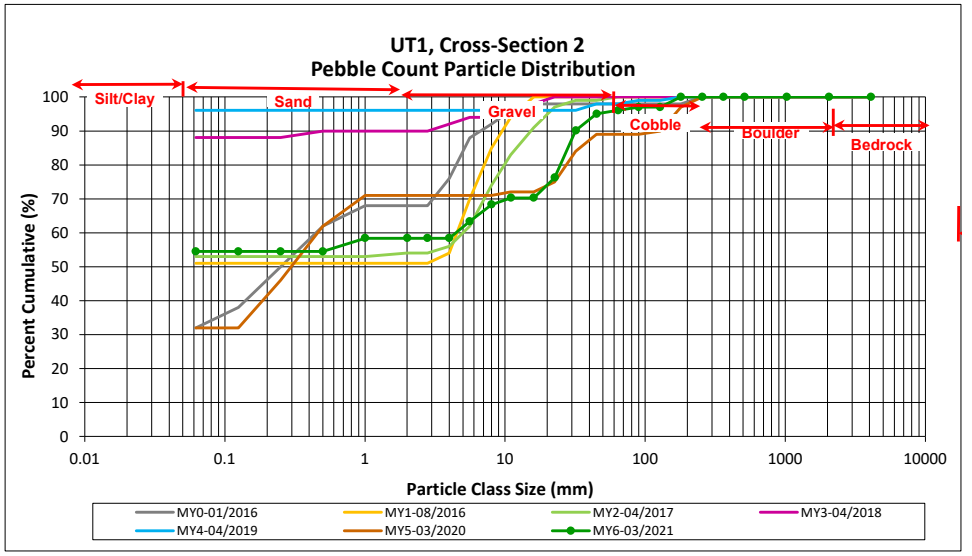
DMS Project No. 94687

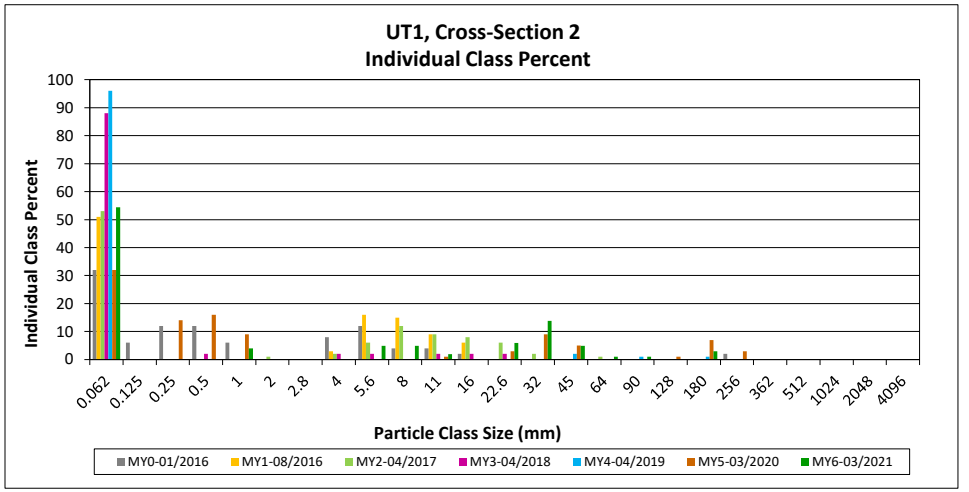
Monitoring Year 6 - 2021

UT1, Cross-Section 2

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062	55	54	54
SAND	Very fine	0.062	0.125			54
	Fine	0.125	0.250			54
	Medium	0.25	0.50			54
	Coarse	0.5	1.0	4	4	58
	Very Coarse	1.0	2.0			58
GRAVEL	Very Fine	2.0	2.8			58
	Very Fine	2.8	4.0			58
	Fine	4.0	5.6	5	5	63
	Fine	5.6	8.0	5	5	68
	Medium	8.0	11.0	2	2	70
	Medium	11.0	16.0			70
	Coarse	16.0	22.6	6	6	76
	Coarse	22.6	32	14	14	90
	Very Coarse	32	45	5	5	95
	Very Coarse	45	64	1	1	96
COBBLE	Small	64	90	1	1	97
	Small	90	128			97
	Large	128	180	3	3	100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	**101**	**100**	**100**

Cross-Section 2	
Channel materials (mm)	
D_{16} =	Silt/Clay
D_{35} =	Silt/Clay
D_{50} =	Silt/Clay
D_{84} =	27.5
D_{95} =	44.8
D_{100} =	180.0



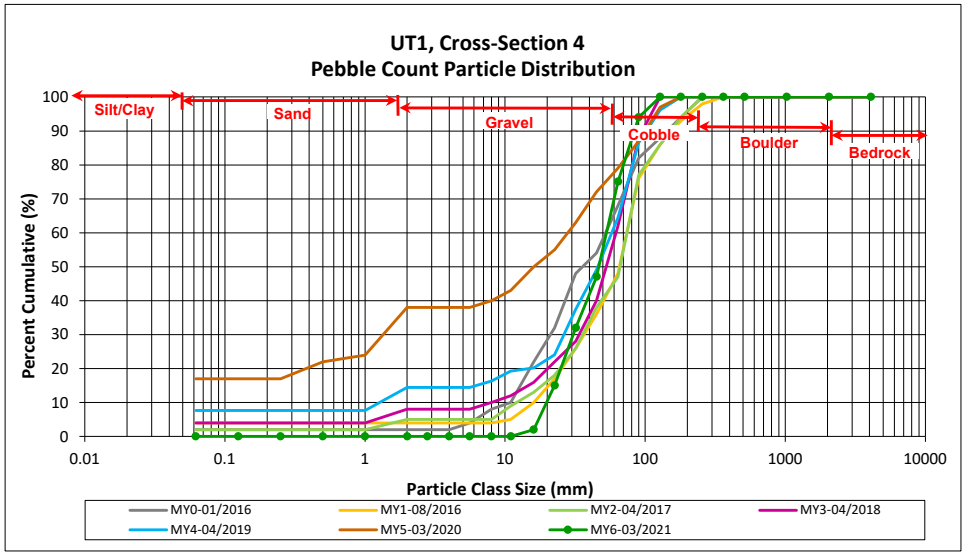


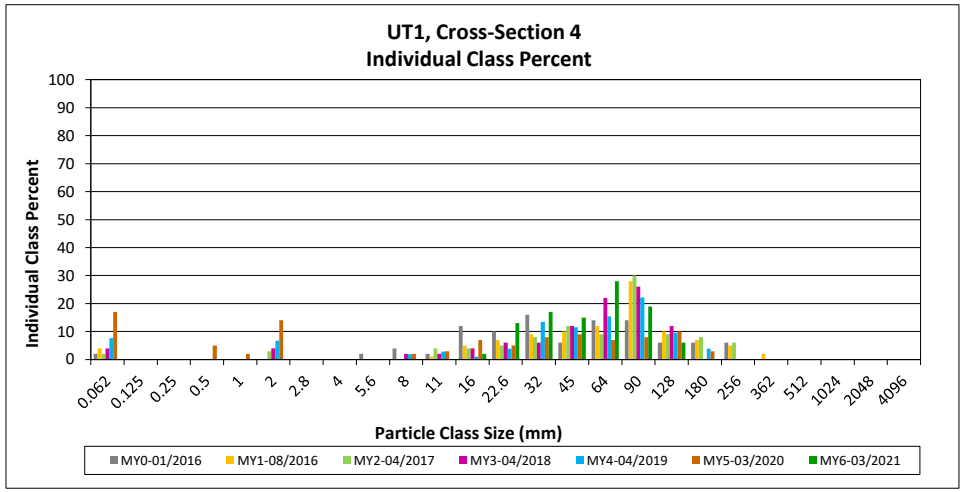
Reachwide and Cross-Section Pebble Count Plots

Crooked Creek #2 Stream and Wetland Mitigation Site
DMS Project No. 94687
Monitoring Year 6 - 2021
UT1, Cross-Section 4

Particle Class		Diameter (mm)		Riffle 100-Count	Summary	
		min	max		Class Percentage	Percent Cumulative
SILT/CLAY	Silt/Clay	0.000	0.062			0
SAND	Very fine	0.062	0.125			0
	Fine	0.125	0.250			0
	Medium	0.25	0.50			0
	Coarse	0.5	1.0			0
	Very Coarse	1.0	2.0			0
GRAVEL	Very Fine	2.0	2.8			0
	Very Fine	2.8	4.0			0
	Fine	4.0	5.6			0
	Fine	5.6	8.0			0
	Medium	8.0	11.0			0
	Medium	11.0	16.0	2	2	2
	Coarse	16.0	22.6	13	13	15
	Coarse	22.6	32	17	17	32
	Very Coarse	32	45	15	15	47
	Very Coarse	45	64	28	28	75
COBBLE	Small	64	90	19	19	94
	Small	90	128	6	6	100
	Large	128	180			100
	Large	180	256			100
BOULDER	Small	256	362			100
	Small	362	512			100
	Medium	512	1024			100
	Large/Very Large	1024	2048			100
BEDROCK	Bedrock	2048	>2048			100
			Total	**100**	**100**	**100**

Cross-Section 4	
Channel materials (mm)	
D_{16} =	23.07
D_{35} =	34.26
D_{50} =	46.7
D_{84} =	75.2
D_{95} =	95.4
D_{100} =	128.0





APPENDIX 5. Hydrology Summary Data and Plots

Table 14. Verification of Bankfull Events
Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021

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	Stream Gage
	MY5	2/7/2020	Stream Gage, Photos
		3/25/2020	
		4/30/2020	
		5/21/2020	
		5/28/2020	
		8/10/2020	
		8/15/2020	
		9/25/2020	
		10/11/2020	
		11/1/2020	
	MY6	1/1/2021	Stream Gage, Photos
		1/28/2021	
		2/15/2021	
		3/16/2021	
		3/25/2021	
		6/20/2021	

Reach	MY of Occurrence	Date of Occurrence (Approximate)	Method
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
	MY5	3/25/2020	Wrack Line
		11/1/2020	Wrack Line
	MY6	4/5/2021	Wrack Line
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
	MY5	3/25/2020	Bankfull Flow Photo
	MY6	4/5/2021	Wrack Line

Recorded In-stream Flow Events

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

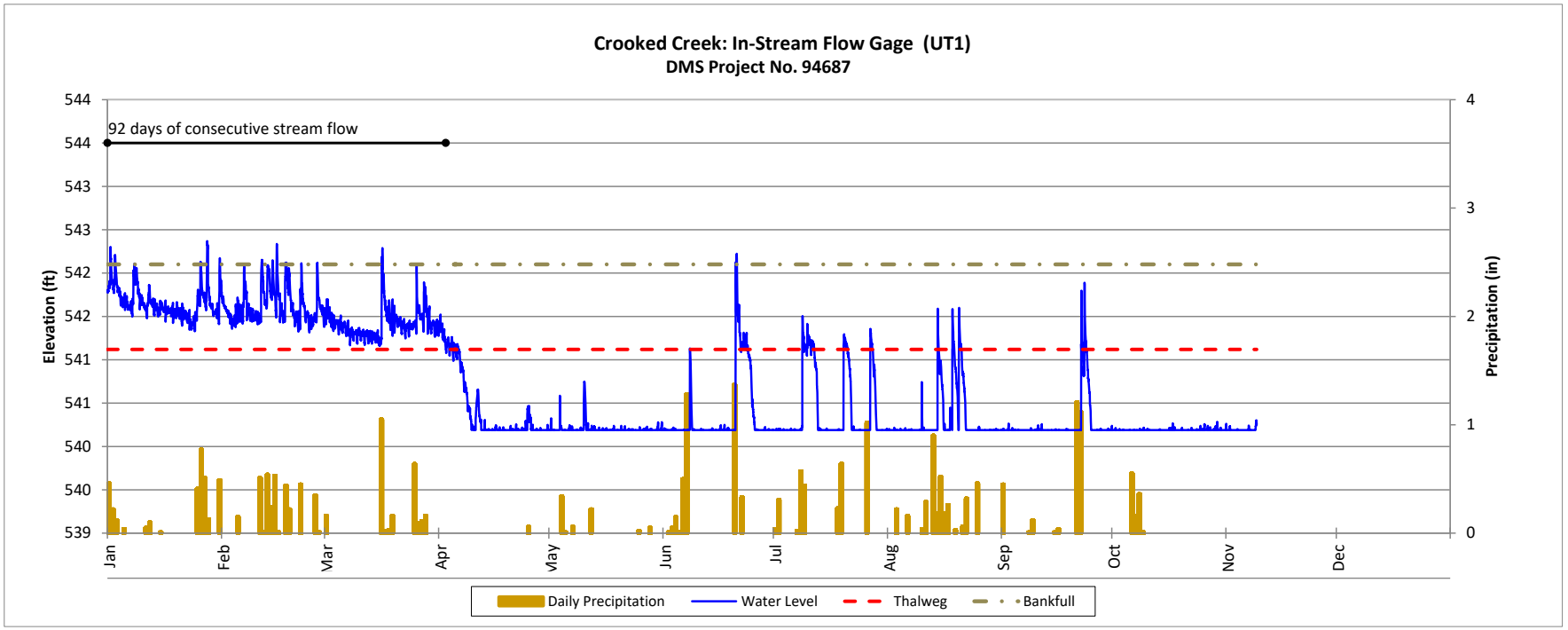


Table 15. Wetland Gage Attainment Summary

Crooked Creek #2 Restoration Project

DMS Project No. 964687

Monitoring Year 6 - 2021

Summary of Groundwater Gage Results for Monitoring Years 1 through 7							
Gage	**Success Criteria Achieved/Max Consecutive Days During Growing Season (Percentage)**						
	MY1 (2016)	**MY2 (2017)**	**MY3 (2018)**	**MY4 (2019)**	**MY5 (2020)**	**MY6 (2021)**	**MY7 (2022)**
1	No/0 Days (0%)	No/7 Days (3%)	No/12 Days (5%)	Yes/22 Days (9.7%)	No/ 15 Days (6.6%)	No/ 14 Days (6.2%)	
2	No/2 Days (0.9%)	No/8 Days (4%)	No/13 Days (6%)	Yes/21 Days (9.3%)	Yes/ 25 Days (11%)	No/ 14 Days (6.2%)	
3	No/1 Days (0.4%)	No/9 Days (4%)	Yes/29 Days (13%)	Yes/34 Days (15%)	Yes/ 25 Days (11%)	Yes/ 18 Days (7.9%)	
4	No/0 Days (0%)	No/6 Days (3%)	No/10 Days (4%)	No/16 Days (7.1%)	No/ 14 Days (6.2%)	No/ 10 Days (4.4%)	
5	No/1 Days (0.4%)	No/7 Days (3%)	No/12 Days (5%)	Yes/22 Days (9.7%)	Yes/ 25 Days (11%)	No/ 14 Days (6.2%)	
6	Yes/26 Days (11.5%)	Yes/75 Days (33%)	Yes/88 Days (39%)	Yes/67 Days (29.6%)	Yes/116 Days (51.1%)	Yes/ 25 Days (11.0%)	
7	Yes/18 Days (8%)	Yes/47 Days (21%)	Yes/45 Days (20%)	Yes/56 Days (24.8%)	Yes/ 54 Days (23.8%)	Yes/ 30 Days (13.2%)	
8	No/14 Days (6.2%)	Yes/31 Days (14%)	Yes/45 Days (20%)	Yes/35 Days (15.5%)	Yes/ 51 Days (22.5%)	Yes/ 26 Days (11.5%)	
9	No/1 Days (0.4%)	No/7 Days (3%)	No/13 Days (6%)	Yes/23 Days (10.2%)	No/ 16 Days (7%)	No/ 14 Days (6.2%)	
10	No/2 Days (0.9%)	No/11 Days (5%)	No/10 Days (4%)	Yes/23 Days (10.2%)	No/ 15 Days (6.6%)	No/ 12 Days (5.3%)	
11*					No/ 14 Days (6.2%)	No/ 8 Days (3.5%)	

Growing season 3/23/2021- 11/4/2021, success criteria is 17 days.

* GWG11 installed 3/27/2020

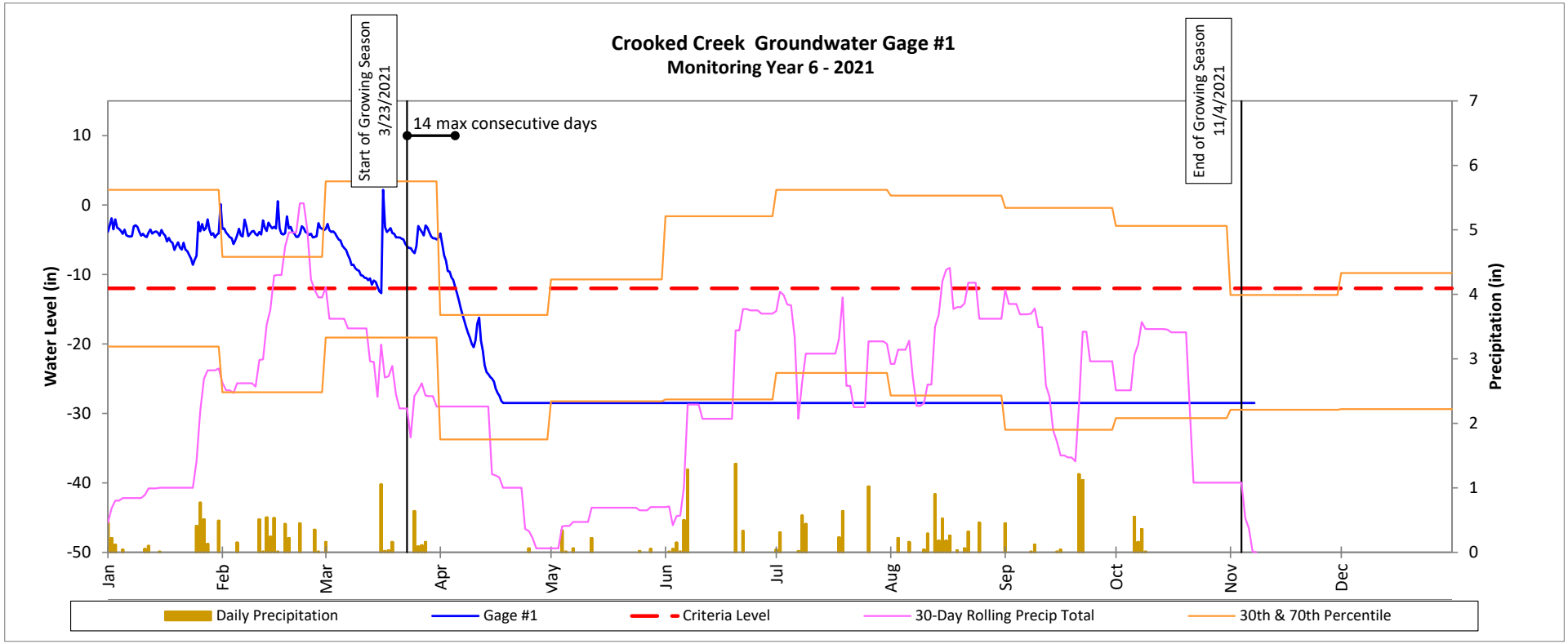
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



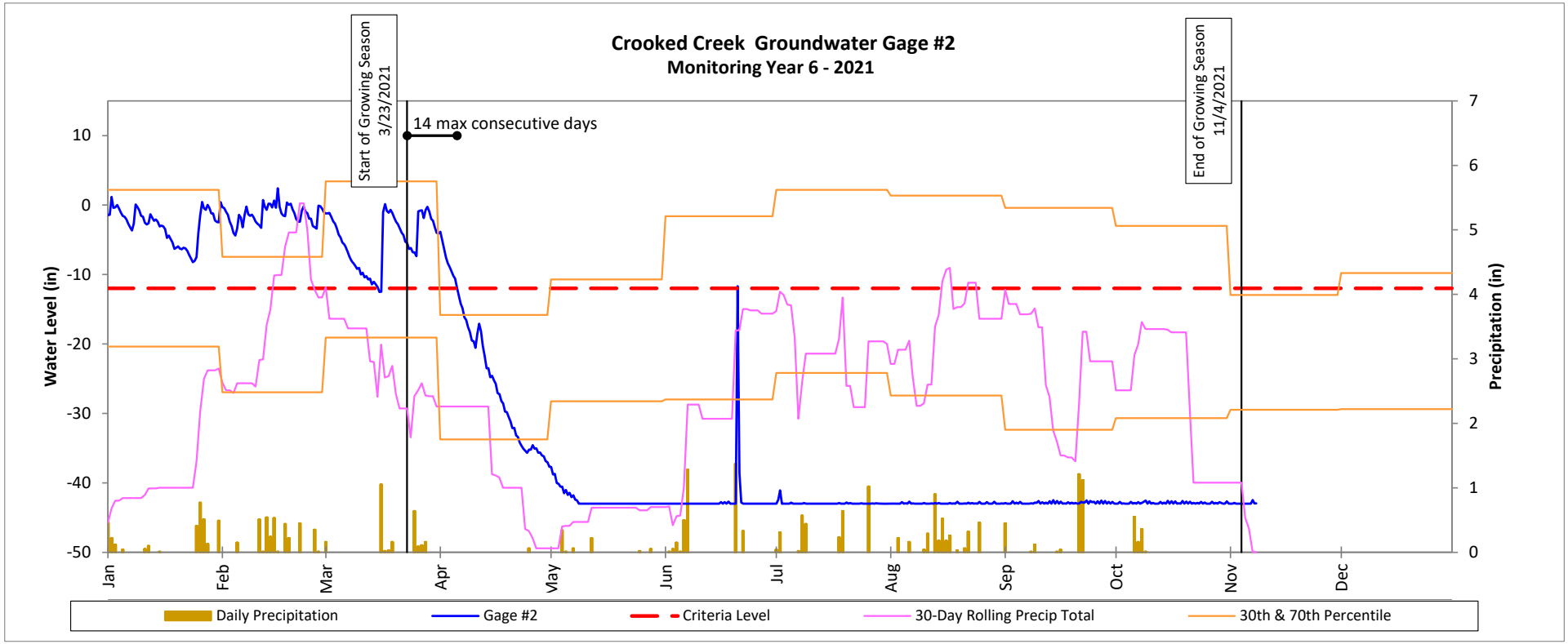
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



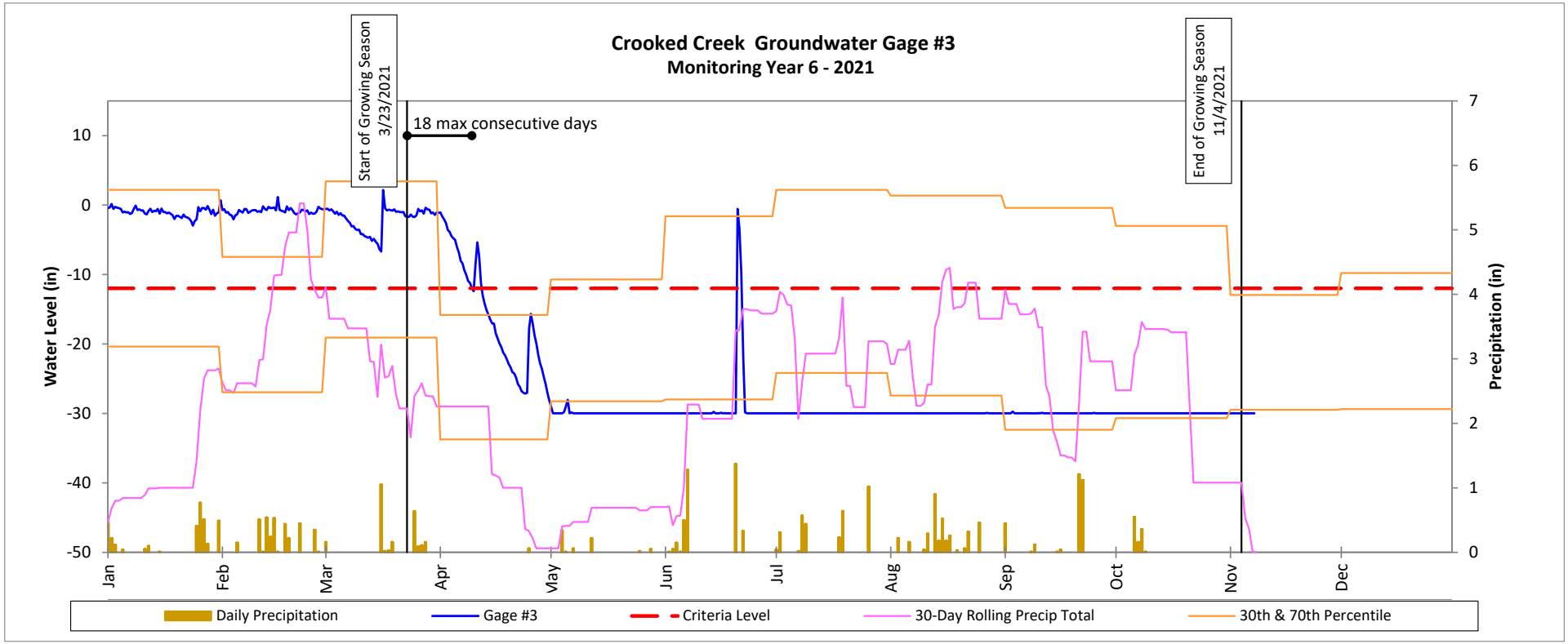
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



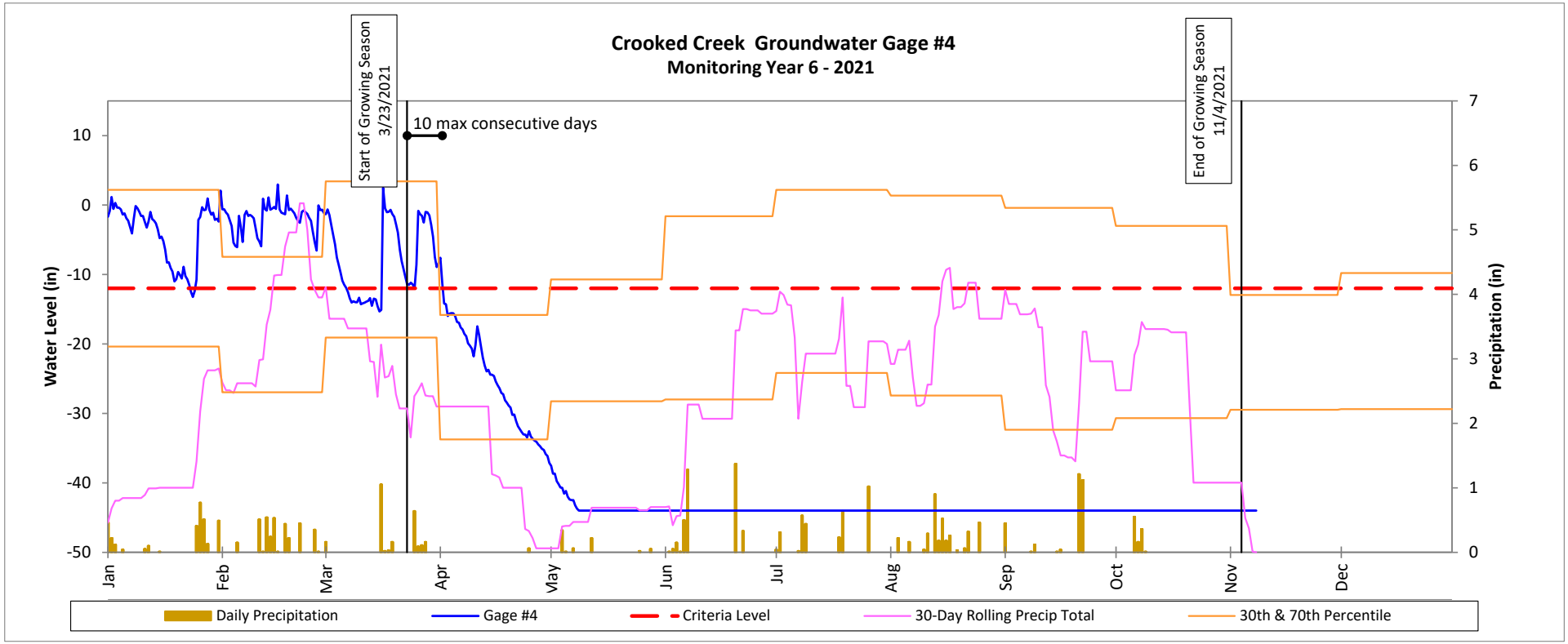
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



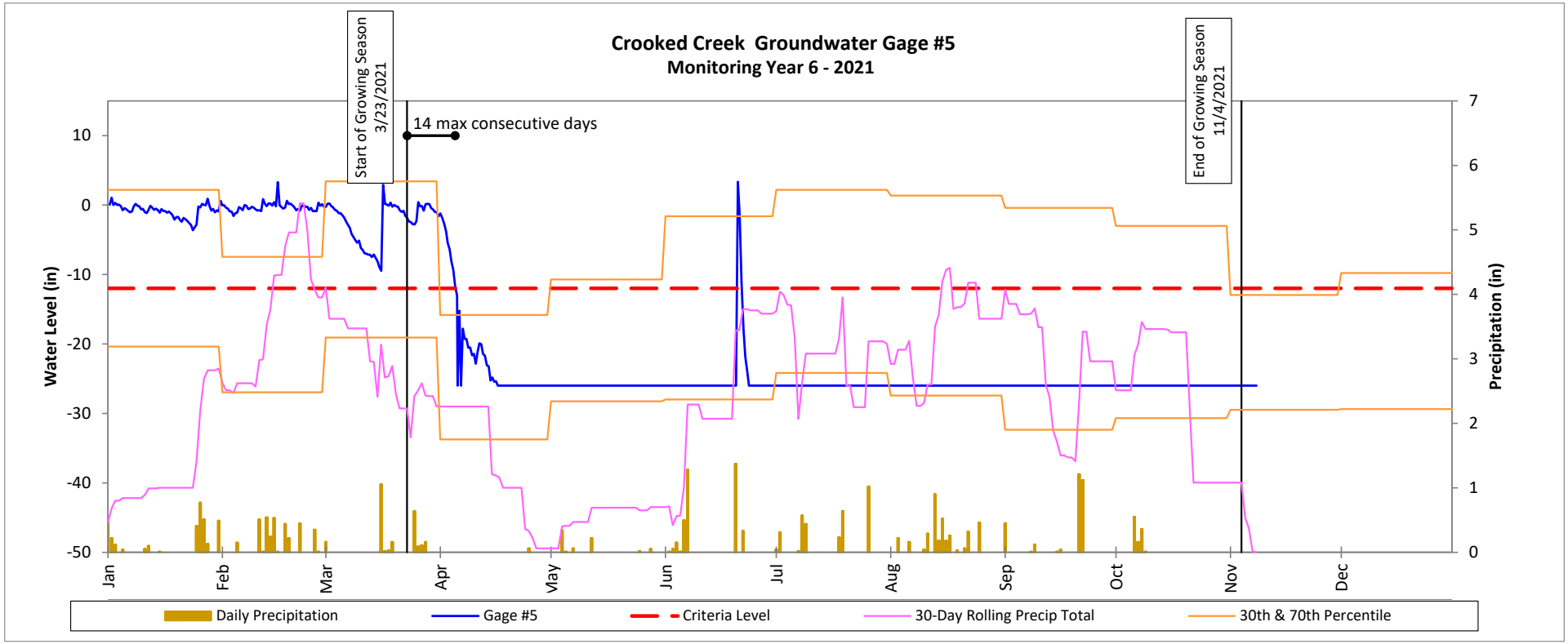
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Creation



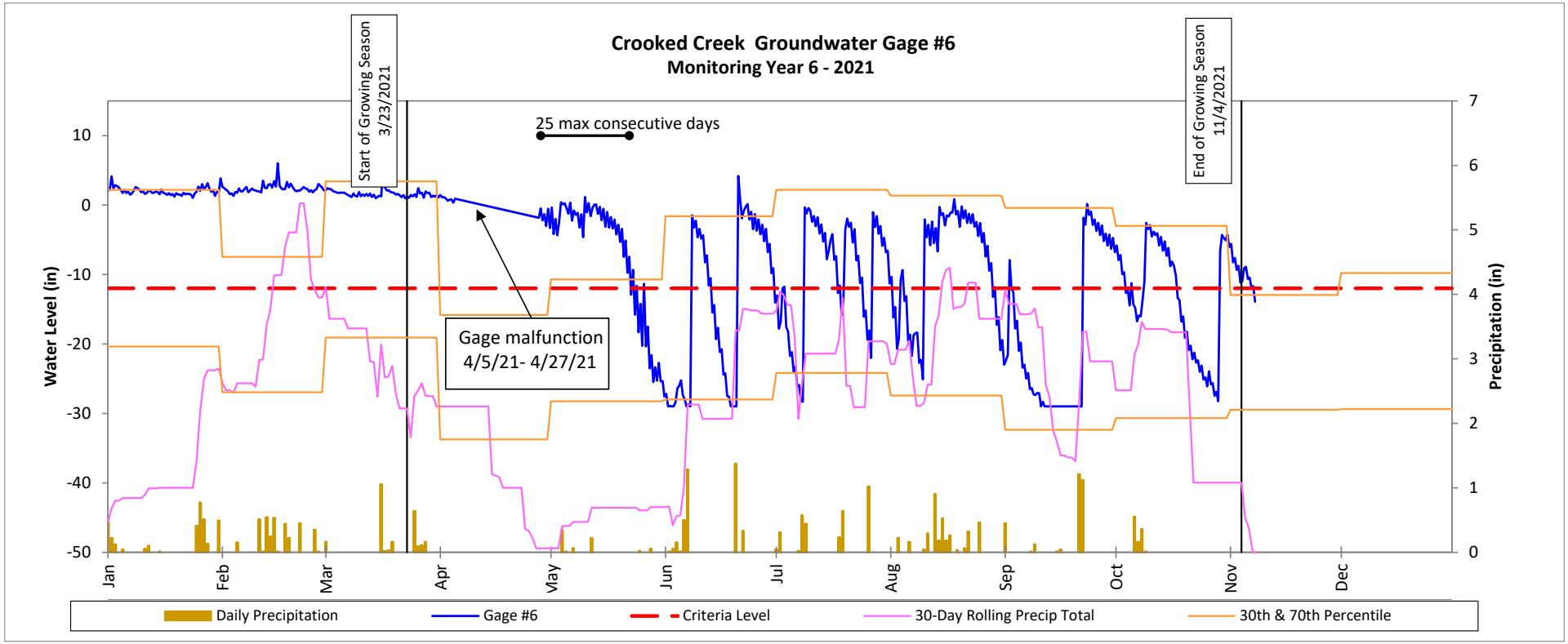
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



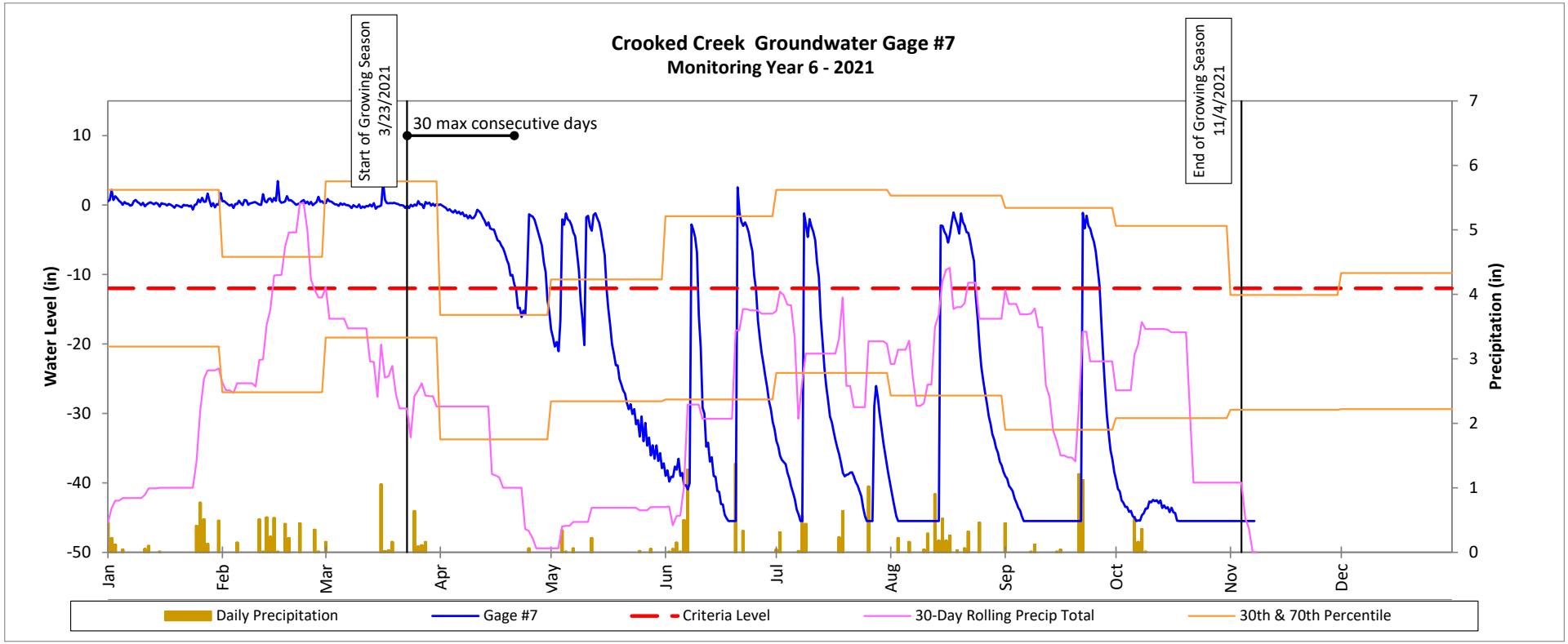
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Restoration



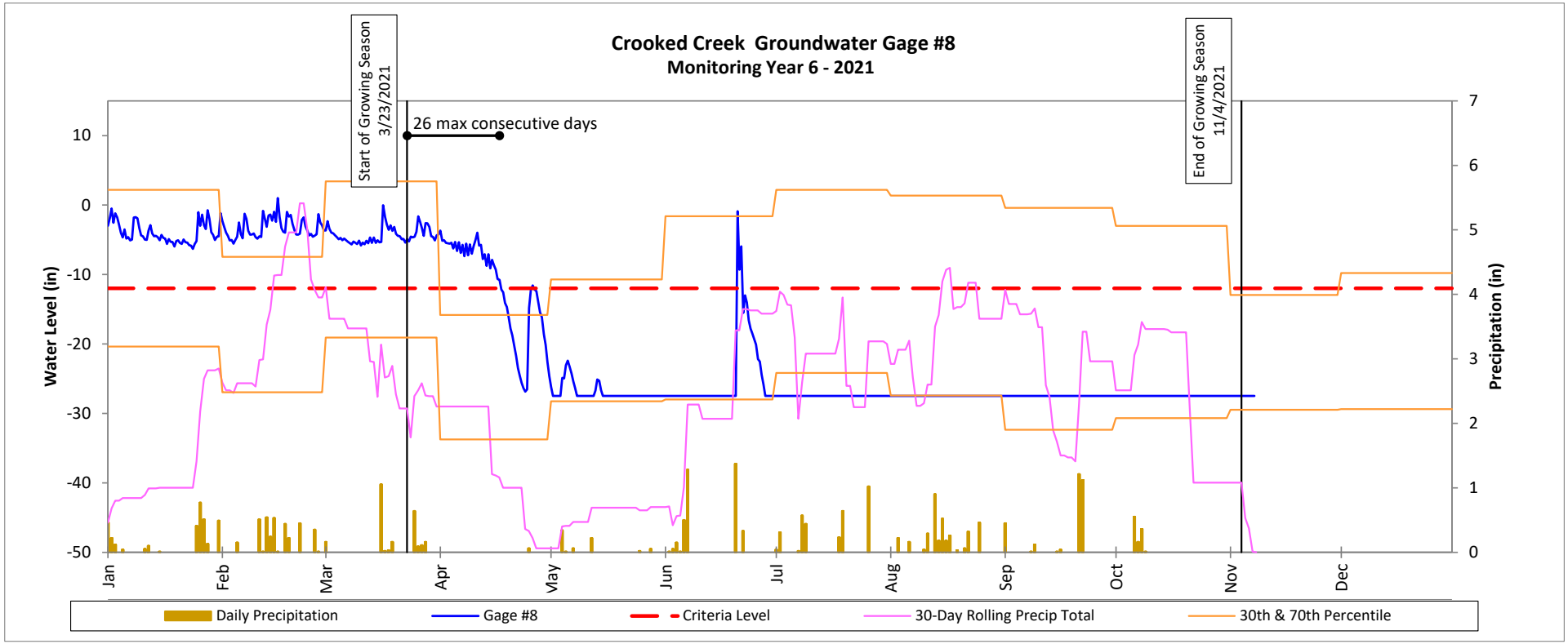
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Creation



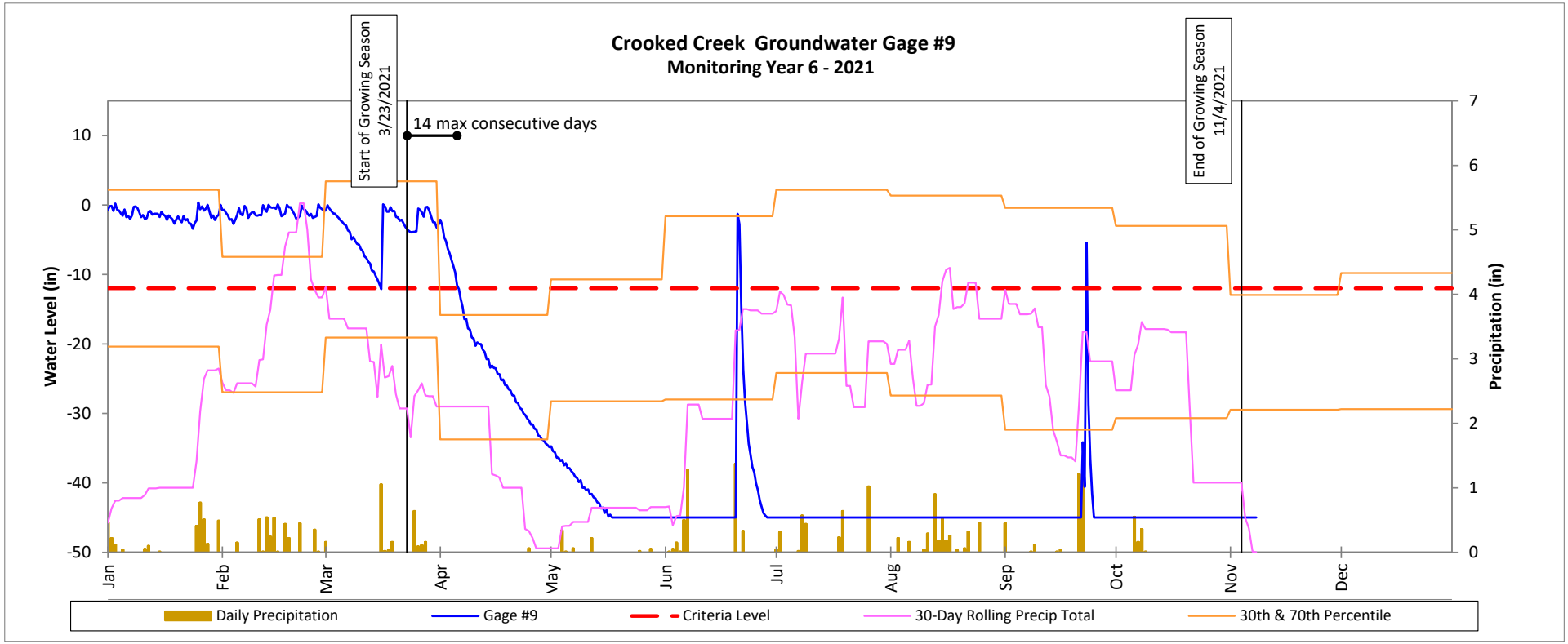
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Creation



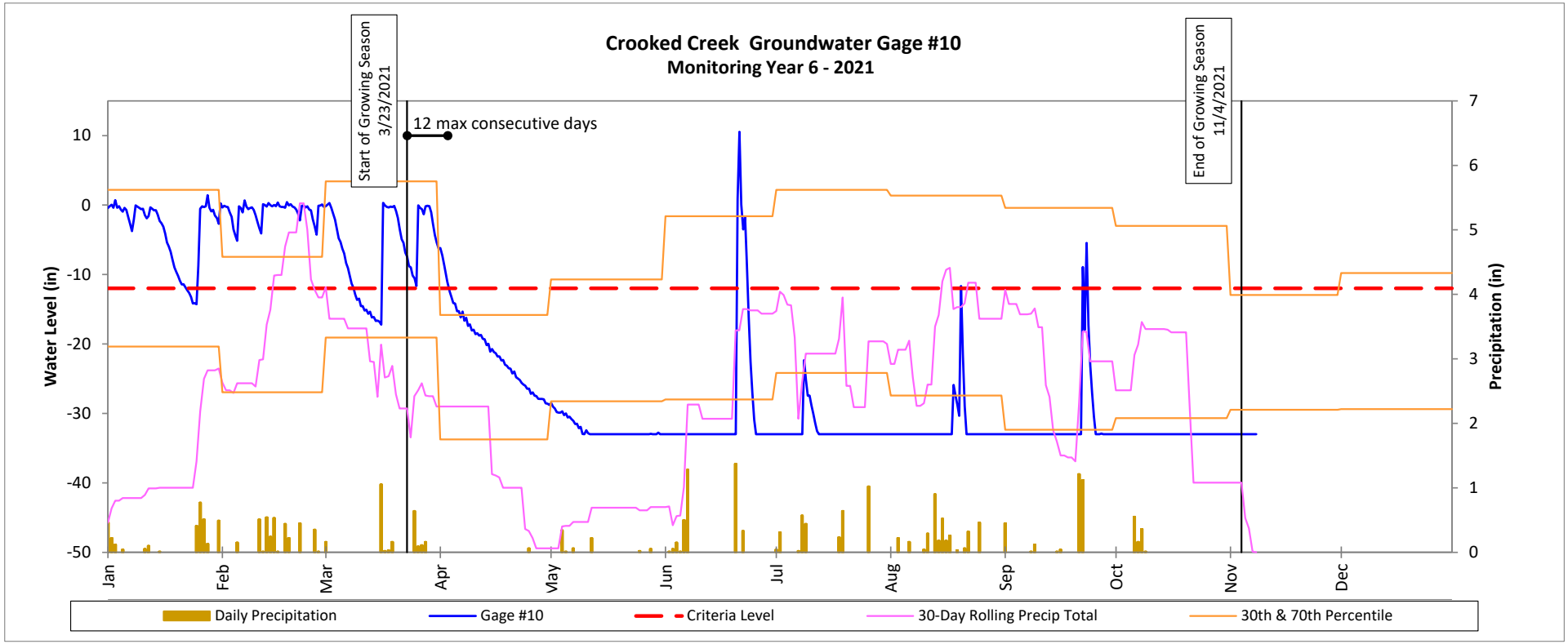
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

Wetland Creation



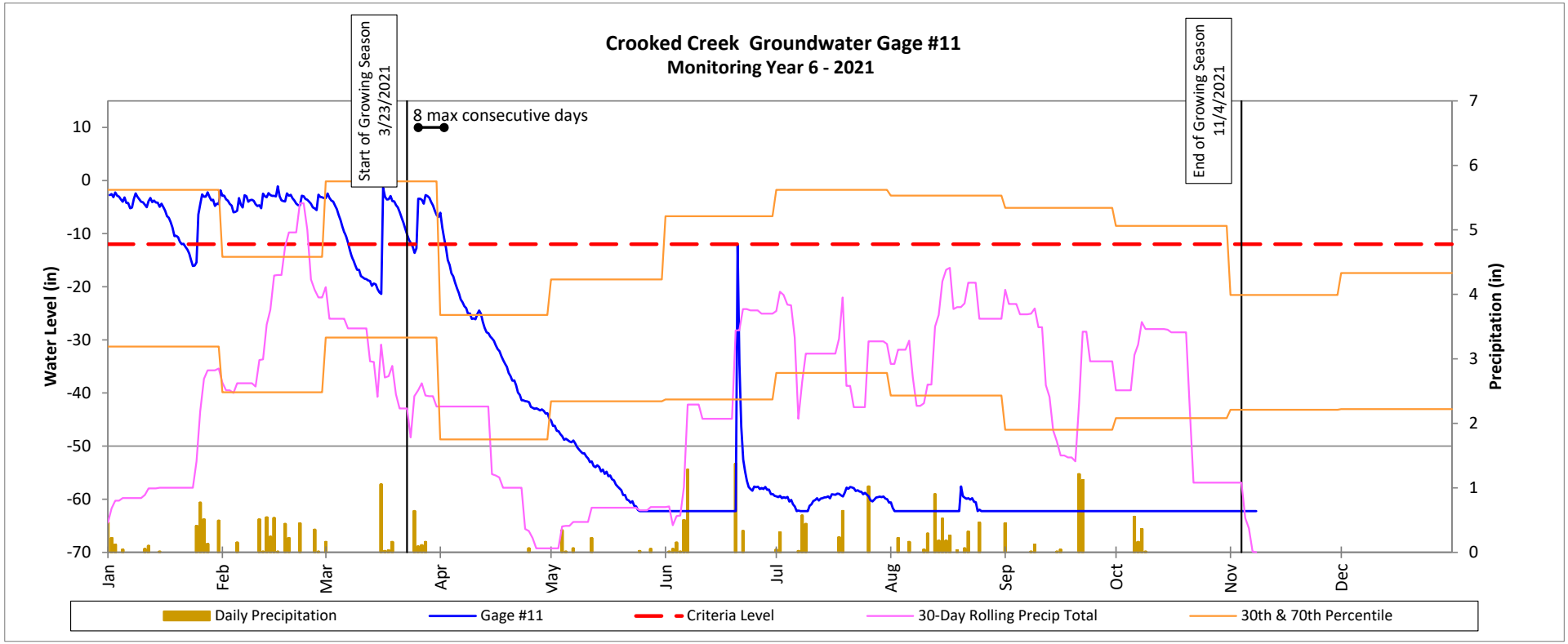
Groundwater Gage Plots

Crooked Creek #2 Restoration Project

DMS Project No. 94687

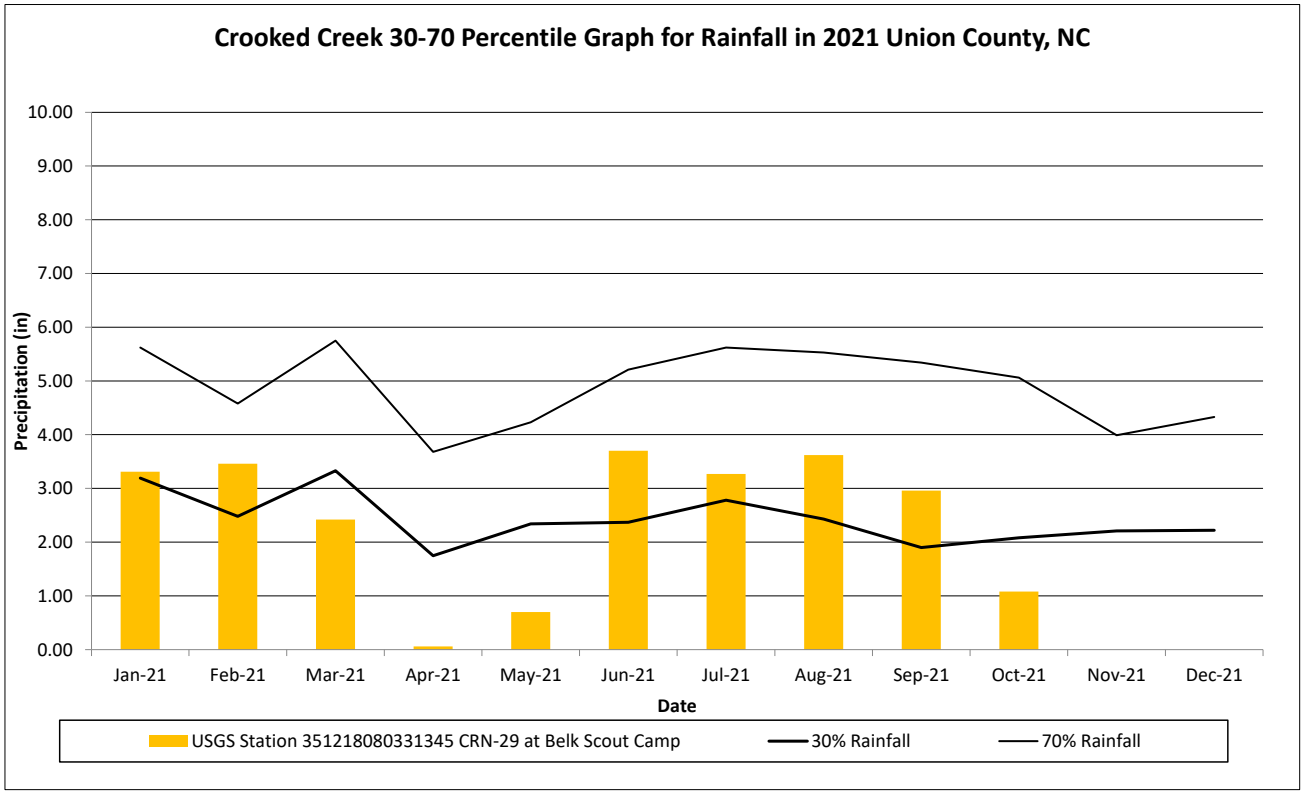
Monitoring Year 6 - 2021

Wetland Creation



Monthly Rainfall Data

Crooked Creek #2 Restoration Project
DMS Project No. 94687
Monitoring Year 6 - 2021



[1] 30th and 70th percentile rainfall data generated from WETS Table: Monroe, NC5771 (1971-2000). (USDA Field Office Climate Data, 2016)

Bankfull Wrackline and Hydrology Photographs
Monitoring Year 6

	
UT2 water in channel – UT2 (4/05/2021)	**Wrack Lines –** UT2 (4/05/2021)
	
Wrack Lines – Crooked Creek (4/05/2021)	**Wrack Lines – UT1** (4/05/2021)

APPENDIX 6. Invasive Species Treatment Logs

Michael Baker
INTERNATIONAL

We Make a Difference

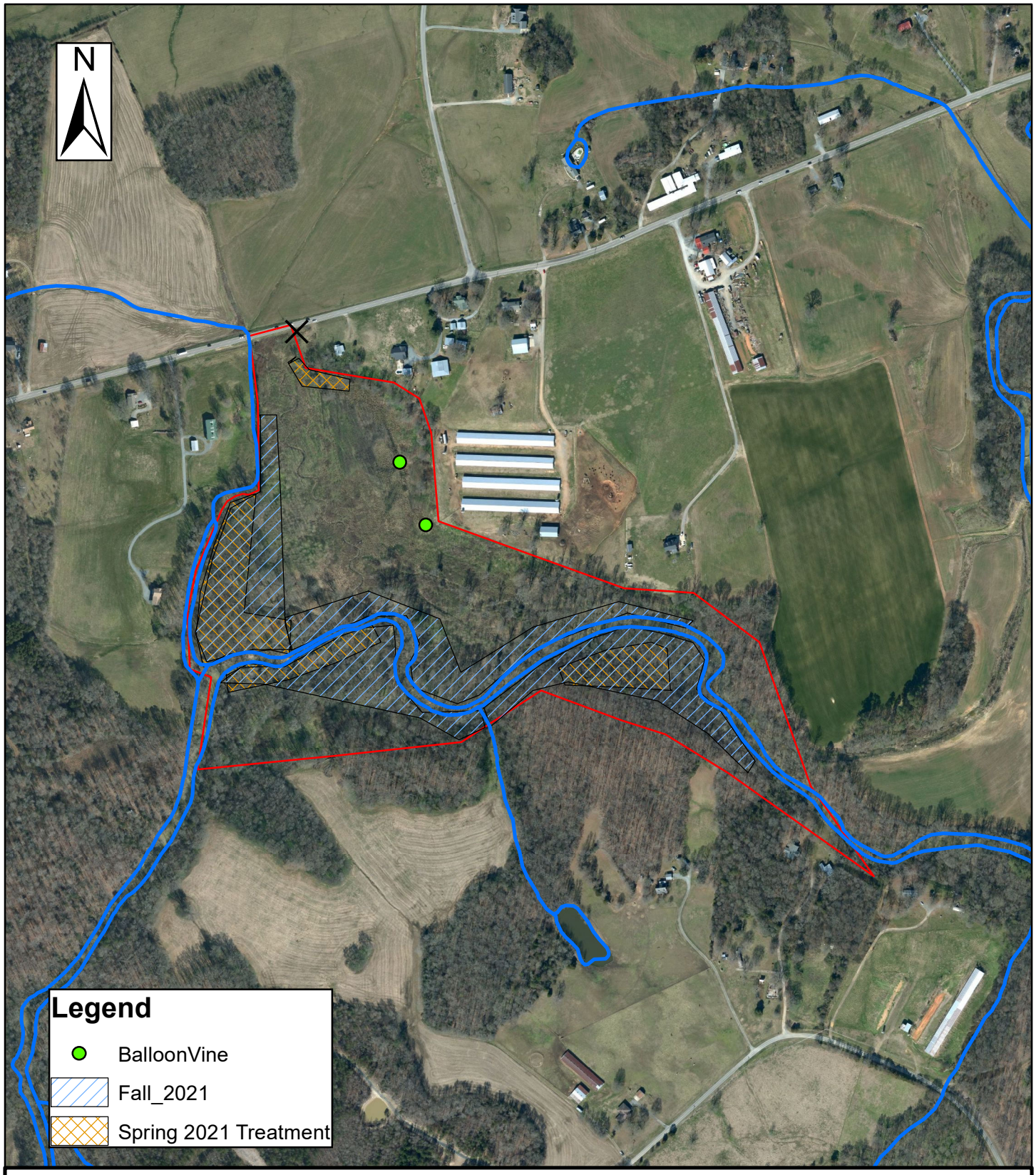
Progress Report for Crooked Creek II (DMS #94687) Invasive Vegetation Management

13 October 2020: Jason York and Drew Powers applied 10 gallons of 3% Rodeo (glyphosate) as a foliar spray on privet (*Ligustrum spp*.) along the northern bank of Crooked Creek. Approximately 60 feet from the banks were treated. Other invasive plants treated included Sacred Bamboo *(Nandina domestica),* Burning Bush *(Euonymus alata),* Japanese Honeysuckle *(Lonicera japonica),* and Callery Pear *(Pyrus calleryana)*. Privet and Callery Pear were also treated with 20% Garlon 4 in Bark Oil Blue as a basal bark application near the northern most easement boundary. No stems were treated that were tall enough to fall on the adjacent fence line. Attached is a map showing the approximate area that was treated.

23 November 2020: Jason York and Drew Powers applied 8 gallons of 4% Garlon 4 with 4% Methylated Seed Oil in Water as a foliar/basal hybrid treatment for privet (*Ligustrum spp*.) in non-aquatic areas along the eastern and southern portions of the Crooked Creek II easement. Several stems of Tree of Heaven (*Ailanthus altissima)* were also treated using the hack and squirt method with 50% glyphosate in the problem area identified on the map in the IFB. A total of 32 ounces of 50% glyphosate were used. A dense stand of young privet occurs along a slope on the southeastern side of Crooked Creek. This population will be sprayed in the spring 2021. Areas of previous treatment on October 13 are responding well. Attached is a map showing the approximate area that was treated.

29 March 2021: Jason York and Drew Powers applied 16 gallons of 4% Garlon 4 Ultra with 4% Methylated Seed Oil in Water as a foliar/basal hybrid treatment on privet (*Ligustrum spp.).* Privet was treated in the western portion of the easement as well as on the southern side of Crooked Creek near the easement boundary. Large populations of Japanese honeysuckle are present within the easement, particularly in areas where previous treatment of privet reduced competition. Honeysuckle will be targeted later in the growing season of 2021. Attached is a map showing the approximate area that has been treated thus far.

29 September 2021: Jason York and Drew Powers applied 9 gallons of 3% Rodeo as a foliar spray on privet *(Ligustrum spp.)*, Tree of Heaven (*Ailanthus altissima)*, honeysuckle (*Lonicera japonica)*, and balloon vine (*Cardiospermum halicacabum).* The majority of the treatment was focused on privet seedlings and root sprouts scattered throughout the easement on both banks of Crooked Creek. Two small patches of balloon vine were treated near the eastern boundary of the easement. Target populations of invasive species within the easement have been greatly reduced since the beginning of the contract; however, as privet populations decrease, Japanese honeysuckle spreads rapidly. Climbing vine are cut from trees and large patches are sprayed, but treatment of all honeysuckle stems is not practical is it would damage surrounding desirable vegetation Attached is a map showing the approximate area that was treated.



Michael Baker
INTERNATIONAL

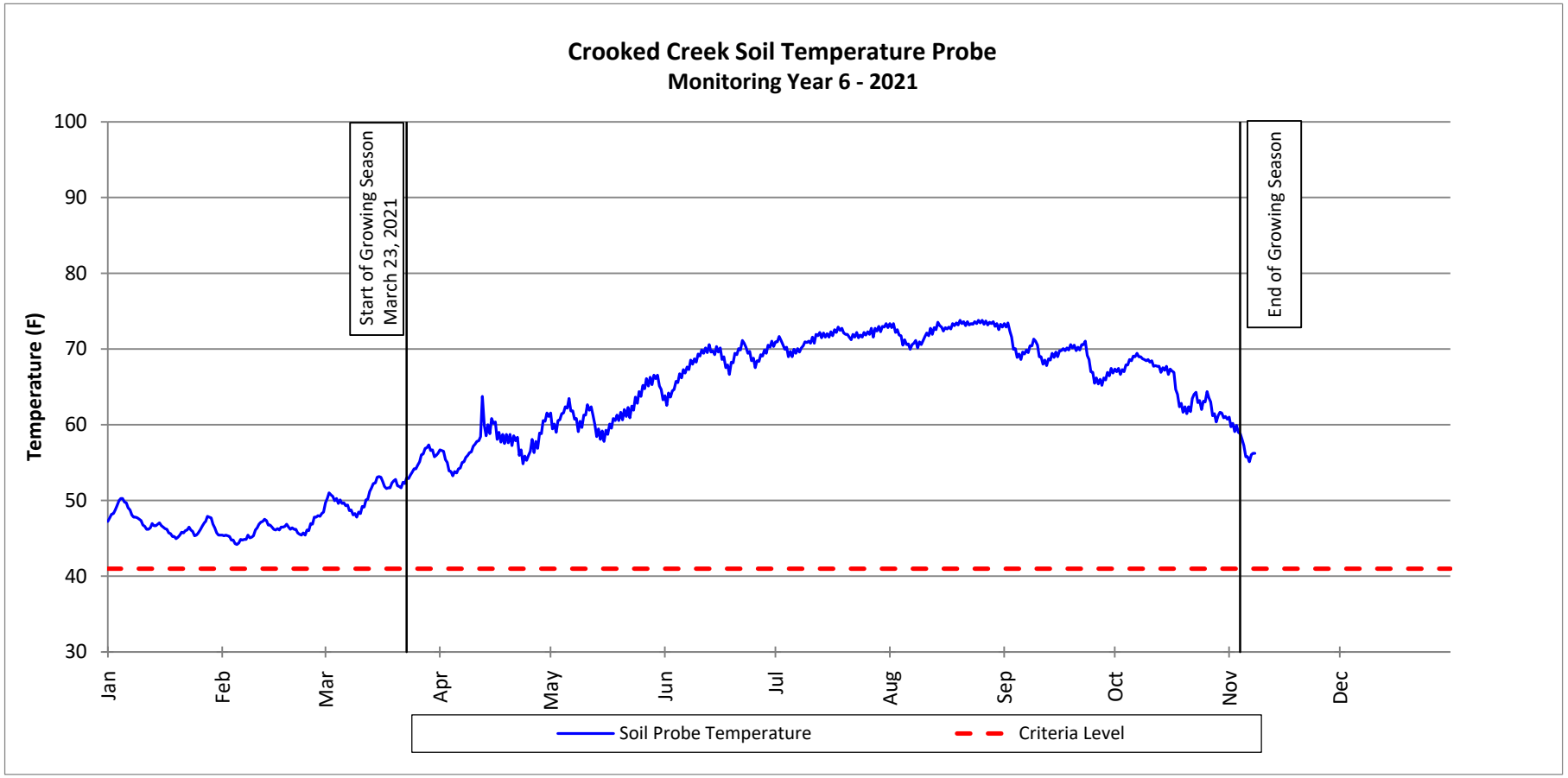
0 337.5 675 1,350
Feet

Crooked Creek II
Invasive Plant Management

APPENDIX 7. Supplemental Soils Temperature and Groundwater Gage Data

Soil Temperature Probe Plots

Crooked Creek #2 Restoration Project
(DMS Project No. 94687)
Wetland Restoration Zone A
Monitoring Year 6 - 2021



Wetland Gage Attainment Summary with Extended Growing Season

Crooked Creek #2 Restoration Project

DMS Project No. 94687

Monitoring Year 6 - 2021

GWG Attainment Summary with March 1st Growing Season Start Date		
Gage	**Most Consecutive Days Meeting Criteria**	**Percent Consecutive Days in Growing Season**
Groundwater Gage #1	**20**	**8.0%**
Groundwater Gage #2	**21**	**8.4%**
Groundwater Gage #3	**41**	**16.5%**
Groundwater Gage #4	**17**	**6.8%**
Groundwater Gage #5	**36**	**14.5%**
Groundwater Gage #6	**36**	**14.5%**
Groundwater Gage #7	**52**	**20.9%**
Groundwater Gage #8	**48**	**19.3%**
Groundwater Gage #9	**21**	**8.4%**
Groundwater Gage #10	**18**	**7.2%**
Groundwater Gage #11	**8**	**3.2%**

Growing Season March 1st to November 4th. Success Criteria of 19 days, adjusted for extended growing season.