Lochill Farm Stream Mitigation Project
Year 1 (2019) Monitoring Report Final

DMS Project ID No. 97083, DEQ Contract No. 6828

USACE Action ID No. SAW-2016-00881, DWR# 16-0370

Orange County, North Carolina, Neuse River Basin: 03020201-030030

MY1 Data Collection Period: October 2019

Submitted to/Prepared for:

NC Department of Environmental Quality
Division of Mitigation Services (DMS)
1652 Mail Service Center
Raleigh, North Carolina 27699-1652

Michael Baker
INTERNATIONAL

Submission Date: January 2020

This document was printed using 30% recycled paper.

TABLE OF CONTENTS

APPENDICES

Michael Baker
INTERNATIONAL

Michael Baker Engineering, Inc.
8000 Regency Parkway, Ste. 600 | Cary, North Carolina 27518
Office: 919.463.5488 | Fax: 919.463.5490

January 24, 2020

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

Subject: Response to DMS Comments for DRAFT MY1 Report
Lochill Farm Stream Mitigation Project, Orange County
DMS Project # 97083, DEQ Contract #6828, Neuse-01 River Basin

Ms. Crocker:

Please find enclosed our responses to the NC Division of Mitigation Services (DMS) review comments dated December 23, 2019 in reference to the Lochill Farm Stream Mitigation Project - DRAFT MY1 Report. We have revised the draft document in response to the review comments as outlined below.

Report Comments/Questions:

- Section 1.4, paragraph 2- provide a sentence that addresses the Riparian Buffer success for vegetation (i.e. state that the site meets the performance criteria of 260 stems per acre, with a minimum of four native hardwood species where no one species is greater than 50 percent of stems per NCAC for buffer).

  Response: A sentence has been added regarding the Riparian Buffer success as requested.

- Section 1.4, paragraph 3, VPA of privet-the privet identified is below the mapping threshold 1,000 sf. Also, it appears that some of the bare areas and low stem density areas are below the mapping threshold of 0.1 acre (~4,300 sf). This threshold is for individual problem areas, not for summing multiple areas. It is ok to leave this for MY1 and the detail is appreciated, but it does not need to be mapped or shown on the CCPV in future years. Having the mapping threshold standardizes the report review for site comparison purposes and understanding magnitude of problem.

  Response: In future monitoring years, the threshold reporting limits for these problem areas will be more closely adhered to, and your explanation about being able to better understand the relative magnitudes of project problems is duly noted. But given that these particular concerns had been noted during the IRT as-built walkover in July, we felt somewhat more inclined to show them in this first report.

- Table 2. Update completion/delivery date for MY1.

  Response: Revision made as requested.

- Table 7. Add Annual Means columns for MY0 for comparison.

  Response: Revision made as requested.

- Add a map with riparian buffer assets (Figure 2 in the Baseline/MY0 report).

  Response: Revision made as requested.

Michael Baker
INTERNATIONAL

Michael Baker Engineering, Inc.
8000 Regency Parkway, Ste. 600 | Cary, North Carolina 27518
Office: 919.463.5488 | Fax: 919.463.5490

Digital files:

- CVS entry tool includes plots where x or y information exceeds the bounds of the selected plot. For example, y may be equal to 15 in a plot that was indicated to be 10x10. Please ensure that the correct plot dimensions are selected for all plots.

  Response: Baker received this comment on many of our projects and spoke with DMS Science and Analysis staff to discuss further. The plot dimensions recorded in CVS were confirmed as correct for each plot. The X/Y grid coordinate portion of the CVS entry tool has always been used for internal purposes at Baker. We have used it to identify the plant plot and number (e.g. 4-15 means plot 4, plant 15) and not for internal plant location, as CVS does not otherwise provide an easy way to carry over clear plant ID numbering from year to year. Using the X/Y coordinate entry this way saves significant time each year during monitoring and helps eliminate errors by reducing confusion. We have long regarded it as a mild flaw in the CVS tool but have found this easy workaround to be a perfectly suitable rectification. Baker is happy to provide DMS with a copy of our internal veg plot maps showing individual plant locations within each plot. Based on our conversations with DMS staff, we have been given permission to continue to use the tool in this modified manner, but will use the X/Y grid entry tool as intended on all future projects.

- DMS requests the raw wetland gage data as a courtesy.

  Response: All individual wetland well gauge data has been included with the revised digital document submission files.

As requested, Baker has provided one (1) hardcopy of the FINAL report, and the updated e-submission digital files will be sent via secure ftp link. Please do not hesitate to contact me should you have any questions regarding our response submittal.

Sincerely,

Scott King, LSS, PWS
Project Manager

Enclosures

1.0 PROJECT SUMMARY

1.1 Project Description

Michael Baker Engineering, Inc. (Michael Baker) restored approximately 3,245 linear feet of existing jurisdictional stream, enhanced 2,227 linear feet of stream, and preserved 733 linear feet of unnamed tributaries to Buckwater Creek. Michael Baker also re-established approximately 3.9-acres of forested riparian buffer associated with this stream system and preserved an additional 11.9-acres. The project is located in the Neuse River Basin, within the Hydrologic Unit Code (HUC) 03020201-030030 (the Middle Eno River), which is identified as a Targeted Local Watershed (TLW) in DMS's 2010 Neuse River Basin Restoration Priority (RBRP) Plan and its March 2016 Update.

The Lochill Farm Stream Mitigation project is located on an active horse farm in Orange County, North Carolina, 6.2 miles northeast of the Town of Hillsborough (Figure 1). Historic agriculture uses on the project site include horse, cattle, and sheep animal operations as well as tobacco and small grain row-cropping and timber harvesting. These activities had negatively impacted both water quality and streambank stability along the project streams and their tributaries (Table 4). The project is being conducted as part of the NCDMS Full Delivery In-Lieu Fee Program and is anticipated to generate at close-out a total of 4,113 stream mitigation credits and 176,511 buffer mitigation credits (Table 1) and is protected by a 15.8-acre permanent conservation easement.

1.2 Goals and Objectives

The goals of this project are identified below:

- Reconnect stream reaches to their floodplains
- Stabilize steep and/or eroding stream banks
- Improve in-stream habitat
- Reestablish forested riparian buffers
- Permanently protect the project

To accomplish these goals, the following objectives were identified:

- To restore appropriate bankfull dimensions, remove spoil berms, and/or raise channel beds, by utilizing either a Priority I Restoration approach (R1) or an Enhancement Level I approach (R3).
- To construct streams of appropriate dimensions, pattern, and profile in restored reaches, slope stream banks and provide bankfull benches on enhanced streams, and utilize bio-engineering to provide long-term stability.
- Construct an appropriate channel morphology for all streams, increasing the number and depths of pools, with structures including cross vanes, geo-lifts, brush-toe, log vanes/weirs, boulder sills, root wads, and/or J-hooks. Also repair stream disconnects in the channels caused by clogged pipe culverts.
- Establish riparian buffers at a 50-foot minimum width along all stream reaches, planted with native tree and shrub species.
- Establish a permanent conservation easement restricting land use in perpetuity. This will prevent site disturbance and allow the project to mature and stabilize.

1.3 Project Success Criteria

The success criteria and performance standards for the project will follow the North Carolina Interagency Review Team (NCIRT) guidance document *Wilmington District Stream and Wetland Compensatory Mitigation Update* dated October 24, 2016 and as described in Section 7 of the approved Mitigation Plan. All specific monitoring activities will follow those outlined in detail in Section 8 of the approved Mitigation Plan and will be conducted for a period of seven years unless otherwise noted. Annual monitoring reports will follow the DMS document *Annual Monitoring Report Format, Data Requirements, and Content Guidance* from June 2017. The performance standards for the riparian buffer assets will be held in accordance with 15A NCAC 02B.0295(n)(2)(B) and 15A NCAC 02B.0295(n)(4), and annual monitoring reports will be submitted at the end of each of the first five monitoring years.

1.4 Monitoring Results and Project Performance

The Year 1 monitoring survey data of the twelve permanent cross-sections indicates that these stream sections are geomorphically stable and are within the lateral/vertical stability and in-stream structure performance categories. Certain cross-sections (as shown in Figure 3 and Table 9 in Appendix D) have shown very minor fluctuations in their geometry from last year, but these fluctuations do not represent a trend towards instability based off visual field evaluations. All reaches are stable and performing as designed, and are rated at 100 percent for all the parameters evaluated (Table 5 in Appendix B). There were no Stream Problem Areas (SPAs) identified.

During Year 1 monitoring, the planted acreage performance categories were functioning well overall. The planted stems endured fairly harsh growing conditions in their first year, with longer than usual saturated conditions in the winter and spring after planting, and then extended dry periods in the summer and fall. However, the average density of total planted stems, based on data collected from the five permanent and one random monitoring plots for the Year 1 monitoring conducted in August 2019, was 708 stems per acre (Table 7 in Appendix C). Thus, the Year 1 vegetation data demonstrate that the Site meets the minimum success interim criteria of 320 trees per acre by the end of Year 3. Furthermore, the vegetation on the project is also meeting the performance criteria for all Riparian Buffer assets, as per 15A NCAC 02B.0295(n)(2)(B), with greater than 260 stems/acre, and with a minimum of four native hardwood tree and/or shrub tree species, where no one species is greater than 50 percent of stems.

There were however, three Vegetation Problem Areas (VPAs) identified during the Year 1 monitoring (Table 6 in Appendix B). The first VPA consists of three areas of low stem density totaling 0.16 acres observed in narrow strips roughly 10 feet wide along the outer buffers of lower Reach R3 and middle Reach R1. These were areas accidentally mowed by the landowner before the fence had been installed to clearly delineate the easement boundary in the pasture. Numerous resprouts of the mowed plants were observed during the fall monitoring period, but the areas will still be supplementally planted in the winter of 2019-2020 with bare-root and/or 1-gallon plants. The second VPA consists of seven small, relatively bare areas observed in the floodplain meander bends along Reach R1 totaling 0.17 acres. These areas do have growing planted stems within them, but the herbaceous vegetation cover is only sparse/scattered. They were seeded in the fall of 2019 and will be seeded again in 2020 and until herbaceous cover is established. Finally, the third VPA consists of four small areas of observed privet (*Ligustrum sinense*) resprouts totaling about 0.02 acres. These areas will be treated in 2020. The exact locations of each of these VPAs is shown in the Current Condition Plan View (CCPV) found in Appendix B.

Additionally, during Year 1 monitoring the pipe crossing on Reach R3 was repaired. The rock side slopes had collapsed and washed out during the heavy fall and winter rains of 2018-2019 that occurred so soon after construction. The crossing slopes were rebuilt using Envirolok bags and backfilled with a soil/fill mix, and then covered on top with filter fabric and crusher-run gravel. The sidewalls of the crossing will be livestaked in the winter of 2019-2020 to establish vegetation for additional stability (see the Maintenance and Repair Photographs in Appendix B).

During Year 1 monitoring, three separate post-construction bankfull events were observed (see Table 10 in Appendix E and the Overbank Event Photographs in Appendix B). The first occurred on 2/23/19 as documented through direct photographs of the event taken on upper and lower Reach R1 along with post-flood visual evidence such as debris jams, flow scour, and wrack lines in the floodplain. The second event occurred on 4/13/19 as documented through photographs of the event taken on Reach R1, from manual cork crest gauge readings, and from visual evidence in the floodplain. The third event occurred on 6/18/19 as documented from manual cork crest gauge readings and visual evidence in the floodplain. Additionally, all three overbank events were captured on the continuous stage recorder located on Reach R1 (see Figure 4 in Appendix E).

As the observed monthly rainfall data for the project presented in Figure 6 in Appendix E demonstrates, the past 12 months have varied dramatically as compared to historic average precipitation. A total of 48.7 inches of rainfall was observed for the project, while Orange County averages 47.2 inches of annual rainfall, an excess of just 1.5 inches. However, while the winter of 2018-2019 saw much greater than average rainfall totals, several months in the summer and fall saw much less than average rainfall totals. Ultimately, the Site came under stage D1 – Moderate Drought conditions as of 10/15/19 as per the NC Drought Management Advisory Council.

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

This report documents the successful completion of the Year 1 monitoring activities for the post-construction monitoring period.

1.5 Technical and Methodological Descriptions

Stream survey data was collected to a minimum of Class C Vertical and Class A Horizontal Accuracy using a Leica TS06 Total Station and was georeferenced to the NAD83 State Plane Coordinate System, FIPS3200 in US Survey Feet, which was derived from the As-built Survey. The survey data from the permanent project cross-sections were collected and classified using the Rosgen Stream Classification System to confirm design stream type (Rosgen 1994 and 1996).

The six vegetation-monitoring quadrants (plots) were installed across the site in accordance with the CVS-DMS Protocol for Recording Vegetation, Version 4.1 (Lee 2007) and the data collected from each was input into the CVS-DMS Data Entry Tool v. 2.3.1 (CVS 2012).

Three automated groundwater monitoring wells were installed in the floodplain along Reach R1 following USACE protocols (USACE 2005). The gauges themselves are all In-Situ brand Rugged Troll 100 data loggers. These were installed at the behest of NCDWR to provide supplemental information about the stream restoration's effect on the existing adjacent jurisdictional wetlands. If during monitoring it becomes clear that the restored stream is not having any detrimental impact to the wetlands, Michael Baker may request to the IRT that the wells be removed.

The specific locations of monitoring features, such as vegetation plots, permanent cross-sections, reference photograph stations, and crest gauges, are shown on the CCPV map found in Appendix B.

1.6 References

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

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

North Carolina Division of Mitigation Services. 2010. Neuse River Basin Restoration Priorities. NC Department of Environmental Quality. Raleigh, NC.

North Carolina Division of Mitigation Services. 2016. Neuse River Basin Restoration Priorities: Neuse-01 Catalog Unit *Update*. NC Department of Environmental Quality. Raleigh, NC.

North Carolina Division of Mitigation Services. 2017. *Annual Monitoring Report Format, Data Requirements, and Content Guidance June 2017.* NC Department of Environmental Quality. Raleigh, NC.

North Carolina Interagency Review Team (NCIRT). 2016. Guidance document "*Wilmington District Stream and Wetland Compensatory Mitigation Update".* October 24, 2016

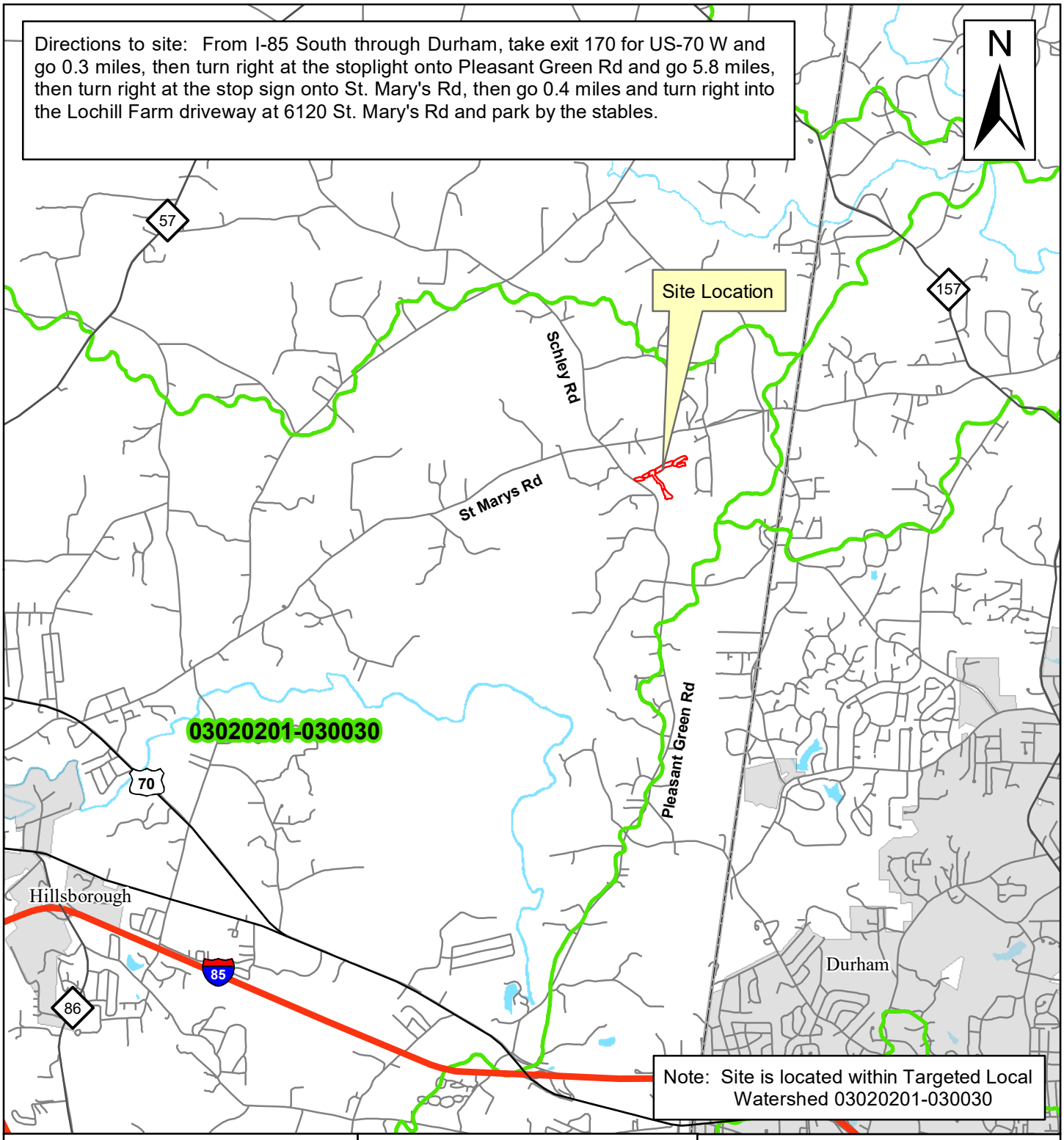
Rosgen, D.L. 1994. A Classification of Natural Rivers. Catena 22:169-199.

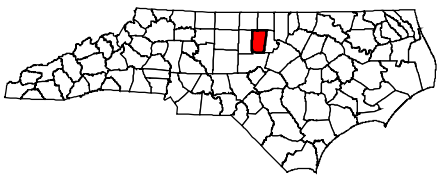
Rosgen, D.L. 1996. Applied River Morphology. Wildlands Hydrology. Pagosa Springs, CO.

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

APPENDIX A

Background Tables and Figures





Orange County

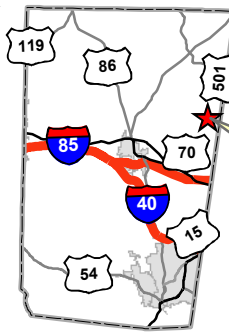
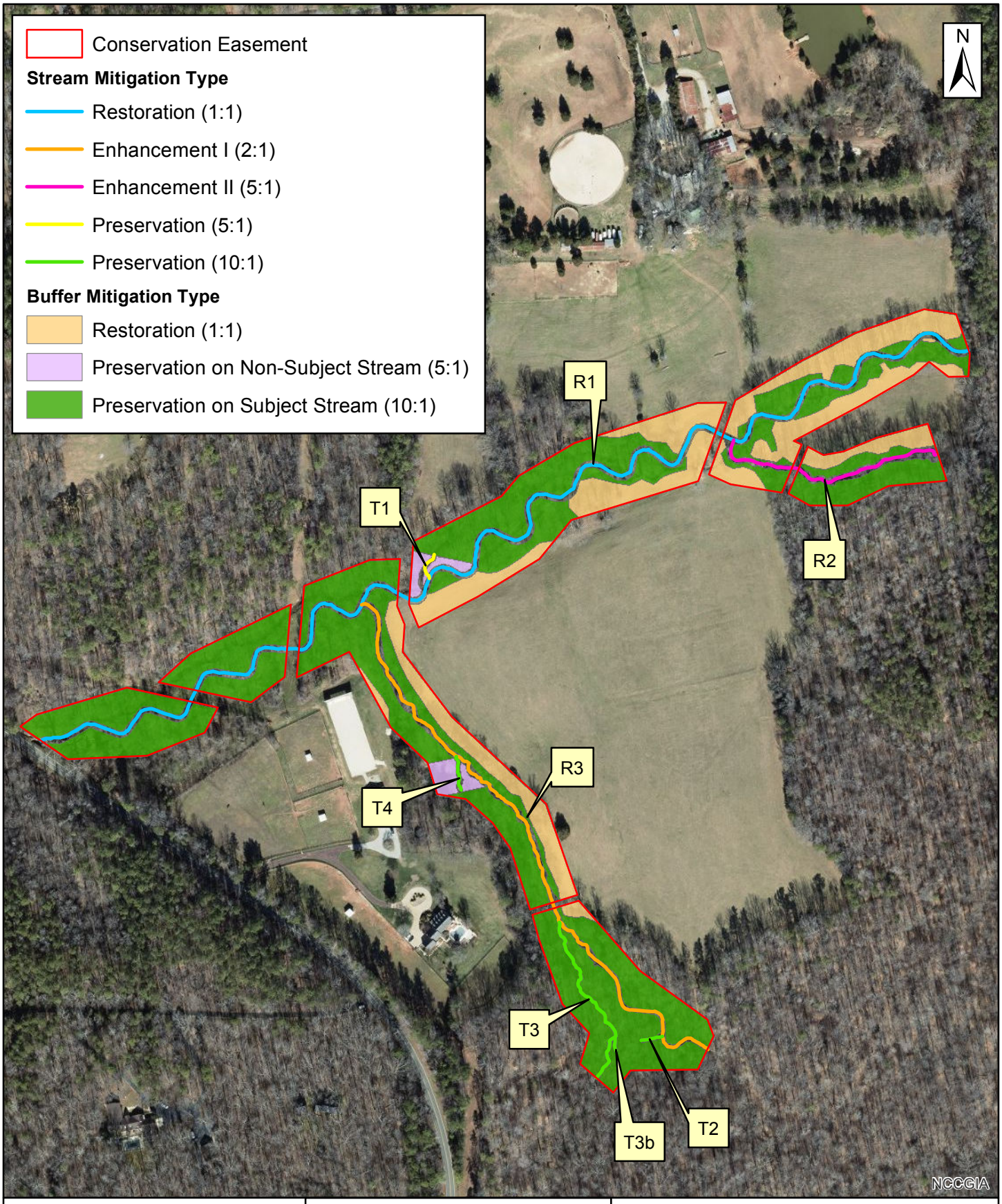


Figure 1
Project Vicinity Map
Lochill Farm Site

Michael Baker
INTERNATIONAL

0 0.5 1 2
Miles



Michael Baker INTERNATIONAL

0 250 500 Feet

Figure 2
Project Asset Map
(Stream and Riparian Buffer)
Lochill Farm Site

Table 1. Project Components and Mitigation Credits
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Project Component (reach ID, etc.)	Wetland Position and HydroType	Existing Footage or Acreage	Stationing	As-Built Restored Footage, or SF [1]	As-Built Centerline Footage, or SF [2]	Mitigation Plan Designed Footage	Restoration Level	Approach Priority Level	Mitigation Ratio (X:1)	Mitigation Plan Credits [3]
Reach R1		2,925	10+00 -42+45	3,245	3,105	3,105	R	PI	1	3,105
Reach R2		590	10+00 -16+05	605	588	600	E	LII	5	120
Reach R3		1,697	10+00 - 26+22	1,622	1,602	1,602	E	LI	2	801
Reach T1		96	10+00 - 10+73	73	73	104	P	-	5	21
Reach T2		49	10+00 - 10+54	54	54	59	P	-	10	6
Reach T3		482	10+00 - 14+82	482	482	482	P	-	10	48
Reach T3b		34	10+00 - 10+34	34	34	34	P	-	10	3
Reach T4		89	10+00 - 10+90	90	89	89	P	-	10	9
Wetland Group 1										
Buffer Group 1 (BG1)				169,553	169,553		R		1	169,553
Buffer Group 2 (BG2)				13,067	13,067		P		5	2,613
Buffer Group 3 (BG3)				424,955	43,451		P		10	4,345

1 All stream stationing and restored footage numbers reported here, discussed in the report text, and shown in the as-built plan sheets use *thalweg* survey values.

2 The stream footage reported here uses the as-built stream *centerline* survey values and have all easement breaks removed from their totals. Buffer group values reported here are the creditable areas as allowed for each group as described in detail in the mitigation plan.

3 Credits reported here are taken directly from the approved mitigation plan Table 11.1

Table 1.1
As-Built Centerline Length and Area Summations by Mitigation Category

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)	Credited Buffer (square feet)
		Riverine	Non-Riverine		
Restoration	3,105				169,553
Enhancement					
Enhancement I	1,602				
Enhancement II	588				
Creation					
Preservation	732				56,518
High Quality Pres					

Table 1.2
Overall Assets Summary

Asset Category	Overall Credits
Stream	**4,113**
RP Wetland	**-**
NR Wetland	**-**
Buffer	**176,511**

Table 2. Project Activity and Reporting History
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Elapsed Time Since grading complete:	**12 months**
Elapsed Time Since planting complete:	**10 months**
Number of Reporting Years[1]:	**1**

Activity or Deliverable	Data Collection Complete	Completion or Delivery
404 permit date	N/A	Mar-18
Mitigation Plan	N/A	Jan-18
Final Design – Construction Plans	N/A	Nov-17
Construction Grading Completed	N/A	Nov-18
As-Built Survey	Dec-18	Dec-18
Livestake and Bareroot Planting Completed	N/A	Jan-19
As-Built Baseline Monitoring Report (MY0)	Feb-19	Apr-19
Year 1 Monitoring	Oct-19	Jan-20
Year 2 Monitoring (anticipated)	Oct-20	Dec-20
Year 3 Monitoring (anticipated)	Oct-21	Dec-21
Year 4 Monitoring (anticipated)	Oct-22	Dec-22
Year 5 Monitoring (anticipated)	Oct-23	Dec-23
Year 6 Monitoring (anticipoated)	Oct-24	Dec-24
Year 7 Monitoring (anticipated)	Oct-25	Dec-25

[1] = The number of monitoring reports excluding the as-built/baseline report

Table 3. Project Contacts
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Designer	8000 Regency Parkway, Suite 600
Michael Baker Engineering, Inc.	Cary, NC 27518 Contact: Scott King, Tel. 919-481-5731
Construction Contractor	114 W. Main St.
River Works, Inc.	Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
Survey Contractor	88 Central Avenue
Kee Mapping and Surveying	Asheville, NC 28801 Contact: Brad Kee, Tel. 828-575-9021
Planting Contractor	114 W. Main St.
River Works, Inc.	Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
Seeding Contractor	114 W. Main St.
River Works, Inc.	Clayton, NC 27520 Contact: Stephen Carroll, Telephone: 919-428-8368
Seed Mix Sources	
Green Resources	Telephone: 336-855-6363
Nursery Stock Suppliers	
Mellow Marsh Farm	Telephone: 919-742-1200
ArborGen	Telephone: 843-528-3204
Monitoring Performers	
Michael Baker Engineering, Inc.	8000 Regency Parkway, Suite 600 Cary, NC 27518
Stream Monitoring POC	Scott King, Tel. 919-481-5731
Vegetation Monitoring POC	Scott King, Tel. 919-481-5731

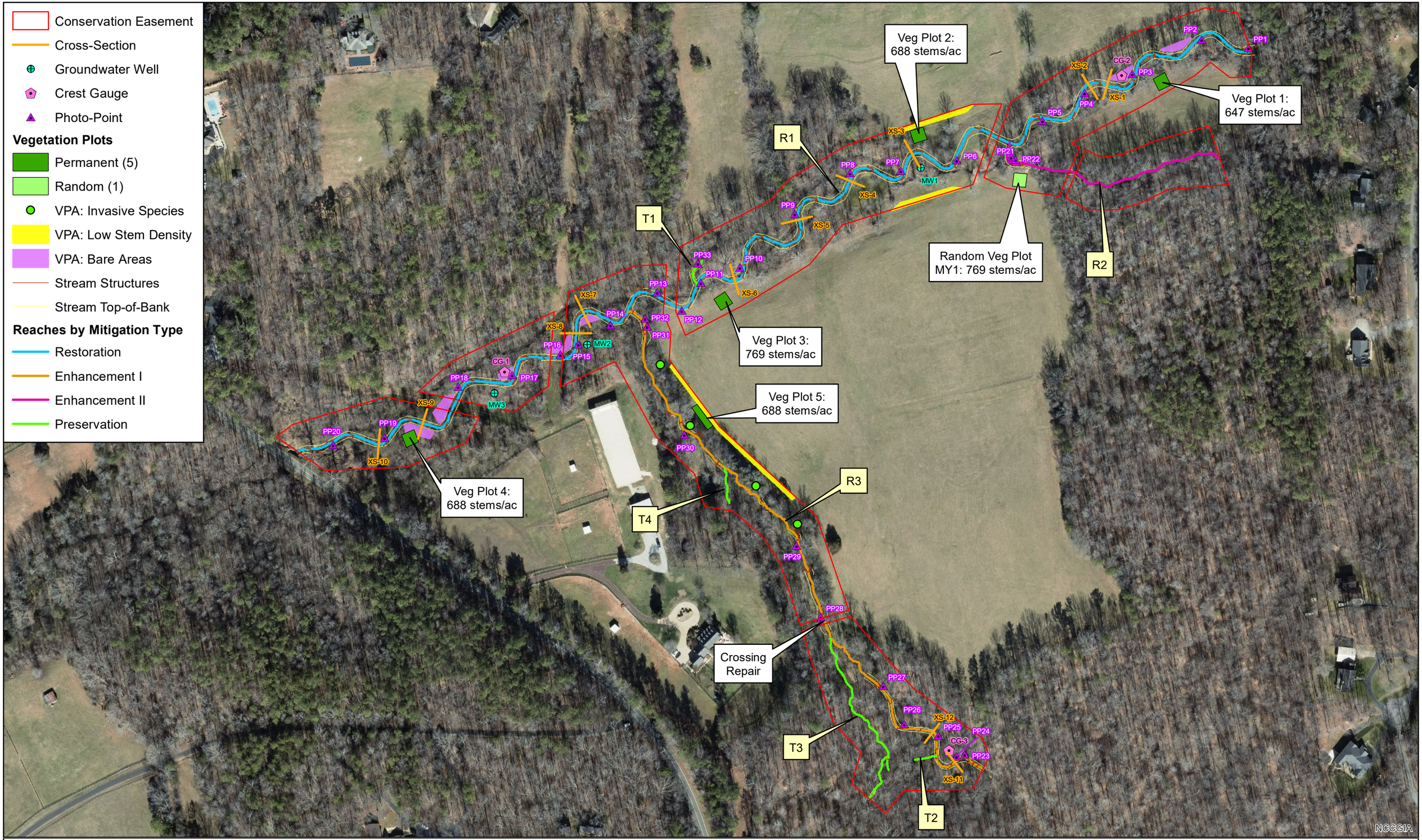
Table 4. Project Attributes

Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Project Name	Lochill Farm Stream Mitigation Project			
County	Orange County			
Project Area (acres)	15.8			
Project Coordinates (latitude and longitude)	36.113419 N, -78.991165 W			
Planted Acreage (Acres of Woody Stems Planted)	8.1			
Project Watershed Summary Information				
Physiographic Province	Piedmont			
River Basin	Neuse			
USGS Hydrologic Unit 8-digit: 3020201	USGS Hydrologic Unit 14-digit: 3020201-030030			
DWR Sub-basin	03-04-01			
Project Drainage Area (Acres and Square Miles)	1,020 acres/1.59 square miles (at downstream end of R1)			
Project Drainage Area Percentage of Impervious Area	<1% impervious area			
CGIA Land Use Classification	80.6% forested, 12.7% agriculture, 6.5% developed, 0.2% open water			
Existing Reach Summary Information				
Parameters	**Reach R1**	**Reach R2**	**Reach R3**	**Reach T1**
Length of reach (linear feet)	2,925	590	1,697	96
Valley confinement (Confined, moderately confined, unconfined)	Unconfined	Unconfined	Unconfined	Unconfined
Drainage area (Acres)	1,020	12	190	0.8
Perennial, Intermittent, Ephemeral	Perennial	Intermittent	Perennial	Intermittent
NCDWR Water Quality Classification	WS-IV, NSW	WS-IV, NSW	WS-IV, NSW	WS-IV, NSW
Stream Classification (existing)	E4 (incised)	B5	E4b to B4	E5
Stream Classification (proposed)	C4	B5	C4b	E5
Evolutionary trend (Simon)	IV - Degradation and Widening	I - Stable System	IV - Degradation and Widening	I - Stable System
FEMA classification	Zone X	Zone X	Zone X	Zone X
Existing Reach Summary Information				
Parameters	**Reach T2**	**Reach T3**	**Reach T3b**	**Reach T4**
Length of reach (linear feet)	49	482	34	89
Valley confinement (Confined, moderately confined, unconfined)	Unconfined	Unconfined	Unconfined	Unconfined
Drainage area (Acres and Square Miles)	0.7	37	36	2.9
Perennial, Intermittent, Ephemeral	Intermittent	Perennial	Perennial	Perennial
NCDWR Water Quality Classification	WS-IV, NSW	WS-IV, NSW	WS-IV, NSW	WS-IV, NSW
Stream Classification (existing)	E5	E5	E5	E5
Stream Classification (proposed)	E5	R5	E5	E5
Evolutionary trend (Simon)	I - Stable System	I - Stable System	I - Stable System	I - Stable System
FEMA classification	Zone X	Zone X	Zone X	Zone X
Regulatory Considerations				
Parameters	**Applicable?**	**Resolved?**	**Supporting Docs?**	
Water of the United States - Section 404	Yes	Yes	PCN / NWP 27 / JD	
Water of the United States - Section 401	Yes	Yes	PCN / NWP 27 / JD	
Endangered Species Act	Yes	Yes	Categorical Exclusion	
Historic Preservation Act	Yes	Yes	Categorical Exclusion	
Coastal Zone Management Act (CZMA or CAMA)	No	N/A	N/A	
FEMA Floodplain Compliance	No	N/A	N/A	
Essential Fisheries Habitat	No	N/A	N/A	

APPENDIX B

Visual Assessment Data



Michael Baker INTERNATIONAL

NCDEQ: Division of Mitigation Services
Project #97083

0 250 500 Feet

N

Figure 3. Current Condition Plan View
Monitoring Year 1
Lochill Farm Mitigation Project

Table 5. Visual Steam Morphology Stability Assessment

Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Reach ID: Reach R1							
Assessed Length (LF):	**3,245**						
Major Channel Category	**Channel Sub-Category**	**Metric**	**Number Stable, Performing as Intended**	**Total Number per As-built**	**Number of Unstable Segments**	**Amount of Unstable Footage**	**% Stable, Performing as Intended**
1. Bed	**1.Vertical Stability**	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture Substrate - Riffle maintains coarser substrate	32	32			100%
	3. Meander Pool Condition	1. Depth - Sufficent (Max Pool Depth/Mean Bkf Depth ≥ 1.5)	34	34			100%
		2. Length - Sufficent (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	34	34			100%
	4. Thalweg Position	1. Thalweg centering at upstream of meander bend (Run)	32	32			100%
		2. Thalweg centering at downstream of meander bend (Glide)	34	34			100%
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover due to active scour and erosion			0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting is expected			0	0	100%
	3. Mass Wasting	Banks slumping, caving or collapse			0	0	100%
				Totals	0	0	100%
3. Engineering Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs	38	38			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	38	38			100%
	2a. Piping	Structures lacking any substantial flow underneath or around sills or arms	38	38			100%
	3. Bank Position	Bank erosion within the structures extent of influence **does not** exceed 15%	38	38			100%
	4. Habitat	Pool forming structures maintaining - Max Pool Depth/Mean Bankfull Depth ratio ≥ 1.5. Rootwads/logs providing some cover at low flow	36	36			100%

Reach ID: Reach R2							
Assessed Length (LF):	**605**						
Major Channel Category	**Channel Sub-Category**	**Metric**	**Number Stable, Performing as Intended**	**Total Number per As-built**	**Number of Unstable Segments**	**Amount of Unstable Footage**	**% Stable, Performing as Intended**
1. Bed	**1.Vertical Stability**	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture Substrate - Riffle maintains coarser substrate	2	2			100%
	3. Meander Pool Condition	1. Depth - Sufficent (Max Pool Depth/Mean Bkf Depth ≥ 1.5)	1	1			100%
		2. Length - Sufficent (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	1	1			100%
	4. Thalweg Position	1. Thalweg centering at upstream of meander bend (Run)	1	1			100%
		2. Thalweg centering at downstream of meander bend (Glide)	1	1			100%
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover due to active scour and erosion			0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting is expected			0	0	100%
	3. Mass Wasting	Banks slumping, caving or collapse			0	0	100%
				Totals	0	0	100%
3. Engineering Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs	1	1			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	1	1			100%
	2a. Piping	Structures lacking any substantial flow underneath or around sills or arms	1	1			100%
	3. Bank Position	Bank erosion within the structures extent of influence **does not** exceed 15%	1	1			100%
	4. Habitat	Pool forming structures maintaining - Max Pool Depth/Mean Bankfull Depth ratio ≥ 1.5. Rootwads/logs providing some cover at low flow	1	1			100%

Table 5. Visual Steam Morphology Stability Assessment

Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Reach ID: Reach R3							
Assessed Length (LF):	**1,622**						
Major Channel Category	**Channel Sub-Category**	**Metric**	**Number Stable, Performing as Intended**	**Total Number per As-built**	**Number of Unstable Segments**	**Amount of Unstable Footage**	**% Stable, Performing as Intended**
1. Bed	**1.Vertical Stability**	1. Aggradation - Bar formation/growth sufficient to significantly deflect flow laterally (not to include point bars)			0	0	100%
		2. Degradation - Evidence of downcutting			0	0	100%
	2. Riffle Condition	1. Texture Substrate - Riffle maintains coarser substrate	8	8			100%
	3. Meander Pool Condition	1. Depth - Sufficent (Max Pool Depth/Mean Bkf Depth ≥ 1.5)	10	10			100%
		2. Length - Sufficent (>30% of centerline distance between tail of upstream riffle and head of downstream riffle)	10	10			100%
	4. Thalweg Position	1. Thalweg centering at upstream of meander bend (Run)	8	8			100%
		2. Thalweg centering at downstream of meander bend (Glide)	10	10			100%
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover due to active scour and erosion			0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting is expected			0	0	100%
	3. Mass Wasting	Banks slumping, caving or collapse			0	0	100%
				Totals	0	0	100%
3. Engineering Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs	19	19			100%
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill	19	19			100%
	2a. Piping	Structures lacking any substantial flow underneath or around sills or arms	19	19			100%
	3. Bank Position	Bank erosion within the structures extent of influence **does not** exceed 15%	19	19			100%
	4. Habitat	Pool forming structures maintaining - Max Pool Depth/Mean Bankfull Depth ratio ≥ 1.5. Rootwads/logs providing some cover at low flow	17	17			100%

Table 6. Vegetation Conditions Assessment

Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Planted Acreage: 9.8						
Vegetation Category	**Defintions**	**Mapping Threshold (acres)**	**CCPV Depiction**	**Number of Polygons**	**Combined Acreage**	**% of Planted Acreage**
1. Bare Areas *	Very limited cover both woody and herbaceous material.	0.1	Purple polygon	7	0.17	1.7%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1	Yellow polygon	3	0.16	1.6%
			Total	**10**	**0.33**	**3.4%**
3. Areas of Poor Growth Rates or Vigor	Areas with woody stems or a size class that are obviously small given the monitoring year.	0.25	N/A	0	0.00	0.0%
			Cumulative Total	**10**	**0.33**	**3.4%**
Easement Acreage: 15.8						
Vegetation Category	**Defintions**	**Mapping Threshold**	**CCPV Depiction**	**Number of Points**	**Combined Acreage**	**% of Planted Acreage**
4. Invasive Areas of Concern	Areas or points (if too small to render as polygons at map scale)	1000 ft²	Green Points	4	0.02	0.1%
5. Easement Encroachment Areas	Areas or points (if too small to render as polygons at map scale)	none	N/A	0	0.00	0.0%

* The bare areas reported here for MY1 **do** have woody stems growing in them but have sparse/scattered herbaceous cover only.

Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-1: Reach 1, view downstream, Station 10+00

PP-2: Reach 1, view downstream, Station 11+50

PP-3: Reach 1, view downstream, Station 13+75

PP-4: Reach 1, view downstream, Station 15+25

PP-5: Reach 1, view downstream, Station 16+50

PP-6: Reach 1, view upstream, Station 19+50

Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-7: Reach 1, view downstream, Station 21+50

PP-8: Reach 1, view downstream, Station 23+00

PP-9: Reach 1, view downstream, Station 25+00

PP-10: Reach 1, view upstream, Station 27+50

PP-11: Reach 1, view downstream, Station 29+00

PP-12: Reach 1, view downstream, Station 30+00

Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-13: Reach 1, view downstream, Station 30+50

PP-14: Reach 1, view downstream, Station 32+00

PP-15: Reach 1, view downstream, Station 33+50

PP-16: Reach 1, view downstream, Station 34+25

PP-17: Reach 1, view downstream, Station 35+75

PP-18: Reach 1, view downstream, Station 37+25

Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-19: Reach 1, view downstream, Station 39+75

PP-20: Reach 1, view downstream, Station 41+00

PP-21: Reach 2, view upstream, Station 15+50

PP-22: Reach 2, view downstream, Station 15+75

PP-23: Reach 3, view upstream, Station 10+50

PP-24: Reach 3, view downstream, Station 10+75

Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-25: Reach R3, view upstream, Station 11+75

PP-26: Reach 3, view downstream, Station 12+75

PP-27: Reach 3, view downstream, Station 14+00

PP-28: Reach 3, view downstream, Station 16+25

PP-29: Reach 3, view downstream, Station 18+25

PP-30: Reach 3, view downstream, Station 22+50

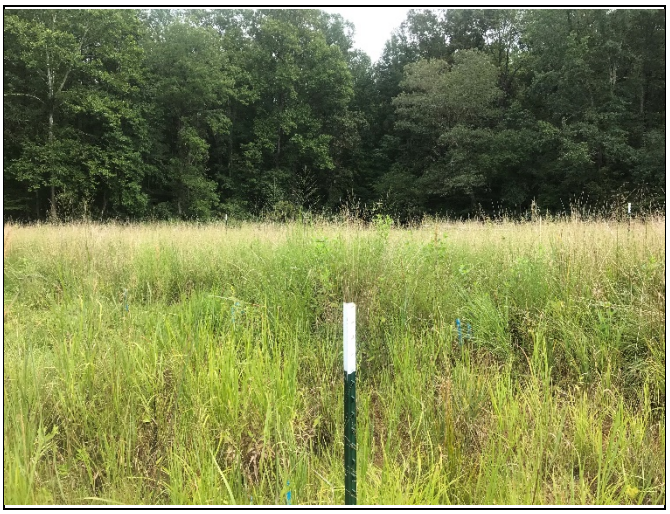
Lochill Farm: MY1 Stream Station Photo-Points (taken 10/23/19)

PP-31: Reach 3, view upstream, Station 25+50

PP-32: Reach 3, view downstream, Station 25+75

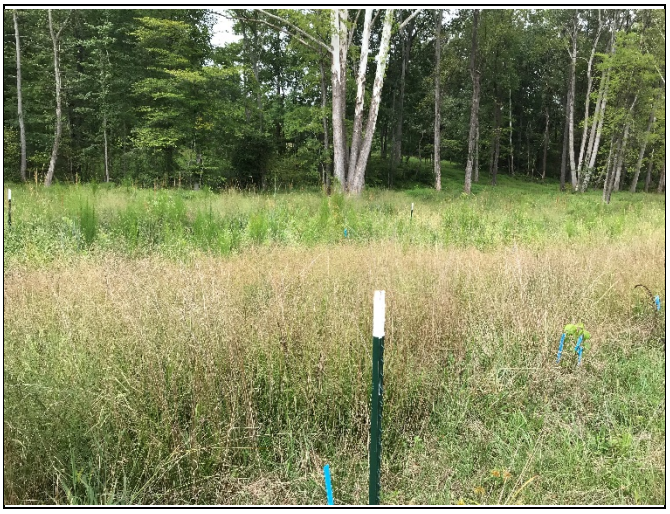
PP-33: Reach T1, view downstream, Station 10+00

Lochill Farm: MY1 Vegetation Plot Photographs (taken 8/26/19)



Vegetation Plot 1

Vegetation Plot 2



Vegetation Plot 3

Vegetation Plot 4

Vegetation Plot 5

Random Vegetation Plot MY1

Lochill Farm: MY1 Vegetation Problem Area (VPA) Photographs

Privet Re-Sprouts along Reach 3 at Station 22+50

Thin herbaceous vegetation establishment in floodplain on R1 at Station 11+75

Thin herbaceous vegetation establishment in floodplain on R1 at Station 13+50

Thin herbaceous vegetation establishment in floodplain on R1 at Station 32+00

Thin herbaceous vegetation establishment in floodplain on R1 at Station 37+50

Thin herbaceous vegetation establishment in floodplain on R1 at Station 38+75

Lochill Farm: MY1 Overbank Event Photographs

Overbank event on lower R1 (photo: 2/23/19)

Overbank event on upper R1 (photo: 2/23/19)

Wrack line on upper R1 floodplain (photo: 3/7/19)

Debris jams by automated crest gauge and tree stem on lower R1 floodplain (photo: 3/7/19)

Overbank event on upper R1 (photo: 4/13/19)

Overbank event on upper R1 (photo: 4/13/19)

Lochill Farm: MY1 Overbank Event Photographs

Manual crest gauge on upper R1 reading 0.71 ft
(photo: 4/18/19)

Debris jam by manual crest gauge on upper R1
(photo: 4/18/19)

Manual crest gauge on upper R3 reading 0.30 ft
(photo: 4/18/19)

Debris jam by manual crest gauge on upper R3
(photo: 4/18/19)

Debris jam on tree stem in floodplain of upper R3
(photo: 4/18/19)

Debris jam on tree in floodplain of upper R3
(photo: 4/18/19)

Lochill Farm: MY1 Overbank Event Photographs

Evidence of scour and debris deposition in floodplain overflow pipe at crossing in upper R3 (photo: 4/18/19)

Wrack line of straw/debris in floodplain of upper R3 (photo: 4/18/19)

Debris jam in lower R1 (photo: 4/18/19)

Debris jam on tree stem in upper R1 (photo: 4/18/19)

Manual crest gauge on upper R1 reading 0.81 ft (photo: 6/19/19)

Debris jams on tree stems in upper R1 (photo: 6/19/19)

Lochill Farm: MY1 Overbank Event Photographs

Debris jam on tree stem in upper R1 (photo: 6/19/19)

Debris jams in floodplain of upper R1 (photo: 6/19/19)

Manual crest gauge on upper R3 reading 0.29 ft (photo: 6/19/19)

Manual crest gauge on upper R3 reading 0.29 ft (photo: 6/19/19)

Debris jam by manual crest gauge on upper R3 (photo: 6/19/19)

Scour flow paths and debris in floodplain of upper R3 (photo: 6/19/19

Lochill Farm: MY1 Maintenance and Repair Photographs

Pipe crossing collapse on R3 (upstream side) at Station 16+20

Pipe crossing collapse on R3 (downstream side) at Station 16+50

Repaired pipe crossing on R3 (upstream side) at Station 16+20

Repaired pipe crossing on R3 (downstream side) at Station 16+50

APPENDIX C

Vegetation Plot Data

Table 7. Planted Stem Counts by Plot and Species
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

			Current Plot Data (MY1 2019)																		Annual Means			Annual Means
			Veg Plot 1			Veg Plot 2			Veg Plot 3			Veg Plot 4			Veg Plot 5			MY1 Random Plot[1]			MY1 (2019)			MY0/AB (2019)
Scientific Name	Common Name	Species Type	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P	V	T	P
Acer negundo	Box Elder	Tree							1		1	1		1	2		2				4		4	5
Alnus serrulata	Tag Alder	Shrub Tree				1		1	3		3	1		1	1		1				6		6	6
Asimina triloba	Pawpaw	Shrub Tree																						1
Betula nigra	River Birch	Tree	2		2	7		7	1		1	4		4	2		2	1		1	17		17	18
Carpinus caroliniana	Iron Wood	Shrub Tree	4		4	3		3	1		1				1		1	1		1	10		10	10
Celtis laevigata	Sugarberry	Shrub Tree				1		1	2		2	2		2	1		1	3		3	9		9	7
Fraxinus pennsylvanica	Green Ash	Tree	3		3							1		1				1		1	5		5	5
Ilex verticillata	Winterberry	Shrub Tree							2		2							1		1	3		3	3
Lindera benzoin	Northern Spicebush	Shrub Tree							2		2	1		1							3		3	3
Liriodendron tulipifera	Tulip Poplar	Tree	6		6	1		1				2		2	1		1	2		2	12		12	10
Nyssa sylvatica	Black Gum	Tree										1		1							1		1	1
Platanus occidentalis	Sycamore	Tree	1		1	4		4	3		3	3		3	5		5	8		8	24		24	19
Quercus michauxii	Swamp Chestnut Oak	Tree										1		1							1		1	1
Quercus phellos	Willow Oak	Tree							2		2				1		1				3		3	7
Viburnum dentatum	Arrow-wood	Shrub Tree													3		3	2		2	5		5	5
Viburnum nudum	Possumhaw	Shrub Tree							2		2										2		2	2
		Stem count	16	0	16	17	0	17	19	0	19	17	0	17	17	0	17	19	0	19	105	0	105	103
		size (ares)	1			1			1			1			1			1			6			6
		size (ACRES)	0.025			0.025			0.025			0.025			0.025			0.025			0.148			0.148
		Species count	5	0	5	6	0	6	10	0	10	10	0	10	9	0	9	8	0	8	15	0	15	16
		Stems per ACRE	647	0	647.5	688	0	688	769	0	768.9	688	0	688	688	0	688	769	0	769	708	0	708	695

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%

P = Planted Stem
V = Volunteer
T = Total

[1] Plot MY1 is a randomly located vegetation plot that will move locations each monitoring year.

APPENDIX D

Stream Geomorphology Data

Figure 3. Cross-Sections with Annual Overlays

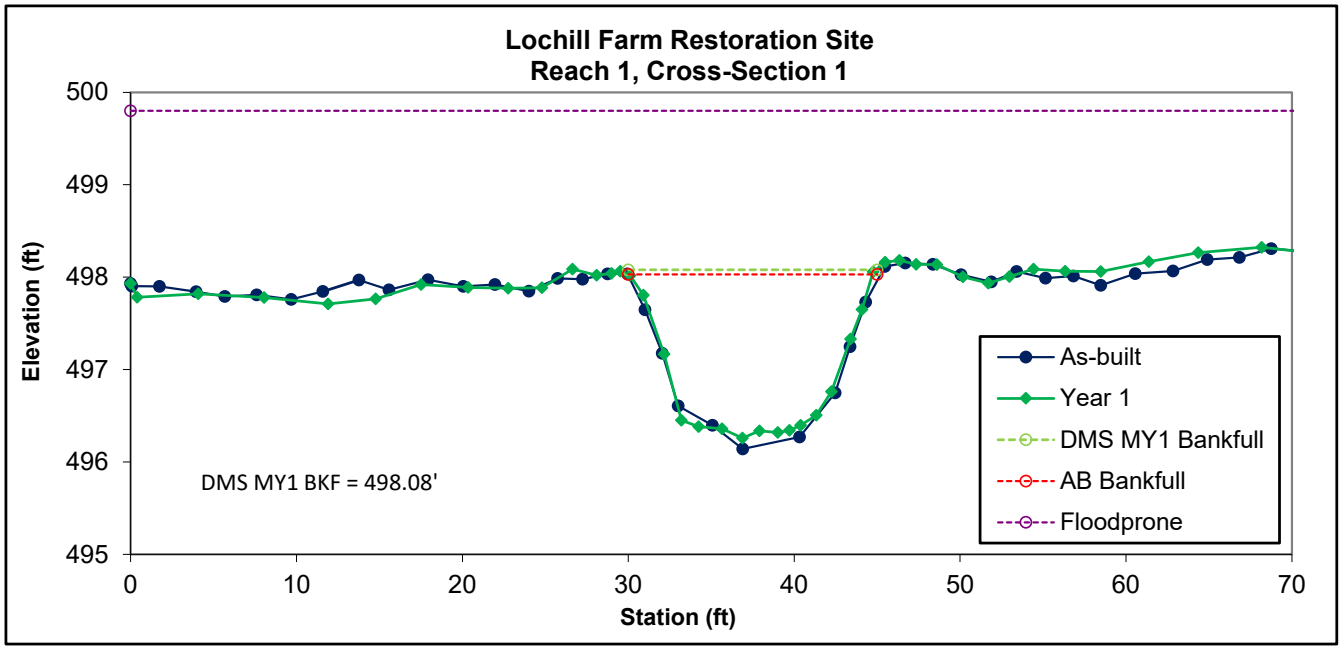
Permanent Cross-Section 1

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	18.5	14.8	1.3	1.8	11.7	1.0	5.1	498.03	498.06



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

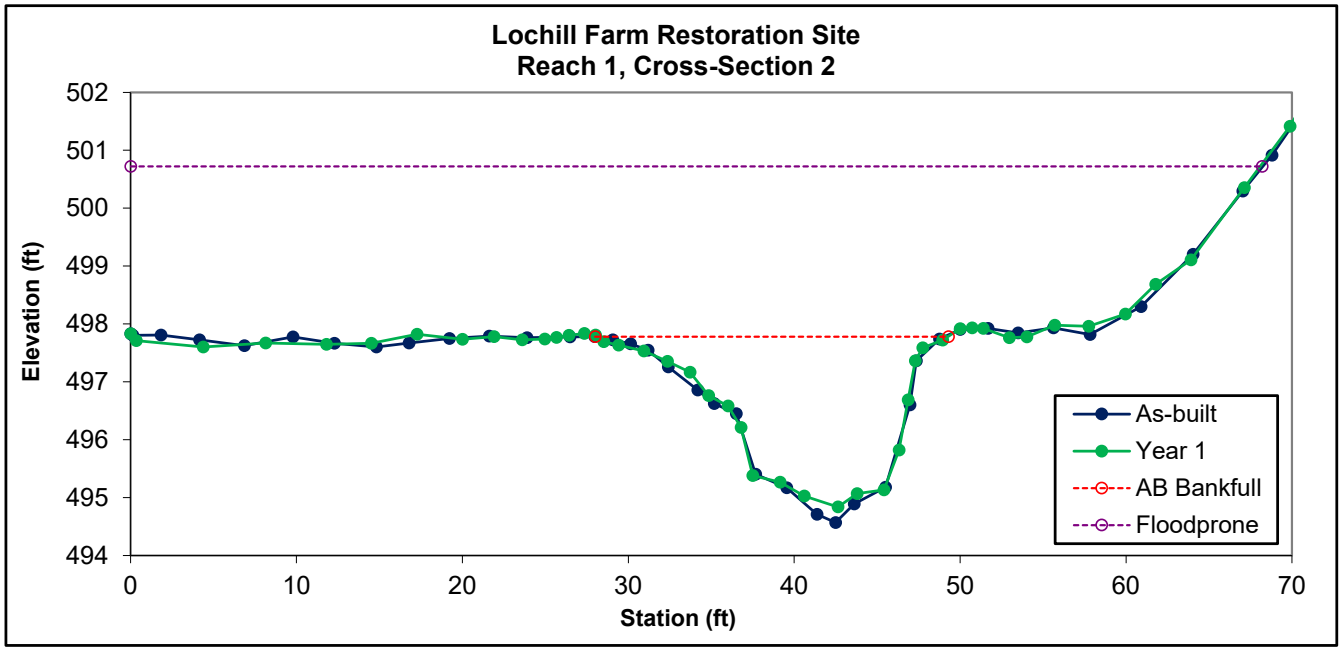
Permanent Cross-Section 2

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	31.3	22.3	1.4	2.9	16.1	--	--	497.78	497.81



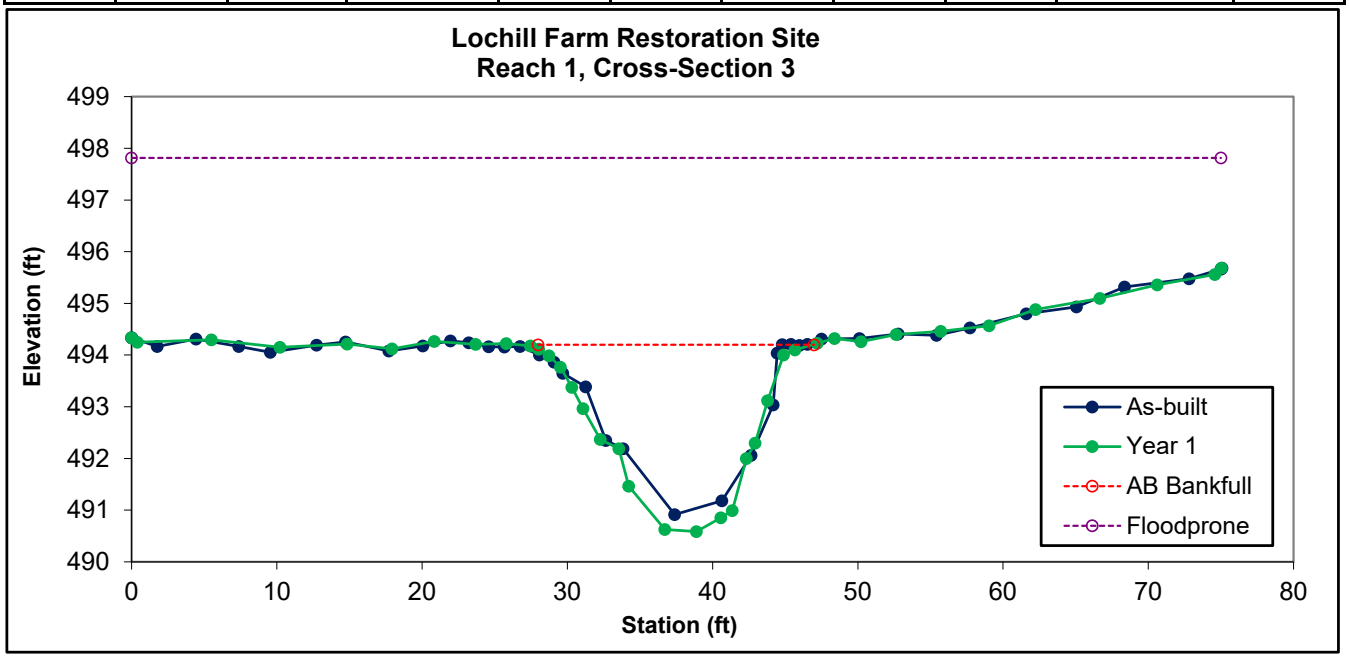
Permanent Cross-Section 3

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	37.7	20.2	1.9	3.6	10.8	--	--	494.20	494.12



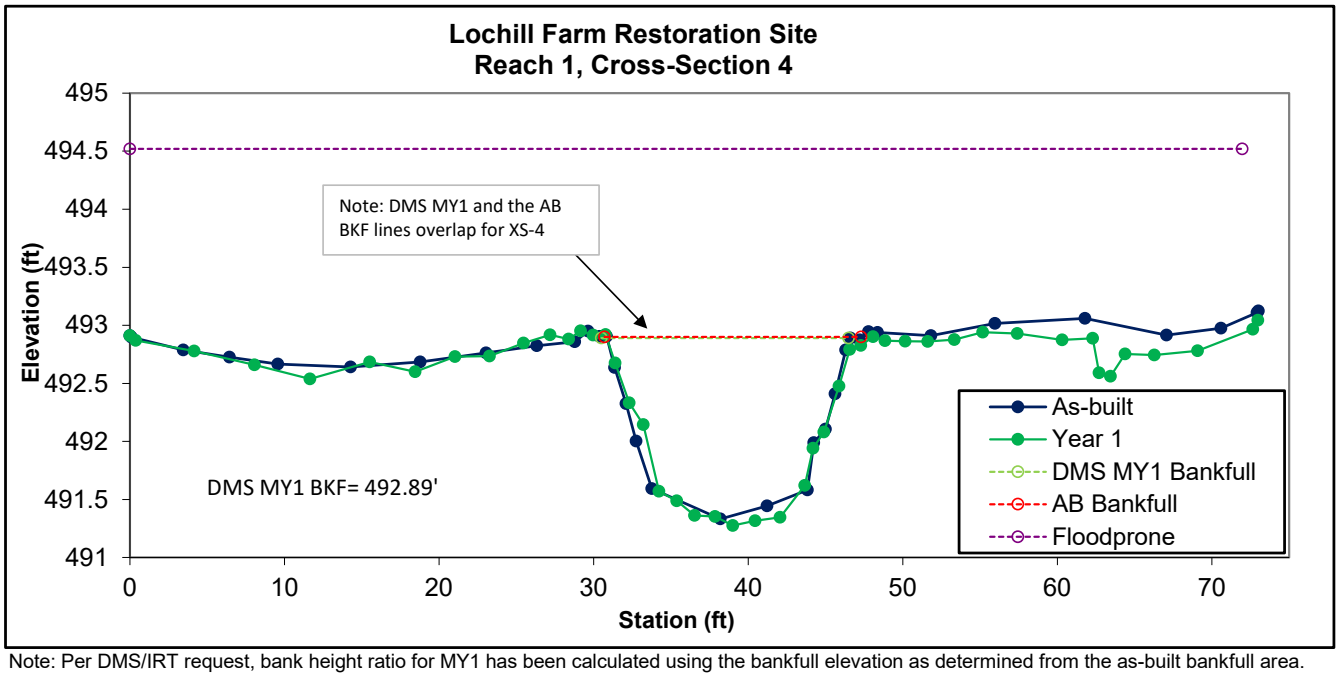
Permanent Cross-Section 4

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	18.5	17.4	1.1	1.6	16.5	1.0	4.2	492.90	492.90



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

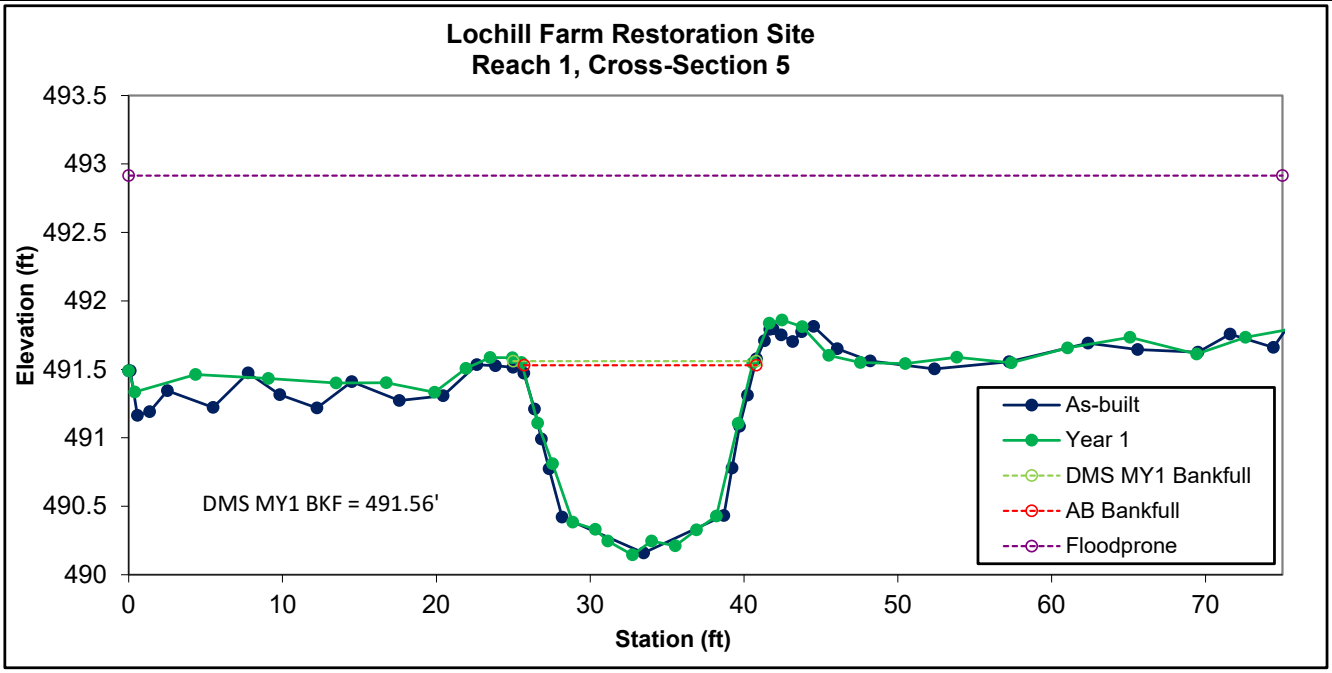
Permanent Cross-Section 5

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	15.0	15.0	1.0	1.4	14.9	1.0	5.1	491.53	491.58



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

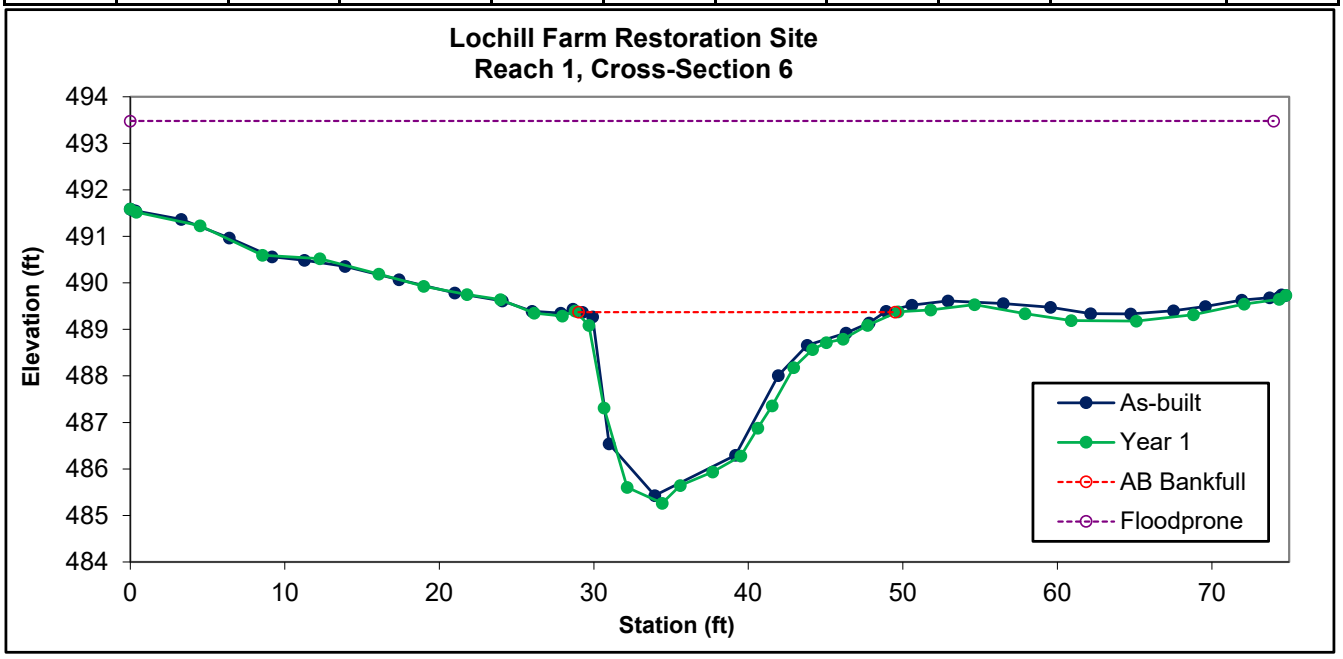
Permanent Cross-Section 6

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	43.4	20.8	2.1	4.1	9.9	--	--	489.37	489.38



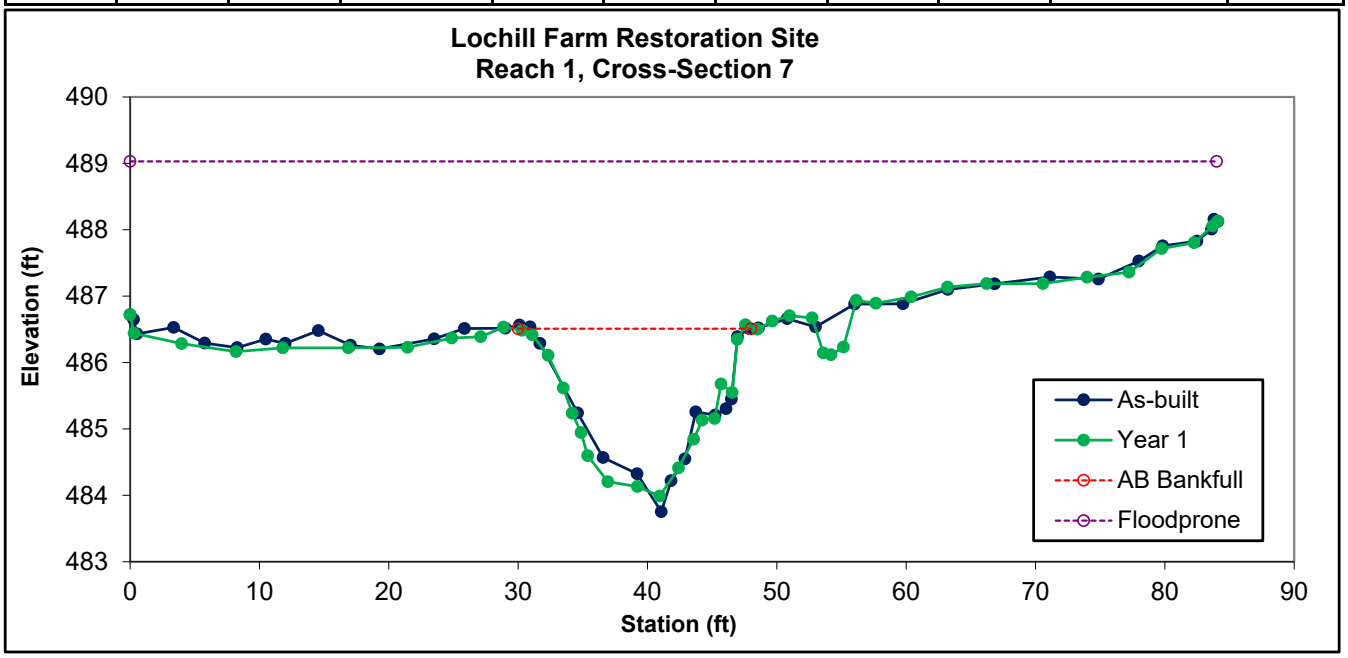
Permanent Cross-Section 7

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	26.1	18.0	1.4	2.5	12.5	--	--	486.51	486.42



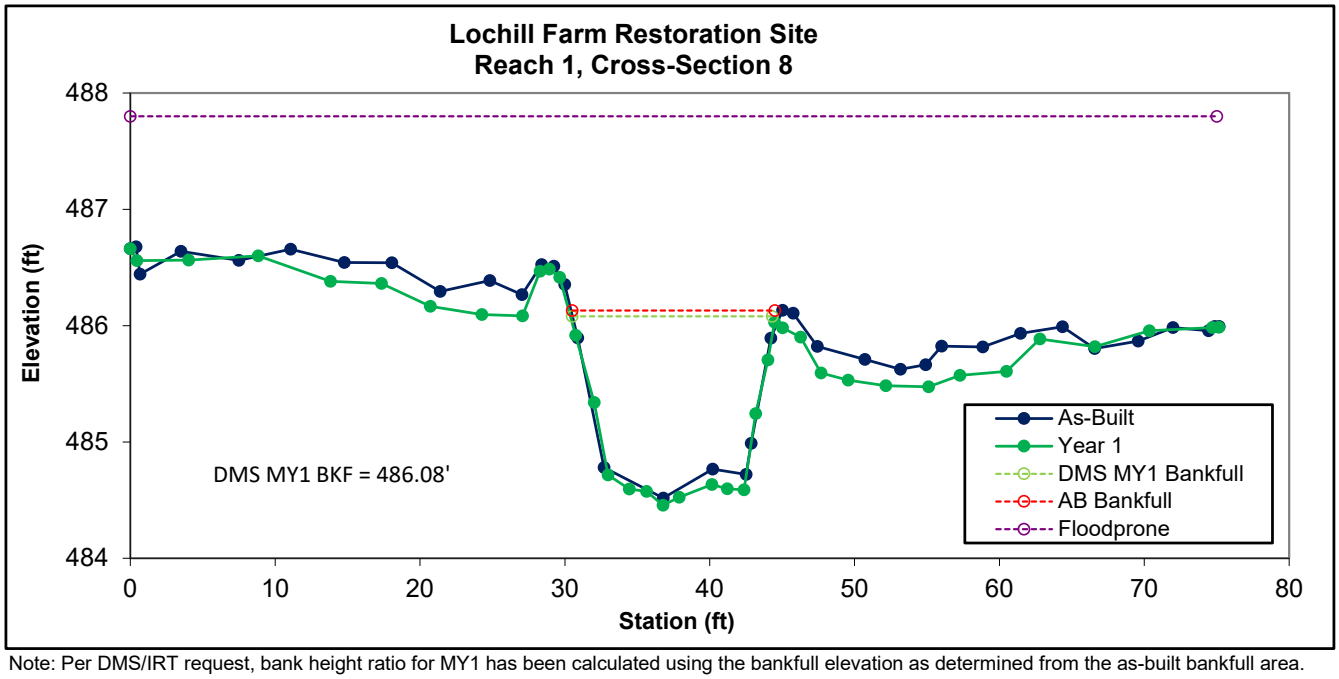
Permanent Cross-Section 8

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	18.0	14.9	1.2	1.7	12.3	1.0	5.0	486.13	486.03



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

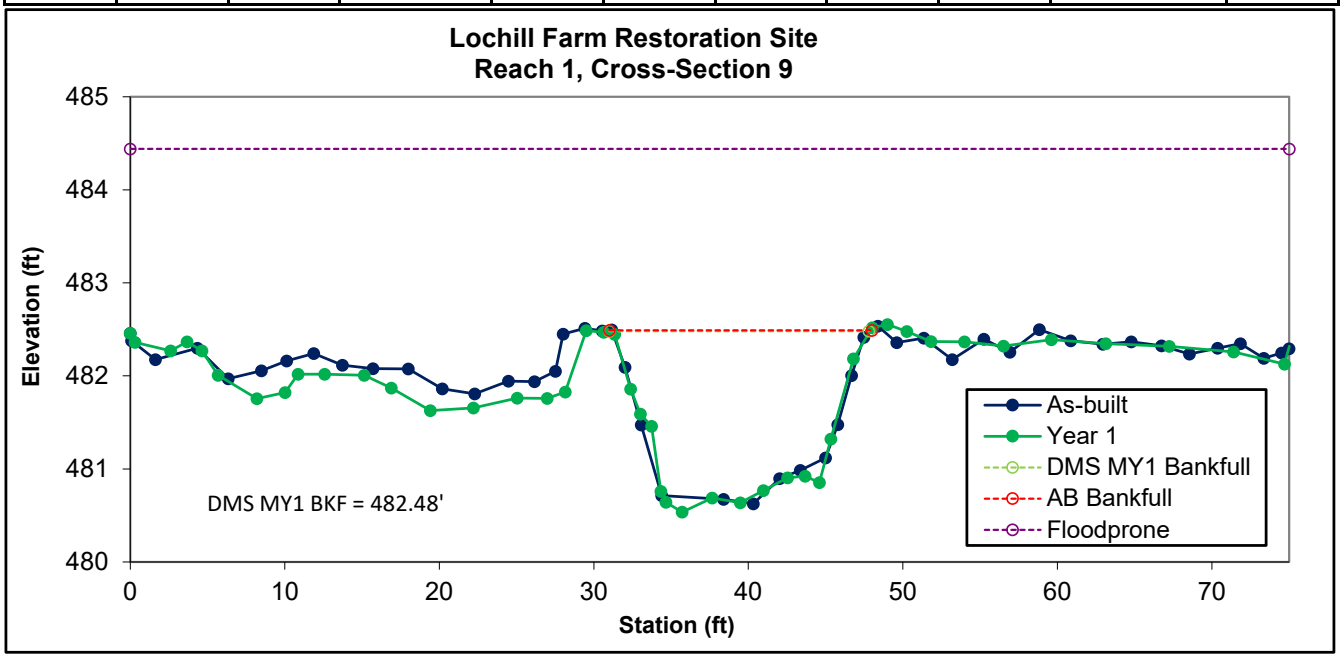
Permanent Cross-Section 9

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	22.8	17.3	1.3	2.0	13.1	1.0	4.3	482.49	482.45



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

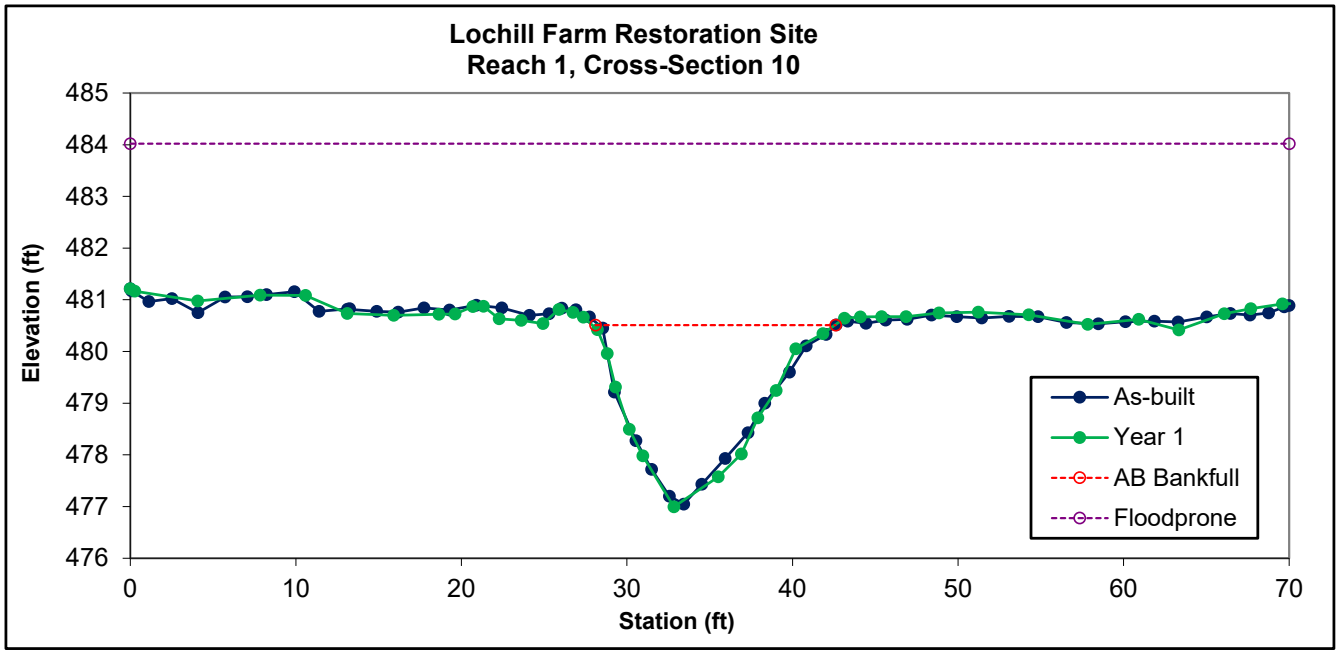
Permanent Cross-Section 10

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	27.3	14.7	1.9	3.5	7.9	--	--	480.51	480.64



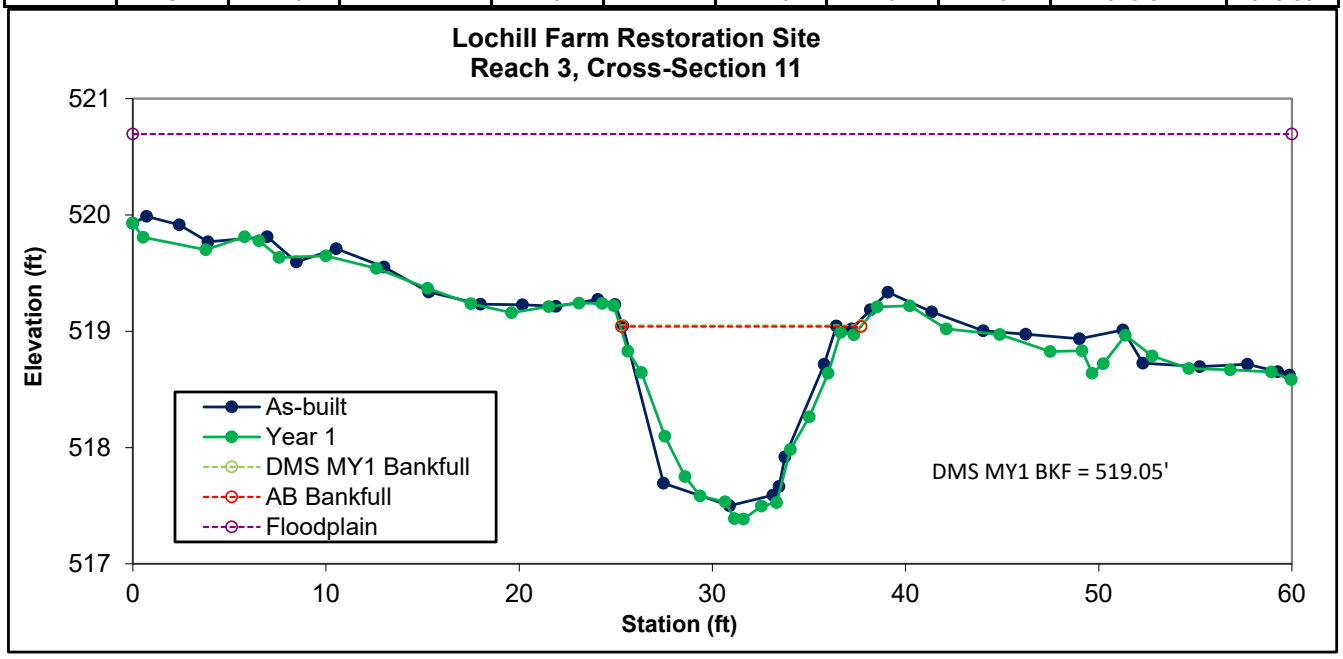
Permanent Cross-Section 11

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Riffle	C	12.0	12.4	1.0	1.7	12.9	1.0	4.8	519.04	518.99



Note: Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

Permanent Cross-Section 12

Year 1 Survey Collected: October 2019

Looking at the Left Bank

Looking at the Right Bank

Feature	Stream Type	BKF Area	BKF Width	BKF Depth	Max BKF Depth	W/D	BH Ratio	ER	BKF Elev	LTOB Elev
Pool	--	16.0	16.6	1.0	1.8	17.3	--	--	516.12	515.98

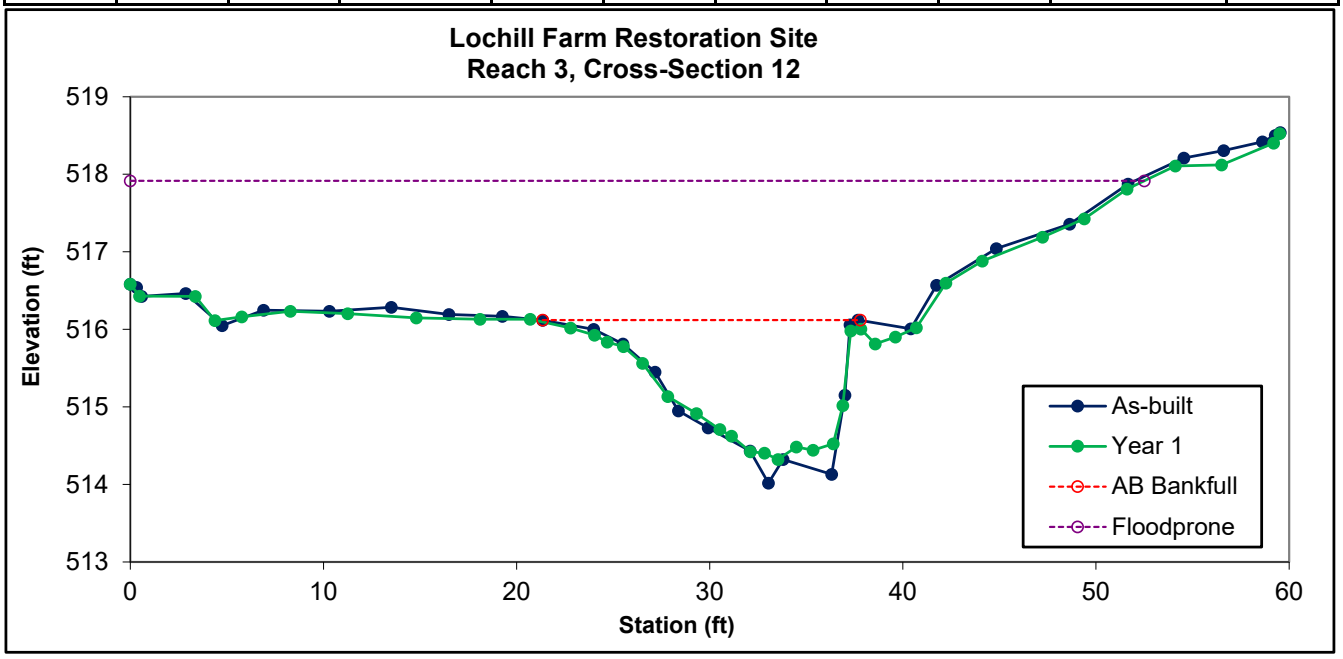


Table 8. Baseline Stream Data Summary
Lochill Farm Stream Mitigation Project - DMS Project No. 97083

Reach 1

Parameter	Pre-Existing Condition				Reference Reach(es) Data Composite				Design				As-built			
Dimension and Substrate - Riffle	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med	Max
BF Width (ft)	10.1	12.4	-----	14.6	8.7	16.8	14.7	33.2	-----	15.7	----	----	14.6	16.0	16.6	16.9
Floodprone Width (ft)	13	56	-----	99	26	79	52	229	65	83	----	100	73	75	75	76
BF Mean Depth (ft)	1.3	1.6	-----	1.9	0.9	1.2	0.9	2.3	-----	1.2	----	----	0.9	1.2	1.2	1.3
BF Max Depth (ft)	1.9	2.3	-----	2.6	1.4	1.8	1.5	2.8	-----	1.5	----	----	1.4	1.7	1.6	1.9
BF Cross-sectional Area (ft²)	15.3	19.4	-----	23.5	10.6	23.3	13.6	75.1	-----	19.0	----	----	15.5	18.6	18.3	22.7
Width/Depth Ratio	5.2	7.9	-----	10.6	7.3	14.5	14.5	18.6	-----	13.0	----	----	12.0	14.0	12.5	18.4
Entrenchment Ratio	1.5	5.0	-----	8.5	2.0	6.6	2.9	26.3	4.1	5.3	----	6.4	4.4	4.7	4.5	5.2
Bank Height Ratio	1.7	2.2	-----	2.6	1.0	1.0	1.0	1.0	-----	1.0	----	----	1.0	1.0	1.0	1.0
d50 (mm)	17.7	21.7	-----	25.6	-----	-----	-----	-----	-----	-----	-----	-----	36	54	59	64
Pattern																
Channel Beltwidth (ft)	25	47	-----	68	14	31	28	52	56	91	-----	125	55	71	73	83
Radius of Curvature (ft)	23	44	-----	65	5	18	19	26	31	39	-----	47	30	36	35	49
Rc/Bankfull width (ft/ft)	1.5	4.0	-----	6.4	0.6	1.5	1.4	2.5	2.0	2.5	-----	3.0	1.9	2.3	2.2	3.0
Meander Wavelength (ft)	52	87	-----	121	32	87	74	196	112	152	-----	192	124	155	152	199
Meander Width Ratio	1.7	4.2	-----	6.7	1.1	2.7	2.4	6.0	3.6	5.8	-----	8.0	3.4	4.4	4.6	5.2
Profile																
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	19	48	48	82
Riffle Slope (ft/ft)	-----	0.0260	-----	-----	0.0100	0.0282	0.0190	0.0670	0.0062	0.0075	-----	0.0101	0.0046	0.0070	0.0068	0.0120
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	21	35	33	62
Pool to Pool Spacing (ft)	49	130	-----	211	13	92	64	277	64	87	-----	110	49	98	102	140
Pool Max Depth (ft)	4.2	5.5	-----	6.8	1.8	2.6	2.5	4.1	2.5	3.3	-----	4.0	2.8	3.3	3.3	3.9
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / Bo%	1% / 10% / 77% / 11% / 1%				-----	-----	-----	-----	-----	-----	-----	-----	0% / 1% / 61% / 38% / 1%			
d16 / d35 / d50 / d84 / d95	4 / 9 / 13 / 49 / 110				----	-----	-----	-----	-----	-----	-----	-----	23 / 41 / 54 / 96 / 158			
Additional Reach Parameters																
Drainage Area (SM)	-----	1.59	-----	-----	0.41	2.57	0.75	8.35	-----	1.59	-----	---	-----	1.59	-----	-----
Impervious cover estimate (%)	-----	0.27%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
Rosgen Classification	-----	E4	-----	-----	-----	C4	-----	-----	-----	C4	-----	-----	-----	C4	-----	-----
BF Velocity (fps)	3.2	3.8	-----	4.3	3.5	4.3	-----	5.0	-----	3.9	-----	-----	-----	-----	-----	-----
BF Discharge (cfs)	-----	75	-----	-----	-----	-----	-----	-----	-----	75	-----	-----	-----	-----	-----	-----
Valley Length	-----	2,559	-----	-----	-----	-----	-----	-----	-----	2,559	-----	-----	-----	2,559	-----	-----
Channel Length (ft)	-----	2,936	-----	-----	-----	-----	-----	-----	-----	3,252	-----	-----	-----	3,245	-----	-----
Sinuosity	-----	1.15	-----	-----	1.2	1.3	-----	1.4	-----	1.27	-----	-----	-----	1.27	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	0.0081	-----	-----	0.0070	0.0112	0.0132	0.0133	0.0052	0.0066	-----	0.0153	-----	0.0066	-----	-----

Table 8. Baseline Stream Data Summary
Lochill Farm Stream Mitigation Project - DMS Project No. 97083

Reach 3

Parameter	Pre-Existing Condition				Reference Reach(es) Data				Design				As-built			
					Composite											
Dimension and Substrate - Riffle	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med	Max	Min	Mean	Med	Max
BF Width (ft)	6.2	8.6	-----	11.0	-----	-----	-----	-----	-----	11.0	----	----	-----	11.8	-----	-----
Floodprone Width (ft)	14	37	-----	60	-----	-----	-----	-----	24.0	42.0	----	60.0	-----	60.3	-----	-----
BF Mean Depth (ft)	0.9	1.1	-----	1.2	-----	-----	-----	-----	-----	0.9	----	----	-----	1.0	-----	-----
BF Max Depth (ft)	1.3	1.4	-----	1.4	-----	-----	-----	-----	-----	1.2	----	----	-----	1.5	-----	-----
BF Cross-sectional Area (ft²)	7.5	9.1	-----	10.6	-----	-----	-----	-----	-----	10.3	----	----	-----	12.1	-----	-----
Width/Depth Ratio	5.2	8.3	-----	11.3	12	15	-----	18	-----	12.2	----	----	-----	11.5	-----	-----
Entrenchment Ratio	2.3	3.9	-----	5.4	-----	-----	-----	-----	2.2	3.9	-----	5.5	-----	5.1	-----	-----
Bank Height Ratio	1.6	1.7	-----	1.7	-----	1.0	-----	-----	-----	1.0	-----	----	-----	1.0	-----	-----
d50 (mm)	----	23.0	----	----	-----	-----	-----	-----	-----	-----	-----	-----	-----	55	-----	-----
Pattern																
*Channel Beltwidth (ft)	-----	-----	-----	-----	-----	-----	-----	-----	54	57	-----	60	55	57	56	61
*Radius of Curvature (ft)	-----	-----	-----	-----	-----	-----	-----	-----	27	30	-----	33	26	30	31	33
*Rc/Bankfull width (ft/ft)	-----	-----	-----	-----	2.0	2.5	-----	3.0	2.0	2.5	-----	3.0	2.2	2.5	2.6	2.8
*Meander Wavelength (ft)	-----	-----	-----	-----	-----	-----	-----	-----	96	123	-----	150	94	125	128	153
*Meander Width Ratio	-----	-----	-----	-----	3.5	6.8	-----	10.0	4.9	5.2	-----	5.5	4.7	4.9	4.7	5.2
Profile																
Riffle Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	24	40	36	60
Riffle Slope (ft/ft)	-----	0.0258	-----	-----	-----	-----	-----	-----	-----	0.027	-----	----	-----	0.027	-----	-----
Pool Length (ft)	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	----	16	25	27	34
Pool to Pool Spacing (ft)	20	36	-----	51	-----	-----	-----	-----	20	39	-----	57	12	34	32	70
Pool Max Depth (ft)	1.4	1.7	-----	2.0	----	-----	-----	----	-----	2.5	-----	----	---	2.1	---	---
Substrate and Transport Parameters																
SC% / Sa% / G% / C% / B%		1% / 11% / 68% / 20% / 0%			-----	-----	-----	-----	-----	-----	-----	-----		0% / 0% / 60% / 39% / 1%		
d16 / d35 / d50 / d84 / d95		5.9 / 13 / 23 / 79 / 141							-----	-----	-----	-----		31 / 43 / 55 / 113 / 170		
Additional Reach Parameters																
Drainage Area (SM)	-----	0.30	-----	-----	-----	-----	-----	-----	-----	0.30	-----	-----	-----	0.30	-----	-----
Impervious cover estimate (%)	-----	0.27%	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----
*Rosgen Classification	-----	B4 to E4b	-----	-----	-----	C4b	-----	-----	-----	C4b	-----	-----	-----	C4b	-----	-----
BF Velocity (fps)	3.6	5.5	-----	7.4	4.0	5.0	-----	6.0	-----	4.4	-----	-----	-----	-----	-----	-----
BF Discharge (cfs)	-----	45	-----	-----	-----	-----	-----	-----	-----	45	-----	-----	-----	-----	-----	-----
Valley Length	-----	1,488	-----	-----	-----	-----	-----	-----	-----	1,488	-----	-----	-----	1,488	-----	-----
Channel Length (ft)	-----	1,599	-----	-----	-----	-----	-----	-----	-----	1,616	-----	-----	-----	1,622	-----	-----
Sinuosity	-----	1.07	-----	-----	1.1	1.2	-----	1.3	-----	1.09	-----	-----	-----	1.09	-----	-----
Water Surface Slope (Channel) (ft/ft)	-----	0.0220	-----	-----	-----	-----	-----	-----	-----	0.0216	-----	-----	-----	0.0213	-----	-----

* These parameters apply only to the upper portion of Reach R3 where the channel was relocated with improved pattern, profile, and in-stream structures.

Table 9. Cross-Section Morphology Data Summary
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Stream Reach	Reach 1																									
	Cross-section X-1 (Riffle)							Cross-section X-2 (Pool)							Cross-section X-3 (Pool)							Cross-section X-4 (Riffle)						
Dimension and substrate	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Based on fixed baseline bankfull elevation																												
BF Width (ft)	15.2	14.8						21.0	22.3						21.5	20.2						16.6	17.4					
BF Mean Depth (ft)	1.3	1.3						1.5	1.4						1.6	1.9						1.1	1.1					
Width/Depth Ratio	12.0	11.7						13.7	16.1						13.8	10.8						15.0	16.5					
BF Cross-sectional Area (ft²)	19.4	18.5						32.3	31.3						33.6	37.7						18.3	18.5					
BF Max Depth (ft)	1.9	1.8						3.2	2.9						3.3	3.6						1.6	1.6					
Width of Floodprone Area (ft)	75	75						-	-						-	-						73	73					
Entrenchment Ratio	4.9	5.1						-	-						-	-						4.4	4.2					
Bank Height Ratio (MY1 will provide standard)*	1.0	1.0						-	-						-	-						1.0	1.0					
Wetted Perimeter (ft)	15.9	15.5						22.8	24.1						23.5	22.2						17.2	18.0					
Hydraulic Radius (ft)	1.2	1.2						1.4	1.3						1.4	1.7						1.1	1.0					
d50 (mm)	36	-						-	-						-	-						-	-					

Stream Reach	Reach 1																									
	Cross-section X-5 (Riffle)							Cross-section X-6 (Pool)							Cross-section X-7 (Pool)							Cross-section X-8 (Riffle)						
Dimension and substrate	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Based on fixed baseline bankfull elevation																												
BF Width (ft)	16.9	15.0						19.6	20.8						16.8	18.0						14.6	14.9					
BF Mean Depth (ft)	0.9	1.0						2.0	2.1						1.5	1.4						1.2	1.2					
Width/Depth Ratio	18.4	14.9						9.6	9.9						11.4	12.5						12.3	12.3					
BF Cross-sectional Area (ft²)	15.5	15.0						40.1	43.4						24.7	26.1						17.3	18.0					
BF Max Depth (ft)	1.4	1.4						3.9	4.1						2.8	2.5						1.6	1.7					
Width of Floodprone Area (ft)	76	76						-	-						-	-						75	75					
Entrenchment Ratio	4.5	5.1						-	-						-	-						5.2	5.0					
Bank Height Ratio (MY1 will provide standard)*	1.0	1.0						-	-						-	-						1.0	1.0					
Wetted Perimeter (ft)	17.4	15.4						22.4	23.4						18.3	19.5						15.4	15.7					
Hydraulic Radius (ft)	0.9	1.0						1.8	1.9						1.4	1.3						1.1	1.1					
d50 (mm)	64	-						-	-						-	-						-	-					

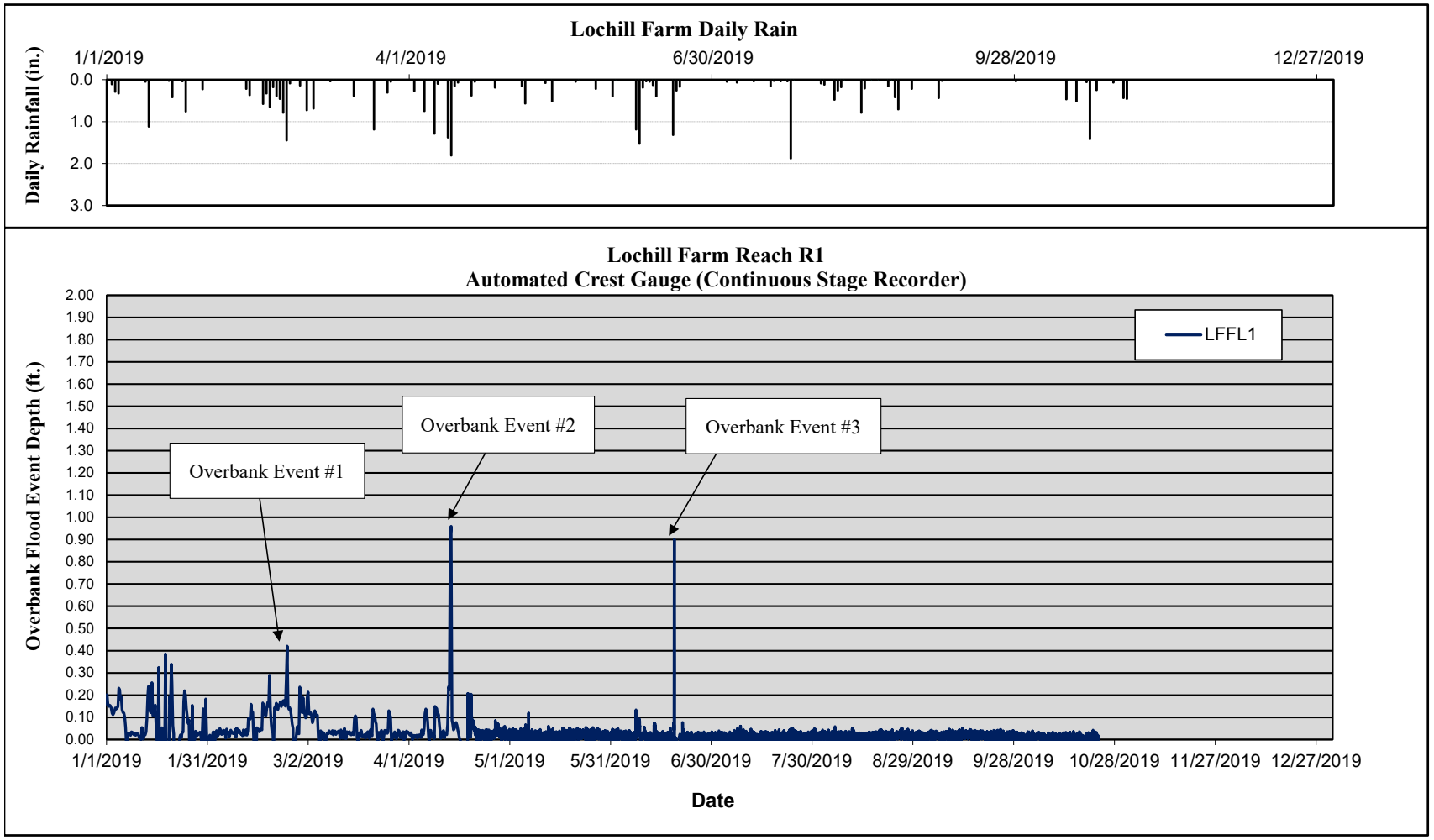
Stream Reach	Reach 1														Reach 3													
	Cross-section X-9 (Riffle)							Cross-section X-10 (Pool)							Cross-section X-11 (Riffle)							Cross-section X-12 (Pool)						
Dimension and substrate	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+	Base	MY1	MY2	MY3	MY4	MY5	MY+
Based on fixed baseline bankfull elevation																												
BF Width (ft)	16.9	17.3						14.3	14.7						11.8	12.4						16.4	16.6					
BF Mean Depth (ft)	1.3	1.3						1.9	1.9						1.0	1.0						1.0	1.0					
Width/Depth Ratio	12.5	13.1						7.6	7.9						11.5	12.9						15.9	17.3					
BF Cross-sectional Area (ft²)	22.7	22.8						26.8	27.3						12.1	12.0						16.9	16.0					
BF Max Depth (ft)	1.9	2.0						3.5	3.5						1.5	1.7						2.1	1.8					
Width of Floodprone Area (ft)	75	75						-	-						60	60						-	-					
Entrenchment Ratio	4.4	4.3						-	-						5.1	4.8						-	-					
Bank Height Ratio (MY1 will provide standard)*	1.0	1.0						-	-						1.0	1.0						-	-					
Wetted Perimeter (ft)	17.7	18.3						16.3	16.6						12.5	13.1						18.0	21.4					
Hydraulic Radius (ft)	1.3	1.2						1.6	1.6						1.0	0.9						0.9	0.8					
d50 (mm)	59	-						-	-						55	-						-	-					

* Per DMS/IRT request, bank height ratio for MY1 has been calculated using the bankfull elevation as determined from the as-built bankfull area. All other values were calculated using the as-built bankfull elevation.

APPENDIX E

Hydrologic Data

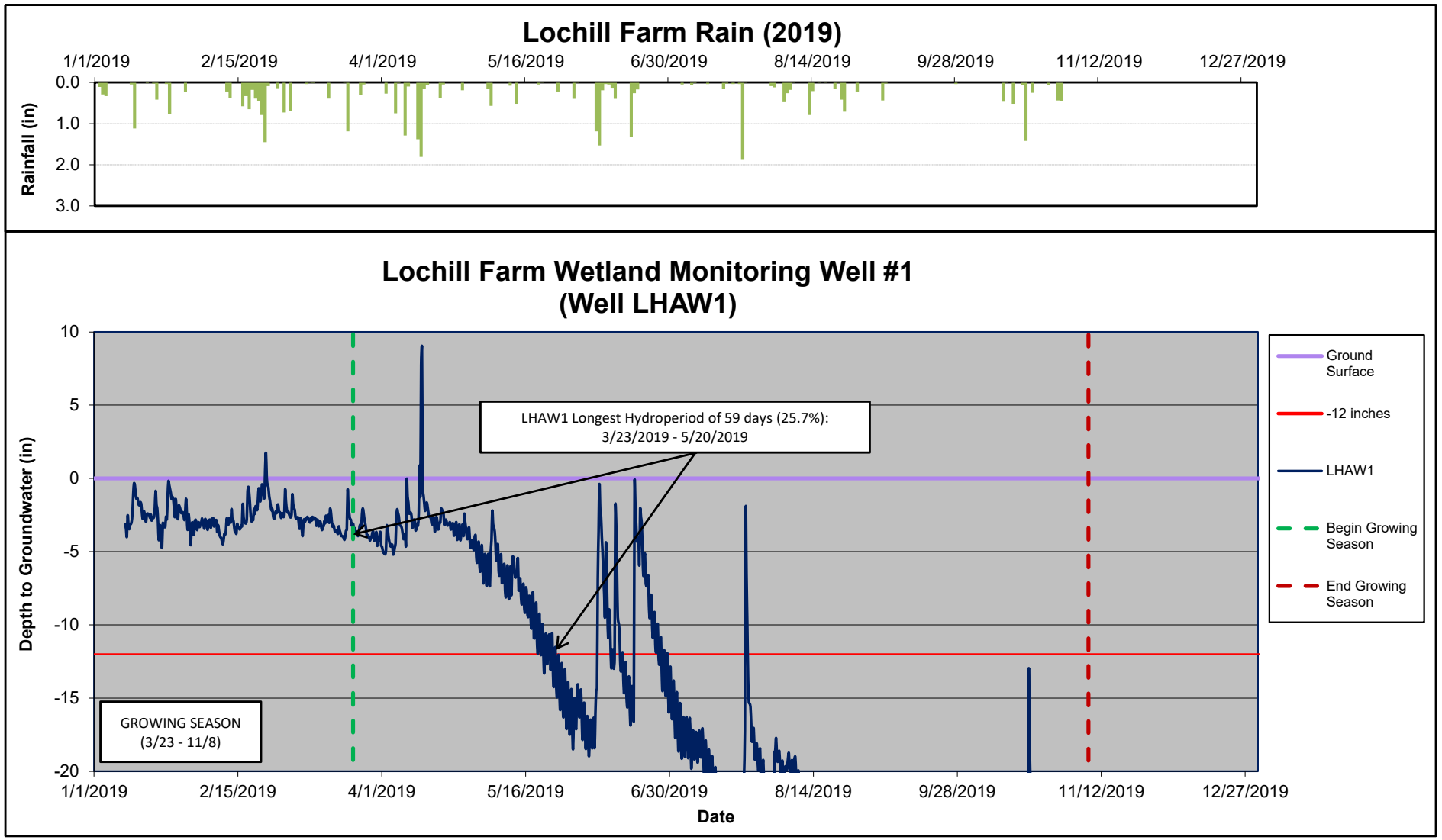
Figure 4. Automated Crest Gauge (Continuous Stage Recorder) Graph

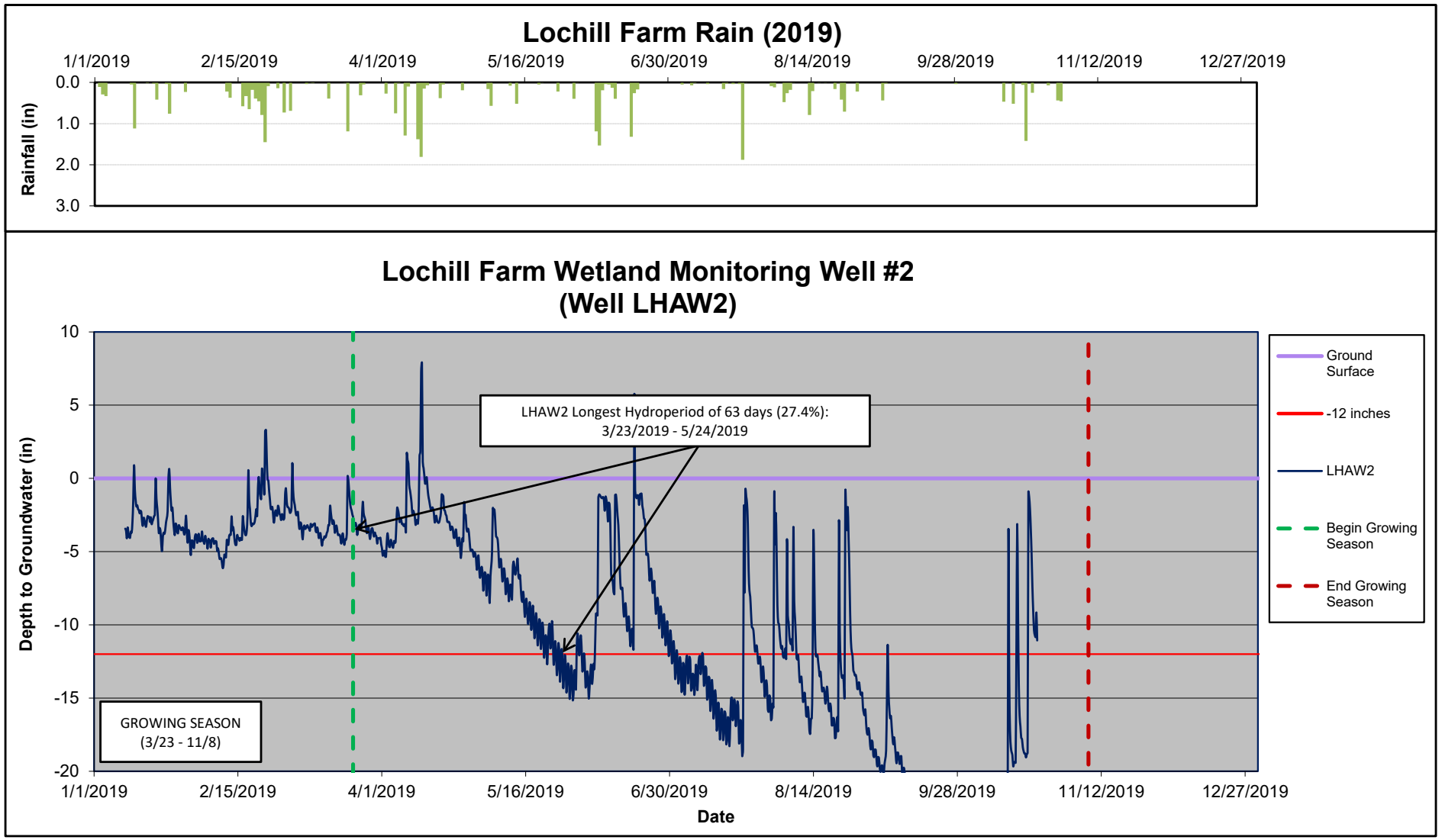


Note: Data collected from 1/1/19 thru 10/31/19

* Readings observed in January 2019 appear to be from floodplain surface inundation caused by extreme saturated conditions. No other evidence of an overbank event was observed.

Figure 5. Wetland Monitoring Well Graphs




Lochill Farm Rain (2019)
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
Lochill Farm Wetland Monitoring Well #2
(Well LHAW2)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
LHAW2 Longest Hydroperiod of 63 days (27.4%):
3/23/2019 - 5/24/2019
GROWING SEASON
(3/23 - 11/8)
Ground Surface
-12 inches
LHAW2
Begin Growing Season
End Growing Season
Date

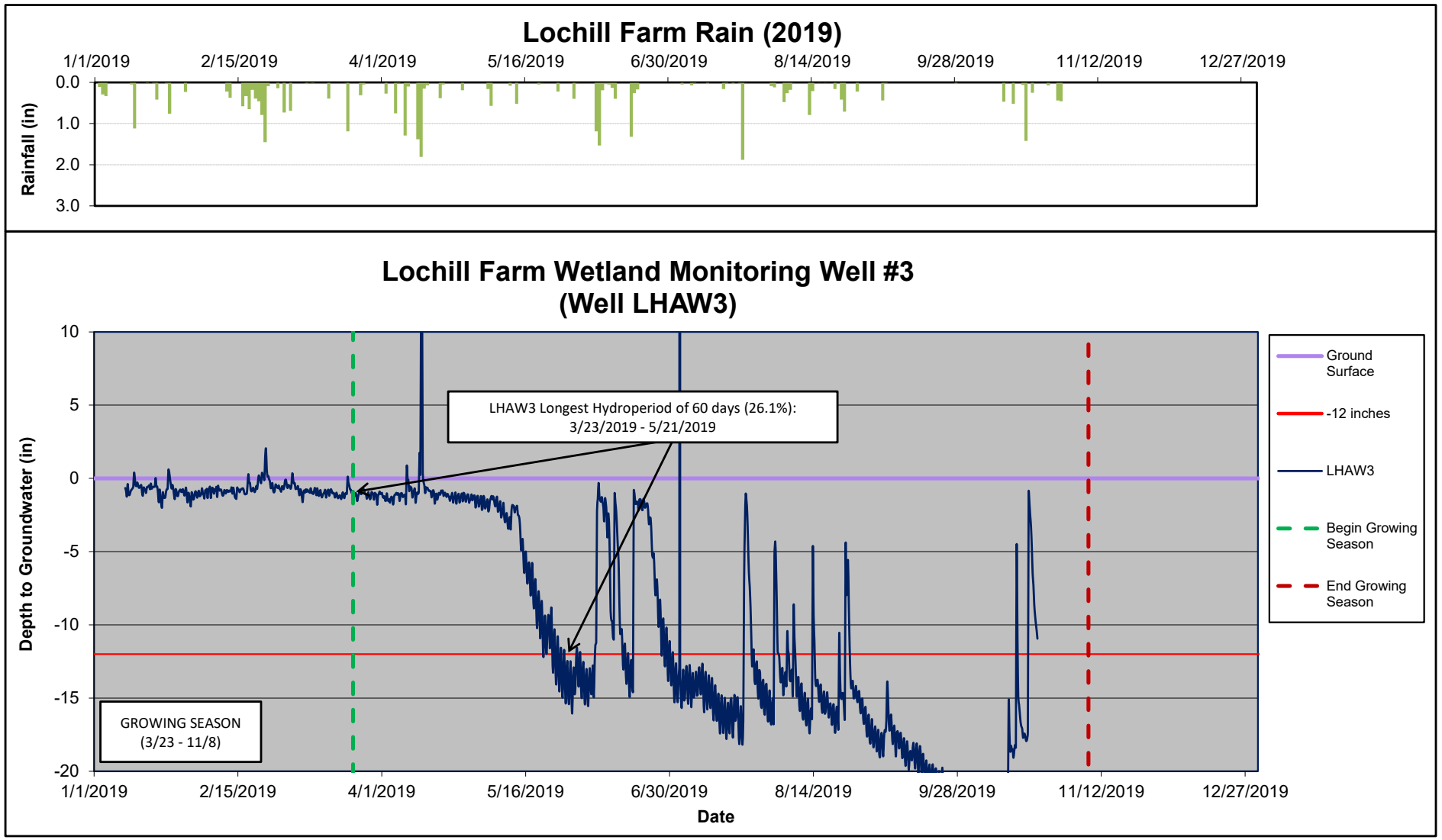
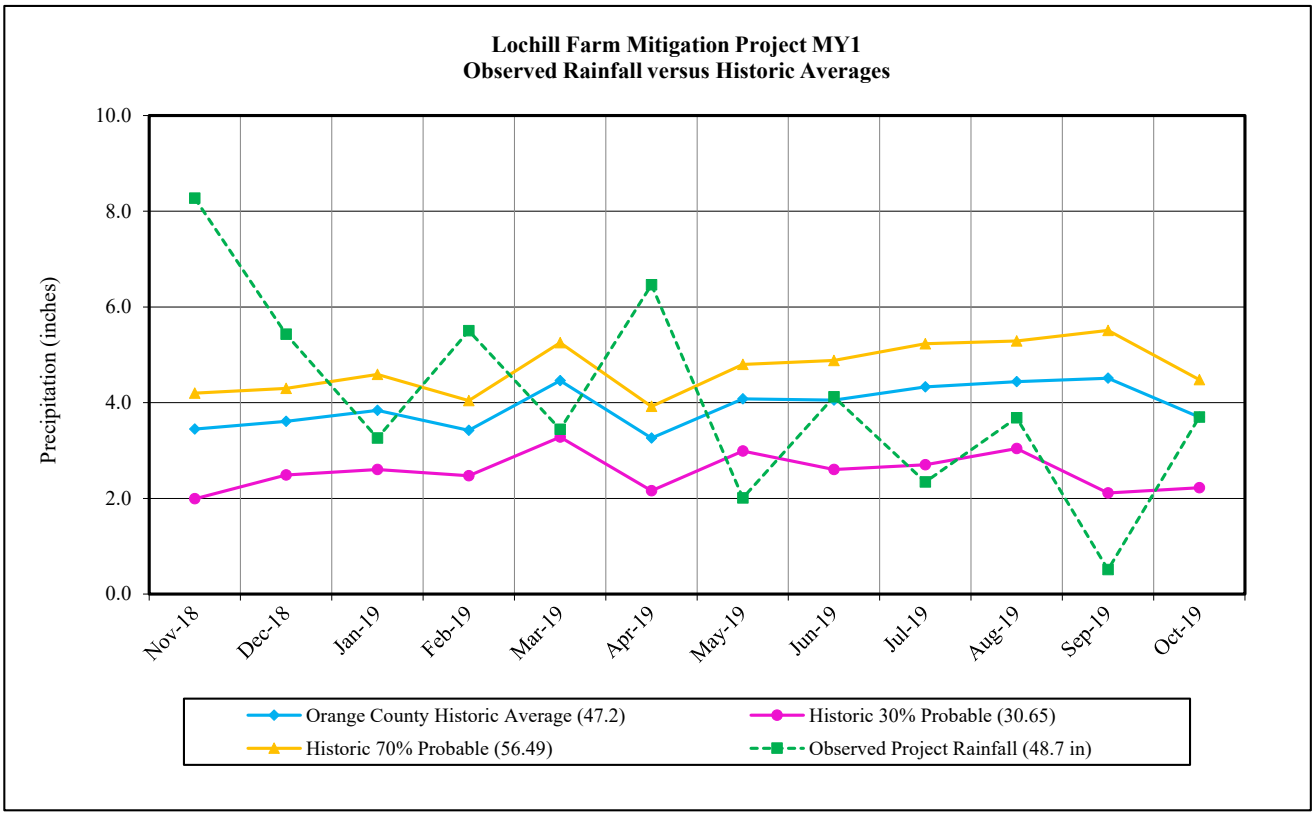
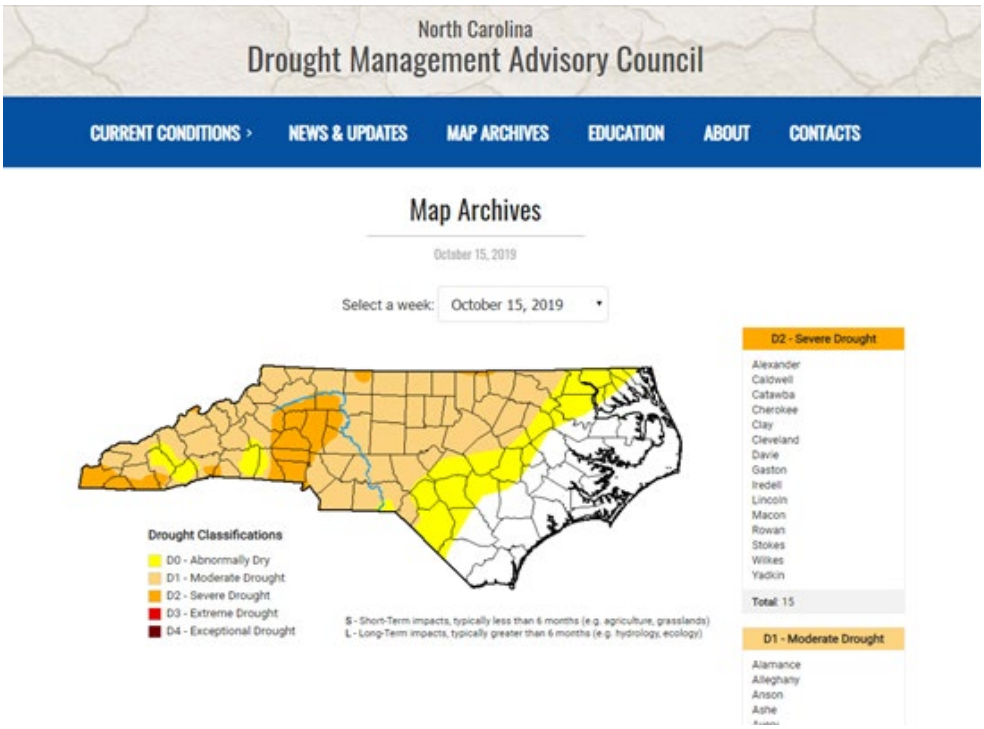

Lochill Farm Rain (2019)
1/1/2019
2/15/2019
4/1/2019
5/16/2019
6/30/2019
8/14/2019
9/28/2019
11/12/2019
12/27/2019
Rainfall (in)
0.0
1.0
2.0
3.0
Lochill Farm Wetland Monitoring Well #3
(Well LHAW3)
Depth to Groundwater (in)
10
5
0
-5
-10
-15
-20
LHAW3 Longest Hydroperiod of 60 days (26.1%):
3/23/2019 - 5/21/2019
GROWING SEASON
(3/23 - 11/8)
Ground Surface
-12 inches
LHAW3
Begin Growing Season
End Growing Season
Date

Figure 6. Observed Rainfall Versus Historic Averages



Note: Historic average annual rainfall for Orange County is 47.2", while the observed proect rainfall recorded a total of 48.7" over the previous 12 months (from 11/1/2018 to 10/31/2019). Project rainfall was collected from the nearest NC-CRONOS station.



Note: The project site in Orange County did experince drought conditions throughout much of the summer and fall months resulting in a D1 - Moderate Drought as of October 15, 2019 (www.ncdrought.org).

Table 10. Verification of Bankfull Events

Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Date of Data Collection	Reach R1 Manual Cork Crest Gauge	Reach R1 Automated Crest Gauge (Continuous Stage Recorder)	Reach R3 Manual Cork Crest Gauge	Date of Bankfull Event Occurrence	Method of Data Collection
Year 1 Monitoring (2019)					
03/07/2019	N/A [1]	0.42 ft	N/A [1]	02/23/2019 (1.3" rain event)	Continuous Stage Recorder, Photos
04/18/2019	0.71 ft	0.96 ft	0.30 ft	04/13/2019 (1.8" rain event)	Cork Crest Gauges, Continuous Stage Recorder, Photos
06/19/2019	0.81 ft	0.90 ft	0.29 ft	06/18/2019 (1.32" rain event)	Cork Crest Gauges, Continuous Stage Recorder, Photos

Note: Manual cork crest gauge readings were corroborated with associated spikes in the automated Continuous Stage Recorder (see graph in Appendix E) and/or with photographs (Appendix B).

[1] Wet cork in manual crest gauges were found to be frozen solid when checked on morning of 3/7/19

Table 11. Wetland Hydrology Summary Data
Lochill Farm Stream Mitigation Project - NCDMS Project No. 97083

Well ID	Percentage of Consecutive Days <12 inches from Ground Surface[1]							Most Consecutive Days Meeting Criteria[2]						
	Year 1 (2019)	Year 2 (2020)	Year 3 (2021)	Year 4 (2022)	Year 5 (2023)	Year 6 (2024)	Year 7 (2025)	Year 1 (2019)	Year 2 (2020)	Year 3 (2021)	Year 4 (2022)	Year 5 (2023)	Year 6 (2024)	Year 7 (2025)
Wetland Monitoring Wells (Installed January 2019)														
SCAW1	25.7							59						
SCAW2	27.4							63						
SCAW3	26.1							60						

[1]Indicates the percentage of the single greatest consecutive number of days within the monitored growing season with a water table 12 inches or less from the soil surface.
[2]Indicates the single greatest consecutive number of days within the monitored growing season with a water table 12 inches or less from the soil surface.
Growing season for Orange County is from March 23 to November 8 and is **230** days long. 12% of the growing season is **27.6** days.

Well ID	Percentage of Cumulative Days <12 inches from Ground Surface							Cumulative Days Meeting Criteria[3]						
	Year 1 (2019)	Year 2 (2020)	Year 3 (2021)	Year 4 (2022)	Year 5 (2023)	Year 6 (2024)	Year 7 (2025)	Year 1 (2019)	Year 2 (2020)	Year 3 (2021)	Year 4 (2022)	Year 5 (2023)	Year 6 (2024)	Year 7 (2025)
Wetland Monitoring Wells (Installed January 2019)														
SCAW1	33.5							77						
SCAW2	46.5							107						
SCAW3	41.3							95						

[3]Indicates the total number of days within the monitored growing season with a water table 12 inches or less from the soil surface.