

MORGAN CREEK FLOODPLAIN RESTORATION SITE #258
Mason Farm Biological Reserve – UNC-Chapel Hill – Orange/Durham Co.
Cape Fear River HUC# 03030002-060080

MY-5 (2015) ANNUAL MONITORING REPORT (Final)

North Carolina Department of Environmental Quality
Division of Mitigation Services (DEQ-DMS) -- Contract # 16-005217

Data Collected: Sep-Dec 2015

Final Report Submitted: Jan 2016




 <p>NC Environmental Quality</p>	<p>NC Division of Environmental Quality DEQ Division of Mitigation Services 1652 Mail Service Center Raleigh, NC 27699-1652</p> <hr/> <p>DMS Project Manager: Kristie Corson</p>
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MOGENSEN MITIGATION INC.
P O Box 690429 Charlotte, NC 28227
704-576-1111 rich@mogmit.com
919-872-1174 gpottern@rjgacarolina.com

1.0. Project Summary

1.1. Project Goals & Objectives

The Morgan Creek Floodplain Restoration Site (DMS # 258) is located on the Mason Farm Biological Reserve (MFBR) in the Jordan Lake watershed (Haw River, Cape Fear River, USGS HUC # 03030002-060080). In the 1940's a soil berm (artificial levee) was constructed along the southwest bank of Morgan Creek to reduce flooding frequency, and ditches were excavated to further drain the floodplain and facilitate farming. The berm, drainage ditches, and land-use activities have degraded the former bottomland wetlands on the site. This restoration project is designed to restore natural floodplain hydrology by constructing five rock-stabilized openings through the berm to increase floodwater access from Morgan Creek, and by replanting native trees and shrubs on poorly vegetated or weed-dominated areas on the floodplain to restore a natural Piedmont Bottomland Forest community. The project includes 14.37 acres of wetland restoration, 5.61 acres of wetland preservation, and 3200 linear feet of riparian buffer preservation along the south bank of Morgan Creek. Specific **goals** and **objectives** for the Morgan Creek Floodplain Restoration project are identified below:

Project Goals:

1. Facilitate regular flooding of the Morgan Creek floodplain behind the berm;
2. Promote attenuation of sediment and nutrients on the flood plain;
3. Reduce downstream flooding by creating additional storm water detention;
4. Reduce erosion by limiting flooding shear stress on Morgan Creek banks ;
5. Restore more natural hydrology to 14.37 acres of impacted wetlands;
6. Preserve 5.61 acres of existing forested wetlands;
7. Re-establish a natural plant community through plantings and invasive species control;
8. Preserve 3200 linear feet of riparian buffer on the south bank of Morgan Creek.

Project Objectives:

1. Create five stable openings in the existing artificial berm to allow flood waters to access the floodplain with the conservation easement area;
2. Plant 14.37 acres of bottomland hardwood wetlands with desirable native trees and shrubs;
3. Demonstrate jurisdictional hydrology in 14.37 acres of restored wetland by measuring groundwater using RDS continuous recording groundwater gauges;
4. Preserve the entire Site through means of a conservation easement or deed restrictions in perpetuity.

1.2. Project Success Criteria

Post-construction monitoring (2011 to 2015) will evaluate the project's success in restoring flood hydrology through the berm openings, groundwater hydrology in wetlands, and reestablishment of native bottomland forest vegetation. No stream channel work was conducted, and no channel morphology monitoring or stream stability success criteria are included.

Restoration of wetland hydrology is evaluated using specific soil saturation criteria for two different soil units delineated by The Catena Group in 2008, based on field analysis of redoximorphic features. Soil Unit #1, which occupies most of the fallow field in the east-central portion of the project easement, is expected to achieve saturation within 12 inches of the ground surface for at least 12.5% of the growing season (27 days). GW monitoring gauges # 1, 2, 4, 5 and 6 are located in Soil Unit #1. Soil Unit #2 lies to the west of Soil Unit #1 and includes the western part of the fallow field and adjacent forested land. Hydrology in Soil Unit #2 is expected to achieve saturation within 12 inches of the ground surface for at least 5% of the growing season (11 days), and includes GW monitoring gauges # 3, 9, A, B, and C. The climatic growing season in Chapel Hill is from March 28 to Nov 3 (227 days).

Restoration of floodplain function is evaluated using crest stage gauges (granular cork type) installed at each of the five berm openings. These manual gauge data are supplemented with stream stage data recorded at USGS stream gauge #02097517 located 1,600 feet upstream of the project site. On average, the berm openings are expected to convey overbank flows from Morgan Creek 2 to 3 times per year.

Five 10 x 10 meter CVS vegetation plots were established, marked and monitored in the planted wetland restoration area following the CVS-EEP Level 2 Vegetation Monitoring Protocol. The success criteria requires a minimum survival rate of 320 native woody stems per acre in MY-3, 288 native woody stems per acre in MY-4, and 260 stems/per acre in MY-5. Areas with low density of native woody stems (planted plus volunteers) and/or exotic invasive species problem areas are identified and mapped in accordance with thresholds specified in the current EEP monitoring guidance document.

1.3. Project Setting & Pre-Restoration Conditions

The Morgan Creek Floodplain Restoration Site (DMS # 258) is located on the Mason Farm Biological Reserve (MFBR) which straddles the Orange/Durham county line, in the Jordan Lake watershed (USGS HUC # 03030002-060080). The project site is within the Durham-Sanford Triassic Basin, an area with broad floodplains due to ancient geologic rifting. Floodplain elevations on the project site are 240 to 245 feet (NAVD83). MFBR is owned by the University of North Carolina at Chapel Hill and is currently used for ecological research and teaching, but prior to the 1980's the floodplain portion of MFBR was used for agriculture. About 1940 an earthen berm (artificial levee) 3,800 feet long and 6 ft high was constructed along the southwest bank of Morgan Creek, 30 to 60 feet from the top of the creek bank. The berm was constructed to reduce flooding frequency, and floodplain ditches were excavated to further drain the area and facilitate farming. These actions significantly degraded wetland hydrology, hydric soil indicators, and native wetland vegetation.

Prior to project construction, approximately 17.5 acres within the project area showed relict redoximorphic features or other evidence of historically supporting wetland hydrology. A 7-acre remnant of intact wetland remains on the easternmost portion of the project site. This area was not effectively dewatered by the berm and ditches, apparently due to beaver dams, log jams, and other factors causing backwater flooding effects around the southeastern end of the berm. The drained wetland areas suitable for restoration include 12 acres of old field scrub and 5 acres of plantation forest. Both the field/scrub and forest areas contain a mix of native and exotic species, described in the Restoration Plan (Ward Consulting Engineers, 2008).

Morgan Creek adjacent to MFBR has a drainage basin area of 41 square miles. Normal baseflow water surface elevation in the creek is typically 2.5 to 3.5 ft below the adjacent floodplain on the project site. Based on USGS gauge records and pre-construction surveys by the project designers, stream flows exceeding 1,000 cfs begin overtopping the banks of Morgan Creek and filling the depressional areas behind the natural levees along the stream banks. Flows above 1,300 cfs (calculated bankfull flow presumably flooded the project area prior to berm construction in the 1940's. The 6-ft berm height was built to contain the 10-year storm event, and would have required flows above 3,400 cfs to flood the project area prior to 2010 when the berm openings were constructed.

1.4. Project Components & Mitigation Assets

The project includes five rock-stabilized trapezoidal openings (gaps) excavated through the berm. Each gap is 15 feet wide at the base (at the existing floodplain elevation) and roughly 50 feet wide at the top of the berm. Mitigation assets include 14.37 acres of wetland restoration (1:1 ratio) and 5.61 acres of wetland preservation (5:1 ratio), generating a total of 15.49 wetland mitigation units. The project conservation easement contains 31.5 acres, including 3200 linear feet of riparian buffer preservation along the south bank of Morgan Creek (Jordan Lake watershed). No mitigation credit is sought for the buffer preservation component.

1.5. Project Design Approach

The Morgan Creek Floodplain (Mason Farm) restoration project was designed by Ward Consulting Engineers (2008) with assistance from The Catena Group, and constructed in 2010. The five berm gaps are located along a 1,400 foot long berm segment in the northwestern portion of the project area. Gap locations were selected to coincide with segments of stable stream bank, adequate space between the bank and the berm, and low areas on the creek side of the berm (behind the natural levee) to facilitate flow passage most easily. The berm gap bed elevations range from 244.1 ft (upper gap) to 242.4 ft (lower gap) and are generally 2.5 to 3.5 ft above normal baseflow elevation in Morgan Creek. Flow through the berm gaps is expected when stage at the USGS stream gauge upstream reaches 7.8 ft.

The berm gap openings were modeled as lateral openings in the HEC-RAS computer model, and discharges were generated from each opening to reflect the volume of water applied to the fields. A second HEC-RAS model was then generated in the floodplain beyond the berm using the peak discharges flowing through the openings to predict the extent of flooding within the MFBR. This second model approximated maximum storm water levels within the existing parking lot and the frequency and duration of flooding in Big Oak Woods (BOW) natural area south of the project area. Flooding into BOW was controlled in order to avoid potential adverse ecological impacts of increased flooding depth, frequency, or duration.

The wetland restoration planting plan was developed from lists of native species found in nearby natural floodplain wetlands along Morgan Creek. The Catena Group conducted post-construction monitoring from 2010 to 2012, after which Mogensen Mitigation, Inc. (MMI) conducted the remainder of monitoring from fall 2013 through 2015.

1.6. Current Conditions & Performance Summary

MMI conducted the MY5 monitoring work during Sep-Dec 2015; monitoring methods and reporting were done following the EEP/DMS Monitoring Report Template, Feb 2014 version.

Vegetation:

CVS vegetation plot data were collected in September 2014. The five plots had 6, 5, 7, 5, and 0 surviving planted stems; only plot #3 exceeded the 260 stems/acre success criterion based on planted stems alone (Tables 6-7). However, four of the five plots have large numbers of volunteer native trees (*Diospyros*, *Fraxinus*, *Liquidambar*, and *Ulmus*) and exceed the success criterion when volunteers are included. The failing plot (#1) missed the success criterion by only one stem. Plots #1 and #5 (no surviving planted stems) are overgrown with dense grasses and herbaceous weeds that impede survival of tree seedlings. Total native woody stem densities (planted plus volunteers) range from 243 to 1,133 stems per acre, and average density for all five plots is 769 stems per acre, nearly three times the success criterion. Native woody stem density in the remainder of the planted areas appears adequate; no low-density area greater than of 0.2 acre was observed.

Exotic invasive weeds are common throughout the project site in both the field/scrub areas and forested areas. Common invasives observed on the floodplain include Japanese stiltgrass (*Microstegium vimineum*), Multiflora rose (*Rosa multiflora*), Japanese honeysuckle (*Lonicera japonica*), Dahurian buckthorn (*Rhamnus davurica*), Chinese privet (*Ligustrum sinense*), White mulberry (*Morus alba*), Porcelain-berry (*Ampelopsis brevipedunculata*), Fescue (*Festuca* spp), and Sericea lespedeza (*Lespedeza cuneata*). Two areas with concentrations of “High Concern” invasive species (mainly *Rosa*) totaling 0.62 acre are included in Figure 2 and Table 5. Elsewhere, “High Concern” invasives are at relatively low densities and/or primarily occurring as groundcover beneath tall shrubs and saplings, and do not appear to be threatening re-establishment of a forest community. Japanese stiltgrass (Low/Moderate Concern) is abundant throughout most of the field/scrub portion of the project and some wooded areas. Stiltgrass combined with other dense herbs is impeding planted tree survival in plot #5 (no planted stems) and volunteer recruitment in plot #1 (no volunteers).

Additional invasive species observed along the Morgan Creek streambank and berm include Kudzu (*Pueraria montana*) and Paper mulberry (*Broussonetia papyrifera*), but these areas are currently forested and the exotic plants are not threatening to project success.

Hydrology:

Nine of the ten groundwater wells met their respective wetland hydrology success criteria in 2015 (Table 9). Only well #4 did not meet its criterion, missing the goal by only 2 days). Over the five year monitoring period (2011 to 2015), four of the five wells in Soil Unit #1 met their 27-day saturation criterion during 3 or more years. Of the five wells in Soil Unit #2 (11-day saturation criterion), well #3 succeeded during only 1 year, well #9 succeeded every year, and the new wells A, B, C all succeeded during their one year of monitoring. Daily precipitation data for 2015 were compiled from CoCoRaHS gauge # NC-DH-33 located at Meadowmont about one mile northeast of the project site.

The berm gaps appear to have conveyed flow from Morgan Creek into the floodplain during at least five storm events in 2015 (Mar 5, Apr 19, Oct 2, Nov 9, and Nov 19) as documented in Table 8 and the stream gauge data included in Appendix D support files. October 2 had the highest recorded stage at the USGS gauge, and cork levels recorded on the berm gap crest gauges were probably deposited on this date. Peak water depths through the berm gaps in 2015 based on crest gauge measurements ranged from 0.7 to 2.7 feet. The berm gap erosion problems reported in 2013-2014 were repaired in 2015, and all five openings are in good condition as of Dec 2015.

Easement Condition:

The Morgan Creek Floodplain conservation easement boundary is not fenced, but is marked by signage on posts at regular intervals along the western and southern boundaries. Existing trails on the MFBR property including the project site are frequently used for walking and wildlife watching, but no evidence of any damage by users was noted. There is no livestock kept on or adjacent to the project site. Some grazing damage by deer and other wild herbivores was noted during CVS plot monitoring.

2.0. Project Monitoring Methods

2.1. Vegetation Methods

Five 10 x 10 meter square CVS vegetation plots were established in 2011 and monitored according to the CVS-EEP Level 2 Vegetation Monitoring Protocol for Recording Vegetation 4.2 (Lee et al 2008). Each plot corner is marked with 1" PVC and/or steel conduit pipe and survey flagging, and plot corners are mapped using a Trimble sub-meter GPS unit. Planted trees and shrubs are measured during Sep-Oct each year, native volunteer stems are counted, and invasive species abundances are described. CVS plot locations are mapped in Figure 2, and vegetation plot data are provided in Tables 6-7. Plant identification manuals used are Radford (1968) and Weakley (2015). Each CVS plot was digitally photographed, usually from the 0,0 plot corner unless dense vegetation or other constraints required photographing from a different corner.

2.2. Hydrology Methods

Nine RDS Ecotone groundwater monitoring gauges were installed between Jun 2010 and Aug 2011 following Technical Note HY-1A-3.1 (USACE 1993). Groundwater Gauge #s 1, 2, 3, 4 and 5 are within the fallow field planted portion of the project, and Gauges #6 and #9 are in areas with existing forest canopy. Gauge #7 was installed in 2010 a reference wetland on the Morgan Creek floodplain upstream of the project area, but was moved in 2012 to a nearby location due to beaver activity at the original site. This well at the new location is referred to as Gauge #10 in the 2012 to 2014 reports. It was damaged and removed in 2014 e s. Gauge #8 was installed in a wetland in the Big Woods area of MFBR south of the project area, and was not monitored after 2012. Three additional gauges designated A, B, and C were installed by DMS in the fall of 2014 in the forest plantation area of the project, near gauge #9.

Two different success criteria for wetland hydrology are based on soil morphology differences described and mapped by The Catena Group (Ward Consulting Engineers, 2008). Groundwater Gauge #s 1, 2, 4, 5, and 6 are within Soil Unit #1, where saturation for 12.5% of the growing season is required. Gauge #s 3, 9, A, B, and C are within Soil Unit #2, where saturation for 5% of the growing season is required. Gauge data and success attainment are provided in Table 9 and Appendix D support files.

Flow events through the berm gaps are evaluated using manual crest stage gages (granular cork type) installed at each of the five berm gaps. Cork levels on the stake inside the gauge are measured at least twice a year, and the gauges are cleaned and reset at each visit. Stage data from USGS stream gauge #02097517 located 1,600 feet upstream of the project site are used for dating the peak events recorded by the crest gauges and documenting other dates when peak flows are likely to have flooded through the berm gaps.

3.0. References

Dunn, J.L. (1977). *Soil Survey of Orange County, North Carolina*. USDA Soil Conservation Service (Natural Resources Conservation Service), Raleigh, NC.

Ward Consulting Engineers (2008). *Mason Farm Wetland/Floodplain Restoration Plan, Chapel Hill, Orange & Durham Counties, North Carolina*. Prepared for NC Ecosystem Enhancement Program, Raleigh, NC, July 2008.

Lee, Michael T., Peet, Robert K., Roberts, Steven D., Wentworth, Thomas R. (2008). *CVS-EEP Protocol for Recording Vegetation version 4.2, October 2008*. Retrieved September 2011, from: <http://cvs.bio.unc.edu/methods.htm>

NC Ecosystem Enhancement Program. (2014). *NC-EEP Monitoring Report Template and Guidance version 1.0, February 2014*. <http://portal.ncdenr.org/web/eep/dbb-resources>

Radford, A.E., H.E. Ahles, and C.R. Bell (1968). *Manual of the Vascular Flora of the Carolinas*. University of North Carolina Press. Chapel Hill, NC.

US Army Corps of Engineers (2003) *Stream Mitigation Guidelines*. US Army Corps of Engineers, US Environmental Protection Agency Region 4, USDA Natural Resources Conservation Service, NC Wildlife Resources Commission, and NC Dept. Environment & Natural Resources.

Weakley, Alan (2015). *Flora of the Southern and Mid-Atlantic States, Working Draft May 2015*. <http://www.herbarium.unc.edu/flora.htm>.

Appendix A. Project Background Tables

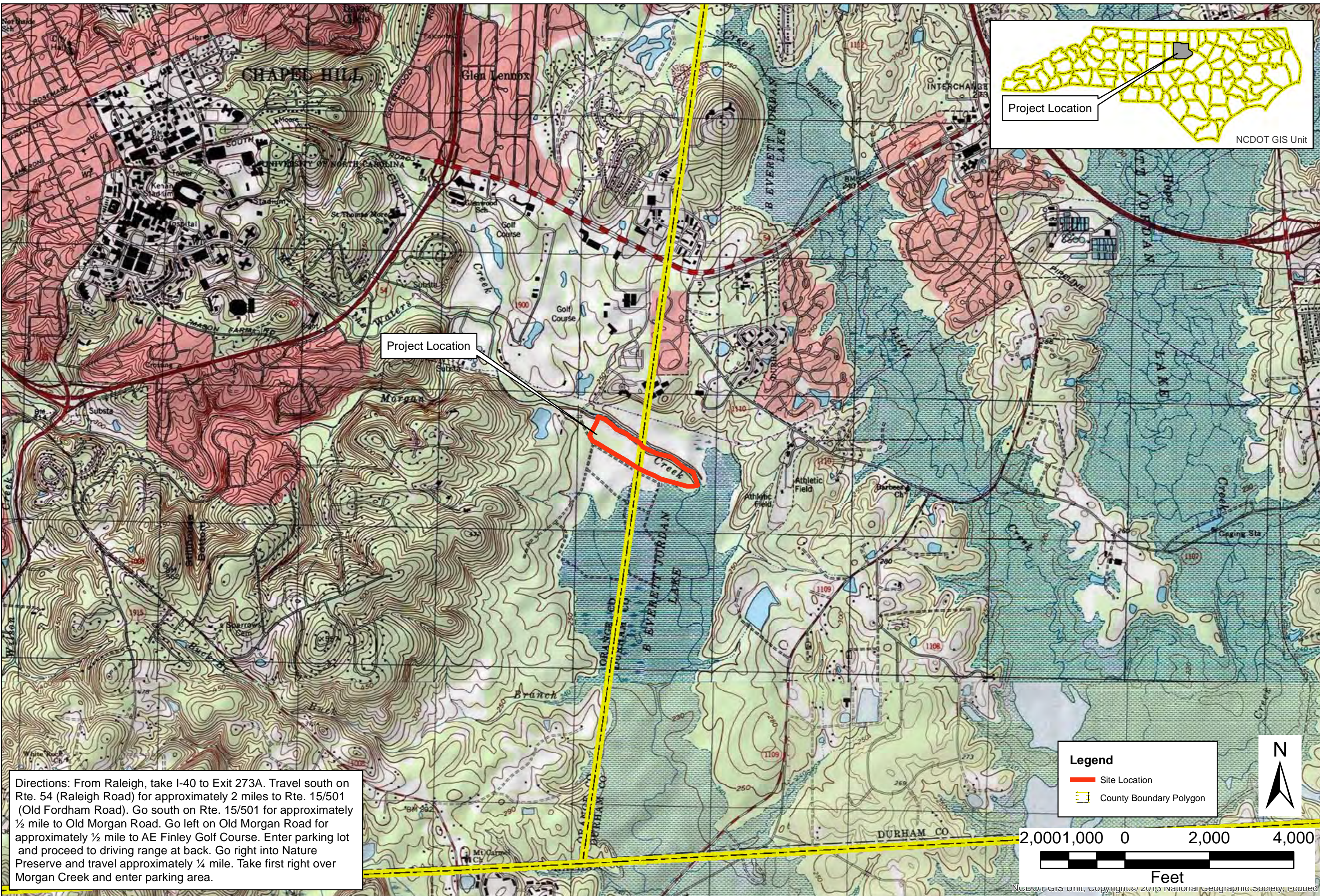
Figure 1. Project Vicinity Map

Table 1. Project Components & Mitigation Credits

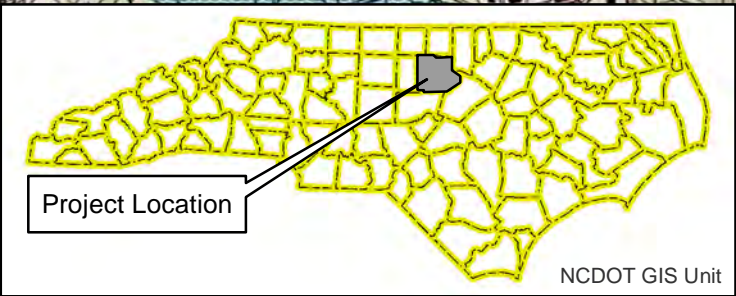
Table 2. Project Activity & Reporting History

Table 3. Project Contacts

Table 4. Project Attributes

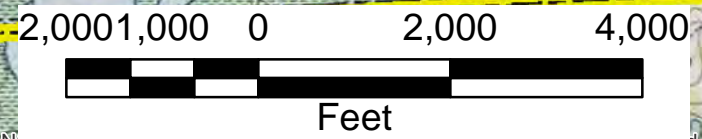


Directions: From Raleigh, take I-40 to Exit 273A. Travel south on Rte. 54 (Raleigh Road) for approximately 2 miles to Rte. 15/501 (Old Fordham Road). Go south on Rte. 15/501 for approximately ½ mile to Old Morgan Road. Go left on Old Morgan Road for approximately ½ mile to AE Finley Golf Course. Enter parking lot and proceed to driving range at back. Go right into Nature Preserve and travel approximately ¼ mile. Take first right over Morgan Creek and enter parking area.



Legend

- Site Location
- County Boundary Polygon



Mogensen Mitigation, Inc.
P.O. Box 690429
Charlotte, NC 28227
(704) 576-1111



December 2015

MORGAN CREEK FLOODPLAIN
(EEP #258)
VICINITY MAP
ORANGE/DURHAM COUNTIES
NORTH CAROLINA



Figure 1

NCDOT GIS Unit, Copyright © 2013 National Geographic Society, i-cubed

Table 1a. Project Components -- Morgan Creek Floodplain - DMS# 258									
Project Component or Reach ID	Existing Feet/Acres	Restoration Level	Approach	Feet or Acres	Stationing	Mitigation Ratio	Mitigation Units	BMP Elements	Comment
Wetlands	14.37	R		14.37		1:1	14.37		
Wetlands	5.61	P		5.61		5:1	1.12		

1 = BR = Bioretention Cell; SF = Sand Filter; SW = Stormwater Wetland; WDP = Wet Detention Pond; DDP = Dry Detention Pond; FS = Filter Strip; Grassed Swale = S; LS = Level Spreader; NI = Natural Infiltration Area, O = Other; CF = Cattle Fencing; WS = Watering System; CH = Livestock Housing

Table 1b. Component Summary -- Morgan Creek Floodplain - DMS# 258							
Restoration Level	Stream (lf)	Riparian Wetland (Ac)		Non-Ripar (Ac)	Upland (Ac)	Buffer (Ac)	BMP
		Riverine	Non-Riverine				
Restoration		14.37					
Enhancement							
Enhancement I							
Enhancement II							
Creation							
Preservation		5.61					
Totals (Feet/Acres)		19.98					
MU Totals		15.49					

Non-Applicable

**Table 2. Project Activity and Reporting History
Morgan Creek Floodplain - DMS# 258**

Activity or Deliverable	Data Collection Complete	Task Completion or Delivery
Conservation easement MOA	NA	Aug-05
Restoration Plan	Jul-06	Aug-06
Final Design – Construction Plans	Aug-06	Nov-08
Permanent Conservation Easement	NA	May-09
Construction	NA	Jul-10
Bare root & containerized plantings	NA	Dec-10
MY-0 Baseline As-built Monitoring	Mar-11	Aug-11
Year 1 Monitoring	Nov-11	Dec-11
Year 2 Monitoring	Oct-12	Nov-12
Year 3 Monitoring	Sep-13	Dec-13
Year 4 Monitoring	Sep-14	Oct-14
Year 5 Monitoring	Nov-15	Dec-15

Table 3. Project Contacts -- Morgan Creek Floodplain - DMS# 258 -- Orange County NC	
Designer Primary project design POC	Ward Consulting Engineers, P.C. 8368 Six Forks Rd, Suite 104 Raleigh, NC 27615- ---- Becky Ward 919-870-0526
Construction Contractor Construction contractor POC	River Works, Inc. 8000 Regency Parkway, Suite 200 Cary, NC 27518 Will Pedersen 919-459-9001
Survey Contractor Survey contractor POC	Turner Land Surveying, PLLC 3201 Glenridge Dr Raleigh, NC 27604 Elisabeth Turner 919-875-1378
Planting Contractor Planting contractor POC	Bruton Natural Systems, Inc. P.O. Box 1197 Fremont, NC 27930 Charlie Bruton 919-424-6555
Seeding Contractor Contractor point of contact	River Works, Inc. 8000 Regency Parkway, Suite 200 Cary, NC 27518 Will Pedersen 919-459-9001
Seed Mix Sources	Green Resource 336-855-6363
Nursery Stock Suppliers	Cure Nursery 919-542-6186; Mellow Marsh Farm, Inc. 919-742-1200; Dykes & Son Nursery 931-668-8833; ArborGen (SuperTree Seedlings) 800-222-1290; NC Forest Service (Claridge Nursery) 919-731-7988
Monitoring Contractor MY 0-2	The Catena Group Inc., 410-B Millstone Dr, Hillsborough NC 27278
Monitoring Contractor MY 3-5	Mogensen Mitigation, Inc., P.O. Box 690423 Charlotte, NC 28227 R.J. Goldstein & Associates, Inc. 1221 Corporation Pkwy, Raleigh, NC 27610
Stream Monitoring POC	N/A
Vegetation Monitoring POC	Rich Mogensen (MMI) 704-576-1111; Gerald Pottner (RJGA) 919-872-1174
Wetland Monitoring POC	Rich Mogensen (MMI) 704-576-1111; Gerald Pottner (RJGA) 919-872-1174

Table 4. Project Attribute Table -- Morgan Creek Floodplain DMS# 258

Project County	Orange/Durham
Physiographic Region	Piedmont (Triassic Basin)
Ecoregion	Central Piedmont
Project River Basin	Cape Fear River Basin
USGS HUC for Project (14 digit)	3.03E+12
NCDWQ Sub-basin for Project	3/6/2006
Within extent of EEP Watershed Plan?	Haw River (Jordan Lake)
WRC Hab Class (Warm, Cool, Cold)	Warm
% of project easement fenced or demarcated	100%
Beaver activity observed during design phase?	No
Restoration Component Attribute Table	
	Site
Drainage area	N/A
Stream order	N/A
Restored length (feet)	N/A
Perennial or Intermittent	N/A
Watershed type (Rural, Urban, Developing etc.)	N/A
Watershed LULC Distribution (e.g.)	N/A
Residential	N/A
Ag-Row Crop	N/A
Ag-Livestock	N/A
Forested	N/A
Etc.	N/A
Watershed impervious cover (%)	N/A
NCDWQ AU/Index number	N/A
NCDWQ classification	WS-IV-NSW
303d listed?	Yes
Upstream of a 303d listed segment?	Yes
Reasons for 303d listing or stressor	Standard Violation
Total acreage of easement	31.54
Total vegetated acreage within the easement	19.75
Total planted acreage as part of the restoration	18.36
Rosgen classification of pre-existing	N/A
Rosgen classification of As-built	N/A
Valley type	N/A
Valley slope	N/A
Valley side slope range (e.g. 2-3.%)	N/A
Valley toe slope range (e.g. 2-3.%)	N/A
Cowardin classification	N/A
Trout waters designation	N/A
Species of concern, endangered etc.? (Y/N)	No
Dominant soil series and characteristics	Chewacla
Series	-
Depth	-
Clay%	-
K	-
T	-
Use N/A for items that may not apply. Use "-" for items that are unavailable and "U" for items that are unknown	

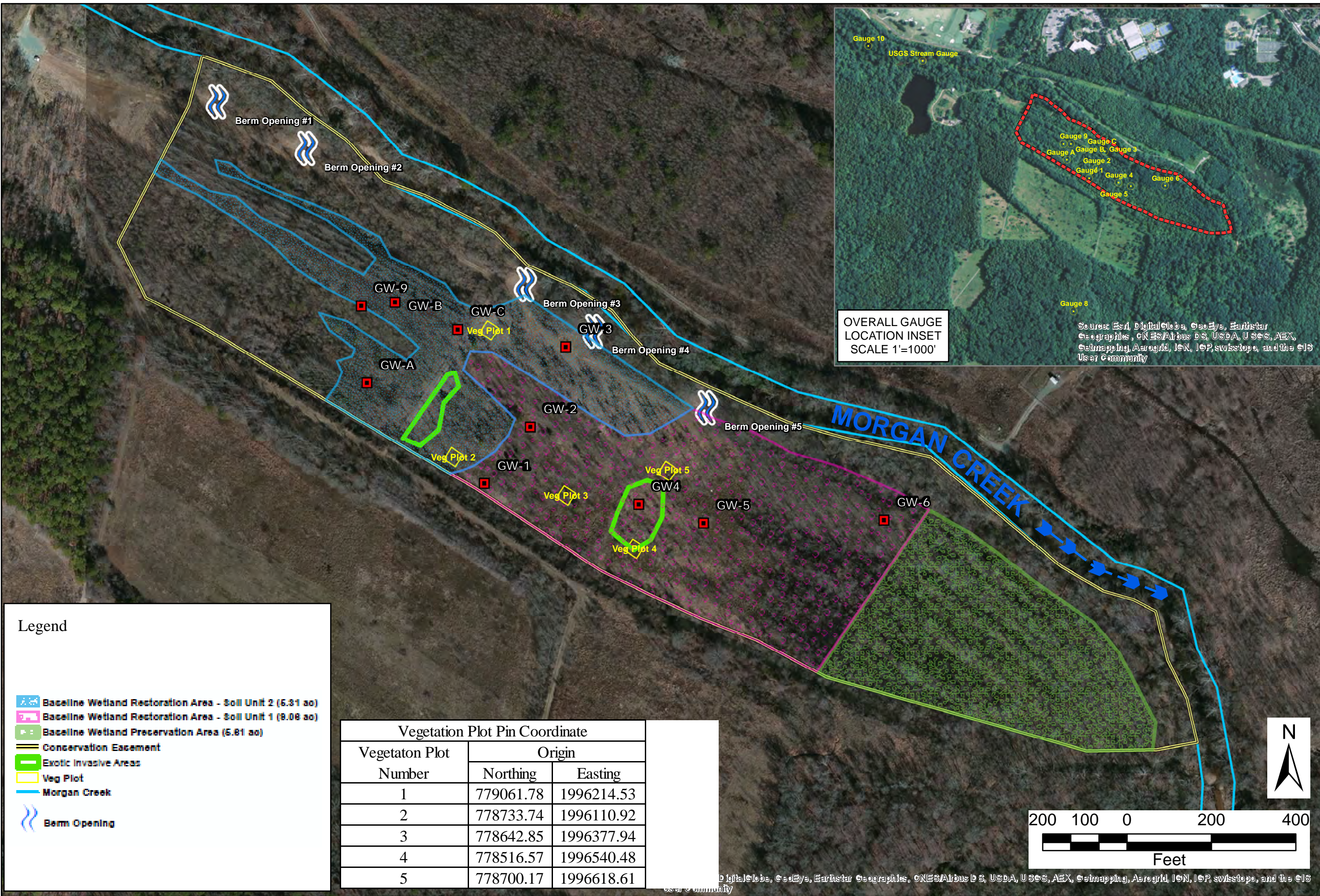
Appendix B. Visual Assessment Data

Figure 2. Current Conditions Plan View (CCPV)

Figure 3. Floodplain Conveyance Assessment

Table 5. Vegetation Condition Assessment

Photos: Vegetation Plots & Berm Gap Photos



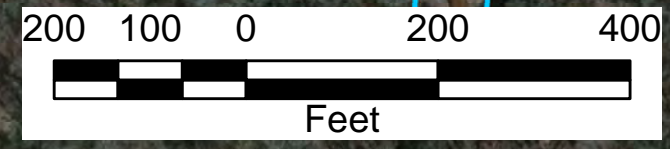
Legend

- Baseline Wetland Restoration Area - Soil Unit 2 (5.31 ac)
- Baseline Wetland Restoration Area - Soil Unit 1 (9.08 ac)
- Baseline Wetland Preservation Area (5.61 ac)
- Conservation Easement
- Exotic Invasive Areas
- Veg Plot
- Morgan Creek
- Berm Opening

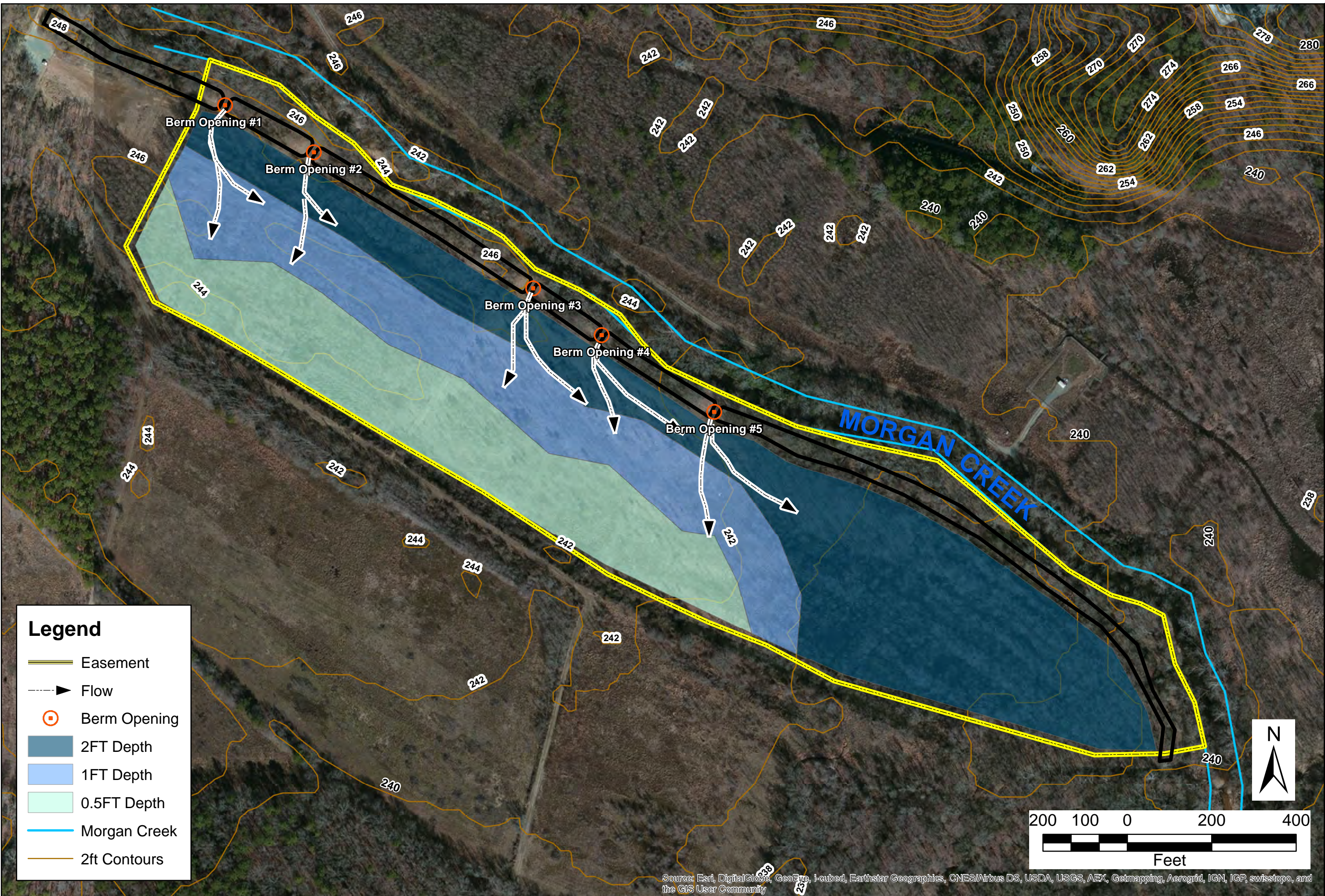
Vegetation Plot Number	Vegetation Plot Pin Coordinate	
	Northing	Easting
1	779061.78	1996214.53
2	778733.74	1996110.92
3	778642.85	1996377.94
4	778516.57	1996540.48
5	778700.17	1996618.61

OVERALL GAUGE LOCATION INSET
SCALE 1"=1000'

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community



Legend

- Easement
- Flow
- Berm Opening
- 2FT Depth
- 1FT Depth
- 0.5FT Depth
- Morgan Creek
- 2ft Contours

Mogensen Mitigation, Inc.
P.O. Box 690429
Charlotte, NC 28227
(704) 576-1111



December 2015

**MORGAN CREEK FLOODPLAIN
(EEP #258)
HIGH-FLOW WATER DEPTH APPROXIMATION**
ORANGE/DURHAM COUNTIES
NORTH CAROLINA



Figure 3

Source: Esri, DigitalGlobe, GeoEye, i-cubed, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AEX, Getmapping, Aerogrid, IGN, IGP, swisstopo, and the GIS User Community

Morgan Creek Floodplain -- DMS #258 -- 2015 (MY5)

Table 5. Vegetation Condition Visual Assessment

Planted
Acreage¹ 11.8 acres

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 acre	none	0	0.00	0.0%
2. Low Stem Density Areas	Woody stem densities clearly below target levels based on MY3, 4, or 5 stem count criteria.	0.1 acre	none	0	0.00	0.0%
Total				0	0.00	0.0%
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 acre	none	0	0.00	0.0%
Cumulative Total				0	0.00	0.0%

Easement
Acreage² 31.5 acres

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).	500 SF	Green polygon	2	0.62	2.0%
5. Easement Encroachment Areas ³	Areas or points (if too small to render as polygons at map scale).	none	none	0	0.00	0.0%

Note: Planted stem survival was poor in some areas, but native volunteer trees have filled in, and no planted area of .25 acre or larger presently has low density of native woody stems.

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 species 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 likely 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 early 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 symbolizing invasives polygons, particularly for situations where the condition 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.

Vegetation Plot Photos - Morgan Creek Floodplain #258 - MY5 (2015)



CVS VegPlot 1: MY-4 Sep 2, 2014



CVS VegPlot 1: MY-5 Sep 22, 2015



CVS VegPlot 2: MY-4 Sep 2, 2014



CVS VegPlot 2: MY-5 Sep 22, 2015

Vegetation Plot Photos - Morgan Creek Floodplain #258 - MY5 (2015)



CVS VegPlot 3: MY-4 Sep 2, 2014



CVS VegPlot 3: MY-5 Sep 22, 2015



CVS VegPlot 4: MY-4 Sep 3, 2014



CVS VegPlot 4: MY-5 Sep 22, 2015

Vegetation Plot Photos - Morgan Creek Floodplain #258 - MY5 (2015)



CVS VegPlot 5: MY-4 Sep 3, 2014



CVS VegPlot 5: MY-5 Sep 22, 2015

Berm Opening Photos - Morgan Creek Floodplain #258 - MY5 (2015)



Berm Opening 1: MY-5 Dec 20, 2015



Berm Opening 2: MY-5 Dec 20, 2015



Berm Opening 3: MY-5 Dec 20, 2015



Berm Opening 4: MY-5 Dec 20, 2015

Berm Opening Photos - Morgan Creek Floodplain #258 - MY5 (2015)



Berm Gap-5 Dec 2015

Berm Opening 5: MY-5 Dec 20, 2015



Drift Lines E of Berm Gap-5 Dec 2015

Drift Lines at Edge of Berm Opening 5: MY-5 Dec 20, 2015

Appendix C: Vegetation Plot Data

Table 6. Vegetation Plot Success Summary

Table 7. CVS Stem Count Total & Planted

Table 6. CVS Vegetation Plot Mitigation Success Summary, Morgan Cr Floodplain #258 - MY5 (2015)

Morgan Creek Floodplain (DMS #258)
Vegetation Plot Summary Information: MY-5 (22-Sep-2015)

Plot #	Riparian Buffer Stems ¹	Stream/Wetland Stems ²	Live Stakes	Invasives	Volunteer ³	Total ⁴	Unknown Growth Form
0001	n/a	6	0	0	0	6	0
0002	n/a	5	0	0	17	22	1
0003	n/a	7	0	0	16	23	1
0004	n/a	5	0	0	23	28	0
0005	n/a	0	0	0	16	16	0

Wetland/Stream Vegetation Totals (per acre)

Plot #	Stream/Wetland Stems ²	Volunteer ³	Total ⁴	Success based on Planted	Success based on Total
0001	243	0	243	No	No
0002	202	688	890	No	Yes
0003	283	648	931	Yes	Yes
0004	202	931	1133	No	Yes
0005	0	647	647	No	Yes
Project Avg	186	583	769	No	Yes

Riparian Buffer Vegetation Totals (per acre)

Plot #	Riparian Buffer Stems ¹	Success Criteria Met?
0001	n/a	n/a
0002	n/a	n/a
0003	n/a	n/a
0004	n/a	n/a
0005	n/a	n/a
Project Avg	n/a	n/a

- Exceeds 260 trees/acre requirements by 10%
- Exceeds 260 trees/acre requirements, but by less than 10%
- Fails to meet 260 trees/acre requirements, by less than 10%
- Fails to meet 260 trees/acre requirements by more than 10%

Stem Class Characteristics:

- ¹ **Buffer Stems:** Native planted hardwood trees. Does NOT include shrubs, pines, or vines.
- ² **Stream/ Wetland Stems:** Native planted hardwood trees and shrubs. Excludes live stakes, vines.
- ³ **Volunteers:** Native woody trees and shrubs NOT planted. No vines.
- ⁴ **Total Stems:** Planted + volunteer native woody trees, shrubs, & live stakes. Excludes exotics, vines.

Table 7.1. CVS Vegetation Plot Mitigation Success Summary, Morgan Cr Floodplain #258 - MY5 (2015) -- Current Year Data

Scientific Name	Common Name	Growth Form	Current Year Plot Data (MY5 2015)															Annual Means		
			E258-01-0001			E258-01-0002			E258-01-0003			E258-01-0004			E258-01-0005			MY5 (2015)		
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T
Acer negundo	boxelder	Tree																		
Acer rubrum	red maple	Tree																		
Alnus serrulata	hazel alder	Shrub				1	1	1	1	1	1						2	2	2	
Betula nigra	river birch	Tree							1	1	1						1	1	1	
Carya cordiformis	bitternut hickory	Tree																		
Cornus amomum	silky dogwood	Shrub	1	1	1				2	2	2						3	3	3	
Diospyros virginiana	persimmon	Tree	2	2	2	1	1	3	2	2	2				1		5	5	8	
Fraxinus pennsylvanica	green ash	Tree						7			3			4		2			16	
Juglans nigra	black walnut	Tree																		
Juniperus virginiana	eastern redcedar	Tree											1						1	
Liquidambar styraciflua	sweetgum	Tree						8			13			13		10			44	
Liriodendron tulipifera	tulip poplar	Tree																		
Nyssa sylvatica	blackgum	Tree																		
Platanus occidentalis	American sycamore	Tree	3	3	3	1	1	1				1	1	1			5	5	5	
Quercus michauxii	swamp chestnut oak	Tree																		
Quercus pagoda	cherrybark oak	Tree							1	1	1						1	1	1	
Quercus phellos	willow oak	Tree				1	1	1				3	3	3			4	4	4	
Sambucus canadensis	common elderberry	Shrub																		
Staphylea trifolia	bladdernut	Shrub																		
Ulmus americana	American elm	Tree				1	1	1						5		3	1	1	9	
Ulmus rubra	slippery elm	Tree										1	1	1			1	1	1	
Vaccinium corymbosum	highbush blueberry	Shrub																		
Viburnum dentatum	southern arrowwood	Shrub																		
Stem count			6	6	6	5	5	22	7	7	23	5	5	28	0	0	16	23	23	95
plot size (ares)			1.0			1.0			1.0			1.0			1.0			5.0		
plot size (ACRES)			0.0247			0.0247			0.0247			0.0247			0.0247			0.1236		
Species count			3	3	3	5	5	7	5	5	7	3	3	7	0	0	4	9	9	12
Stems per ACRE			243	243	243	202	202	890	283	283	931	202	202	1133	0	0	647	186	186	769

Exceeds 260 trees/acre requirements by 10%
 Exceeds 260 trees/acre requirements, but by less than 10%
 Fails to meet 260 trees/acre requirements, by less than 10%
 Fails to meet 260 trees/acre requirements by more than 10%

PnoLS stems/acre -- success based on Planted Stems only (excl live stakes).
 Total (T) stems/acre -- success based on Planted + Volunteer Native Stems.

Table 7.2. CVS Vegetation Plot Mitigation Success Summary, Morgan Cr Floodplain #258 - MY5 (2015) - Annual Means MY0 to MY5

Scientific Name	Common Name	Growth Form	Annual Means - All Plots																		
			MY5 (2015)			MY4 (2014)			MY3 (2013)			MY2 (2012)			MY1 (2011)			MY0 (2011)			
			PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	PnoLS	P-all	T	
Acer negundo	boxelder	Tree									4			3							
Acer rubrum	red maple	Tree									1			6							
Alnus serrulata	hazel alder	Shrub	2	2	2	2	2	2	2	2	2	2	3	3	3	4	4	4	6	6	6
Betula nigra	river birch	Tree	1	1	1	2	2	2	2	2	2	3	3	3	4	4	4	5	5	5	
Carya cordiformis	bitternut hickory	Tree																1	1	1	
Cornus amomum	silky dogwood	Shrub	3	3	3	3	3	5	3	3	3	6	6	18	6	6	6	7	7	7	
Diospyros virginiana	persimmon	Tree	5	5	8	5	5	10	5	5	5	5	5	8	6	6	6	6	6	6	
Fraxinus pennsylvanica	green ash	Tree			16			8			21			18							
Juglans nigra	black walnut	Tree												1							
Juniperus virginiana	eastern redcedar	Tree			1			1			1										
Liquidambar styraciflua	sweetgum	Tree			44			52			106			57							
Liriodendron tulipifera	tulip poplar	Tree										1	1	1	1	1	1	3	3	3	
Nyssa sylvatica	blackgum	Tree							2	2	2	3	3	3	3	3	3	2	2	2	
Platanus occidentalis	American sycamore	Tree	4	4	4	4	4	5	4	4	4	4	4	5	4	4	4	4	4	4	
Quercus michauxii	swamp chestnut oak	Tree										1	1	1	1	1	1	1	1	1	
Quercus pagoda	cherrybark oak	Tree	1	1	1	1	1	1	1	1	1			2							
Quercus phellos	willow oak	Tree	4	4	4	4	4	4	4	4	4	5	5	5	6	6	6	6	6	6	
Sambucus canadensis	common elderberry	Shrub												1	5	5	5	7	7	7	
Staphylea trifolia	bladdernut	Shrub																5	5	5	
Ulmus americana	American elm	Tree	1	1	9	1	1	3			2										
Ulmus rubra	slippery elm	Tree	1	1	1	2	2	2	2	2	2	3	3	13	1	1	1				
Vaccinium corymbosum	highbush blueberry	Shrub																4	4	4	
Viburnum dentatum	southern arrowwood	Shrub										1	1	1	3	3	3	8	8	8	
Stem count			22	22	94	24	24	95	25	25	160	35	35	149	44	44	44	65	65	65	
plot size (ares)			5.0			5.0			5.0			5.0			5.0			5.0			
plot size (ACRES)			0.1236			0.1236			0.1236			0.1236			0.1236			0.1236			
Species count			9	9	12	9	9	12	9	9	15	11	11	18	12	12	12	14	14	14	
Stems per ACRE			178	178	761	194	194	769	202	202	1295	283	283	1206	356	356	356	526	526	526	

Exceeds 260 trees/acre requirements by 10%
 Exceeds 260 trees/acre requirements, but by less than 10%
 Fails to meet 260 trees/acre requirements, by less than 10%
 Fails to meet 260 trees/acre requirements by more than 10%

PnoLS stems/acre -- success based on Planted Stems only (excl live stakes).
 Total (T) stems/acre -- success based on Planted + Volunteer Native Stems.

Appendix D. Stream Survey Data

Figure 4.1-4.10. Groundwater Gauge Plots with Precipitation Data

Figure 5. Monthly Rainfall Data with Percentiles, 2015

Table 8. Verification of Bankfull Events

Table 9. Wetland Hydrology Criteria Attainment

[e-Table: Groundwater & Rain Gauge Raw Data](#)

[e-Table: Morgan Cr Stream Gauge Raw Data](#)

Figure 4.1. Groundwater Wells and Daily Precipitation Data, 2015 (MY5): Morgan Cr Floodplain Site #258.

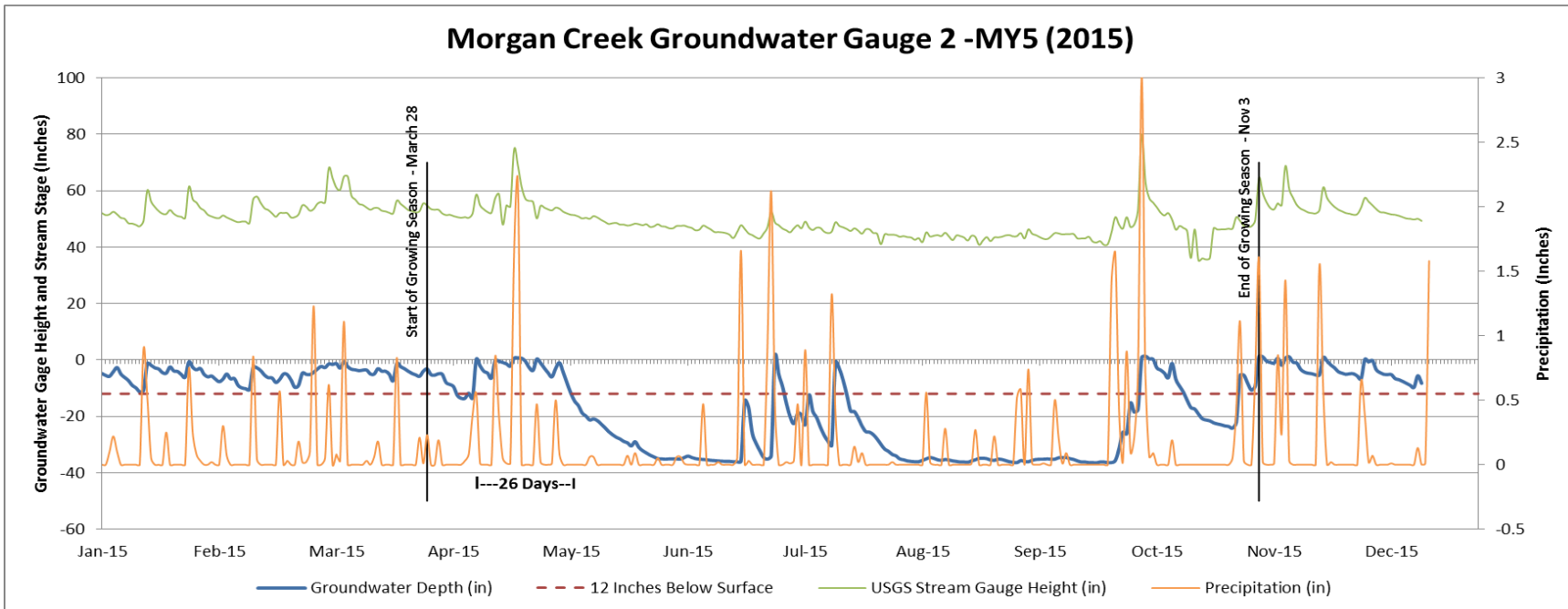
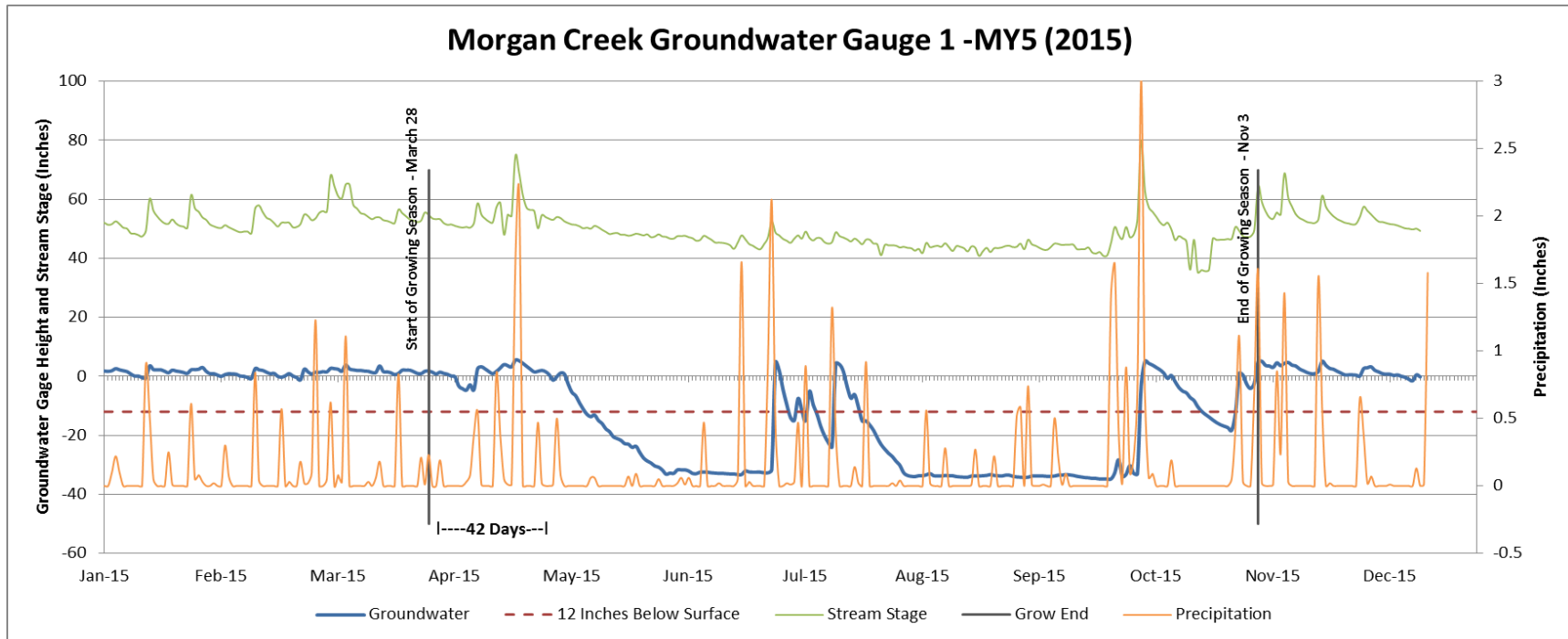


Figure 4.2. Groundwater Wells and Daily Precipitation Data, 2015 (MY5): Morgan Cr Floodplain Site #258.

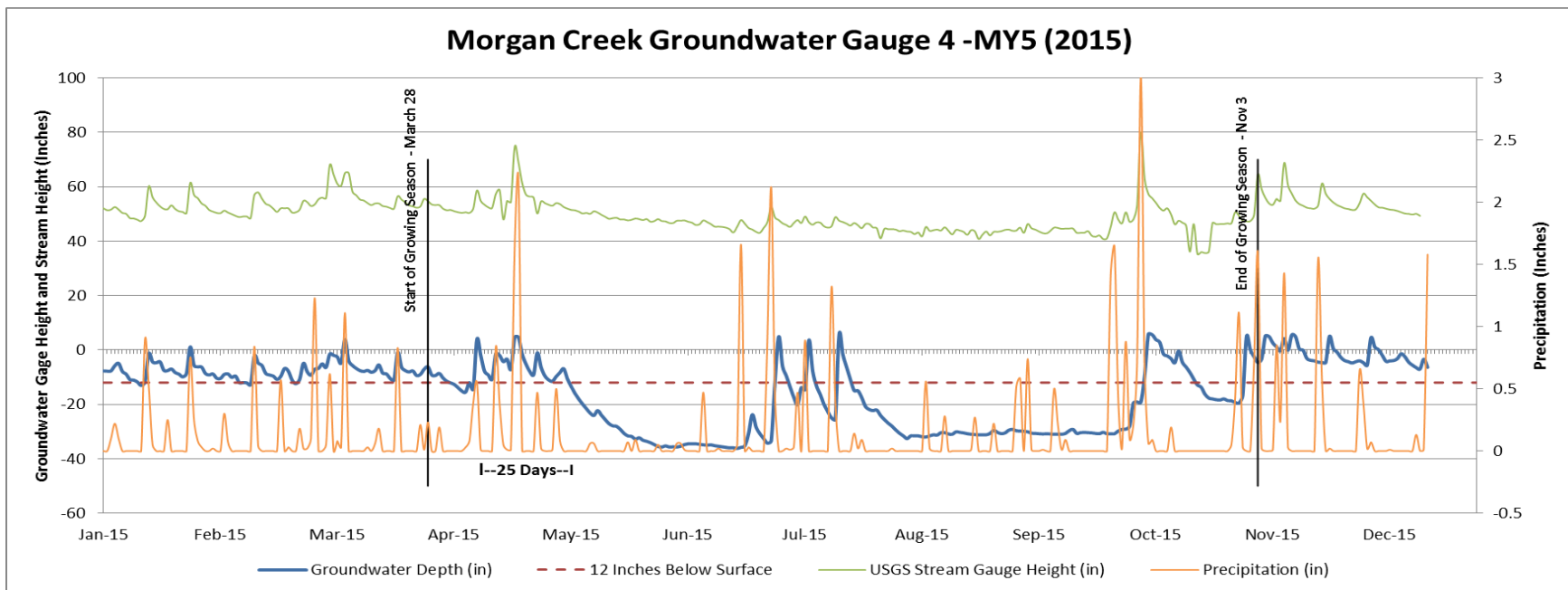
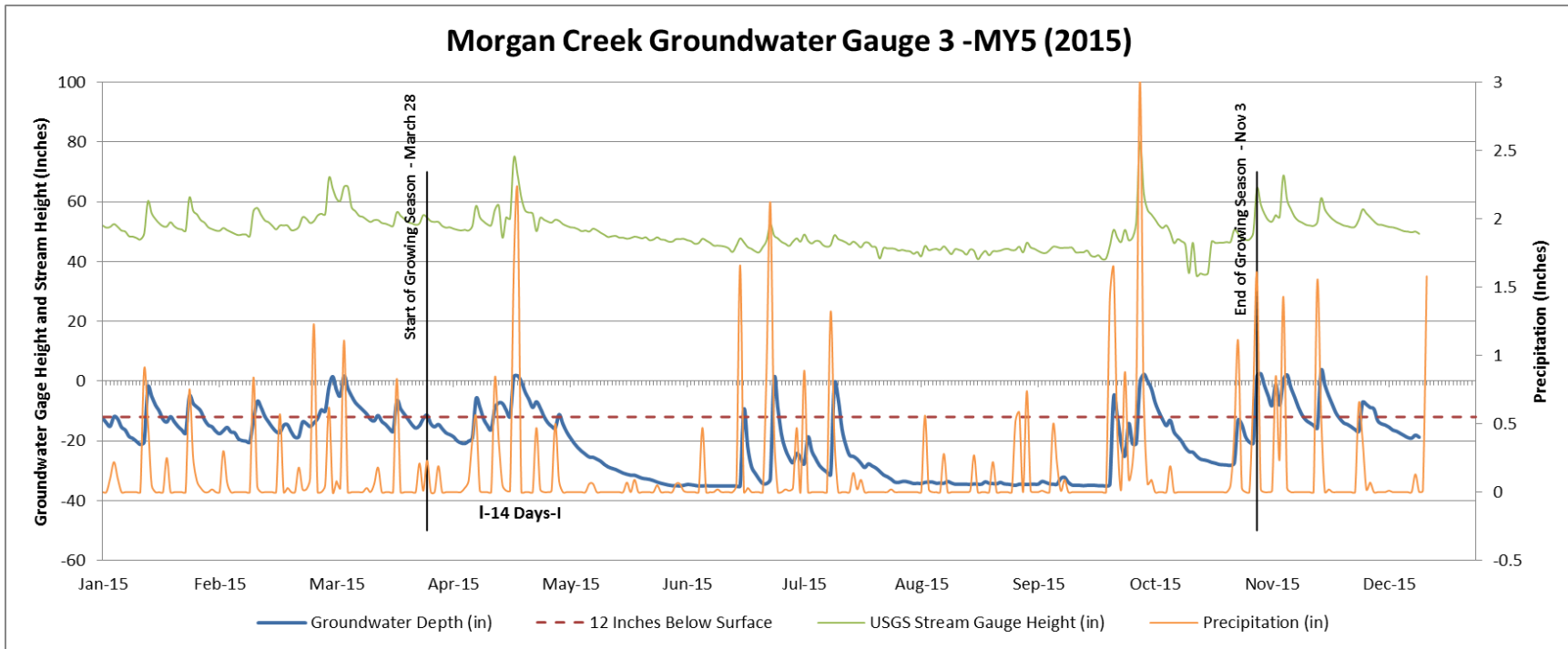


Figure 4.3. Groundwater Wells and Daily Precipitation Data, 2015 (MY5): Morgan Cr Floodplain Site #258.

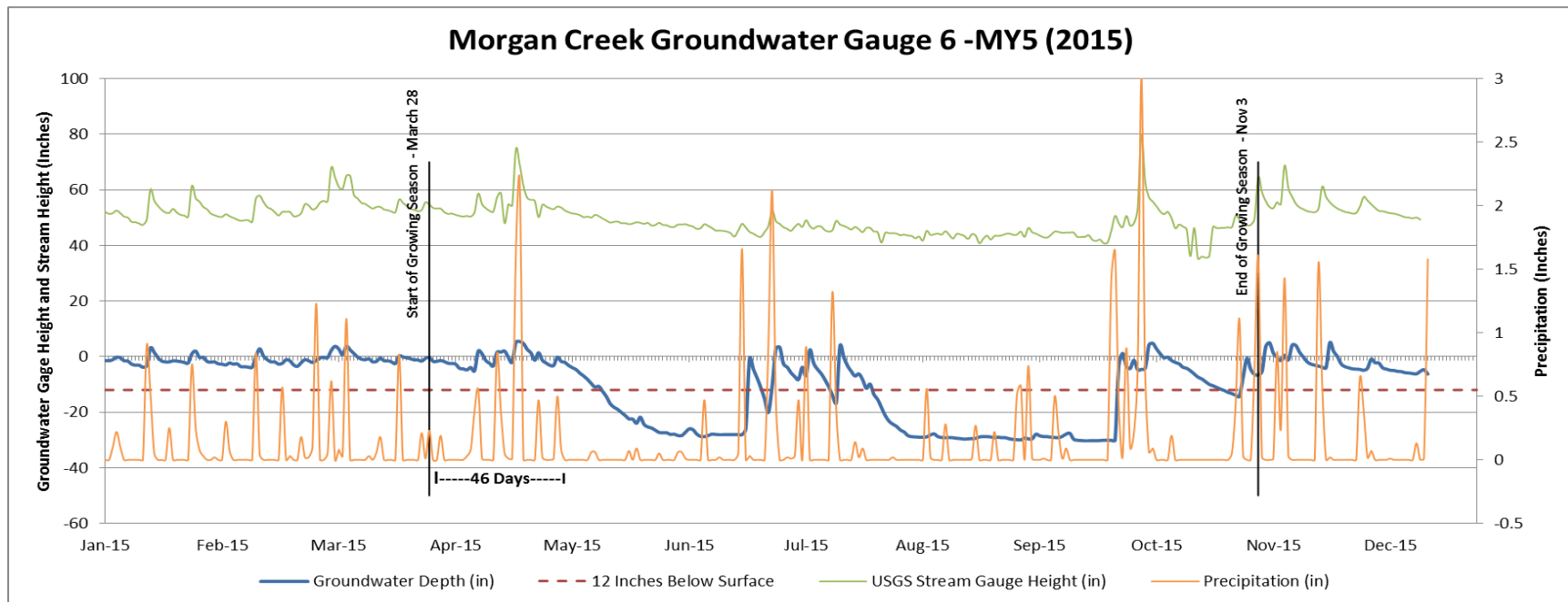
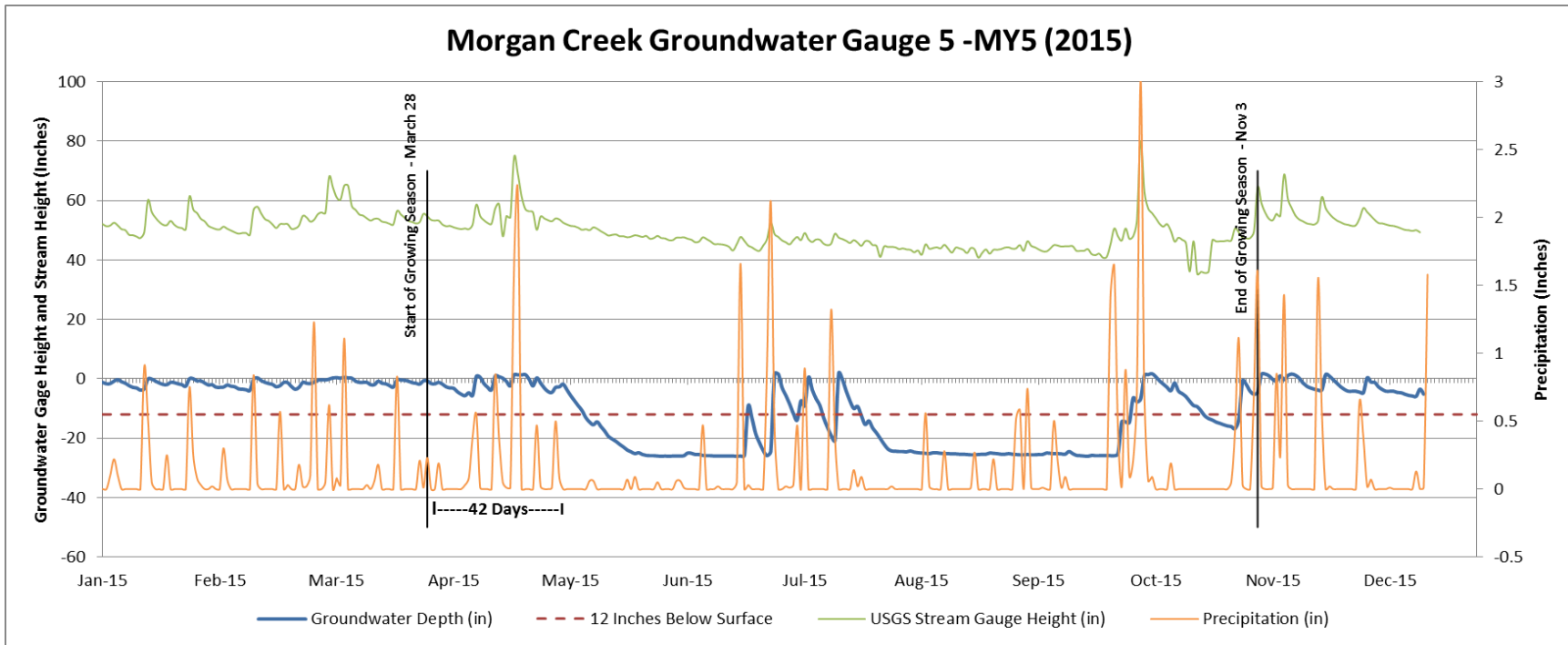


Figure 4.4. Groundwater Wells and Daily Precipitation Data, 2015 (MY5): Morgan Cr Floodplain Site #258.

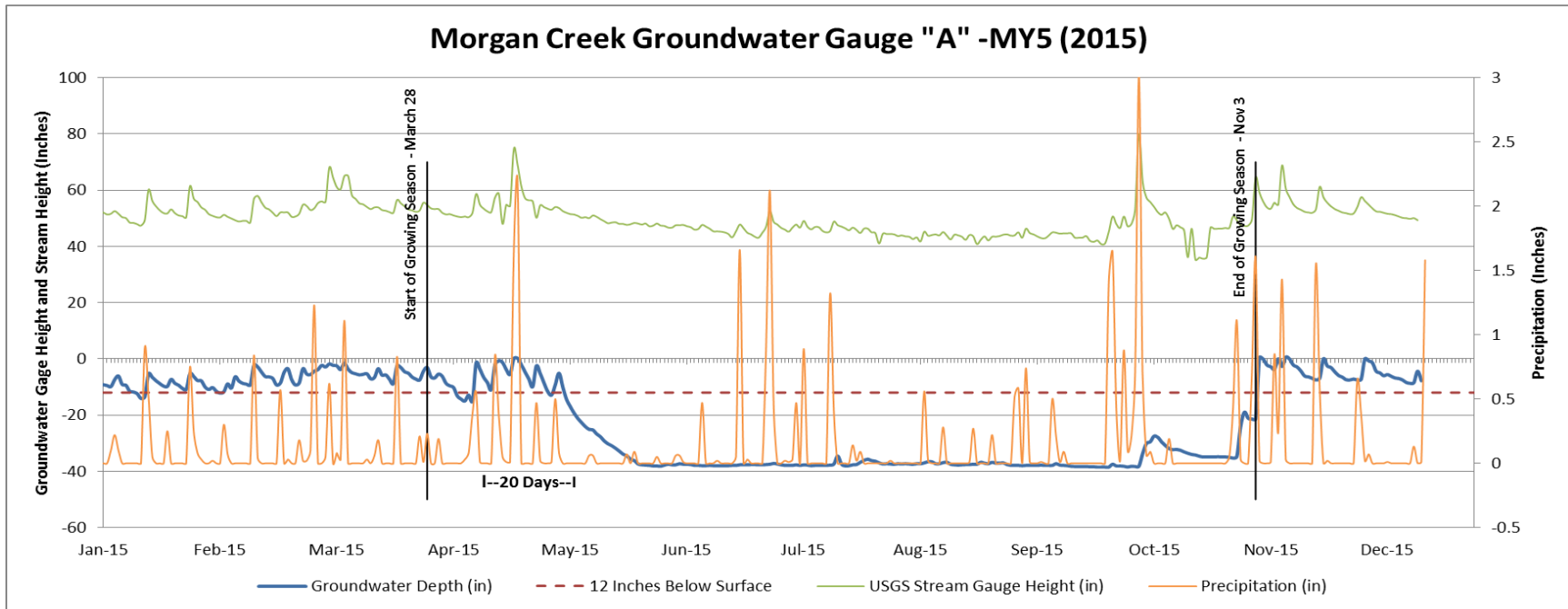
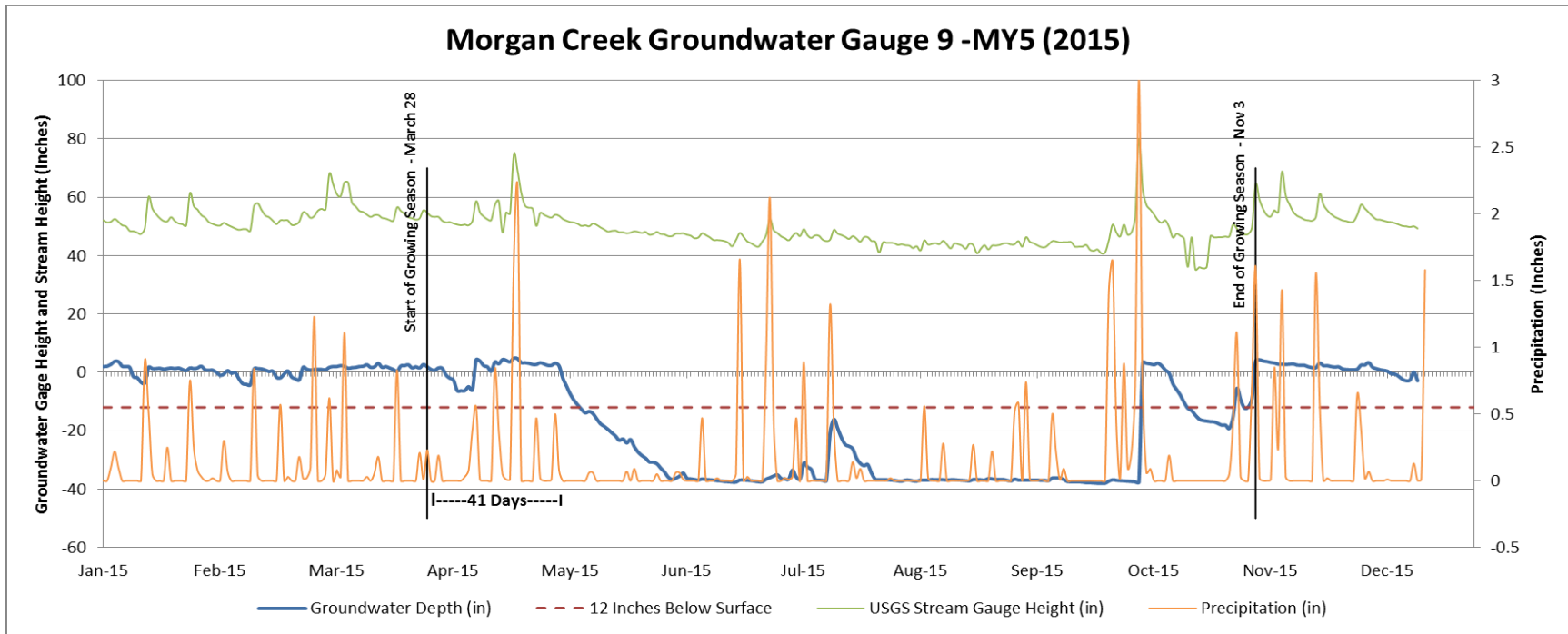


Figure 4.5. Groundwater Wells and Daily Precipitation Data, 2015 (MY5): Morgan Cr Floodplain Site #258.

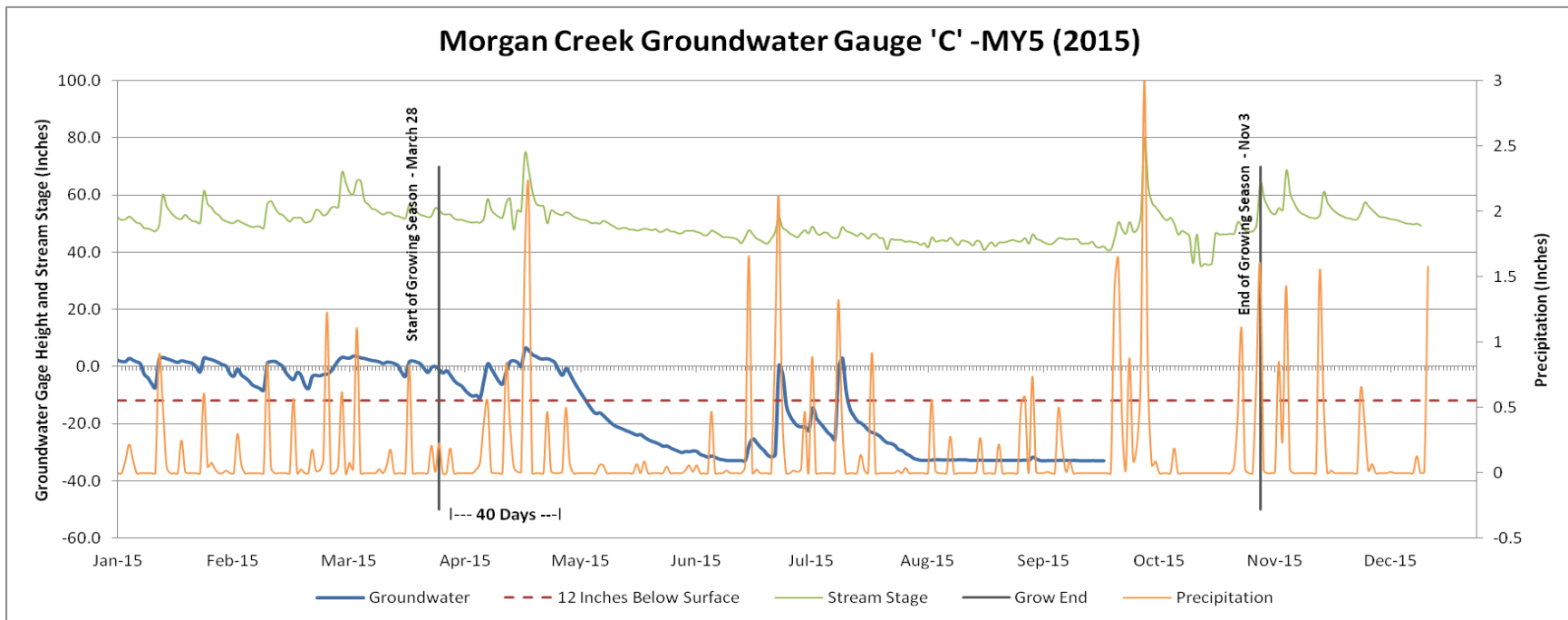
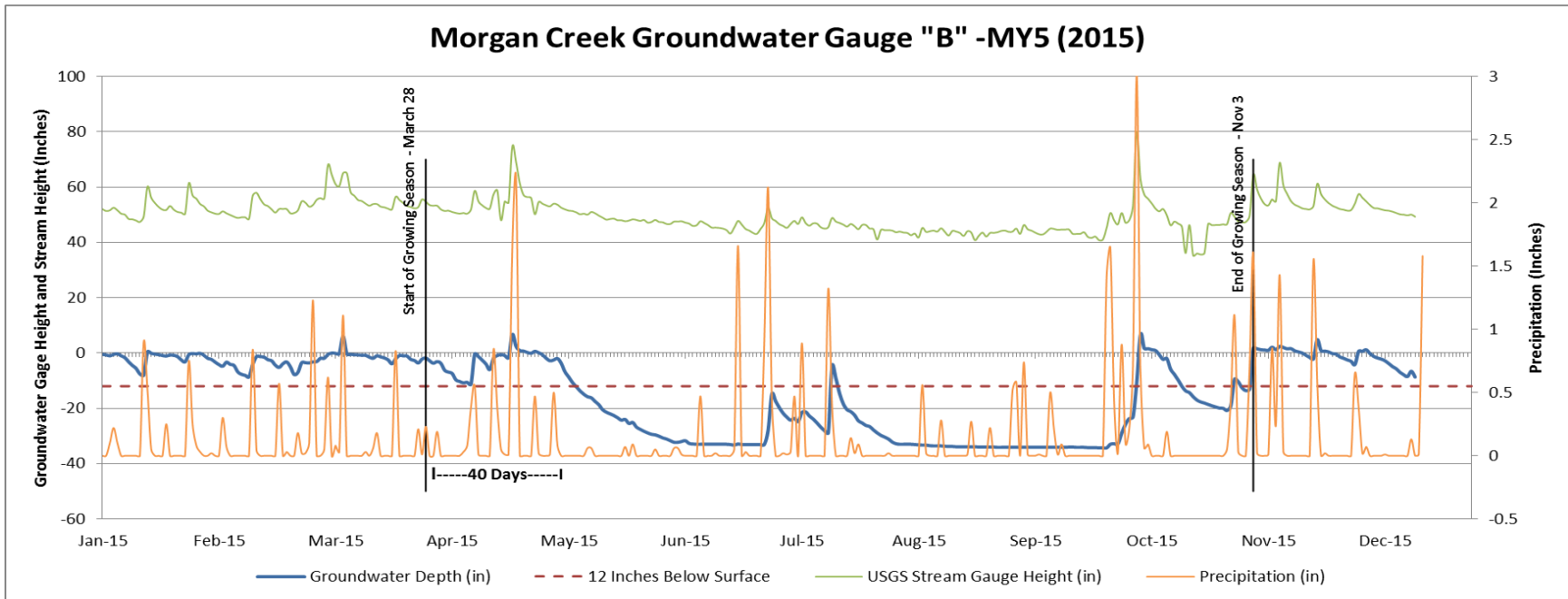


Figure 5. Monthly Rainfall Totals for 2015, with 30th and 70th Percentile Climate Normals, Chapel Hill, NC

Month & Year	Rainfall at Third Fork Cr Gauge, inches	1980 - 2010 monthly climate normals	
		30th P*	70th P*
Jan-15	2.91	2.55	4.92
Feb-15	2.76	2.44	4.59
Mar-15	3.61	3.42	5.57
Apr-15	3.46	2.16	4.02
May-15	2.03	2.29	4.12
Jun-15	4.65	3.01	5.48
Jul-15	5.19	3.42	5.20
Aug-15	2.59	3.04	5.53
Sep-15	5.54	2.61	5.07
Oct-15	5.07	2.50	4.57
Nov-15	5.83	2.47	3.81
Dec-15		2.35	3.69

Monthly rainfall totals at Third Fork Creek, USGS Gauge# 355511078570745 (4 miles ENE of project site)
 Monthly Climate values are based on the 30 year period from 1981 to 2010 at Williams Airport, Orange Co.

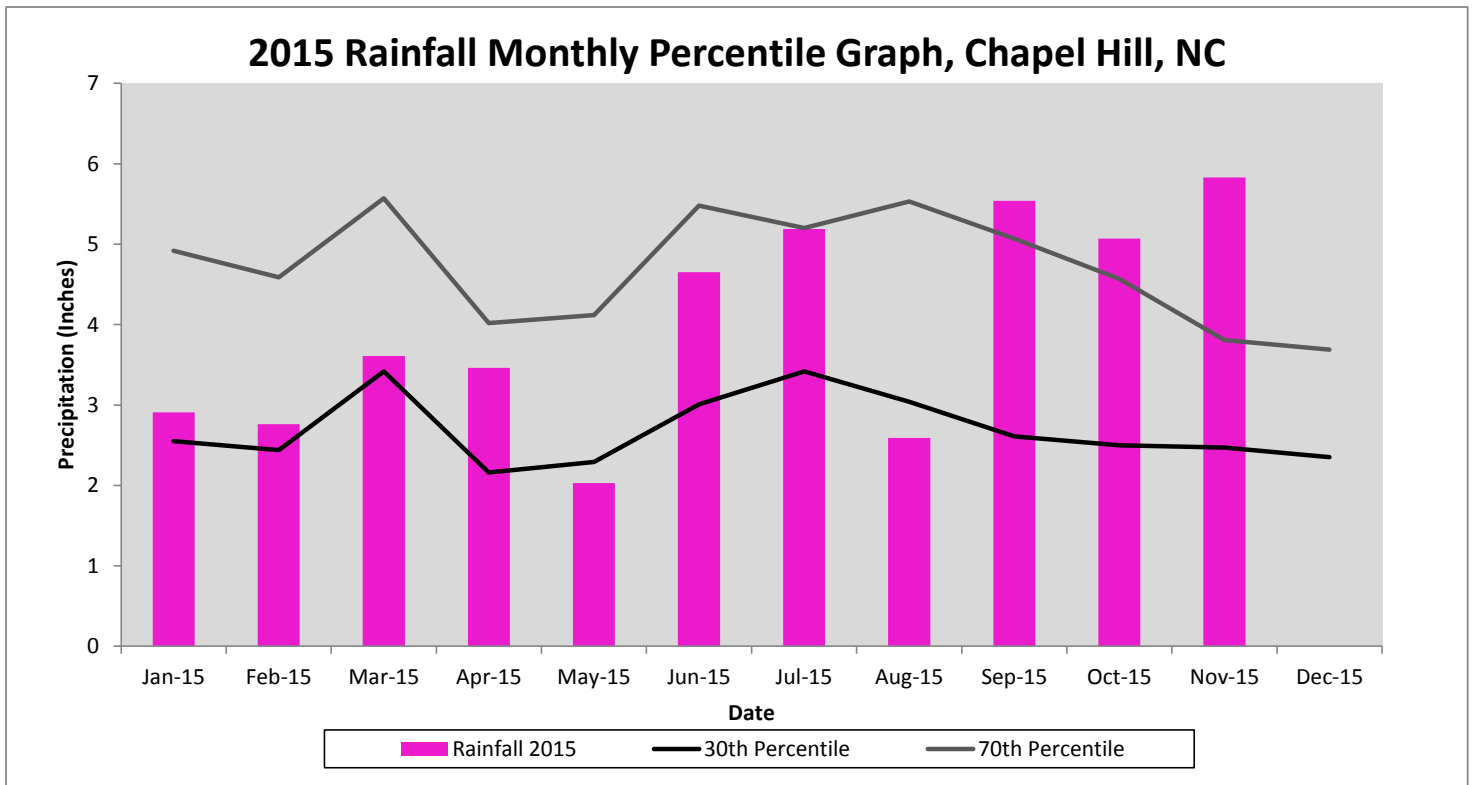


Table 8. Bankfull Events Accessing Floodplain Through Berm Openings**Morgan Creek Floodplain -DMS # 258**

Date of Data Collection	Date of Occurrence	Data Method / Evidence	Photo #
17-Dec-10	unk	Visual observation of wrack lines	MY-01 #6
3-Jun-11	27-May-11	USGS Gauge height > 11.0 feet, Visual indicators / wrack	MY-01 #7
1-Aug-11	31-Jul-11	USGS Gauge height > 9.0 feet, Visual indicators / wrack	MY-01 #8
7-Sep-11	7-Sep-11	USGS Gauge height > 8.5 feet	n/a
23-May-12	23-May-12	USGS Gauge height > 8.0 feet	n/a
28-Jul-12	28-Jul-12	USGS Gauge height > 9.7 feet	n/a
3-Sep-12	3-Sep-12	USGS Gauge height > 9.3 feet	n/a
19-Sep-12	19-Sep-12	USGS Gauge height > 10.1 feet, Visual indicators / wrack	MY-02 #6
30-Jun-13	30-Jun-13	USGS Gauge height > 8.5 feet	n/a
1-Jul-13	1-Jul-13	USGS Gauge height > 8.5 feet	n/a
7-Mar-14	7-Mar-14	USGS Gauge height > 8.5 feet	n/a
16-May-14	16-May-14	USGS Gauge height > 8.5 feet	n/a
2-Sep-14	unk	*Berm Gap 1 - Crest Gauge Flood Elevation 2 feet	n/a
2-Sep-14	unk	*Berm Gap 2 - Crest Gauge Flood Elevation 3 feet	n/a
2-Sep-14	unk	*Berm Gap 3 - Damaged	n/a
2-Sep-14	unk	*Berm Gap 4 - Crest Gauge Flood Elevation 2.3 feet	n/a
2-Sep-14	unk	*Berm Gap 5 - Crest Gauge Flood Elevation 3 feet	n/a
5-Mar-15	5-Mar-15	USGS Gauge height > 8.0 feet	n/a
19-Apr-15	19-Apr-15	USGS Gauge height > 9.5 feet	n/a
2-Oct-15	2-Oct-15	USGS Gauge height > 10.2 feet	n/a
9-Nov-15	9-Nov-15	USGS Gauge height > 7.9 feet	n/a
19-Nov-15	19-Nov-15	USGS Gauge height > 8.0 feet	n/a
16-Dec-15	2-Oct-15	*Berm Gap 1 - Crest Gauge Flood Elevation 0.7 feet	n/a
16-Dec-15	2-Oct-15	*Berm Gap 2 - Crest Gauge Flood Elevation 1.5 feet	n/a
16-Dec-15	2-Oct-15	*Berm Gap 3 - Crest Gauge Flood Elevation 1.2 feet	n/a
16-Dec-15	2-Oct-15	*Berm Gap 4 - Crest Gauge Flood Elevation 2.7 feet	n/a
16-Dec-15	2-Oct-15	*Berm Gap 5 - Crest Gauge Flood Elevation 1.9 feet	n/a

Table 9. Wetland Hydrology Criteria Attainment, Morgan Creek Floodplain -- DMS #258

Gauge #	2010			2011			2012			2013			2014			2015			2011-15
	Max # Consec Days	% Growing Season	Success Criteria Attained	Max # Consec Days	% Growing Season	Success Criteria Attained	Max # Consec Days	% Growing Season	Success Criteria Attained	Max # Consec Days	% Growing Season	Success Criteria Attained	Max # Consec Days	% Growing Season	Success Criteria Attained	Max # Consec Days	% Growing Season	Success Criteria Attained	Years of Success
1	20	9	No	61	28	Yes	35	16	Yes	50	22	Yes	46	21	Yes	42	19	Yes	5 of 5
2	53	24	Yes	34	15	Yes	8	4	No	23	10	No	39	18	Yes	27	13	Yes	3 of 5
3	5	2	No	5	2	No	3	1	No	-	-	-	7	3	No	14	6	Yes	1 of 4
4	3	1	No	8	4	No	23	10	No	48	21	Yes	39	18	Yes	25	11	No	2 of 5
5	24	11	No	53	24	Yes	61	28	Yes	52	23	Yes	46	21	Yes	42	19	Yes	5 of 5
6	23	10	No	51	23	Yes	25	25	Yes	51	23	Yes	46	21	Yes	46	21	Yes	5 of 5
9	0	0	No	32	14	Yes	11	11	Yes	32	15	Yes	45	20	Yes	41	19	Yes	5 of 5
10	reference wetland		-	61	18	Yes	42	42	Yes	169	76	Yes	-	-	-	-	-	-	3 of 3
A	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	20	9	Yes	1 of 1
B	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	18	Yes	1 of 1
C	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	40	18	Yes	1 of 1

Gauges 1, 2, 4, 5, 6 are in Restoration Soil Unit 1; success criterion = 12.5 % of growing season (27 consecutive days)

Gauges 3, 9, A, B, C are in Restoration Soil Unit 2; success criteria = 5% of growing season (11 consecutive days)

Growing Season (Chapel Hill, NC)= March 28 to November 3 = 227 days.