MUDDY RUN II STREAM AND WETLAND RESTORATION PROJECT
MONITORING REPORT
MONITORING YEAR 4
FINAL

DUPLIN COUNTY, NORTH CAROLINA
CONTRACT NO. 004631 - PROJECT NO. 95354

Prepared for:

Division of Mitigation Services

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February 6, 2018

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RE: Muddy Run II Stream and Wetland Restoration Site: MY4 Monitoring Report (NCDMS ID 95354)

Listed below are comments provided by DMS on January 17, 2018 regarding the Muddy Run II Stream and Wetland Restoration Site: Year 4 Monitoring Report and RES' responses.

At the 2016 IRT credit release, this project was released as proposed with the following notes: "Adjust as needed at the 2017 credit release. Explain in detail differences in stream footage from Mitigation Plan to As-Built. Were there changes to this easement?" Please provide response to these questions in the Monitoring report and be ready to discuss at credit release.
Thalweg vs. centerline survey and construction field adjustments account for the 5% increase in stream footage from Mitigation Plan to As-Built. There were no changes to the easement. This has been added to the report.

It is understood that morphology was not captured on this site for this monitoring year. This information below is for your understanding and preparation for credit release. Cross sections / cross section tables – A couple of methods are currently being utilized to calculate the BHR from year to year. To compare subsequent monitoring years to the As-built condition one can hold the bankfull depth static (denominator) while allowing the Low TOB max depth (numerator) to vary. Another method that has been proposed and is being evaluated is to hold the As-built cross-sectional area static within each years' new cross section and allow that to determine the max bankfull depth for each year. However, if there are large changes in the W/D ratio either method can make for somewhat distorted BHR values depending upon the direction and magnitude of the change in the W/D ratio. Please update calculations to reflect changes observed in the overlays and explain in detail as a table footnote how the calculations were made. Be prepared to defend the method used for credit release and justify through context if any changes observed in a cross section represent an issue.

CCPV and asset table 1:

a. Stream credit shapefile. The shapefile that DMS has for stream credit doesn't match the lengths shown in the report, although the total length is longer than reported in as-built (it's in the ballpark). Please provide the correct shapefile for the stream asset (divided by reach). This should match credit (within reason) and not include areas of road breaks.
   Done.

b. Reach 6 credit: the map shows the upper portion of reach 6 as having EII credit, but the Mitigation plan shows this as a non-credit area. I think you could list the upper portion of this reach and the side channel as additional stream, not for credit. Please update CCPV.
The upper portion of Reach 6 (893 ft) and the side channel (307 ft) that confluences with it are now shown as "Channel – No Credit" on the CCPV and a footnote about them has been added to Table 1. Reach 6 is also is discussed in Section 1.3.1.

Please provide a footnote with the number of trees replanted in 2016 under table 2 or under your vegetation table.
4,400 trees were replanted in 2016. This has been added as a footnote under Table 2.

Page 7, please state what monitoring guidance was used for this project (i.e. 2003 IRT stream mitigation guidelines). The report is not specific.
The monitoring guidance used was the EEP Monitoring Requirements and Performance Standards Guidance for Stream and-or Wetland Mitigation (11/07/2011). This has been added to the report.

Page 11, Section 5.1.2: the 260 trees per acre standard is for MY5, please revise.
Done.

Table 10. Are these all the bankfull events or just 2017? It may be helpful to show number by monitoring year for context. I understand this is a shallow channel that regularly gets out of bank.
These were all bankfull events for just 2017. The table has been updated to include bankfull events from each monitoring year.

What is RES doing to address the minor encroachment noted on the report? Update to describe.
In the areas of minor encroachment RES will communicate with landowners and install additional signage. This has been added to the report.

Table 12. Some of the hydroperiods shown for this MY do not match their table below (Table 12A does not match table 12B for MY4). Correct and update.
Done.

As RES explained and we discussed in the field, there will need to be a strategy for repairing the isolated bank and floodplain scour on Reach 5A, including ensuring the encroachment is eliminated as soon as possible.
RES plans to address the floodplain scour by seeding and matting the bare areas and hand grading and livestaking the head cuts. The bank scour will be remedied by adding rip rap behind the structure and livestakes to the bank. Additional t-posts with easement markers will be added to the encroachment area to deter any vehicle use through the easement. This has been added to the report.

Muddy Run II
Duplin County, North Carolina
DMS Project ID 95354

Cape Fear River Basin
HUC 0030007060010

Prepared by:

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EXECUTIVE SUMMARY

The Muddy Run II Stream and Wetland Restoration Project is located within an agricultural watershed in Duplin County, North Carolina, approximately six miles south of Beulaville. The stream channels were heavily impacted by channelization and agricultural practices. The project involved the restoration and protection of streams in the Muddy Creek watershed. The purpose of this restoration project was to restore and enhance a stream/wetland complex located within the Cape Fear River Basin.

The project lies within USGS Hydrologic Unit Code 03030007060010 (USGS, 1998) and within the North Carolina Division of Water Quality (NCDWQ) Cape Fear River Subbasin 03-06-22 (NCDENR, 2002). The project consists of six unnamed tributaries to Muddy Creek, but the project has been divided into nine distinct reaches for design purposes. Reach 1 is one of the upstream-most portions of the project; it begins on the edge of an existing agricultural field and extends to STA 04+48. Similarly, Reach 2 is one of the upper-most portions of the stream project. It begins in a disturbed forest corridor between several agricultural fields and extends to STA 19+14. Reach 3a starts at the confluence of Reaches 1 and 2 (STA 00+00) and flows north north-west through a disturbed hardwood buffer and several agricultural fields before being partially diverted to enter Reach 3b near STA 37+23. Reach 3b flows to the north and west where it flows into Reach 3c at STA 57+92. Reach 3c flows through a pine plantation to STA 65+30, where it flows into Reach 3 of the Muddy Run project. Reach 4 is a perennial channel that flows through a forested area from a ditch draining an agricultural field. Reach 4 flows into Reach 3A at STA 18+76. Reach 5a consists of the main stem beginning at STA 00+00 where it adjoins with Reach 1C of the Muddy Run project. Reach 5a flows north and flows into Reach 5b at STA 19+59. Reach 5b is the most downstream reach of the project, ending at the right-of-way for State Highway 41. Reach 6 begins in a forested area south of Reach 5 and flows in a northerly direction to the confluence with Reach 5a near STA 9+20. Two areas containing drained hydric soil were identified for restoration, located along Reach 3b and Reach 5a.

The Muddy Run I Mitigation Project is located upstream of Reach 5A and downstream of Reach 3C. Muddy Run II was constructed immediately following Muddy Run.

This Year 4 Annual Monitoring Report presents the data from 28 vegetation monitoring plots, four manual crest gauges, four auto crest gauges, an auto-logging rain gauge, seven wetland restoration groundwater gauges, three reference groundwater gauges, 59 stream cross sections, 20 sets of bank pins, and photo reference locations, as required by the approved Mitigation Plan for the site.

The Year 4 vegetation monitoring observations for Muddy Run II Site are summarized in this report. Planted-stem survival for Monitoring Year 4 for all 28 Vegetation Plots (VP) at Muddy Run II was above the interim success criterion of 260 trees per acre at the end of Monitoring Year 4. The average stem density (excluding live stakes) across all vegetation plots was 638 stems per acre. Invasive Chinese privet (*Ligustrum sinense*) was observed along small portions of Reach 1B during Year 3 monitoring. Invasive treatment was performed in this area during July 2017. This area will continue to be monitored for invasive species. The Muddy Run II Site has met the Year 4 vegetation survival success criterion of 260 trees per acre as specified in the Mitigation Plan.

During the Year 4 monitoring season, the restored stream channel remained stable and continued to provide the intended habitat and hydrologic functions. Monitoring Year 4 activities confirmed the stream reaches are stable and the banks are well vegetated. One stream area of concern was noted during the MY4 activities.

All seven wetland gauges achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Groundwater gauge data indicates the hydroperiods being very responsive to rainfall events.

Following 2016 monitoring the NCIRT requested a review of the differential between the Approved Mitigation Plan and Baseline Monitoring Report. The table below details the discrepancies by reach. The primary cause of the 5% increase in baseline SMUs is survey methodology (thalweg vs. centerline). The Mitigation Plan lengths were based on centerline. Wetland credits are unchanged from Mitigation Plan to Baseline Monitoring Report.

Reach	Mitigation Type	Proposed Length (LF)*	Mitigation Ratio	Proposed SMUs	Baseline SMUs
Reach 1	Headwater Valley	401	1:1	401	398
Reach 2	Headwater Valley	504	1:1	504	504
Reach 2	P1 Restoration	1,369	1:1	1,369	1,410
Reach 3a	P1 Restoration	3,440	1:1	3,440	3,586
Reach 3b	P1 Restoration	1,852	1:1	1,852	1,979
Reach 3c	Enhancement I	707	1:1.5	471	472
Reach 4	P1 Restoration	172	1:1	172	173
Reach 5a	P1 Restoration	1,774	1:1	1,774	1,926
Reach 5b	Enhancement II	401	1:2.5	160	164
Reach 6	Enhancement II	317	1:2.5	127	127
	Total	**11,411**		**10,270**	**10,739****

*The proposed lengths represent the total proposed channel length minus the length of the proposed channel associated with crossings (easement breaks).
**The contracted amount of credits for this Site was 10,375 SMUs.

TABLE OF CONTENTS

Appendix A. Project Background Data and Maps

Appendix B. Visual Assessment Data

Appendix C. Vegetation Plot Data

Appendix D. Hydrology Data

1 PROJECT GOALS, BACKGROUND AND ATTRIBUTES

1.1 Location and Setting

The Muddy Run Stream Site ("Site") is located in Duplin County approximately 1.4 miles east of Chinquapin, NC (Figure 1). The project is in the Cape Fear River Basin (8-digit USGS HUC 03030007, 14-digit USGS HUC 03030007060010) (USGS, 1998) and the NCDWQ Cape Fear 03-06-22 sub-basin (NCDWQ, 2002). To access the Site from the town of Chinquapin, travel east on Highway 50, take the first left onto Pickett Bay Road (SR 1819), go 1.1 miles, then turn left onto Kenney Crawley Road. This private road is gravel and will split just past the residential house on the right. Keeping to the left will take you to the Reaches 3b, 3c, 5b, and 6. Going to the right at the split will take you to Reaches 1, 2, 3a, and 4.

1.2 Project Goals and Objectives

The Muddy Run II stream and wetland mitigation project will provide numerous ecological and water quality benefits within the Cape Fear River Basin. While many of these benefits are limited to the project area, others, such as pollutant removal and improved aquatic and terrestrial habitat, have more far-reaching effects. Expected improvements to water quality, hydrology, and habitat are outlined below.

Design Goals and Objectives

Benefits Related to Water Quality	
Nutrient removal	Benefit will be achieved through filtering of runoff from adjacent CAFOs through buffer areas, the conversion of active farm fields to forested buffers, improved denitrification and nutrient uptake through buffer zones, and installation of BMPs at the headwaters of selected reaches and ditch outlets.
Sediment removal	Benefit will be achieved through the stabilization of eroding stream banks and reduction of sediment loss from field areas due to lack of vegetative cover. Channel velocities will also be decreased through a reduction in slope, therefore decreasing erosive forces.
Increase dissolved oxygen concentration	Benefit will be achieved through the construction of instream structures to increase turbulence and dissolved oxygen concentrations and riparian canopy restoration to lower water temperature to increase dissolved oxygen capacity.
Runoff filtration	Benefit will be achieved through the restoration of buffer areas that will receive and filter runoff, thereby reducing nutrients and sediment concentrations reaching water bodies downstream.
Benefits to Flood Attenuation	
Water storage	Benefit will be achieved through the restoration of buffer areas which will infiltrate more water during precipitation events than under current site conditions.
Improved groundwater recharge	Benefit will be achieved through the increased storage of precipitation in buffer areas, ephemeral depressions, and reconnection of existing floodplain. Greater storage of water will lead to improved infiltration and groundwater recharge.
Improved/restored hydrologic connections	Benefit will be achieved by restoring the stream to a natural meandering pattern with an appropriately sized channel, such that the channel's floodplain will be flooded more frequently at flows greater than the bankfull stage.
Benefits Related to Ecological Processes	
Restoration of habitats	Benefit will be achieved by restoring riparian buffer habitat to appropriate bottomland hardwood ecosystem.
Improved substrate and instream cover	Benefit will be achieved through the construction of instream structures designed to improve bedform diversity and to trap detritus. Stream will be designed with the appropriate channel dimension and will prevent aggradation and sedimentation within the channel. Substrate will become coarser as a result of the stabilization of stream banks and an overall decrease in the amount fine materials deposited in the stream.

Addition of large woody debris	Benefit will be achieved through the addition of wood structures as part of the restoration design. Such structures may include log vanes, root wads, and log weirs.
Reduced temperature of water due to shading	Benefit will be achieved through the restoration of canopy tree species to the stream buffer areas.
Restoration of terrestrial habitat	Benefit will be achieved through the restoration of riparian buffer bottomland hardwood habitats.

1.3 Project Structure

Table 1. Muddy Run II Project Components – Stream Mitigation

Reach	Mitigation Type	Proposed Stationing	Existing Length (LF)	As-Built Length (LF)	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	0+00 to 4+48	438	398	1:1	398
Reach 2	Headwater Valley	0+00 to 5+04	504	504	1:1	504
Reach 2	P1 Restoration	5+04 to 19+14	1,223	1,410	1:1	1,410
Reach 3a	P1 Restoration	0+00 to 37+23	3,301	3,586	1:1	3,586
Reach 3b	P1 Restoration	37+23 to 57+92	NA	1,979	1:1	1,979
Reach 3c	Enhancement I	57+92 to 65+30	737	708	1:1.5	472
Reach 4	P1 Restoration	0+44 to 2+17	120	173	1:1	173
Reach 5a	P1 Restoration	0+00 to 19+59	1,602	1,926	1:1	1,926
Reach 5b	Enhancement II	19+59 to 23+68	401	409	1:2.5	164
Reach 6	Enhancement II	9+02 to 12+19	317	318	1:2.5	127
		Total	**8,643**	**11,411**		**10,739**

*As-Built length does not include channel in easement breaks.
** SMUs does not include channel in irrigation access areas inside easement.

Table 2. Muddy Run II Project Components – Wetland Mitigation

Wetland	Mitigation Type	Mitigation Area (ac)	Mitigation Ratio	WMUs
WA	Restoration	3.60	1:1	3.60
WB	Restoration	1.32	1:1	1.32
	Total	**4.92**		**4.92**

1.3.1 Restoration Type and Approach

Reach 1
Headwater valley restoration approach was performed along Reach 1. The existing channel/ditch was backfilled, and flow has been directed from its current position along the tree line back to within the historic valley location down to the confluence with Reaches 2 and 3a. A 100 foot wide forested buffer has been planted throughout the reach. The upstream limit of Reach 1 ties into an existing headwater valley system comprised of intermittent sections of single and multiple channels. This system will be used as a reference site for incorporating a small baseflow channel into the headwater valley restoration design.

Reach 2
Similar to Reach 1, headwater valley restoration was performed along the upper section of Reach 2. The existing channel was backfilled with existing spoil material located along the channel, a result of

previous dredging activities. Areas within the 100 foot buffer that were disturbed or lack riparian vegetation were planted. Grade control structures were installed along three ditches that enter Reach 2 at the upstream end of the project. These structures raised the upstream channel bed elevations slightly to tie into existing ditches to the project reach. An existing CMP culvert located along the upstream section was removed and replaced outside the easement (upstream) to continue to allow the landowner access to all areas of his property. Priority 1 restoration was performed for the majority of Reach 2. Restoration activities involved relocating the channel to the north through an existing wooded area consisting primarily of pines and a few hardwoods. Existing spoil piles located along the channel banks were removed and used to fill the existing ditch. Diffuse flow structures have been installed along several ditches that outlet to the reach from both the north and south. The structures will attenuate and disperse flows as the existing ditches enter the proposed easement.

Reach 3a

Priority Level I restoration was performed on Reach 3a. The restoration approach on this reach included relocating the channel on either side of its current location to follow the natural valley and removing the adjacent roadbed to allow continuous access to the floodplain. Two existing 36" CMP culvert crossings were located along this reach. Each culvert was removed and replaced in-line with the proposed stream to allow the landowners to access portions of their respective properties to the west of the project site. Reach 3a now flows in a northwesterly direction until it reaches a property line. At this point, the existing ditch that continued to flow in a northerly direction was plugged and a diversion structure was installed. The structure is designed to pass 100 percent of baseflow and small storms through the project, and divert up to 70 percent of storms larger than the 25-yr storm to the existing ditch and offsite. See Section 7.3.1.1 (Stream Hydrologic Analysis) for hydraulic analysis details.

Just downstream of the diversion structure, the channel was relocated south of several turkey houses, and now flows in a westerly direction as Reach 3b. The network of ditches surrounding the turkey houses appear to cross a small ridge, directing flow away from the project area. An additional culvert crossing was constructed where flow will be diverted to the west at the turkey houses. Priority I restoration is appropriate for this channel because it is the only mitigation approach that addresses bed and bank instability, establishes a forested riparian buffer, and significantly enhances aquatic habitat. Diffuse flow structures were constructed where existing agricultural ditches enter the easement area.

The diversion structure was constructed at the downstream end of Reach 3a to alleviate and prevent flooding caused by rerouting flow and increased drainage areas, to provide continued flow through the existing ditch for storms larger than bankfull (design) events, and to reduce impacts from proposed grading activities. Per discussions with Mr. Lanier (owner of parcel northwest of proposed structure), larger storm events overtop the existing ditch flowing to the north. This flooding may be attributed to inefficiencies with existing structures and ditch alignments in conjunction with low gradients. The culvert associated with the gravel access road that leads from Ludie Brown Road to the turkey houses outlets perpendicular to the receiving ditch that flows to the northeast and under Ludie Brown Road. This ditch continues to the northeast and crosses Route 111, where it flows to the north into Muddy Creek. By diverting up to 70 percent of higher flows through the existing ditch and offsite, existing flooding issues will be reduced adjacent to the turkey houses. This diversion also decreases potential flooding impacts that would occur if 100 percent of storm events were passed through the proposed channel, Reach 3b. There are several residential parcels within zero to 200 feet of the proposed easement along Reach 3b. Because the topography is very flat through this area, the flooding associated with the majority of storm events greater than bankfull would negatively impact these parcels.

Finally, by diverting a percentage of the proposed higher flows, flooding impacts will also be reduced along Reaches 5a and 5b and at the existing HWY 41 culvert at the downstream end of the project. Currently, agricultural fields are present along the north side of Reach 5a. By reducing high flows, the

flooding extent and duration will be reduced; thus, preventing adverse impacts to crops. If 100 percent of higher storm events were allowed to pass through the project, significant grading would be required to cut floodplain terraces/benches to relieve flooding of the adjacent agricultural fields.

Approximately 1,611 LF of the existing ditch that flows to the north from the Reach 3a/3b diversion structure will be impacted (dewatered). This length includes the segment of the ditch from the diversion structure downstream to the Muddy Creek floodplain. The channel impacts resulting from the proposed channel relocation will be addressed in the ensuing NWP application.

Reach 3b
Priority Level I restoration was performed on Reach 3b. The restoration approach on this reach included relocating the channel in a westerly direction through an open pasture. The pasture area has been extensively modified and substantial grading was required. The design then moves the channel to a historic drainage way as observed on LiDAR and historical aerial photographs. The flow path is now connected to a small relic channel identified in the forested area west of the pasture. Subsequent topographic survey confirmed positive drainage along the relic channel which follows a low lying feature observed on LiDAR. The restoration approach included some minor grading to enlarge the existing channel and to create a diverse bed habitat by constructing pools. Log grade control structures were installed at the confluence with Reach 3c and at the connection to the relic channel. Small, mechanical equipment and hand tools were used to minimize damage to the existing forested buffer. A livestock protected culvert crossing was constructed near the existing pasture along an existing farm path to allow the landowner uninterrupted access to his property.

Reach 3c
Enhancement I was performed on Reach 3c as it flows through a forested area downstream from Reach 3b to Reach 3 of the Muddy Run Stream Mitigation Project. A grade control structure was installed at the upstream end to stabilize the transition from an existing agricultural ditch to the stable channel. A crossing was constructed along the upper section to allow the landowner access to both sides of his property. Enhancement activities included removing portions of existing spoil piles located along top of banks, cutting floodplain benches and laying back banks, and installing woody debris habitat structures. Diffuse flow structures were also constructed at the downstream limit where existing agricultural ditches enter the easement area. Invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 4
Priority 1 restoration was performed on the downstream end of Reach 4 as it flows through a forested area below a ditch draining an agricultural field. A grade control structure was installed at the upstream end to transition from the existing ditch to a stable channel. The lower section of the reach was constructed into an E-type channel before its confluence with Reach 3a. Invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 5a
Priority Level I restoration was performed on Reach 5a. The channel was relocated north of its current location into the adjacent agricultural field. The existing ditch was backfilled and plugged at any locations that may cross the proposed channel. The upstream end of the reach ties into Reach 1C of the Muddy Run Stream Mitigation Project. The single-thread channel will flows through proposed wetland WB beginning approximately 300 feet downstream of the Muddy Run project. A CMP culvert crossing was installed in-line with the proposed design near the middle of the reach to allow the landowners access to the adjacent parcels. Priority I restoration is appropriate for this channel because it is the only

mitigation approach that addresses bed and bank instability, establishes a forested riparian buffer, and significantly enhances aquatic habitat.

Reach 5b
Enhancement Level II was performed on Reach 5b. Several log grade controls and woody debris structures were installed along the bed to increase aquatic habitat and bed diversity. The right bank along the reach was laid back and spoil piles along the tops of banks were removed using small equipment to minimize impacts to the existing buffer. Additionally, invasive species management was performed throughout the buffer, and any bare or disturbed areas were planted with native riparian vegetation.

Reach 6
Enhancement Level II was performed on the downstream section of Reach 6 (STA 9+02 to STA 12+19). The right and left banks were laid back, and the channel was backfilled using spoil located adjacent to the channel such that positive drainage is maintained throughout the reach down to the confluence with Reach 5a. Invasive species management was performed throughout the buffer where enhancement took place, and any bare or disturbed areas were planted with native riparian vegetation. A 50 foot wide buffer was provided along the upper section of Reach 6 (STA 0+00 to STA 9+02); however, no enhancement activities were performed through this section other than filling portions of the channel. This additional easement was provided to account for any hydrologic impacts that may occur as a result of the proposed enhancement activities.

1.4 Project History, Contacts and Attribute Data

1.4.1 Project History

The Site was restored by Environmental Banc & Exchange, LLC (EBX) through a full-delivery contract awarded by NCDMS in 2011. EBX was acquired by Resource Environmental Solutions, LLC (RES) in 2014 and now oversees the project tasks. Tables 2, 3, and 4 in **Appendix A** provide a time sequence and information pertaining to the project activities, history, contacts, and baseline information.

1.4.2 Project Watersheds

The easement totals 37.6 acres and is broken into nine reaches. Reach 1 has a drainage area of 68 acres; it begins at the start of the restoration project (STA 0+00) and extends west to STA 4+48. Reach 2 has a drainage area of 114 acres; it begins at STA 0+00 and extends to STA 19+14. Reach 3a (Sta. 0+00 to 37+23) begins at the confluence of Reaches 1 and 2 and has a drainage area of 227 acres. Reach 3b has a drainage area of 333 acres and flows west into Reach 3c; it begins at STA 37+23 and extends to STA 57+92. Reach 3c has a drainage area of 370 acres extending north to south and flows into Reach 3 of the Muddy Run project; it begins at STA 57+92 and extends to STA 65+30. Reach 4 has a drainage area of 46 acres and flows from the east into Reach 3a; it begins at STA 0+44 and extends to STA STA 2+17. Reach 5a begins at the downstream limit of the Muddy Run project, flows into Reach 5b, and has a drainage area of 774 acres; it begins at STA 0+00 and extends to STA 19+59. Reach 5b has a drainage area of 908 acres; it starts at STA 19+59 and extends to STA 23+68. Reach 6 has a drainage area of 318 acres and flows from the south into Reach 5a; it starts at STA 9+02 and extends to STA 12+19 **(Figure 2).** The land use in the project watershed is approximately 38 percent cultivated, 32 percent evergreen forest, 15 percent shrub/scrub, 6 percent bottomland forest/hardwood swamp, 5 percent mixed forest, 2 percent developed, and 2 percent managed herbaceous cover.

2 Success Criteria

The success criteria for the Site stream restoration was assembled from the EEP Monitoring Requirements and Performance Standards Guidance for Stream and-or Wetland Mitigation (11/07/2011). Specific success criteria components are presented below.

2.1 Stream Restoration

2.1.1 Bankfull Events

Two bankfull flow events must be documented within the seven-year monitoring period. The two bankfull events must occur in separate years. Otherwise, the stream monitoring will continue until two bankfull events have been documented in separate years. Bankfull events will be documented using crest gauges, auto-logging crest gauges, photographs, and visual assessments for evidence of debris rack lines.

2.1.2 Cross Sections

There should be little change in as-built cross-sections. If changes do take place, they should be evaluated to determine if they represent a movement toward a less stable condition (for example down-cutting or erosion), or are minor changes that represent an increase in stability (for example settling, vegetative changes, deposition along the banks, or decrease in width/depth ratio). Cross-sections are classified using the Rosgen stream classification method, and all monitored cross-sections should fall within the quantitative parameters defined for channels of the design stream type.

2.1.3 Digital Image Stations

Digital images are used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal images should not indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral images should not indicate excessive erosion or continuing degradation of the banks over time. A series of images over time should indicate successional maturation of riparian vegetation.

2.2 Wetland Restoration

The NRCS does not have a current WETs table for Duplin County upon which to base a normal rainfall amount and average growing season. The closest comparable data was determined to be from Sampson County. The growing season for Sampson County is 242 days long, extending from March 17 to November 14, and is based on a daily minimum temperature greater than 28 degrees Fahrenheit occurring in five of ten years.

Because of the surface roughing and shallow depressions, a range of hydroperiods are expected. The water balance indicates that the site will have a positive water balance in the early part of the growing season for four to five weeks, on average. The hydrology success criterion for the site is to restore the water table at the site so that it will remain continuously within 12 inches of the soil surface for at least nine percent of the growing season (approximately 22 days) at each groundwater gauge location during normal rainfall years. Overbank flooding events will provide additional inputs that may extend the hydroperiod in some years.

Gauge data will be compared to reference wetland well data in growing seasons with less than normal rainfall. In periods of low rainfall, if a restoration gauge hydroperiod exceeds the reference gauge hydroperiod, and both exceed five percent of the growing season, then the gauge will be deemed

successful. If a gauge location fails to meet these success criteria in the seven year monitoring period, then monitoring may be extended, remedial actions may be undertaken, or the limits of wetland restoration will be determined.

2.3 Vegetation

Specific and measurable success criteria for plant density within the riparian buffers on the site will follow NCDMS Guidance. Vegetation monitoring plots are 0.02 acres in size, and cover greater than two percent of the planted area. Vegetation monitoring will occur annually in the fall of each year. The interim measures of vegetative success for the site will be the survival of at least 320 three-year-old trees per acre at the end of Year 3, 260 trees per acre at the end of Year 5, and the final vegetative success criteria will be 210 trees per acre at the end of Year 7. Invasive species on the site will be monitored and treated if necessary throughout the required vegetation monitoring period.

2.4 Scheduling/Reporting

The monitoring program will be implemented to document system development and progress toward achieving the success criteria. The restored stream morphology will be assessed to determine the success of the mitigation. The monitoring program will be undertaken for seven years or until the final success criteria are achieved, whichever is longer.

Monitoring reports will be prepared in the fall of each year of monitoring and submitted to NCDMS. The monitoring reports will include all information, and will be in the format required by NCDMS in Version 2.0 of the NCDMS Monitoring Report Template.

3 MONITORING PLAN

Annual monitoring data will be reported using the DMS monitoring template. Annual monitoring shall be conducted for stream, wetland, and vegetation monitoring parameters as noted below.

3.1 Stream Restoration

3.1.1 As-Built Survey

An as-built survey was conducted following construction to document channel size, condition, and location. The survey will include a complete profile of thalweg, water surface, bankfull, and top of bank to compare with future geomorphic data. Longitudinal profiles will not be required in annual monitoring reports unless requested by NCDMS or USACE.

3.1.2 Bankfull Events

Four sets of manual and auto-logging crest gauges were installed on the site, one along Reach 2, one along Reach 3a, one along Reach 3b, and one along Reach 5a. The auto logging crest gauges were installed within the channel and will continuously record flow conditions at an hourly interval. Manual crest gauges were installed on the bank at bankfull elevation. Crest gauges will be checked during each site visit to determine if a bankfull event has occurred since the last site visit. Crest gauge readings and debris rack lines will be photographed to document evidence of bankfull events.

3.1.3 Cross Sections

A total of 59 permanent cross sections were installed to monitor channel dimensions and stability. Four cross sections were installed along Reach 1 and ten cross sections were installed along Reach 2. There were 21 cross sections (nine runs, nine pools, and three riffles) installed along Reach 3A and six cross sections installed along Reach 3B. Four cross sections were installed along Reach 3C and two cross

sections were installed along Reach 4. Reach 5A had eight cross sections installed, while Reach 5B and 6 each had two cross sections installed. Cross sections were typically located at representative shallow and pool sections along each stream reach. Each cross section was permanently marked with 3/8 rebar pin to establish a monument location at each end. A marker pole was also installed at both ends of each cross section to allow ease locating during monitoring activities. Cross section surveys will be performed in monitoring years 1, 2, 3, 5, and 7 and will include all breaks in slope including top of bank, bottom of bank, streambed, edge of water, and thalweg.

3.1.4 Digital Image Stations

Digital photographs will be taken at least once a year to visually document stream and vegetation conditions. This monitoring practice will continue for seven years following construction and planting. Permanent photo point locations at cross sections and vegetation plots have been established so that the same directional view and location may be repeated each monitoring year. Monitoring photographs will also be used to document any stream and vegetation problematic areas such as erosion, stream and bank instability, easement encroachment and vegetation damage.

3.1.5 Bank Pin Arrays

Twenty bank pin arrays have been installed at cross sections located on meander pools. These bank pin arrays were installed along the upstream and downstream third of the meander. Bank pins are a minimum of three feet long, and have been installed just above the water surface and every two feet above the lowest pin. Bank pin exposure will be recorded at each monitoring event, and the exposed pin will be driven flush with the bank.

3.1.6 Visual Assessment Monitoring

Visual monitoring of all mitigation areas will be conducted a minimum of twice per monitoring year by qualified individuals. The visual assessments will include vegetation density, vigor, invasive species, and easement encroachments. Visual assessments of stream stability will include a complete stream walk and structure inspection. Digital images will be taken at fixed representative locations to record each monitoring event as well as any noted problem areas or areas of concern. Results of visual monitoring will be presented in a plan view exhibit with a brief description of problem areas and digital images. Photographs will be used to subjectively evaluate channel aggradation or degradation, bank erosion, success of riparian vegetation, and effectiveness of erosion control measures. Longitudinal photos should indicate the absence of developing bars within the channel or an excessive increase in channel depth. Lateral photos should not indicate excessive erosion or continuing degradation of the banks over time. A series of photos over time should indicate successional maturation of riparian vegetation.

3.1.7 Surface Flow

Headwater valley restoration areas will be monitored to document intermittent or seasonal surface flow. This will be accomplished through direct observation, photo documentation of hydrology conditions, and dye tests if necessary.

3.2 Vegetation

A total of 28 vegetation plots were randomly established within the planted stream riparian buffer easement. Each vegetation plot measures 22 feet by 40 feet (0.02 acres) and has all four corners marked with PVC posts. Planted woody vegetation was assessed within each plot to establish a baseline dataset. Within each vegetation plot, each planted stem was identified for species, “X” and “Y” origin located, and measured for height. Reference digital photographs were also captured to document baseline conditions. Species composition, density, growth patterns, damaged stems, and survival ratios will be

measured and reported on an annual basis. Vegetation plot data will be reported for each plot as well as an overall site average.

3.3 Wetland Hydrology

Wetland hydrology will be monitored to document hydric conditions in the wetland restoration areas. Seven automatic recording pressure transducer gauges were installed in representative locations across the restoration areas and an additional three gauges were installed in reference wetlands. The gauges will be downloaded quarterly and wetland hydroperiods will be calculated during the growing season. Gauge installation followed current regulatory and NCDMS guidance. Visual observations of primary and secondary wetland hydrology indicators will also be recorded during quarterly site visits.

4 MAINTENANCE AND CONTINGENCY PLAN

All identified problematic areas or areas of concern such as stream bank erosion/instability, aggradation/degradation, lack of targeted vegetation, and invasive/exotic species which prevent the site from meeting performance success criteria will be evaluated on a case by case basis. These areas will be documented and remedial actions will be discussed amongst NCDMS staff to determine a plan of action. If it is determined remedial action is required, a plan will be provided.

4.1 Stream

During the Year 4 monitoring activities, one stream problem area was documented. This area (SPA1) is located on Reach 5A at station 19+50 and consists of right bank erosion caused by a dislodged structure from the toe of the bank. This area is mapped on the CCPV figure in **Appendix B**. Stream problem area 1 (SPA1) will be addressed by adding rip rap behind the dislodged structure and livestaking the bank to reduce further erosion. Stream problem areas identified during MY3 were inspected during MY4. Formerly SPA1, is now considered a vegetation problem area (see VPA2 below). The stream problem area is localized and the overall condition of the project streams on site are stable. Stream issues are described in **Appendix B**.

4.2 Vegetation

Two vegetation problem areas were identified during monitoring Year 4 activities and is mapped on the CCPV figures. Vegetation problem area 1 (VPA1) is an area where encroachment from the adjacent farming operation occurred. This area is approximately a tenth of an acre in size and occurs on Reach 3A. RES will communicate with landowners and install additional signage in this area to prevent future issues. Vegetation problem area 2 (VPA2, formerly SPA1 in MY3), is a bare slope with gully and rill erosion on Reach 5A. RES plans to reseed and mat this area as well as hand grade and livestake the associated headcuts. The two vegetation problem areas from MY4 are small and do not pose a threat to vegetation success criteria being met. All vegetation issues are described in **Appendix B**.

4.3 Wetlands

No wetland problem areas were noted during the Year 4 monitoring period. During the 2017 growing season, all seven wells recorded water continuously within 12 inches of the soil surface for at least nine percent of the growing season. If any wetland problem areas are noted in the future, they will be documented and mapped on the Current Conditions Plan View (CCPV) as part of the annual stream and wetland monitoring report. Detailed wetland hydrology data is provided in **Appendix D.**

5 YEAR 4 MONITORING CONDITIONS (MY4)

The Muddy Run II Year 4 Monitoring activities were completed in November 2017. All Year 4 monitoring data is present below and in the appendices. Data presented shows the site has one stream problem areas and two vegetation problem areas; however, the site is on track to meeting stream, wetland and vegetation interim success criteria.

5.1 Year 4 Monitoring Data Collection

5.1.1 Morphological State of the Channel

Visual assessment of the stream channel was performed to document signs of instability, such as eroding banks, structural instability, or excessive sedimentation. No indication of instability was observed during visual assessment and all structures are functioning as designed.

Stream geomorphic data, including cross-sections, pebble counts, and bank pin arrays were not collected during Monitoring Year 4 activities per the monitoring guidance and schedule stated in the Mitigation Plan and As-Built Baseline Documents. This data will be collected in Monitoring Year 5 and documented in the MY5 report.

5.1.2 Vegetation

The Year 4 monitoring (MY-4) vegetation survey was completed in November 2017 and resulted in an average of 638 planted stems per acre, well above the interim survival density of 260 stems per acre at the end of Year 5 monitoring. The average stems per vegetation plot was 13 planted stems. The minimum planted stems per plot was 8 stems and the maximum was 21 stems per plot. Sweetgum (*Liquidambar styraciflua*), Loblolly Pine (*Pinus taeda*), Winged Sumac (*Rhus copallinum*), Tulip Poplar (*Liriodendron tulipifera*), Serviceberry (*Amelanchier arborea*), and Red Maple (*Acer rubrum*) were noted volunteers during MY4 activities. Abundant herbaceous ground cover may have prevented the observance of these species in previous monitoring years. Vegetation summary data tables and plot photos can be found in **Appendix C**.

5.1.3 Photo Documentation

Permanent photo point locations have been established at cross sections, vegetation plots, stream crossings, and stream structures by RES staff. Any additional problem areas or areas of concern will also be documented with a digital photograph during monitoring activities. Stream digital photographs can be found in **Appendix B** and **Appendix C** for vegetation photos.

5.1.4 Stream Hydrology

Four sets of manual and auto-logging crest gauges were installed on the site, one along Reach 2, one along Reach 3a, one along Reach 3b, and one along Reach 5b. The auto logging crest gauges were installed within the channel and continuously record flow conditions at hourly intervals. Reaches 2, 3a, and 5b documented bankfull events during the Year 4 monitoring period. Crest gauge 1, which is located on Reach 2, documented five out of bank events during MY4 with a highest reading of 1.1 feet. Crest gauge 2 (Reach 3a) logged seven bankfull event during monitoring year 4 with a reading of 2.0 feet above bankfull elevation. Crest gauge 3 (Reach 3b) had no bankfull event readings during monitoring year 4. Crest gauge 4 (Reach 5b) documented eight bankfull events during MY4 with a highest reading of 2.8 feet. Crest gauge summary data and photo documentation of the bankfull events can be found in **Appendix D**.

5.1.5 Wetland Hydrology

All seven wetland restoration gauges achieved the success criteria by remaining continuously within 12 inches of the soil surface for at least nine percent of the growing season. Groundwater gauge data indicate the hydroperiods being very responsive to rainfall events. Of the three reference wetlands gauges, only one (RAW2) did not meet success criteria, documenting 6 consecutive days (2%) throughout the growing season. Wetland gauge and rainfall data is presented in **Appendix D**.

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Appendix A

Project Background Data and Maps

Appendix A. **General Tables and Figures**
Table 1 Project Components and Mitigation Credits
Monitoring Report Year 4

Table 1. Project Components and Mitigation Credits

Mitigation Credits

	Stream		Riparian Wetland		Non-riparian Wetland		Buffer	Nitrogen Nutrient Offset	Phosphorous Nutrient Offset
Type	R	RE	R	RE	R	RE			
Totals	10,739		4.92	N/A	N/A	N/A	N/A	N/A	N/A

Project Components

Project Component -or- Reach ID	As-Built Stationing/Location (LF)	Existing Footage/Acreage	Approach (PI, PII etc.)	Restoration -or- Restoration Equivalent	Restoration Footage or Acreage	Mitigation Ratio
Reach 1	0+00 – 4+48	438	HWV	Restoration	398	1 : 1
Reach 2	0+00 – 5+04	504	HWV	Restoration	504	1 : 1
Reach 2	5+04 – 19+14	1,223	P1	Restoration	1,410	1 : 1
Reach 3A	0+00 – 37+23	3,301	P1	Restoration	3,586	1 : 1
Reach 3B	37+23 – 57+92	NA	P1	Restoration	1,979	1 : 1
Reach 3C	57+92 – 65+30	737	Enh. I	Rest. Equivalent	708	1 : 1.5
Reach 4	0+44 – 2+17	120	P1	Restoration	173	1 : 1
Reach 5A	0+00 – 19+59	1,602	P1	Restoration	1,926	1 : 1
Reach 5B	19+59 – 23+68	401	Enh. II	Rest. Equivalent	409	1 : 2.5
Reach 6*	9+02 – 12+19	317	Enh. II	Rest. Equivalent	318	1 : 2.5

Component Summation

Restoration Level	Stream (linear feet)	Riparian Wetland (acres)		Non-riparian Wetland (acres)	Buffer (square feet)	Upland (acres)
		Riverine	Non-Riverine			
Restoration	9,074	4.92				
Headwater Valley	902					
Enhancement						
Enhancement I	708					
Enhancement II	727					
Creation						
Preservation						
High Quality Preservation						

BMP

Element	Location	Purpose/Function	Notes
---	---	---	---
---	---	---	---
---	---	---	---

BMP Elements
BR = Bioretention Cell; SF = Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; S = Grassed Swale; LS = Level Spreader; NI = Natural Infiltration Area; FB = Forested Buffer

*The upper portion of Reach 6 (893 ft) and the side channel (307 ft) that confluences with it were given a 50 ft buffer and are included in the easement to account for hydrologic impacts. No credit was generated from these channels.

Table 2. Project Activity and Reporting History

Project Activity and Reporting History Muddy Run II Stream and Wetland Restoration / NCDMS Project #95354		
Activity or Report	**Data Collection Complete**	**Completion or Delivery**
Mitigation Plan	NA	January 2014
Final Design – Construction Plans	NA	March 2014
Construction Completed	NA	May 2014
Site Planting Completed	NA	May 2014
Baseline Monitoring Document (Year 0 Monitoring – baseline)	June 2014	August 2014
Year 1 Monitoring	December 2014	December 2014
Year 2 Monitoring	December 2015	February 2016
Adaptive Management Repair and Supplemental Replanting*		April 2016
Invasive Species Control		October 2016
Year 3 Monitoring	November 2016	February 2017
Year 4 Monitoring	November 2017	February 2018
Year 5 Monitoring		

*4,400 trees

Table 3. Project Contacts

Project Contacts Table Muddy Run II Stream and Wetland Restoration /NCDMS Project # 95354	
Designer	WK Dickson and Co., Inc. 720 Corporate Center Drive Raleigh, NC 27607 (919) 782-0495 Frasier Mullen, PE
Construction Contractor	GP Jenkins 6566 HWY 55 W Kinston, NC 28504 (252) 569-1222 Gary Jenkins
Planting Contractor	H&J Forestry Matt Hitch
Seeding Contractor	Rain Services, Inc. Lupe Cruz
Seed Mix Sources	Green Resource
Nursery Stock Suppliers	Arbogen
Full Delivery Provider Project Manager:	Resource Environmental Solutions 302 Jefferson Street, Suite 110 Raleigh, NC 27605 (919) 829-9909 Daniel Ingram
Monitoring Performers Project Manager:	Resource Environmental Solutions, LLC 302 Jefferson Street. Suite 110 Raleigh, NC 27605 (919) 741-6268 Ryan Medric

Table 4. Project Information

Project Information			
Project Name	Muddy Run II Stream and Wetland Restoration		
County	Duplin		
Project Area (acres)	37.6		
Project Coordinates (latitude and longitude)	34.830843^0 N , -77.792838 ^{0} W		
Project Watershed Summary Information			
Physiographic Province	Coastal Plain		
River Basin	Cape Fear		
USGS Hydrologic Unit 8-digit	03030007	USGS Hydrologic Unit 14-digit	0303007060010
DWQ Sub-basin	03-06-22		
Project Drainage Area (acres)	908		
Project Drainage Area Percentage of Impervious Area	<1%		
CGIA Land Use Classification			

Reach Summary Information

Parameters	Reach 1	Reach 2	Reach 3a	Reach 3b	Reach 3c	Reach 4	Reach 5a	Reach 5b	Reach 6
Length of Reach (linear feet)	398	1914	3586	1979	708	173	1926	409	318
Valley Classification									
Drainage Area (acres)	68	114	227	333	370	46	774	908	77
NCDWQ Stream Identification	24.75	24.75	36.5	NA	40.5	32.0	35.5	37.5	20.75
NCDWQ Water Quality	NA	NA	NA	NA	NA	NA	NA	NA	NA
Morphological Description (stream									
Evolutionary Trend									
Underlying Mapped Soils	Rains	Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro/ Rains	Goldsboro / Rains	Goldsboro	Goldsboro / Rains
Drainage Class	---	---	---	---	---				
Soil Hydric Status	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric	Hydric
Slope	0.0043	0.0021	0.0016	0.0023	0.0022	0.0034	0.0024	0.0015	0.0024
FEMA Classification	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X	Zone X
Native Vegetation Community	Coastal Plain Small Stream Swamp								
Percent Composition of Exotic	0%	0%	0%	0%	0%	0%	0%	0%	0%

Wetland Summary Information

Parameters	Wetland A	Wetland B
Size of Wetland (acres)	3.60	1.32
Wetland Type (non-riparian, riparian riverine or riparian	Riparian	Riparian
Mapped Soil Series	Goldsboro	Rains
Drainage class	Moderately Well	Poorly
Soil Hydric Status	Yes	Yes
Source of Hydrology	Runoff/Overbank Flows	Runoff/Overbank Flows
Hydrologic Impairment	Ditched/Incised Channel	Ditched/Incised Channel
Native vegetation community	Cultivated	Cultivated
Percent composition of exotic invasive vegetation	NA	NA

Regulatory Considerations

Regulation	Applicable?	Resolved?	Supporting Documentation
Waters of the United States – Section 404	X	X	USACE NWP 27
Waters of the United States – Section 401	X	X	401 Water Quality Cert.
Endangered Species Act	X	X	USFWS (Corr. Letter)
Historic Preservation Act	X	X	SHPO (Corr. Letter)
Coastal Zone Management Act (CZMA)/ Coastal Area Management Act (CAMA)	N/A	N/A	N/A
FEMA Floodplain Compliance			
Essential Fisheries Habitat	N/A	N/A	N/A

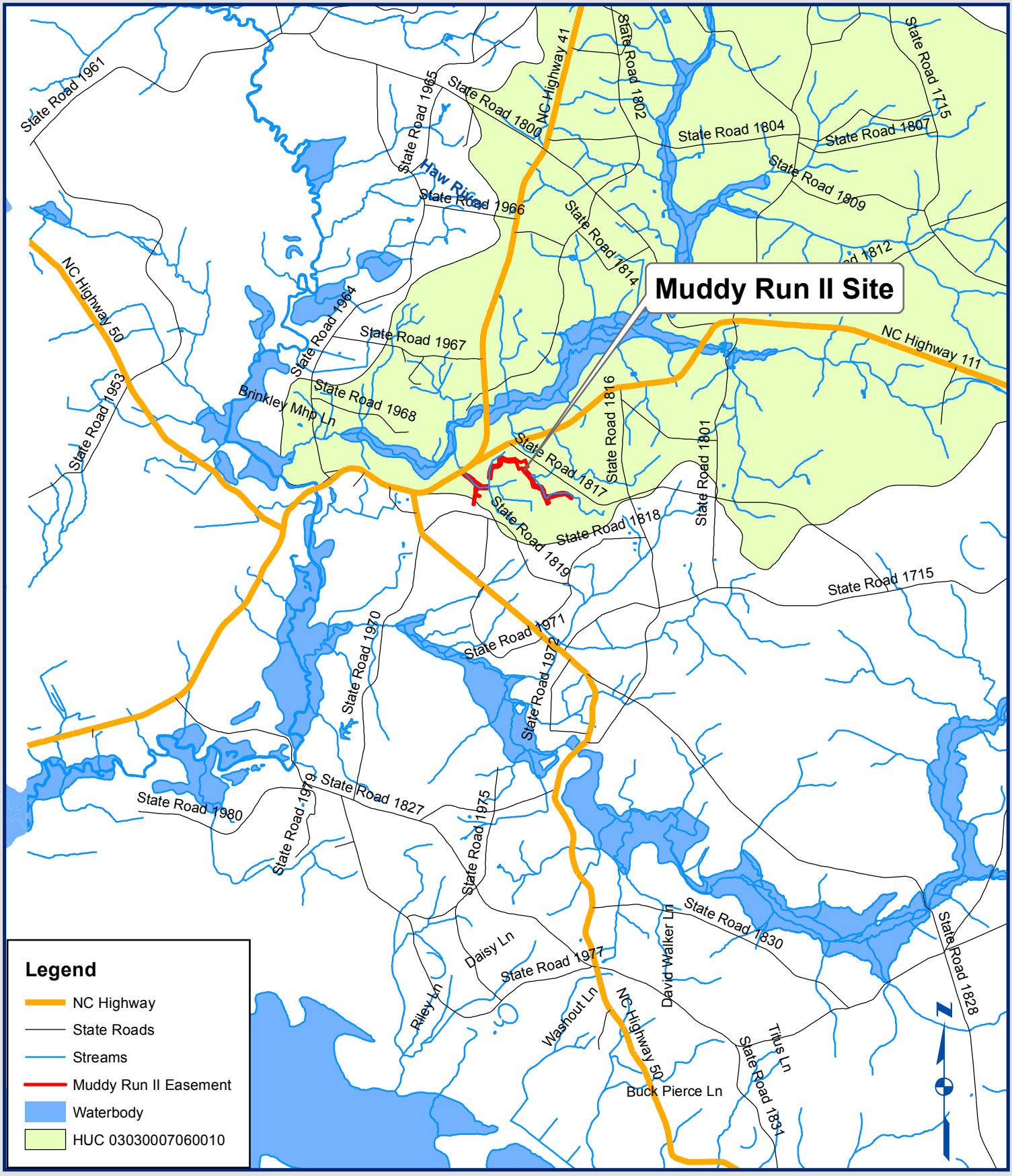

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Figure 1.
Project Vicinity Map
Muddy Run II Mitigation Site

0 0.75 1.5 3 Miles

1 inch = 1.5 miles

DUPLIN COUNTY
Scale: NTS

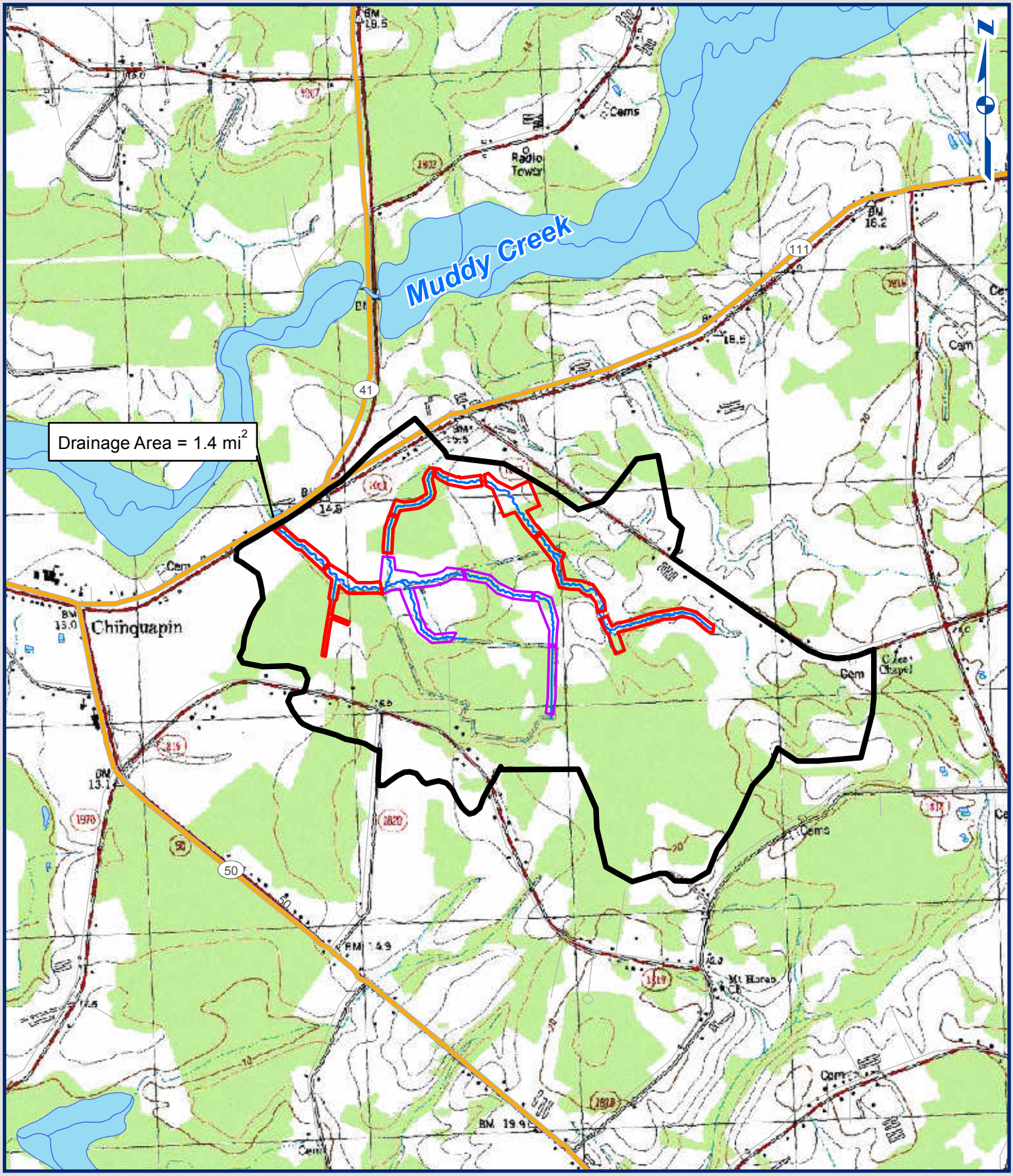

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Figure 2.
USGS/Watershed Map
Muddy Run II Mitigation Site

0 1,000 2,000 4,000 Feet

1 inch = 2,000 feet

- Proposed Streams
- Waterbodies
- Muddy Run II Easement
- Muddy Run Easement
- Drainage Area

Appendix B

Visual Assessment Data

Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

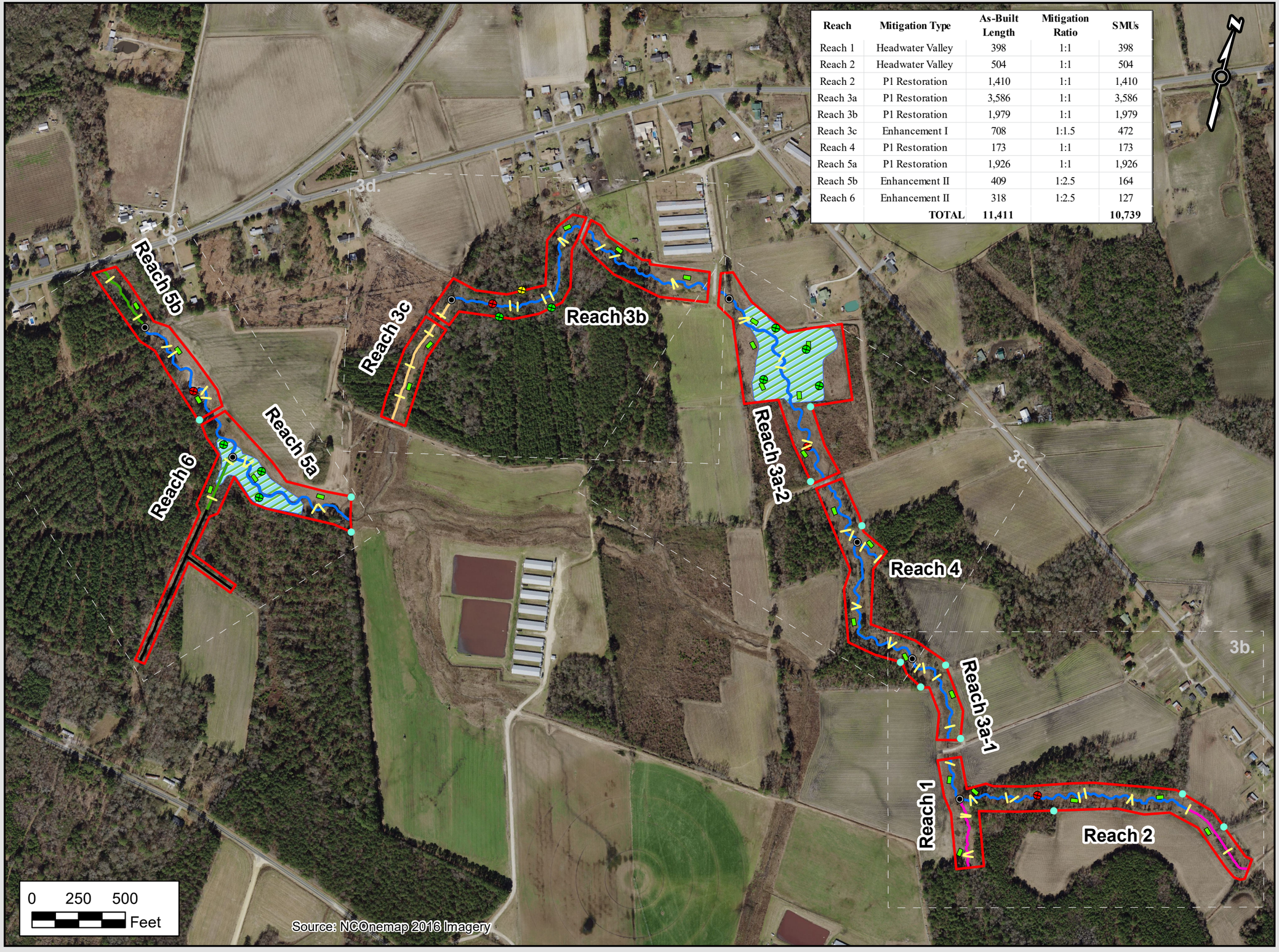

Figure 3a.
Muddy Run II
Mitigation Site
Current Conditions Map
Duplin County, NC
MY4 2017

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Legend

- Easement Boundary
- Cross Sections
- Crest Gauges
- Reach Breaks
- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Channel - No Credit
- Wetland Restoration Area
- Agricultural BMP

Vegetation Plots

Met Year 4 Success

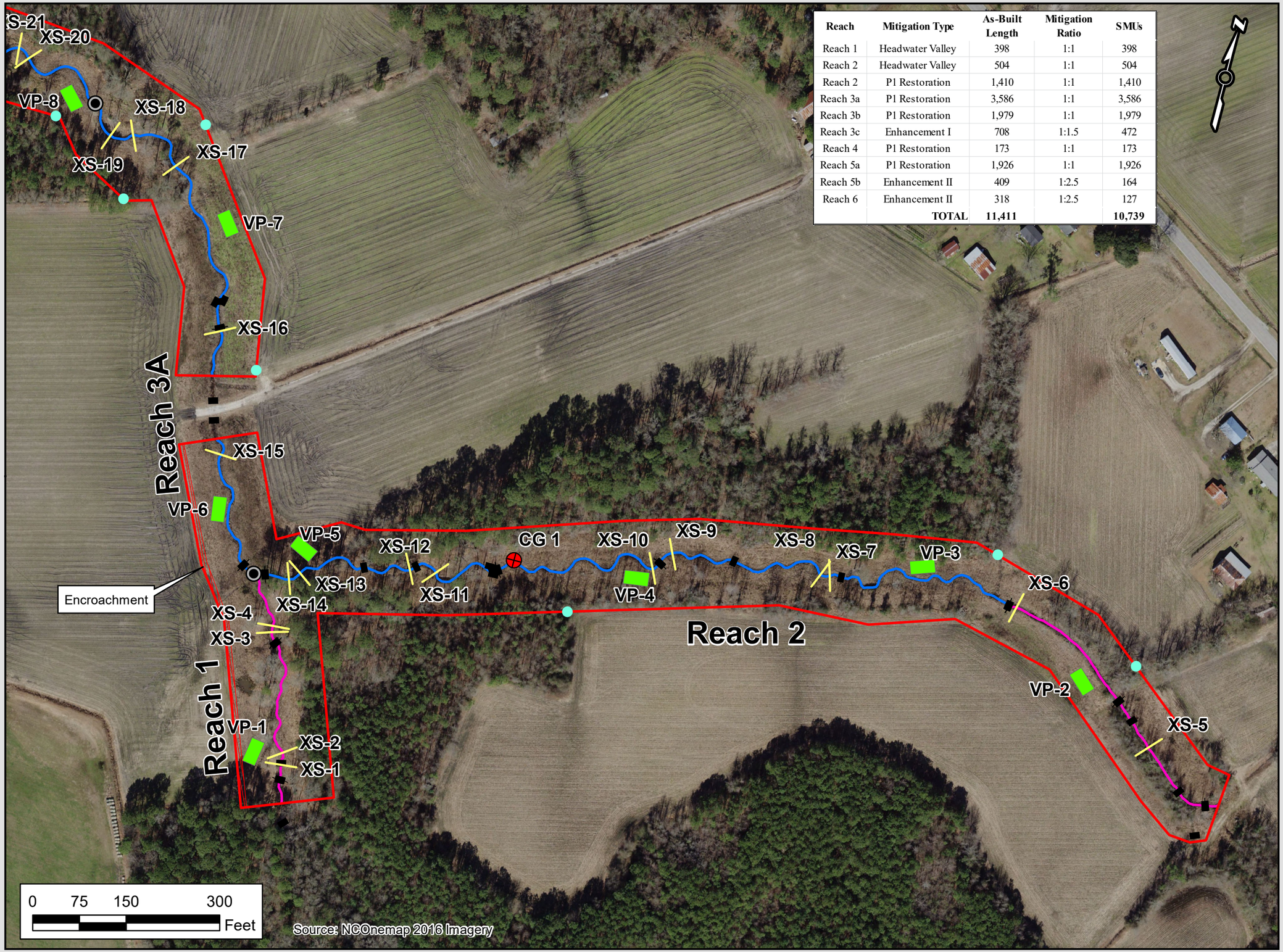
- Yes
- No

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Figure 3b.
Muddy Run II
Mitigation Site
Current Conditions Map
Duplin County, NC
MY4 2017

Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	11,411		10,739



Legend

- Easement Boundary
- Cross Sections
- Stream Structures
- Reach Breaks
- Crest Gauges

Mitigation

- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Channel - No Credit
- Agricultural BMP

Vegetation Plots

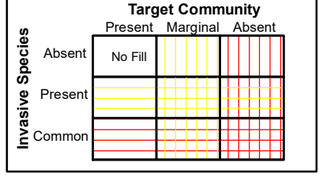
Met Year 4 Success

- Yes
- No

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions



Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	11,411		10,739

VP-15
VP-17
AW3
AW2
XS-31
XS-29
XS-30
XS-28
AW1
VP-16
VP-13
AW4
VP-14
XS-27
CG 2
XS-26
VP-12
Reach 3A
VP-11
XS-24
XS-25
VP-10
Reach 4
XS-47
XS-46
XS-23
XS-22
XS-21
XS-20
VP-9
VP-8

0 50 100 Feet

Source: NCOnemap 2016 Imagery

NC 911 B

Figure 3c. Muddy Run II Mitigation Site Current Conditions Map Duplin County, NC MY4 2017

res

Legend

- Easement Boundary
- Agricultural BMP
- Crest Gauges
- Cross Sections
- Stream Structures
- Reach Breaks

Mitigation

- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Channel - No Credit
- Wetland Restoration

Vegetation Plots

Met Year 4 Success

- Yes
- No

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions

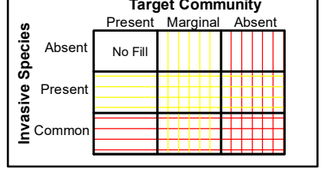


Figure 3d.
Muddy Run II
Mitigation Site
Current Conditions Map
Duplin County, NC
MY4 2017

VP-20
XS-36
XS-37
XS-35
VP-19
XS-34
VP-18
XS-33
XS-32
Reach 3B
REFAW2
XS-39
XS-38
CG 3
XS-41
XS-40
REFAW1
XS-42
REFAW3
XS-43
VP-21
Reach 3C
XS-44
VP-22
XS-45

0 75 150
Feet

Source: NCOnemap 2016 Imagery

Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	11,411		10,739

Legend

- Easement Boundary
- Cross Sections
- Reach Breaks
- Stream Structures
- Vegetation Plots
- Crest Gauges

Mitigation

- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Channel - No Credit

Vegetation Plots

Met Year 4 Success

- Yes
- No

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions

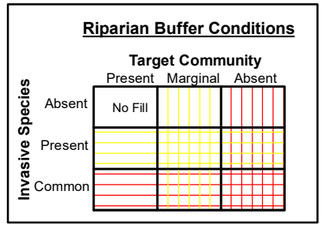
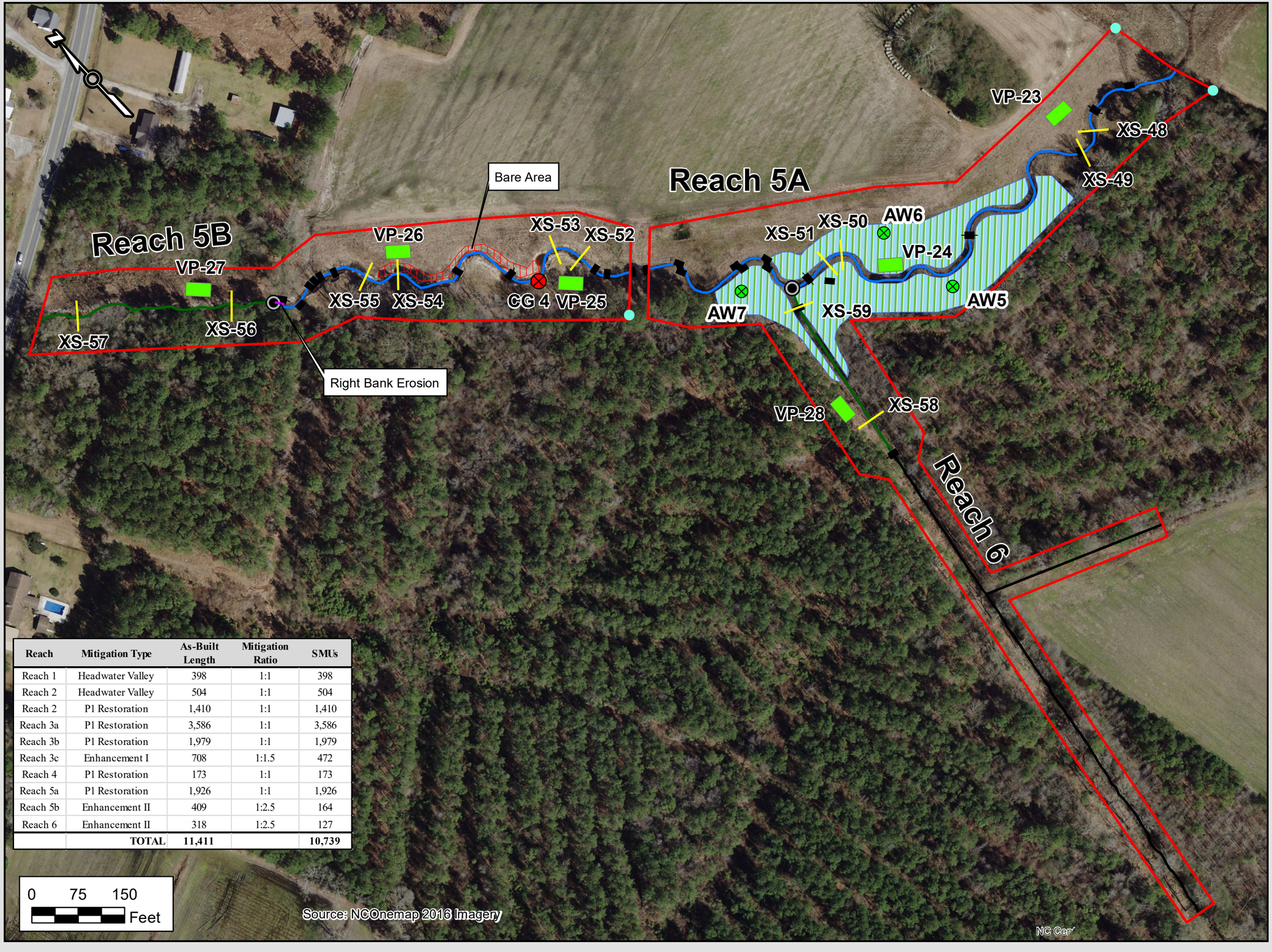


Figure 3e.
Muddy Run II
Mitigation Site
Current Conditions Map
Duplin County, NC
MY4 2017



Reach	Mitigation Type	As-Built Length	Mitigation Ratio	SMUs
Reach 1	Headwater Valley	398	1:1	398
Reach 2	Headwater Valley	504	1:1	504
Reach 2	P1 Restoration	1,410	1:1	1,410
Reach 3a	P1 Restoration	3,586	1:1	3,586
Reach 3b	P1 Restoration	1,979	1:1	1,979
Reach 3c	Enhancement I	708	1:1.5	472
Reach 4	P1 Restoration	173	1:1	173
Reach 5a	P1 Restoration	1,926	1:1	1,926
Reach 5b	Enhancement II	409	1:2.5	164
Reach 6	Enhancement II	318	1:2.5	127
	TOTAL	**11,411**		**10,739**

Legend

- Easement Boundary
- Cross Sections
- Reach Breaks
- Stream Structures
- Crest Gauges

Mitigation

- P1 Restoration
- HWV Restoration
- Enhancement I
- Enhancement II
- Channel - No Credit
- Wetland Restoration
- Agricultural BMP

Vegetation Plots

Met Year 4 Success

- Yes
- No

Well Hydroperiod

- < 5%
- 5-8%
- > 9%

Riparian Buffer Conditions

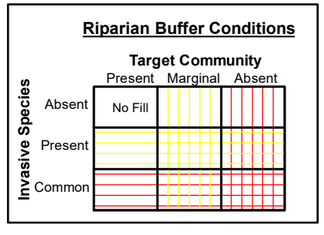


Table 5a **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 1**
Assessed Length **398**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	4	4			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%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5b **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 2**
Assessed Length **1914**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	14	14			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	13	13			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	14	14			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5c **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3A**
Assessed Length **3586**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	21	21			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	11	11			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	20	21			95%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	10	10			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5d **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3B**
Assessed Length **1979**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	17	17			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	9	9			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	17	17			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	1	1			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	7	7			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5e **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 3C**
Assessed Length **708**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	5	5			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	3	3			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	5	5			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	2	2			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5f **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 4**
Assessed Length **173**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	3	3			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	2	2			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	3	3			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	1	1			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5g **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 5A**
Assessed Length **1926**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			1	10	100%	0	0	100%
	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%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	1	10	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	21	22			95%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	16	16			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	22	22			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	6	6			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 5h **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 5B**
Assessed Length **409**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered 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 sills or arms.	1	1			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

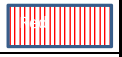
Table 5a **Visual Stream Morphology Stability Assessment**
Reach ID **Reach 6**
Assessed Length **318**

Major Channel Category	Channel Sub-Category	Metric	Number [1] Stable, Performing as Intended	Total [1] Number in As-built	Number of Unstable Segments	Amount of Unstable Footage	% Stable [2], Performing as Intended	Number with Stabilizing Woody Vegetation	Footage with Stabilizing Woody Vegetation	Adjusted % for Stabilizing Woody Vegetation
1. Bed	1. **Vertical Stability** (Riffle and Run units)	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	NA	NA			100%			
	3. Meander Pool Condition	1. Depth Sufficient (Max Pool Depth : Mean Bankfull Depth ≥ 1.6)	NA	NA			100%			
		2. Length appropriate (>30% of centerline distance between tail of upstream riffle and head of downstrem riffle)	NA	NA			100%			
	4.**Thalweg Position**	1. Thalweg centering at upstream of meander bend (Run)	NA	NA			100%			
		2. Thalweg centering at downstream of meander (Glide)	NA	NA			100%			
2. Bank	**1. Scoured/Eroding**	Bank lacking vegetative cover resulting simply from poor growth and/or scour and erosion			0	0	100%	0	0	100%
	2. Undercut	Banks undercut/overhanging to the extent that mass wasting appears likely. Does NOT include undercuts that are modest, appear sustainable and are providing habitat.			0	0	100%	0	0	100%
	3. Mass Wasting	Bank slumping, calving, or collapse			0	0	100%	0	0	100%
				Totals	0	0	100%	0	0	100%
3. Engineered Structures	**1. Overall Integrity**	Structures physically intact with no dislodged boulders or logs.	2	2			100%			
	2. Grade Control	Grade control structures exhibiting maintenance of grade across the sill.	2	2			100%			
	2a. Piping	Structures lacking any substantial flow underneath sills or arms.	2	2			100%			
	3. Bank Protection	Bank erosion within the structures extent of influence does not exceed 15%. (See guidance for this table in EEP monitoring guidance document)	0	0			100%			
	4. Habitat	Pool forming structures maintaining ~ Max Pool Depth : Mean Bankfull Depth ratio ≥ 1.6 Rootwads/logs providing some cover at base-flow.	0	0			100%			

[1] Bed - Coastal plain sand bed channels have a mobile bed along their entire length during geomorphically significant flows. Therefore, the number of shallows and pools, bedform shape, and thalweg position will vary by monitoring event and are not suitable indicators of stability or function.
[2] Percentage based on visual assessment of channel bed condition.

Table 6 Vegetation Condition Assessment

Planted Acreage[1] **17**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Planted Acreage
1. Bare Areas	Very limited cover of both woody and herbaceous material.	0.1 acres		1	0.08	0.5%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acres		0	0.00	0.0%
			Total	1	0.08	0.5%
3. 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 acres		0	0.00	0.0%
			Cumulative Total	1	0.08	0.5%

Easement Acreage[2] **37.6**

Vegetation Category	Definitions	Mapping Threshold	CCPV Depiction	Number of Polygons	Combined Acreage	% of Easement Acreage
4. Invasive Areas of Concern[4]	Areas or points (if too small to render as polygons at map scale).	1000 SF		0	0.00	0.0%
5. Easement Encroachment Areas[3]	Areas or points (if too small to render as polygons at map scale).	none		1	0.11	0.7%

1 = Enter the planted acreage within the easement. This number is calculated as the easement acreage minus any existing mature tree stands that were not subject to supplemental planting of the understory, the channel acreage, crossings or any other elements not directly planted as part of the project effort.

2 = The acreage within the easement boundaries.

3 = Encroachment may occur within or outside of planted areas and will therefore be calculated against the overall easement acreage. In the event a polygon is cataloged into items 1, 2 or 3 in the table and is the result of encroachment, the associated acreage should be tallied in the relevant item (i.e., item 1,2 or 3) as well as a parallel tally in item 5.

4 = Invasives may occur in or out of planted areas, but still within the easement and will therefore be calculated against the overall easement acreage. Invasives of concern/interest are listed below. The list of high concern spcies are those with the potential to directly outcompete native, young, woody stems in the short-term (e.g. monitoring period or shortly thereafter) or affect the community structure for existing, more established tree/shrub stands over timeframes that are slightly longer (e.g. 1-2 decades). The low/moderate concern group are those species that generally do not have this capacity over the timeframes discussed and therefore are not expected to be mapped with regularity, but can be mapped, if in the judgement of the observer their coverage, density or distribution is suppressing the viability, density, or growth of planted woody stems. Decisions as to whether remediation will be needed are based on the integration of risk factors by EEP such as species present, their coverage, distribution relative to native biomass, and the practicality of treatment. For example, even modest amounts of Kudzu or Japanese Knotweed early in the projects history will warrant control, but potentially large coverages of Microstegium in the herb layer will not likley trigger control because of the limited capacities to impact tree/shrub layers within the timeframes discussed and the potential impacts of treating extensive amounts of ground cover. Those species with the "watch list" designator in gray shade are of interest as well, but have yet to be observed across the state with any frequency. Those in *red italics* are of particular interest given their extreme risk/threat level for mapping as points where isolated specimens are found, particularly ealry in a projects monitoring history. However, areas of discreet, dense patches will of course be mapped as polygons. The symbology scheme below was one that was found to be helpful for symbolzing invasives polygons, particulalry for situations where the conditon for an area is somewhere between isolated specimens and dense, discreet patches. In any case, the point or polygon/area feature can be symbolized to describe things like high or low concern and species can be listed as a map inset, in legend items if the number of species are limited or in the narrative section of the executive summary.

Table 7. Stream Problem Areas Muddy Run II Stream and Wetland Restoration Project - Project # 95354			
Feature Issue	**Station # / Range**	**Suspected Cause; Repair**	**Photo Number**
Right Bank Erosion	Reach 5A @ Sta. 19+50	Structure from drainage feature dislodged causing water to flow behind it and scour the right bank; continue to monitor	SPA1

Table 8. Vegetation Problem Areas Muddy Run II Stream and Wetland Restoration Project - Project # 95354			
Feature Category	**Station Numbers**	**Suspected Cause; Repair**	**Photo Number**
Encroachment	Reach 1 & 3A at Sta. 1+00 to 9+97 (Reach 1) & 3+00 to 18+73(Reach 3A)	Apparent mowing behind easement markers; continue to monitor and notify landowner	VPA1
Bare Area/Head Cut Erosion	Reach 5A at Sta. 14+50 to 18+00	Slopes are sandy, and the area lacks substantial herbaceous vegetation; seed area and/or establish live stakes to minimize additional erosion.	VPA2

Figure 4. Vegetation Plot Photos

Vegetation Plot 1 (11/8/2017)

Vegetation Plot 2 (11/8/2017)

Vegetation Plot 3 (11/8/2017)

Vegetation Plot 4 (11/8/2017)

Vegetation Plot 5 (11/8/2017)

Vegetation Plot 6 (11/8/2017)

Vegetation Plot 7 (11/8/2017)

Vegetation Plot 8 (11/8/2017)

Vegetation Plot 9 (11/8/2017)

Vegetation Plot 10 (11/8/2017)

Vegetation Plot 11 (11/8/2017)

Vegetation Plot 12 (11/7/2017)

Vegetation Plot 13 (11/7/2017)

Vegetation Plot 14 (11/7/2017)

Vegetation Plot 15 (11/7/2017)

Vegetation Plot 16 (11/7/2017)

Vegetation Plot 17 (11/7/2017)

Vegetation Plot 18 (11/7/2017)

Vegetation Plot 19 (11/7/2017)

Vegetation Plot 20 (11/7/2017)

Vegetation Plot 21 (11/7/2017)

Vegetation Plot 22 (11/7/2017)

Vegetation Plot 23 (11/9/2017)

Vegetation Plot 24 (11/9/2017)

Vegetation Plot 25 (11/9/2017)


Vegetation Plot 26 (11/9/2017)


Vegetation Plot 27 (11/9/2017)


Vegetation Plot 28 (11/9/2017)

Figure 5. Stream and Vegetation Problem Area Photos

Stream Problem Area Photos

MY4 – SPA1 – Right Bank Erosion on Reach 5A at Sta. 19+50

Vegetation Problem Areas Photos

MY4 – VPA1 – Encroachment on Reach 1 & 3A at Sta. 1+00 to 9+97 (Reach 1) & 3+00 to 18+73(Reach 3A)

MY4 – VPA2 – Bare Area/ Head Cut Erosion Reach 5A at Sta. 14+50 to 18+00

MY4 – VPA2 – Bare Area/ Head Cut Erosion Reach 5A at Sta. 17+40

Appendix C

Vegetation Plot Data

Table 9a. Planted Stem Count Summary
Table 9b. Planted Species Totals
Table 9c. Planted Stem Counts (Species by Plot)

Table 9a. Monitoring Year 4 Stem Count Summary

	Baseline		Year 1		Year 2				Year 3				Year 4			
	Planted		Planted		Planted		Volunteers		Planted		Volunteers		Planted		Volunteers	
Vegetation Plot	Stems Planted	Stems/Acre Baseline	Living Stems	Stems/Acre Year 1	Living Stems	Stems/Acre Year 2	Living Stems	Total Stems/Acre Year 2	Living Stems	Stems/Acre Year 3	Living Stems	Total Stems/Acre Year 3	Living Stems	Stems/Acre Year 3	Living Stems	Total Stems/Acre Year 4
1	16	800	16	800	13	650	1	750	13	650	50	3150	13	650	186	9950
2	17	850	14	700	11	550	--	550	11	550	0	550	11	550	43	2700
3	15	750	13	650	11	550	--	550	11	550	0	550	10	500	53	3150
4	14	700	12	600	8	400	--	400	13	650	5	900	13	650	34	2350
5	16	800	12	600	10	500	--	500	11	550	0	550	13	650	21	1700
6	17	850	14	700	13	650	--	650	13	650	0	650	13	650	7	1000
7	15	750	13	650	12	600	--	600	12	600	0	600	12	600	0	600
8	16	800	14	700	12	600	--	600	13	650	0	650	13	650	63	3800
9	17	850	11	550	10	500	--	500	17	850	0	850	13	650	7	1000
10	14	700	9	450	6	300	1	350	6	300	1	350	8	400	2	500
11	13	650	13	650	11	550	--	550	11	550	0	550	12	600	19	1550
12	15	750	9	450	11	550	--	550	13	650	0	650	13	650	3	800
13	16	800	14	700	14	700	--	650	14	700	0	700	13	650	16	1450
14	14	700	10	500	10	500	--	500	9	450	0	450	9	450	129	6900
15	15	750	13	650	13	650	5	900	19	950	0	950	20	1000	65	3350
16	16	800	15	750	14	700	--	700	12	600	0	600	12	600	71	4150
17	15	750	10	500	11	550	1	600	12	600	0	600	12	600	7	950
18	14	700	14	700	13	650	1	700	14	700	0	700	14	700	71	4250
19	9	450	8	400	11	550	--	550	13	650	0	650	9	450	168	8850
20	10	500	7	350	5	250	--	250	8	400	1	450	8	400	76	4200
21	18	900	16	800	15	750	--	750	12	600	0	600	13	650	12	1250
22	16	800	13	650	12	600	--	600	11	550	0	550	11	550	23	1700
23	13	650	11	550	12	600	--	600	14	700	35	2450	14	700	60	3700
24	17	850	11	550	8	400	--	400	8	400	0	400	8	400	33	2050
25	16	800	12	600	11	550	--	550	21	1050	0	1050	21	1050	4	1250
26	11	550	7	350	6	300	--	300	20	1000	34	2700	18	900	64	4100
27	19	950	17	850	16	800	--	800	16	800	0	800	16	800	12	1400
28	17	850	17	850	15	750	--	750	14	700	0	700	15	750	68	4150
Average	**15.0**	**752**	**12.3**	**616**	**11.2**	**561**	**2**	**577**	**12.9**	**645**	**5**	**870**	**12.8**	**638**	**47**	**2957**
Min	**9**	**450**	**7**	**350**	**5**	**250**	**1**	**250**	**6**	**300**	**0**	**350**	**8**	**400**	**0**	**500**
Max	**19**	**950**	**17**	**850**	**16**	**800**	**5**	**900**	**21**	**1050**	**50**	**2700**	**21**	**1050**	**186**	**9950**

Table 9b. Planted Species Totals

Species	Common Name	Total Planted
Trees - Bare Root		
Taxodium distichum	Bald Cypress	1,800
Fraxinus pennsylvanica	Green Ash	1,900
Quercus lyrata	Overcup Oak	1,800
Betula nigra	River birch	1,800
Quercus michauxii	Swamp Chestnut Oak	2,200
Nyssa biflora	Swamp Tupelo	2,000
Plantanus occidentalis	American Sycamore	2,200
Quercus laurifolia	Laurel Oak	1,800
	Total	**15,500**

Live Stakes		
Salix nigra	Black Willow	3,000
	Total	**3,000**

Table 9c. Planted Stem Counts (Species by Plot)

		Vegetation Plot 1						Vegetation Plot 2						Vegetation Plot 3						Vegetation Plot 4						Vegetation Plot 5					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress	3	3	2	2	2														1	1	1	1	1		1	1	1	1	1	
Fraxinus pennsylvanica	Green Ash																			5	5	4	9	9		1	1	1	1	1	
Quercus sp.	Unknown Oak sp.							2						2	1					1						1	1				
Quercus lyrata	Overcup Oak							8	8	8	8	8		4	4	2	4	4								8	7	6	6	6	
Betula nigra	River birch	6	6	5	5	5								2												2	1	1	1	1	
Quercus michauxii	Swamp Chestnut Oak	2	2	2	2	2		2	2	2	2	2		1	1	1	1	1								1	1	1	1	1	
Nyssa biflora	Swamp Tupelo							4	4	1	1	1		3	3	3	3	3		2	1	1	1	1							
Plantanus occidentalis	American Sycamore	1	1	1	1	1								3	3	3	3	2		5	5	2	2	2					1	1	
Quercus laurifolia	Laurel Oak	4	4	3	3	3		1	0						1											2				2	
Quercus nigra	Water Oak																														
	Species Count	**5**	**5**	**5**	**5**	**5**		**5**	**4**	**3**	**3**	**3**		**6**	**6**	**4**	**4**	**4**		**5**	**4**	**4**	**4**	**4**		**7**	**6**	**5**	**6**	**7**	
	Stem Count	**16**	**16**	**13**	**13**	**13**		**17**	**14**	**11**	**11**	**11**		**15**	**13**	**9**	**11**	**10**		**14**	**12**	**8**	**13**	**13**		**16**	**12**	**10**	**11**	**13**	
	Stems per Acre	**800**	**800**	**650**	**650**	**650**		**850**	**700**	**550**	**550**	**550**		**750**	**650**	**450**	**550**	**500**		**700**	**600**	**400**	**650**	**650**		**800**	**600**	**500**	**550**	**650**	

		Vegetation Plot 6						Vegetation Plot 7						Vegetation Plot 8						Vegetation Plot 9						Vegetation Plot 10					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress	6	6	5	5	5		5	5	5	5	5		5	5	5	5	5					1								
Fraxinus pennsylvanica	Green Ash							2	2	2	2	2																		1	
Quercus sp.	Unknown Oak sp.							1						1						1											
Quercus lyrata	Overcup Oak	2	1	2	2	2		3	3	3	3	3		2	2	2	2	1					3	1		3	2	2	2	2	
Betula nigra	River birch	3	3	3	3	3		3	2	2	2	2								10	6	6	6	6		3	1	1	1	1	
Quercus michauxii	Swamp Chestnut Oak																														
Nyssa biflora	Swamp Tupelo							1	1					3	3	2	2	2								4	2				
Plantanus occidentalis	American Sycamore	1	1	2	3	2								2	2	1	2	2		2	1	1	4	4		1	1	1	1	1	
Quercus laurifolia	Laurel Oak	5	3	2	1	1								3	2	2	2	3		4	4	3	3	2		3	3	2	2	3	
Quercus nigra	Water Oak																														
	Species Count	**5**	**5**	**5**	**5**	**5**		**6**	**5**	**4**	**4**	**4**		**6**	**5**	**5**	**5**	**5**		**4**	**3**	**3**	**5**	**4**		**5**	**5**	**4**	**4**	**5**	
	Stem Count	**17**	**14**	**14**	**14**	**13**		**15**	**13**	**12**	**12**	**12**		**16**	**14**	**12**	**13**	**13**		**17**	**11**	**10**	**17**	**13**		**14**	**9**	**6**	**6**	**8**	
	Stems per Acre	**850**	**700**	**700**	**700**	**650**		**750**	**650**	**600**	**600**	**600**		**800**	**700**	**600**	**650**	**650**		**850**	**550**	**500**	**850**	**650**		**700**	**450**	**300**	**300**	**400**	

		Vegetation Plot 11						Vegetation Plot 12						Vegetation Plot 13						Vegetation Plot 14						Vegetation Plot 15					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress	2	2	2	2	2								1	1	1	1	1		1	1					2	2	2	3	3	
Fraxinus pennsylvanica	Green Ash	2	2	2	2	2		1	1	1	1	1		2	2	3	3	2		3	3	3	3	3		1	1	1	1	1	
Quercus sp.	Unknown Oak sp.							2						1																	
Quercus lyrata	Overcup Oak					1		2	2	5	5	5																			
Betula nigra	River birch	1	1	1	1	1		3						1	1	1	1	1		1		3	3	3		1	1	1	2	2	
Quercus michauxii	Swamp Chestnut Oak							5	5	5	5	5		7	6	5	5	5								6	5	3	2	3	
Nyssa biflora	Swamp Tupelo	4	4	2	2	2								4	4	4	4	4		9	6	6	2	2		3	3	2	2	1	
Plantanus occidentalis	American Sycamore	1	1	1	1	1		2	1	1	2	2											1	1		1	1	1	8	7	
Quercus laurifolia	Laurel Oak	3	3	2	3	2																				1					
Quercus nigra	Water Oak																											1	1		
Quercus phellos	Willow Oak					1																								1	
	Species Count	**6**	**6**	**6**	**6**	**7**		**6**	**4**	**4**	**4**	**4**		**6**	**5**	**5**	**5**	**5**		**4**	**3**	**3**	**4**	**4**		**7**	**6**	**7**	**7**	**7**	
	Stem Count	**13**	**13**	**10**	**11**	**12**		**15**	**9**	**12**	**13**	**13**		**16**	**14**	**14**	**14**	**13**		**14**	**10**	**12**	**9**	**9**		**15**	**13**	**11**	**19**	**18**	
	Stems per Acre	**650**	**650**	**500**	**550**	**600**		**750**	**450**	**600**	**650**	**650**		**800**	**700**	**700**	**700**	**650**		**700**	**500**	**600**	**450**	**450**		**750**	**650**	**550**	**950**	**900**	

		Vegetation Plot 16						Vegetation Plot 17						Vegetation Plot 18						Vegetation Plot 19						Vegetation Plot 20					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress																			1	1	2	1	2							
Fraxinus pennsylvanica	Green Ash													6	6	7	6	7		1			1						2	2	
Quercus sp.	Unknown Oak sp.							1																							
Quercus lyrata	Overcup Oak									1	1	1		3	3	4	4	4		1	1	3	1	3					1		
Betula nigra	River birch							6	4	4	4	4		1	1	1	1	1		1	1	3	3	3					1	1	
Quercus michauxii	Swamp Chestnut Oak	7	7	7	6	6		1	1	1	1	1										1	1	1		2	3	3	2	2	
Nyssa biflora	Swamp Tupelo	8	8	7	6	6		4	2	2	2	2		4	4	4	3	2								6	3	1			
Plantanus occidentalis	American Sycamore							3	3	4	4	4								5	5	5	5			2	1				
Quercus laurifolia	Laurel Oak	1																											2		
Quercus nigra	Water Oak																													1	
Quercus phellos	Willow Oak																													2	
	Species Count	**3**	**2**	**2**	**2**	**2**		**5**	**4**	**5**	**5**	**5**		**4**	**4**	**4**	**4**	**4**		**5**	**4**	**5**	**6**	**4**		**3**	**3**	**2**	**5**	**5**	
	Stem Count	**16**	**15**	**14**	**12**	**12**		**15**	**10**	**12**	**12**	**12**		**14**	**14**	**16**	**14**	**14**		**9**	**8**	**14**	**12**	**9**		**10**	**7**	**4**	**8**	**8**	
	Stems per Acre	**800**	**750**	**700**	**600**	**600**		**750**	**500**	**600**	**600**	**600**		**700**	**700**	**800**	**700**	**700**		**450**	**400**	**700**	**600**	**450**		**500**	**350**	**200**	**400**	**400**	

Table 9c. Planted Stem Counts (Species by Plot) Continued

		Vegetation Plot 21						Vegetation Plot 22						Vegetation Plot 23						Vegetation Plot 24						Vegetation Plot 25					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress	2	3		3	3		8	8	8	8	8		2	2	2	3	3		1	1								4	4	
Fraxinus pennsylvanica	Green Ash	6	6	6	4	5								7	6	6	6	2											1	2	
Quercus sp.	Unknown Oak sp.	1												1															1		
Quercus lyrata	Overcup Oak	3	4	2	3	2								1	2	2	2	2			1	1	1	1						1	
Betula nigra	River birch							3	3	3	3	3						1		6	3	3	3	3		4	3	3	1	1	
Quercus michauxii	Swamp Chestnut Oak	2	2	3	2	2												1								5	4	4	2	1	
Nyssa biflora	Swamp Tupelo																	3		3	3	3	3	3		6	5	4			
Plantanus occidentalis	American Sycamore																1			1									7	8	
Quercus laurifolia	Laurel Oak	4	1			1		5	2	1				2	1	3	2	3		6	3	1	1	1		1			5	2	
Quercus nigra	Water Oak																													1	
	Species Count	**6**	**5**	**3**	**4**	**5**		**3**	**3**	**3**	**2**	**2**		**5**	**4**	**4**	**5**	**7**		**5**	**5**	**4**	**4**	**4**		**4**	**3**	**3**	**7**	**8**	
	Stem Count	**18**	**16**	**11**	**12**	**13**		**16**	**13**	**12**	**11**	**11**		**13**	**11**	**13**	**14**	**15**		**17**	**11**	**8**	**8**	**8**		**16**	**12**	**11**	**21**	**20**	
	Stems per Acre	**900**	**800**	**550**	**600**	**650**		**800**	**650**	**600**	**550**	**550**		**650**	**550**	**650**	**700**	**750**		**850**	**550**	**400**	**400**	**400**		**800**	**600**	**550**	**1050**	**1000**	

		Vegetation Plot 26						Vegetation Plot 27						Vegetation Plot 28					
Species	**Common Name**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**	**MY0**	**MY1**	**MY2**	**MY3**	**MY4**	**MY5**
Taxodium distichum	Bald Cypress																		
Fraxinus pennsylvanica	Green Ash				4	4		9	9	9	9	9							
Quercus sp.	Unknown Oak sp.				4														
Quercus lyrata	Overcup Oak	4	4	3	5	4		1						4	4	4	4	4	
Betula nigra	River birch	1			1	1								1	1	1	1	1	
Quercus michauxii	Swamp Chestnut Oak	2	2	3	3	3		1	1	1	1	1		1	1	1	1	1	
Nyssa biflora	Swamp Tupelo	3	1																
Plantanus occidentalis	American Sycamore	1			1	1		1	1	1	1	1		7	7	6	6	6	
Quercus laurifolia	Laurel Oak				2	1		7	6	5	5	4		4	4	3	2	3	
Quercus nigra	Water Oak					1													
Quercus phellos	Willow Oak					1													
Liriodendron tulipifera	Tulip Poplar					2													
	Species Count	**5**	**3**	**2**	**7**	**9**		**5**	**4**	**4**	**4**	**4**		**5**	**5**	**5**	**5**	**5**	
	Stem Count	**11**	**7**	**6**	**20**	**18**		**19**	**17**	**16**	**16**	**15**		**17**	**17**	**15**	**14**	**15**	
	Stems per Acre	**550**	**350**	**300**	**1000**	**900**		**950**	**850**	**800**	**800**	**750**		**850**	**850**	**750**	**700**	**750**	

Appendix D

Hydrology Data

Table 10. Documentation Significant Flow Events

Crest Gauge	Number of Bankfull Events	Maximum Bankfull Height (ft.)
Crest Gauge 1		
MY1	1	0.40
MY2	1	0.60
MY3	4	1.60
MY4	5	1.10
Crest Gauge 2		
MY1	8	1.50
MY2	19	2.00
MY3	8	2.00
MY4	7	2.00
Crest Gauge 3		
MY1	0	N/A
MY2	4	0.20
MY3	2	2.18
MY4	0	N/A
Crest Gauge 4		
MY1	2	0.45
MY2	1	0.40
MY3	1	3.80
MY4	8	2.80

Table 11. Rainfall Summary

Month	Average	Normal Limits		Wallace Station Precipitation	On-Site Auto Rain Gauage
		30 Percent	70 Percent		
January	4.33	3.32	5.03	4.26	4.21
February	3.23	2.14	3.87	1.82	0.28
March	4.50	3.23	5.32	2.85	0.55
April	3.16	1.70	3.85	7.74	0.55
May	3.68	2.69	4.34	5.47	*
June	4.49	3.11	5.34	5.67	*
July	6.06	4.16	7.22	5.22	1.15
August	5.40	3.12	6.56	8.21	9.24
September	5.00	2.04	6.07	5.86	4.54
October	3.21	1.62	3.92	2.51	2.95
November	2.89	1.83	3.49	0.76	0.32
December	3.24	2.14	3.88	---	---
Total	49.19	31.10	58.89	50.37	23.78

*No data collected during May or June. On-Site Rain Gauge failed and was replaced in July.

Table 12a. Wetland Hydrology Criteria Attainment

2017 Max Hydroperiod (Growing Season 17-Mar through 14-Nov, 242 days) Success Criterion 9% = 22 Consecutive Days					
	Consecutive		Cumulative		
Gauge	Days	Percent of growing Season	Days	Percent of growing Season	Occurrences
AW1	49	20	131	54	19
AW2	26	11	96	40	19
AW3	52	21	149	61	17
AW4	69	28	222	92	6
AW5	55	23	160	66	15
AW6	55	23	184	76	13
AW7	59	24	215	89	8
RAW1*	33	13	41	17	2
RAW2	6	2	28	12	14
RAW3	34	14	87	36	9

*Data only represents March 17, 2017 - May 2, 2017

Table 12b. MY1-MY4 Wetland Hydrology Gauge Summary

Gauge	MY1-2014 Consecutive		MY2-2015 Consecutive		MY3-2016 Consecutive		MY4-2017 Consecutive	
	Days	Percent of growing Season	Days	Percent of growing Season	Days	Percent of growing Season	Days	Percent of growing Season
AW1	22	9	63	26	22	9	49	20
AW2	22	9	41	17	21	9	26	11
AW3	13	5	38	16	32	13	52	21
AW4	67	28	77	32	95	39	69	28
AW5	7	3	38	16	32	13	55	23
AW6	43	18	65	27	22	9	55	23
AW7	5	2	72	30	36	15	59	24
RAW1*	22	9	49	20	33	13	33	13
RAW2	10	4	19	8	15	6	6	2
RAW3	20	8	41	17	32	13	34	14

*MY4-2017 data only represents March 17, 2017 - May 2, 2017

Chart 1. 2017 Precipitation Data for Muddy Run II Site

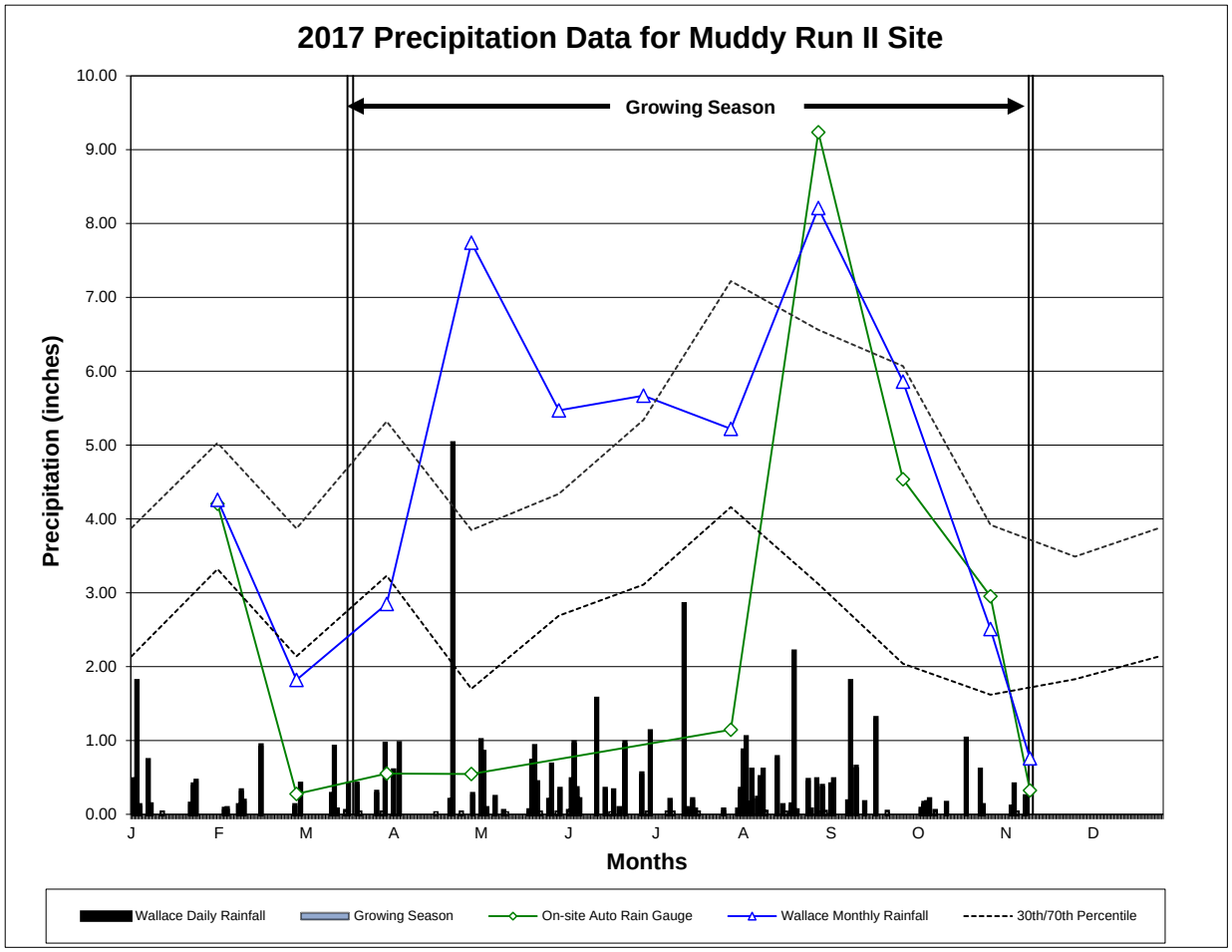
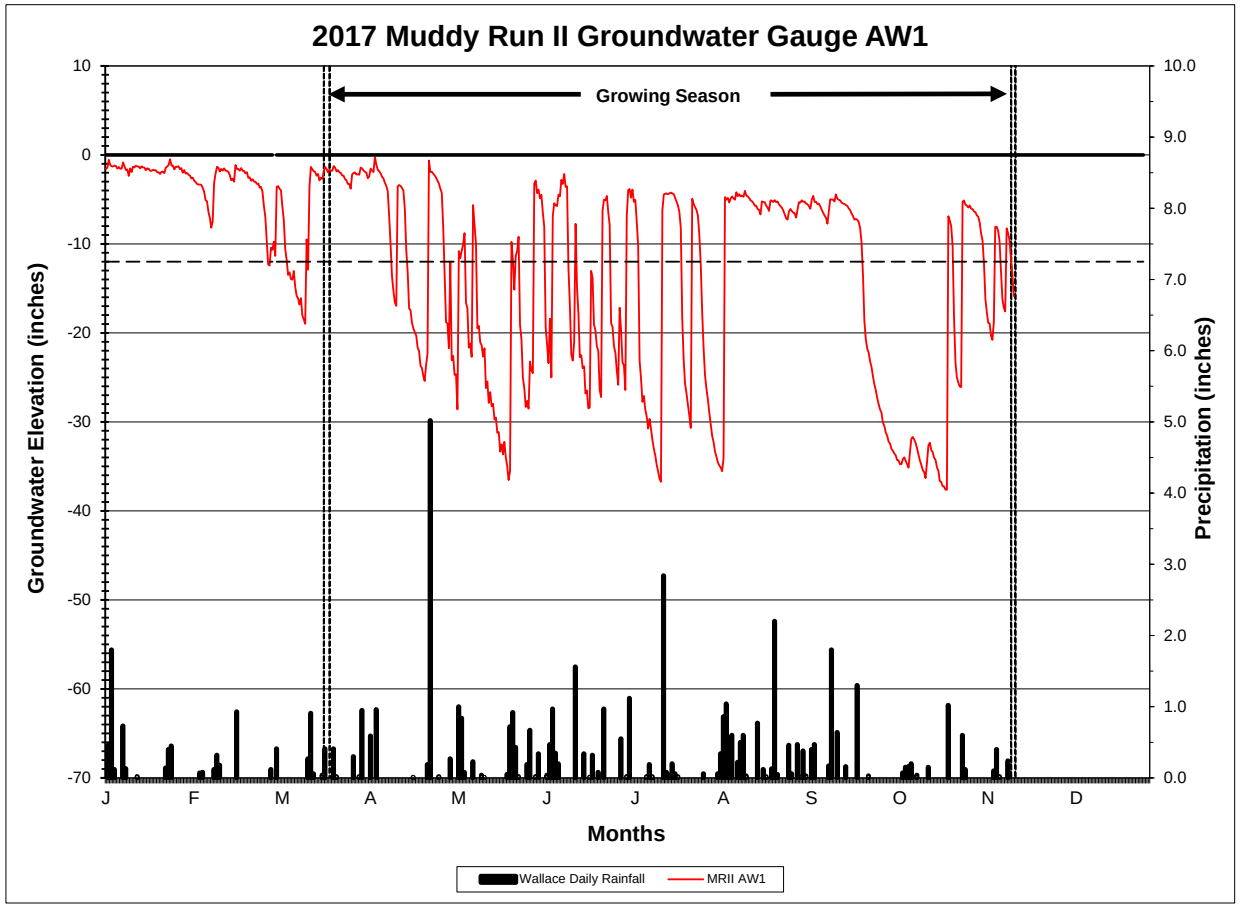
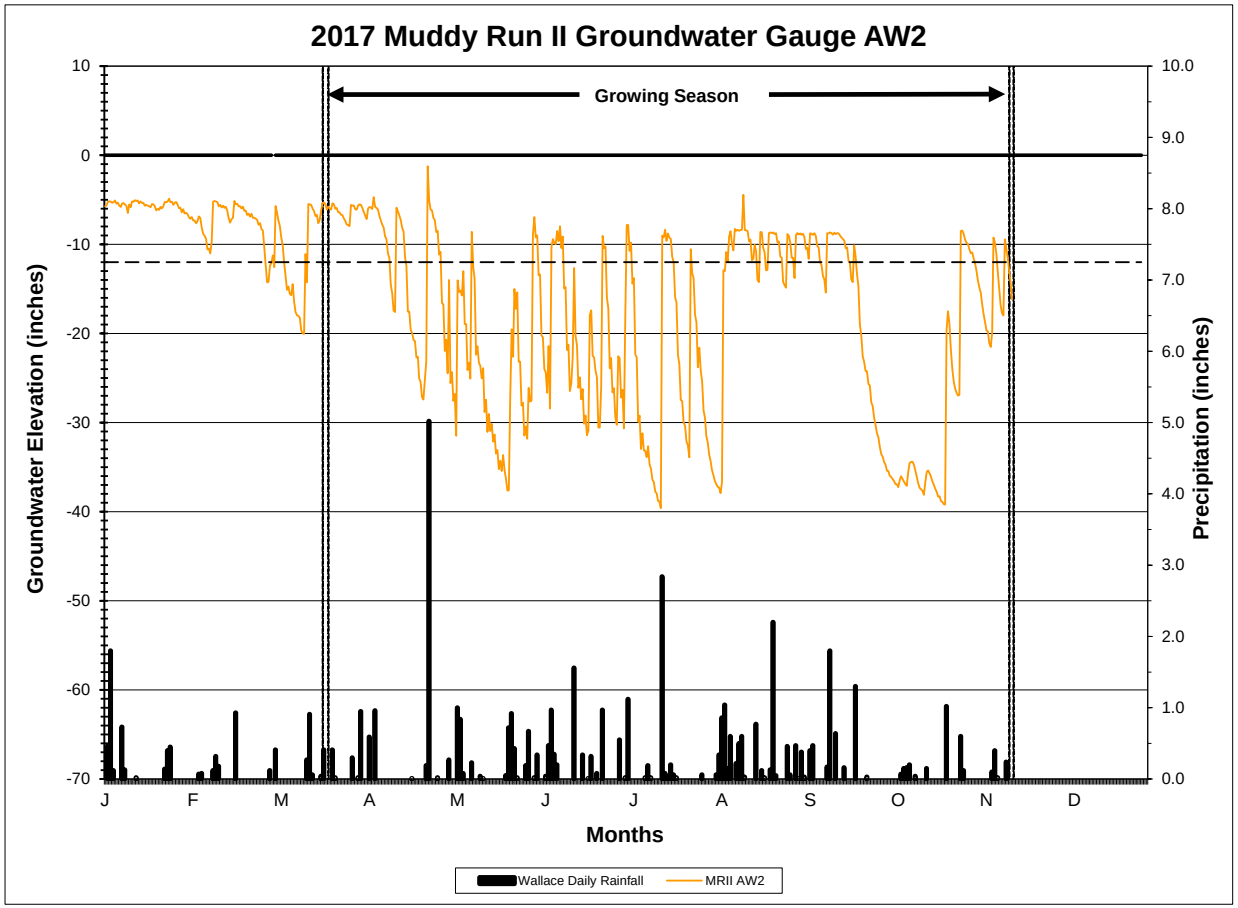
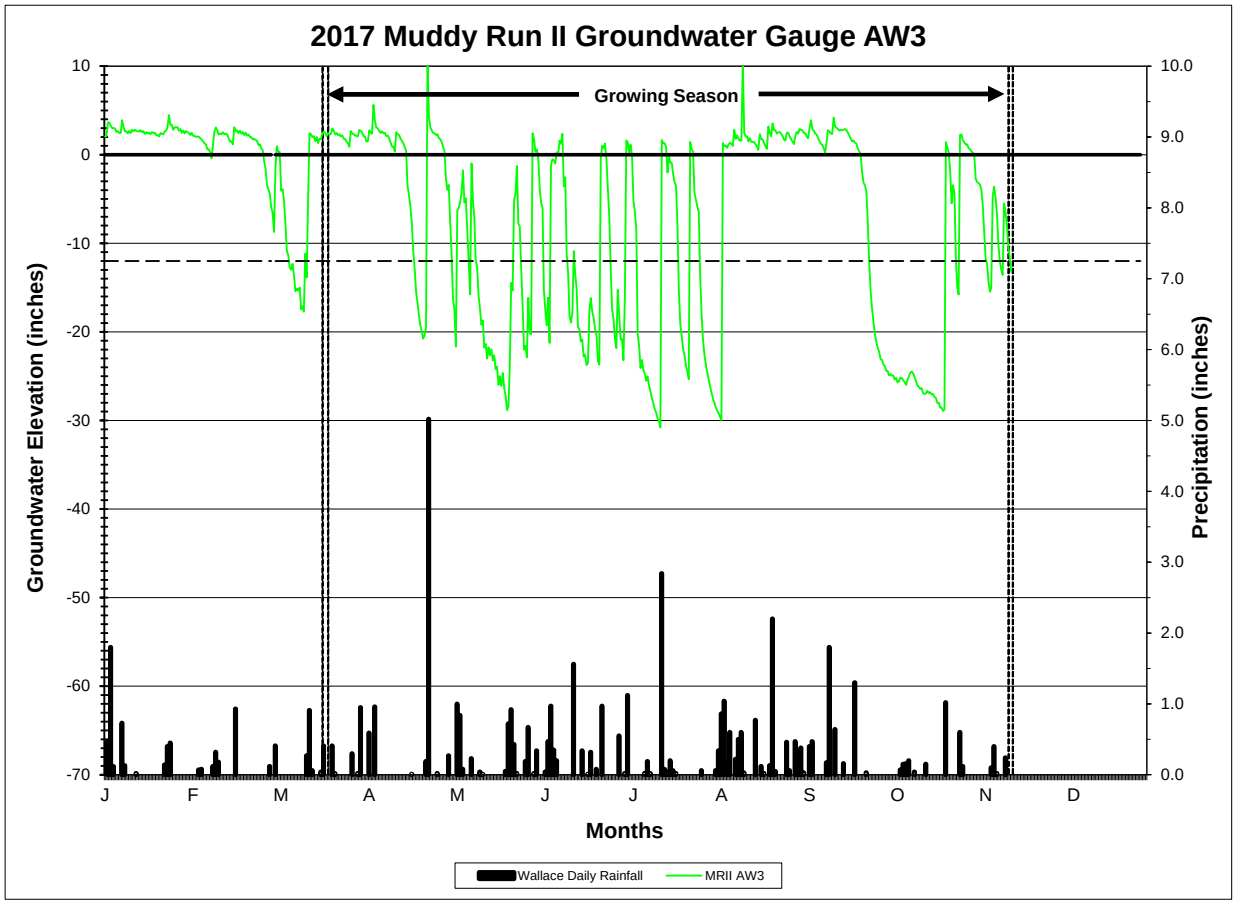
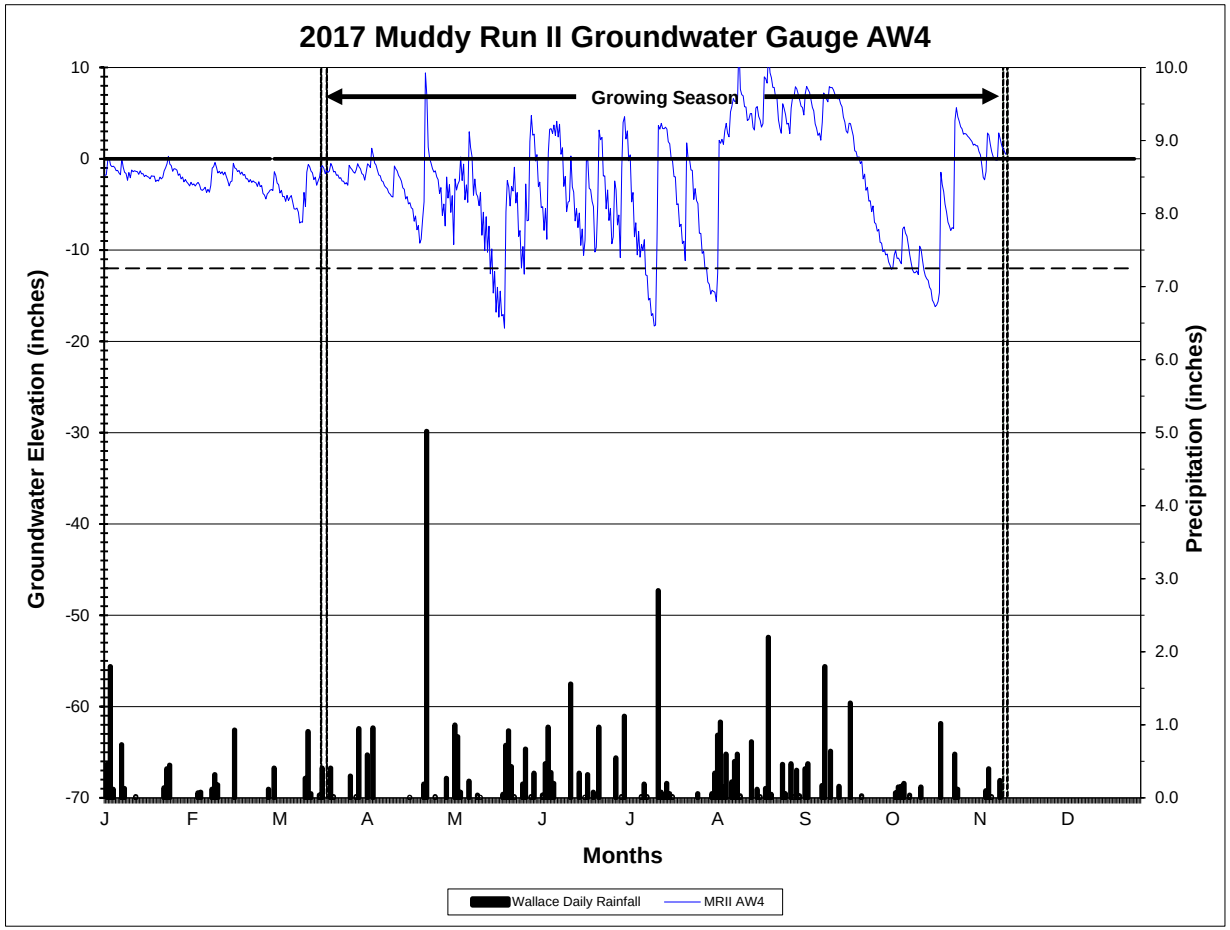


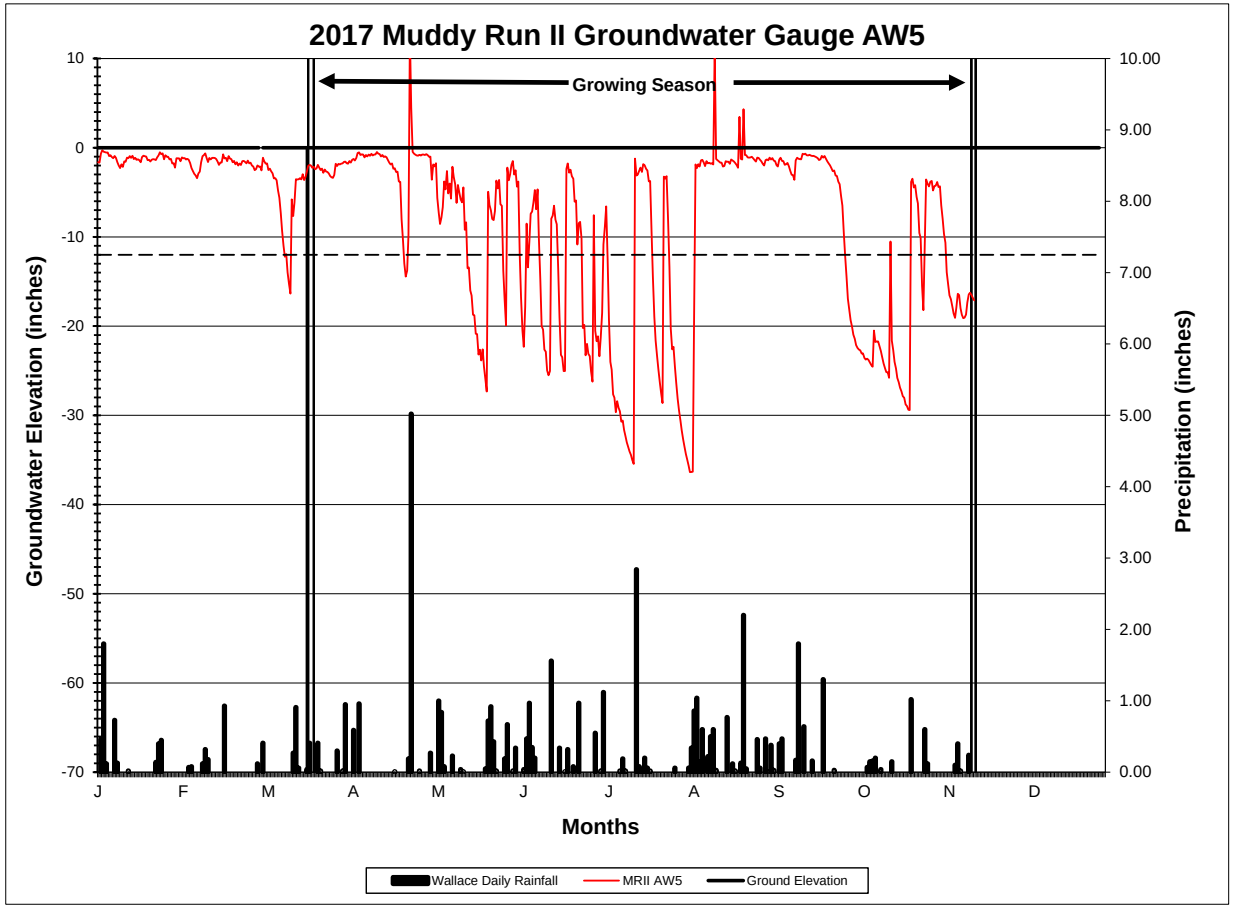
Chart 2. Muddy Run II Groundwater Monitoring Gauge Hydrographs

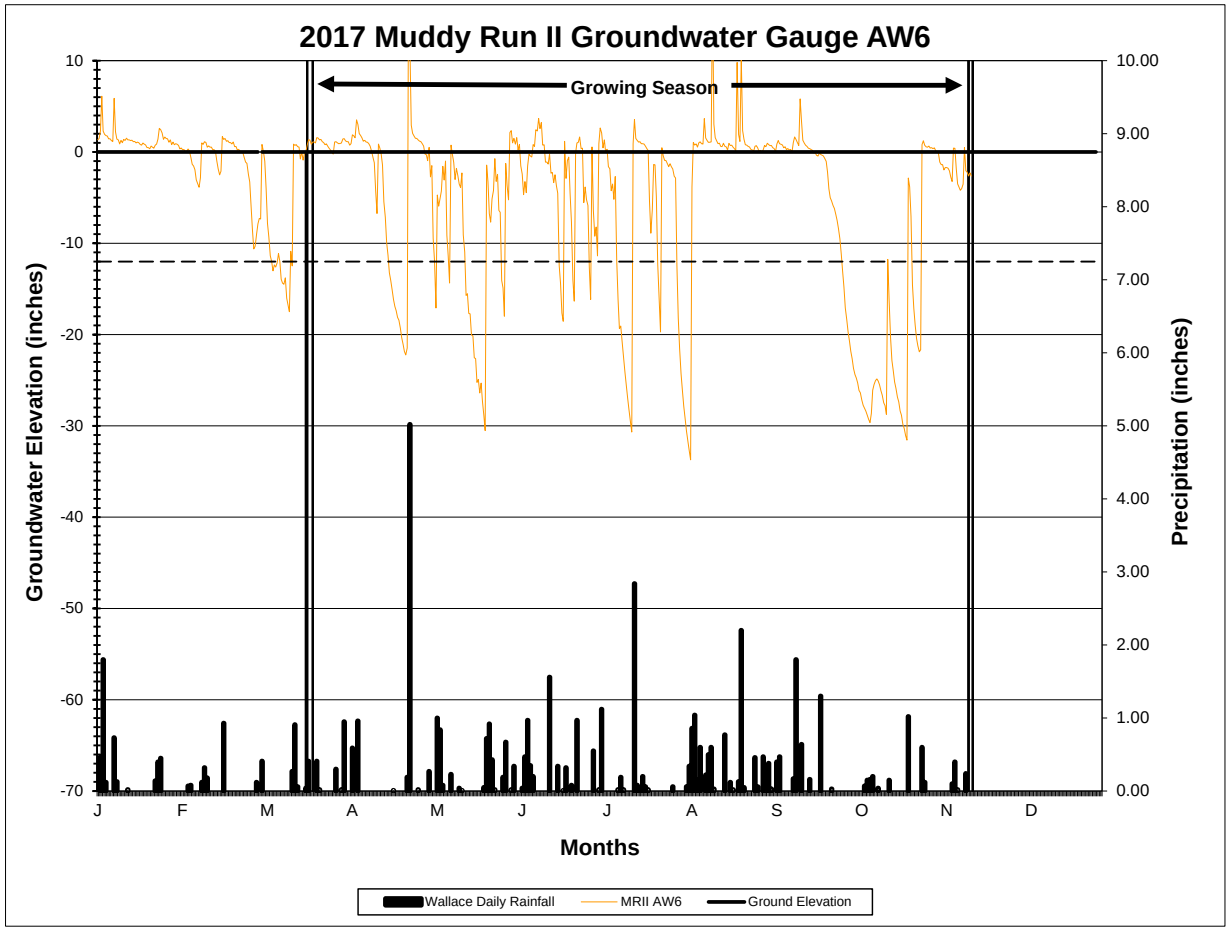


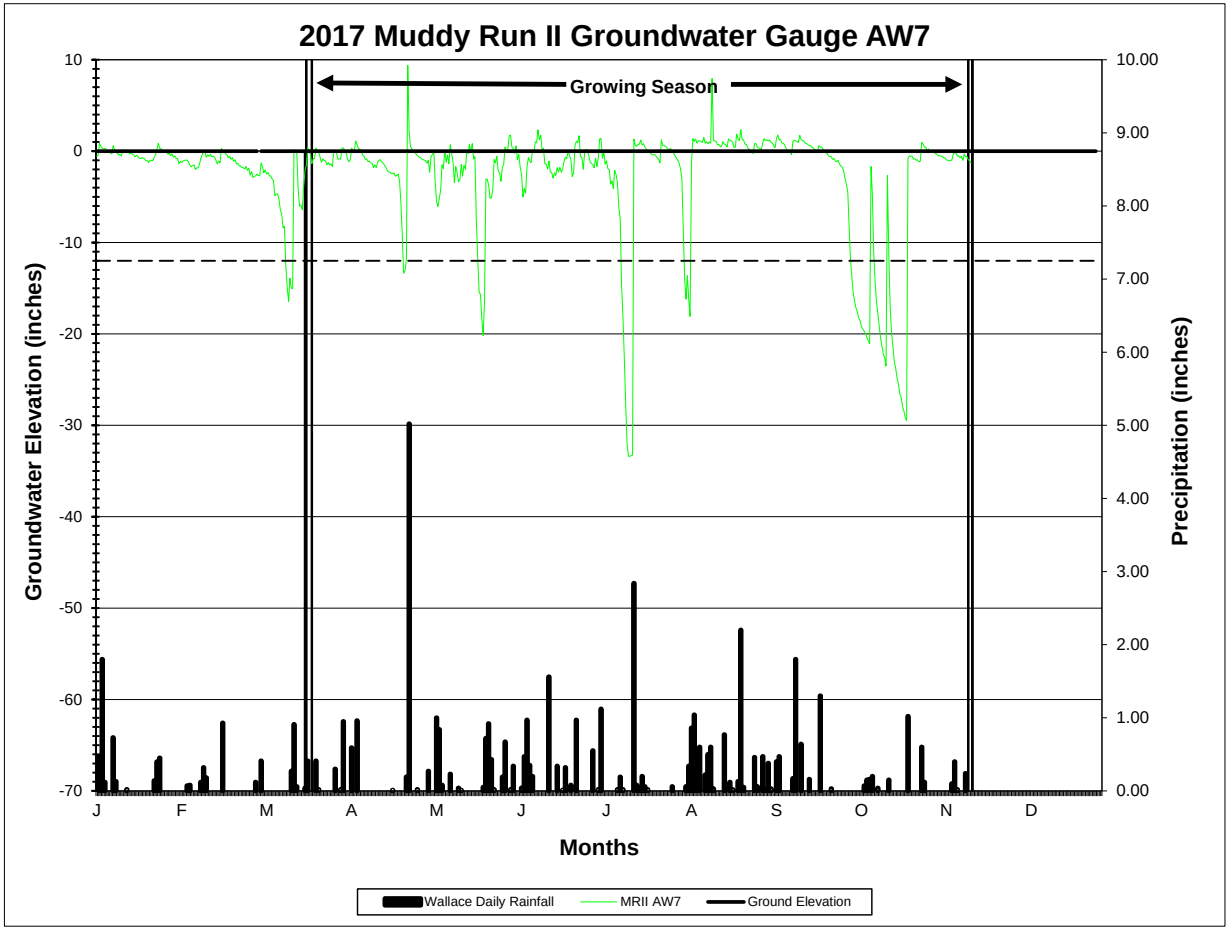

2017 Muddy Run II Groundwater Gauge AW2
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII AW2

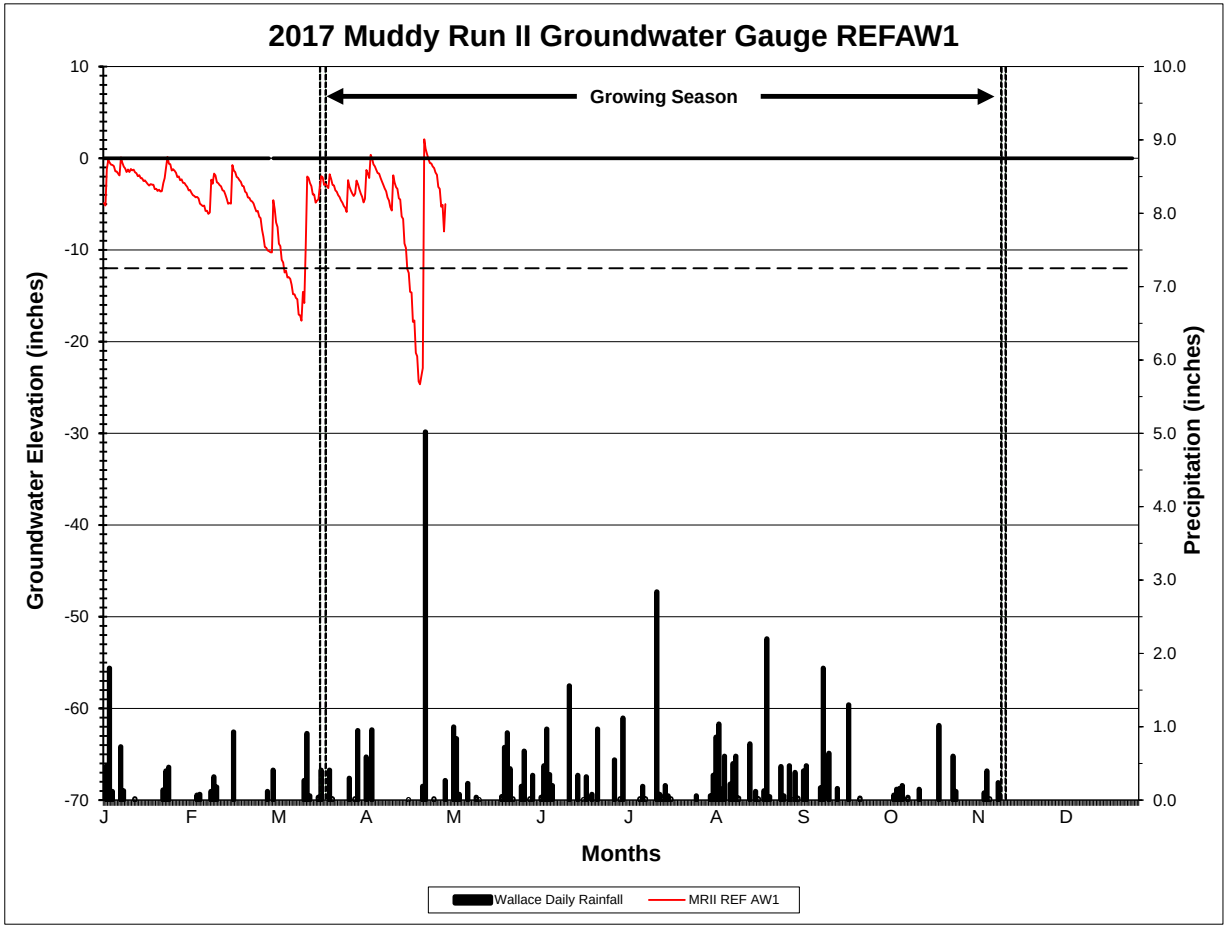

2017 Muddy Run II Groundwater Gauge AW3
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII AW3


2017 Muddy Run II Groundwater Gauge AW4
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
Months
J
F
M
A
M
J
J
A
S
O
N
D
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
Wallace Daily Rainfall
MRII AW4

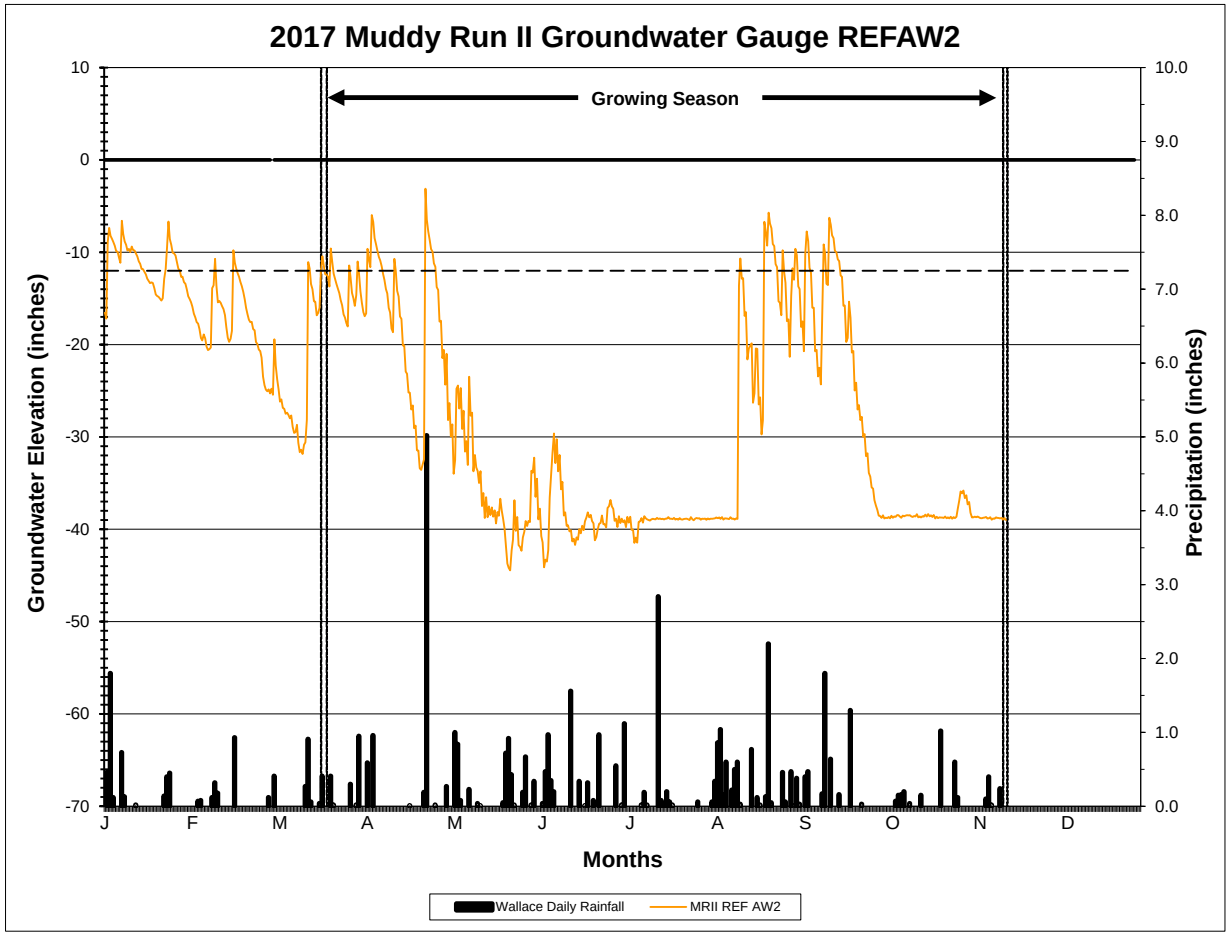

2017 Muddy Run II Groundwater Gauge AW5
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII AW5
Ground Elevation


2017 Muddy Run II Groundwater Gauge AW6
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII AW6
Ground Elevation


2017 Muddy Run II Groundwater Gauge AW7
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.00
9.00
8.00
7.00
6.00
5.00
4.00
3.00
2.00
1.00
0.00
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII AW7
Ground Elevation



*Groundwater gauge failed May-Nov 2017


2017 Muddy Run II Groundwater Gauge REFAW2
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII REF AW2

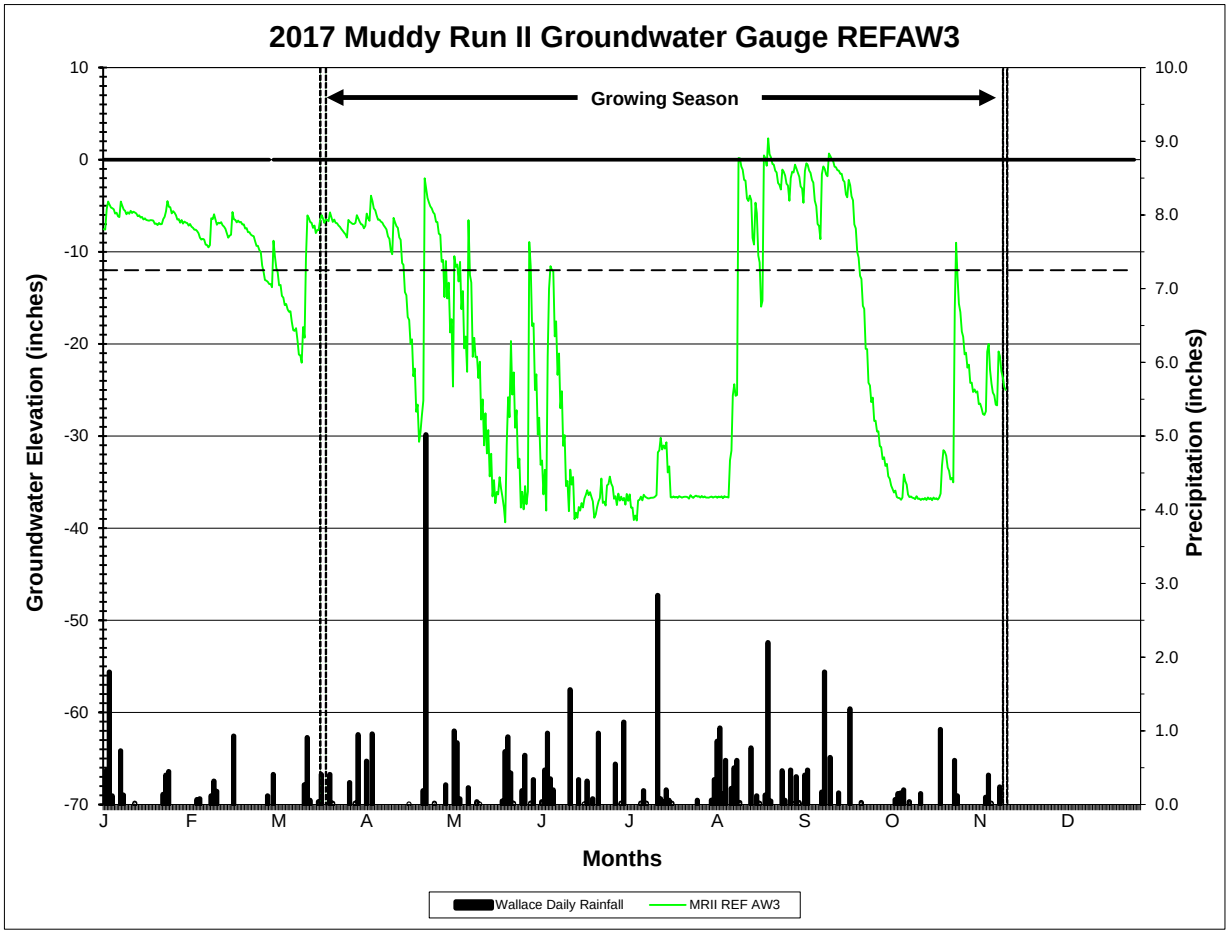

2017 Muddy Run II Groundwater Gauge REFAW3
Growing Season
Groundwater Elevation (inches)
Precipitation (inches)
10
0
-10
-20
-30
-40
-50
-60
-70
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
J
F
M
A
M
J
J
A
S
O
N
D
Months
Wallace Daily Rainfall
MRII REF AW3

Figure 6. Crest Gauge Verification Photos

Photo 1. Crest Gauge 1 (Reach 2 – 1.1 ft. – 4/24/17)

Photo 2. Crest Gauge 2 (Reach 3A – 2.0 ft. – 4/24/17)

Photo 3. Crest Gauge 4 (Reach 5A – 2.8 ft. – 4/24/17)