Privateer Farms Restoration Site

Annual Monitoring Report for 2007 (Year 3)

November 2007

Prepared for:

NC Department of Transportation

Project Development and Environmental Analysis Branch

Office of Natural Environment

1598 Mail Service Center

Raleigh, NC 27699-1598

NC Ecosystem Enhancement Program

1652 Mail Service Center,

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EXECUTIVE SUMMARY

The Privateer Farms Stream Restoration site ("Site") was restored through a full-delivery contract with the North Carolina Department of Transportation (NCDOT). Administrative management of the project has been transferred to the North Carolina Ecosystem Enhancement Program (NCEEP). The goals and objectives of this project were as follows:

1. Restore riverine wetlands through stream restoration, filling of agricultural drainage ditches, restoration of a natural topography, and planting
2. Enhance riverine wetlands through stream restoration and supplemental planting
3. Increase stream length across Privateer Farms Restoration Project from 25,000 (LF) to approximately 34,005 LF through dimension, pattern and profile adjustments
4. Restore floodplain and other low-lying areas to their historic wetland ecosystem.

Construction of this project was completed in April 2005. Stability of the Site must be annually monitored and documented during a five-year period following construction completion. This report documents the monitoring data collected at the Site during the 2007 growing season (Year 3 of the 5-year monitoring period).

Table 1
Background Information.

Project Name	Privateer Farms
Designer's Name	Baker Engineering NY, Inc. 8000 Regency Parkway, Cary, NC, 27518 (919) 463-5488
Contractor's Name	River Works, Inc.
Project County	Bladen and Cumberland Counties
Directions to Project Site	From Raleigh, follow I-40 east to exit 328 (I- 95). Merge onto I-95 south and proceed to exit 49 (NC 53). Take NC 53 south approximately 12.4 miles to the site. Turn right into site at a blue sign labeled "Privateer Farms Road." From Elizabethtown, follow NC 53 north. Travel through the town of White Oak. From White Oak, travel approximately 5.0 miles to entrance of the farm. Turn left into the site at a blue sign labeled "Privateer Farms Road."
Drainage Area	6.0 mi^2 (End of Reach 5-end of the project)
USGS Hydro Unit	03030005
NCDWQ Sub-basin	03-06-15 and 03-06-16
Project Length	34,005 LF (Restoration)
Restoration Approach	34,005 LF of dimension, pattern, and profile
	402.5 acres of riverine wetland restoration
	25 acres of riverine wetland enhancement
Date of Completion	April 2005
Monitoring Dates	Monthly through each growing season for 5 years.

Table of Contents

Tables and Figures

Appendices (<u>Appendix materials are located on the enclosed CD</u>)

1.0 Background Information

The Privateer Farms Restoration Site is located in Bladen and Cumberland Counties, North Carolina, approximately fourteen miles southeast of Fayetteville (Figure 1). Land use for the Site over the past 20 years had been primarily row crop agriculture. Stream and riparian functions on the Site had been severely impacted as a result of agricultural conversion. Harrison Creek had historically meandered through the Site, but was channelized in the early 1980s to reduce flooding and provide a drainage outlet for the extensive network of ditches excavated across the Site. Subsequent to channelization, Harrison Creek existed as a large canal running straight through the Site.

Restoration activities for the Site involved moving the stream channel back to its historic location and elevation, and filling drainage ditches to raise the local water table and restore wetland and stream hydrology. The plan also included scarification of the fields and breaking of the local plow pan to increase surface water storage and provide a range of hydrologic conditions suitable for a variety of native wetland plant species. The restoration plan for the Site predicted the restoration of 405 acres of riverine wetlands, 25 acres of riverine wetland enhancement, and 33,985 linear feet (LF) of stream restoration. Following construction, the as-built data indicated that the total area of restored riverine wetlands was 402.5 acres (excluding 2.5 acres for road accesses), with 25 acres of enhanced riverine wetlands, and 34,005 LF of restored stream channel.

This Annual Monitoring Report presents data from 30 hydrologic monitoring stations and 15 vegetation monitoring stations placed throughout the Site, in addition to stream monitoring data, as required by the approved Restoration Plan.

1.1 Goals and Objectives

The goals and objectives of this project were as follows:

- Restore 402.5 acres of riverine wetlands
- Enhance 25 acres of riverine wetlands
- Increase stream length across the Site from 25,000 LF to approximately 34,005 LF through dimension, pattern and profile adjustments
- Restore Harrison Creek's floodplain and other low lying areas to their historic wetland ecosystem
- Monitor success of the restored and enhanced features during a five-year period following construction.

1.2 Project Location

The Site is located approximately fourteen miles southeast of Fayetteville in Bladen and Cumberland Counties. From Raleigh, follow Interstate I-40 east to exit 328 (I-95). Merge onto I-95 south and proceed to exit 49 (NC 53). Take NC 53 south approximately 12.4 miles to the entrance of the Site. Turn right into the Site at a blue road sign that reads "Privateer Farms Road."

From Elizabethtown, follow NC 53 north. Travel through the town of White Oak. From White Oak, travel approximately 5.0 miles to entrance of farm. Turn left at a blue road sign that reads "Privateer Farms Road."

1.3 Project Description

The goal of the project is to restore natural stream and wetland systems to the Site. The stream system that historically flowed through the Site was channelized and, as a result, was highly incised ("Gc" type stream – Rosgen classification) prior to restoration. The natural channel design for the restored stream involved the construction of a new, meandering channel across the agricultural fields. The furthest upstream portion of the project used sections of the remnant historic channel for Harrison Creek that were still visible within the

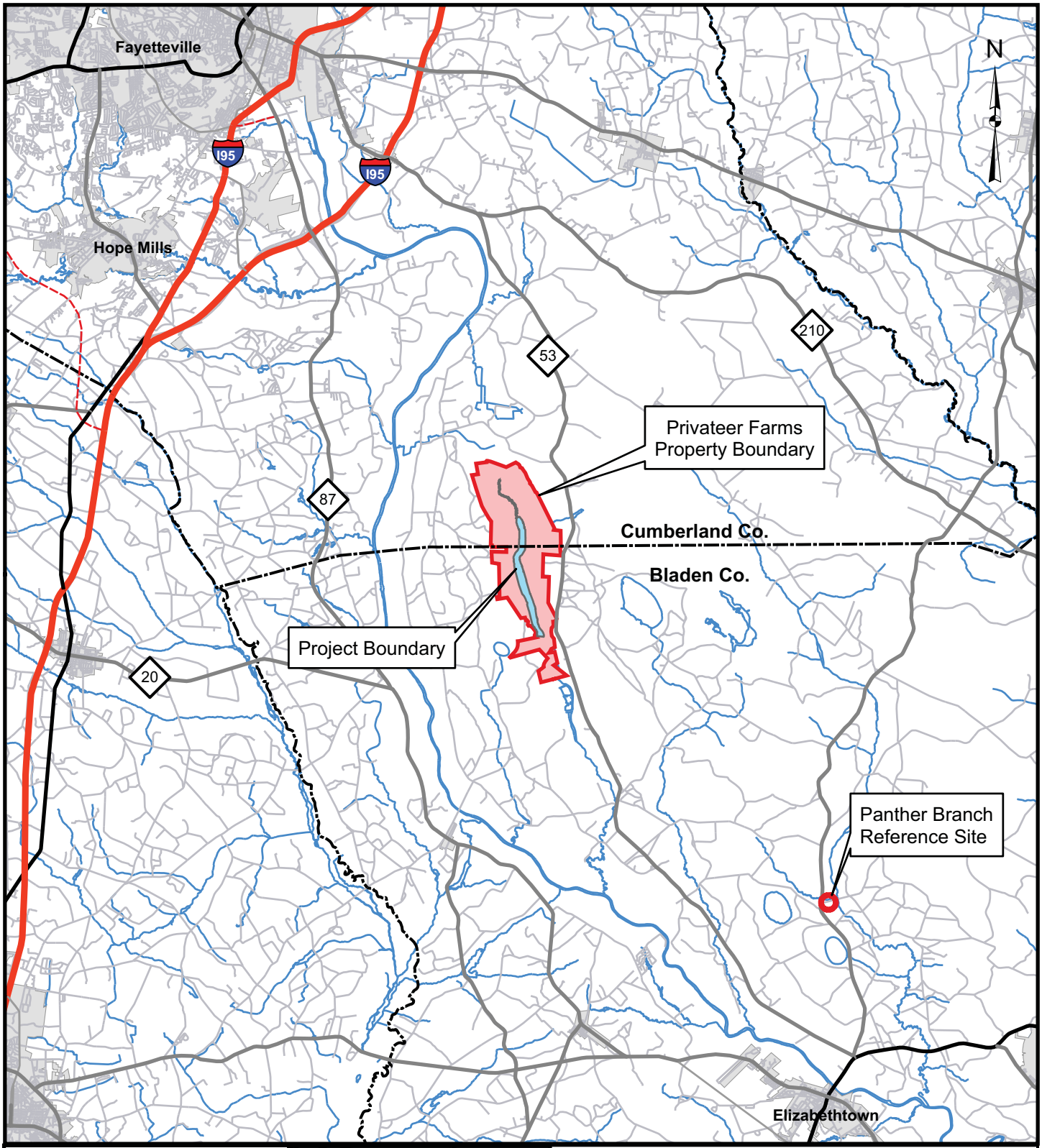
existing wetland areas. The remaining portion of the restored channel was constructed as a Rosgen "C" stream type with design dimensions based on historic reference parameters for Harrison Creek. These reference parameters were determined from historic aerial photographs, the topography of the valley, and local reference reach information. The total stream length across the Site was increased from approximately 25,000 LF to 34,005 LF.

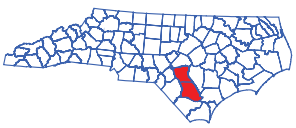
The channel design allows discharges greater than bankfull flows to spread onto the floodplain, dissipating flow energies and reducing stress on streambanks. In-stream structures were used to control streambed grade, reduce stress on streambanks, and promote bedform sequences and habitat diversity. The in-stream structures consisted of root-wads, log vanes, and log weirs that promote a diversity of habitat features in the restored channel. Where grade control was a consideration, constructed riffles were installed to provide long-term stability. Streambanks were stabilized using a combination of erosion control matting, bare-root planting, and transplants. Transplants provided immediate shading to the restored stream, as well as living root mass to increase streambank stability and create holding areas for fish and other aquatic biota.

While restoration of the stream channel followed the historic pattern of Harrison Creek, the restored stream would most appropriately be considered a tributary to Harrison Creek. Flow from the headwaters of Harrison Creek has been channelized around the perimeter of the farm. Due to elevation differences between the restored stream and the channelized stream around the perimeter of the farm, flow from the headwaters of Harrison Creek could not be diverted back into the restoration channel without causing significant hydrologic trespass issues beyond the property boundary of Privateer Farms. The restored channel functions as a headwater tributary to Harrison Creek. It has a drainage area of approximately one square mile at the upper limits of the project, increasing to six square miles at the downstream end of the project (Figure 2).

Due to the extensive length of stream restoration and changes in drainage area from the beginning to the end of the Site, the project was divided into five stream reaches. Design ratios were the same for each design reach and were based on reference reach information; however, the size of each restored channel reach increased from upstream to downstream to reflect the increasing drainage area.

The large road that ran from north to south through the middle of the project area was graded to floodplain level to allow spreading of flood flows over the restored floodplain. The excavated road material was used to fill the road-side canals. The two roads that crossed the project area from east to west were left in place to allow access across the Site to other parts of the farm.





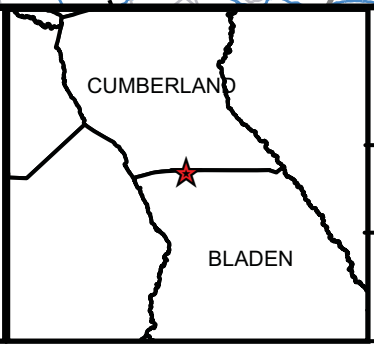


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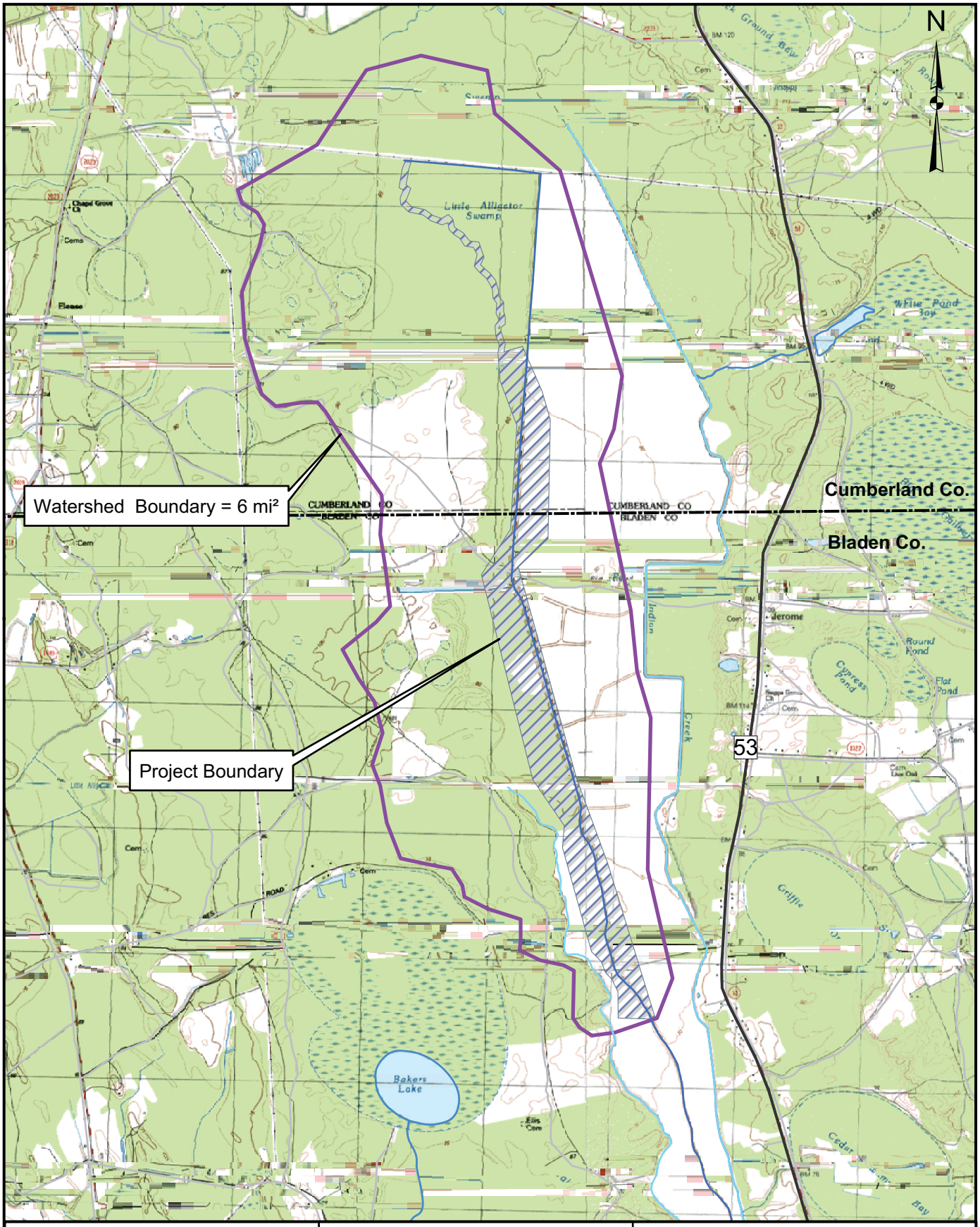
Figure 1. Project Vicinity Map

0 2 4 8 Miles



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0 2,000 4,000 Feet

Figure 2. Watershed Map

2.0 Monitoring Results – 2007 (Year 3) Data

The five-year monitoring plan for the Site includes criteria to evaluate the success of the wetland hydrology, vegetation components of the project, and stream components of the project. The specific locations of vegetation plots, monitoring wells, permanent cross-sections, crest gauges, and a rainfall gauge are shown on the as-built drawing sheets in Figures 3a through 3d. Photo points are located at each of the monitoring wells, and at each of the grade control structures along the restored stream channel. Site photographs are included in Appendix 1.

2.1 Vegetation

Bare root trees were planted within all areas of the conservation easement. A minimum 50-foot buffer was established along all restored stream reaches. In most areas, the final buffer area was more than several hundred feet wide and included restored wetland areas. In general, bare-root vegetation was planted at a target density of 680 stems per acre, or an 8-foot by 8-foot grid. Planting of bare-root trees was conducted during the dormant season, with all trees installed prior to March 20, 2005.

Observations were made during construction of the Site regarding the relative wetness of areas to be planted. Planting zones were determined based on these assessments, and planted species were matched according to their wetness tolerance and the anticipated wetness of the planting area. Species planted are summarized in Table 2.

Table 2
Bare-root Tree Species Planted Across the Restoration Site.

Common Name	Scientific Name	Percent Planted by Species	Total Number of Stems	Wetness Tolerance [1]
Willow oak	*Quercus phellos*	8.6%	23,300	weak – moderate
Swamp chestnut	*Quercus michauxii*	8.6%	23,300	weak
Laurel oak	*Quercus laurifolia*	6.0%	16,200	moderate – weak
Overcup oak	*Quercus lyrata*	6.3%	17,000	moderate
Swamp tupelo	*Nyssa biflora*	7.9%	21,300	tolerant
Water tupelo	*Nyssa aquatica*	8.2%	22,000	tolerant
Bald cypress	*Taxodium distichum*	11.6%	31,200	tolerant
Water oak	*Quercus nigra*	8.6%	23,300	weak – moderate
Sycamore	*Platanus occidentalis*	10.8%	29,200	moderate
Green ash	*Fraxinus pennsylvanica*	10.8%	29,200	moderate
Shumard oak	*Quercus shumardii*	6.5%	17,500	weak
Cherrybark oak	*Quercus pagoda*	5.9%	15,900	weak –intolerant

Notes:
1. Based on information from US Army Corps of Engineers (USACE) Wetland Research Program (WRP) Technical Note VN-RS-4.1 (1997).

PROJECT: 0157 PRIVATEER FARMS

STATE	PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	0157	1	34

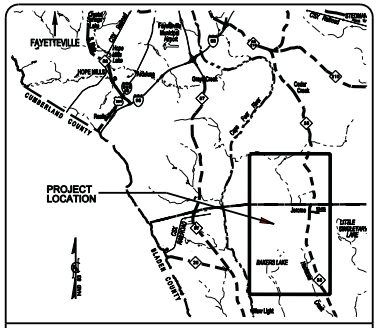
STATE PROJ. NO.	F. A. PROJ. NO.	DESCRIPTION

AS–BUILT

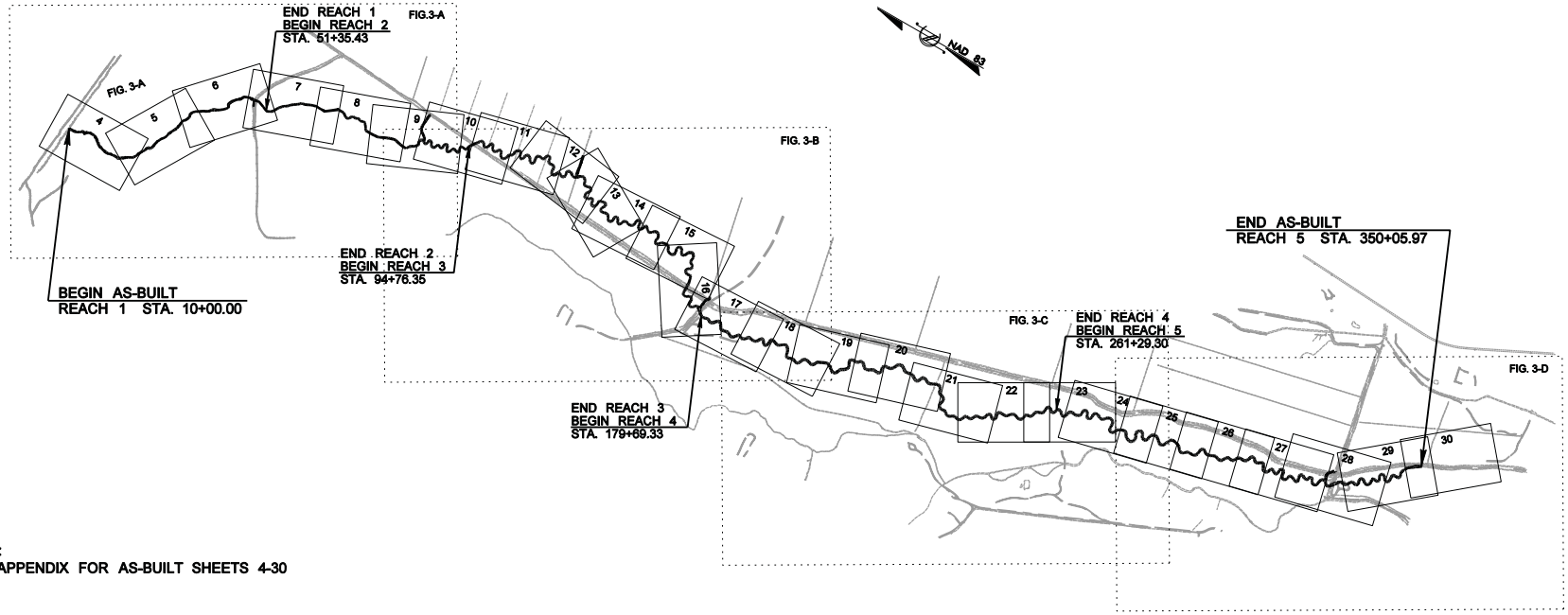
BLADEN /CUMBERLAND COUNTY

LOCATION: *OFF NC 53 NEAR JEROME*
SOUTHEAST OF FAYETTEVILLE

TYPE OF WORK: *WETLAND AND STREAM RESTORATION*



VICINITY MAP



NOTE:
SEE APPENDIX FOR AS-BUILT SHEETS 4-30

GRAPHIC SCALES

50 25 0 50 100
PLANS

50 25 0 50 100
PROFILE (HORIZONTAL)

5 0 5 10
PROFILE (VERTICAL)

PROJECT SUMMARY

PROPOSED DESIGN REACH 1 LENGTH	=	4,135.43 FEET
PROPOSED DESIGN REACH 2 LENGTH	=	4,340.92 FEET
PROPOSED DESIGN REACH 3 LENGTH	=	8,492.98 FEET
PROPOSED DESIGN REACH 4 LENGTH	=	8,159.97 FEET
PROPOSED DESIGN REACH 5 LENGTH	=	8,855.70 FEET
TOTAL DESIGN LENGTH	=	33,985.00 FEET
TOTAL AS–BUILT LENGTH	=	34,005.97 FEET
PROPOSED RESTORED WETLAND AREA	=	402.5 ACRES
PROPOSED ENHANCED WETLAND AREA	=	25 ACRES

PREPARED FOR THE OFFICE OF:

NORTH CAROLINA
ECOSYSTEM ENHANCEMENT PROGRAM

1652 MAIL SERVICE CENTER
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CONTACT:

KRISTIN MIGUEZ
PROJECT MANAGER

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JULY 2004
CONSTRUCTION BEGAN:

MARCH 2005
END OF CONSTRUCTION:

KEVIN L. TWEEDY, PE
PROJECT ENGINEER

PROJECT ENGINEER

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KEVIN L. TWEEDY
027337
JUNE 27, 2005

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P.E.
SIGNATURE:

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

PROJECT REFERENCE NO.	SHEET NO.
0157	31

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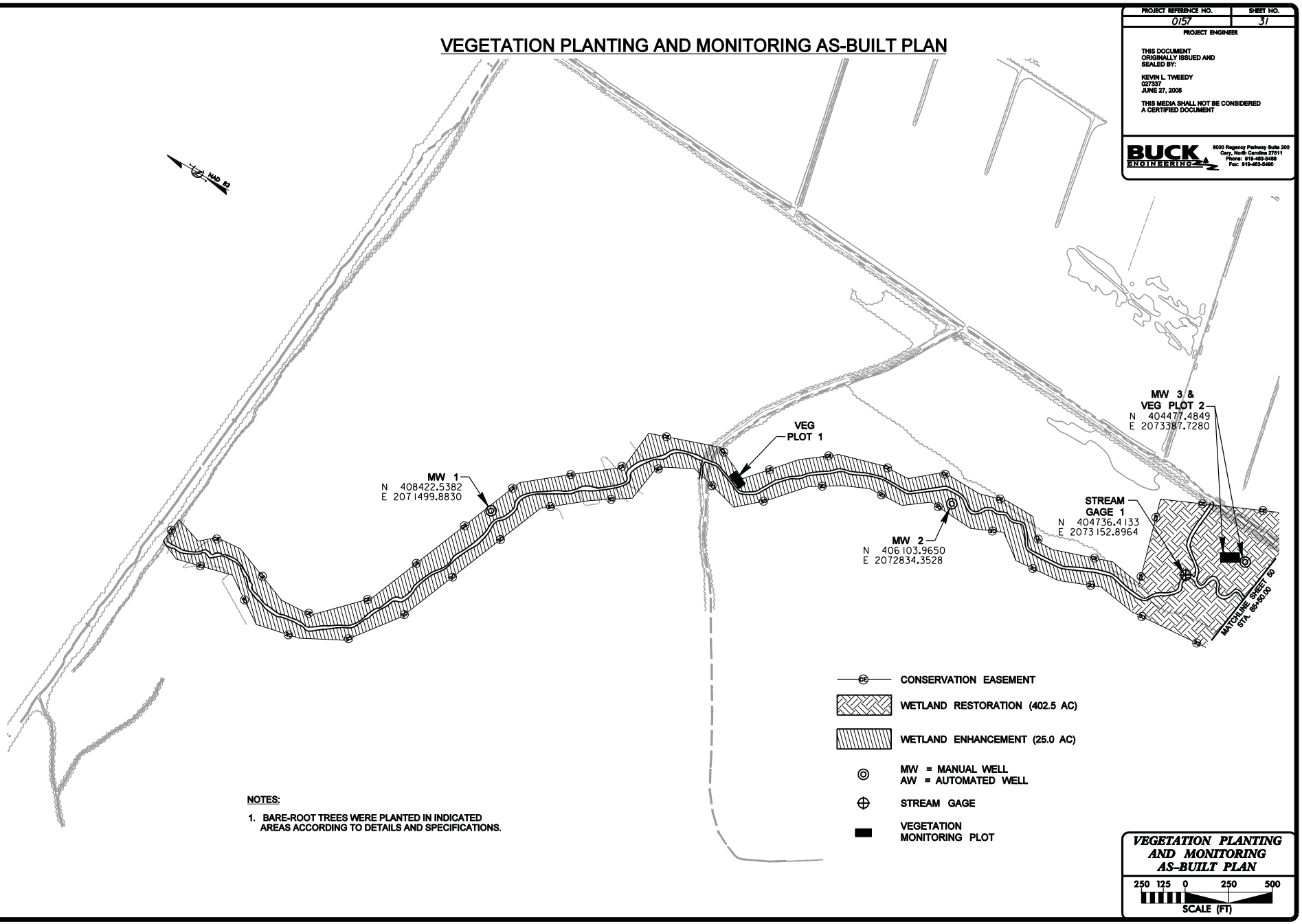

NOTES:

1. BARE-ROOT TREES WERE PLANTED IN INDICATED AREAS ACCORDING TO DETAILS AND SPECIFICATIONS.

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

2/26/03
11/10/2005
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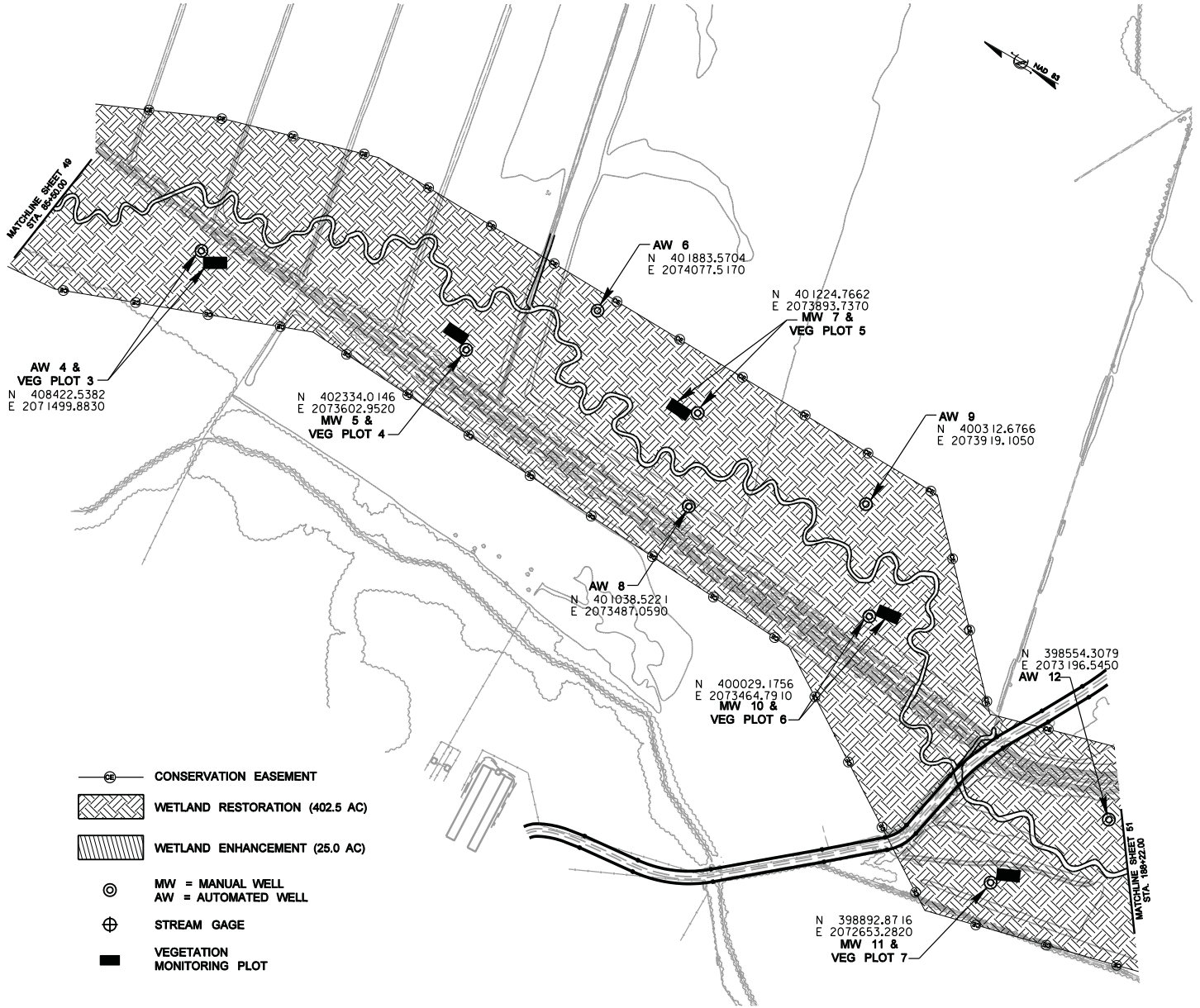
VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



PROJECT REFERENCE NO.	SHEET NO.
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VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

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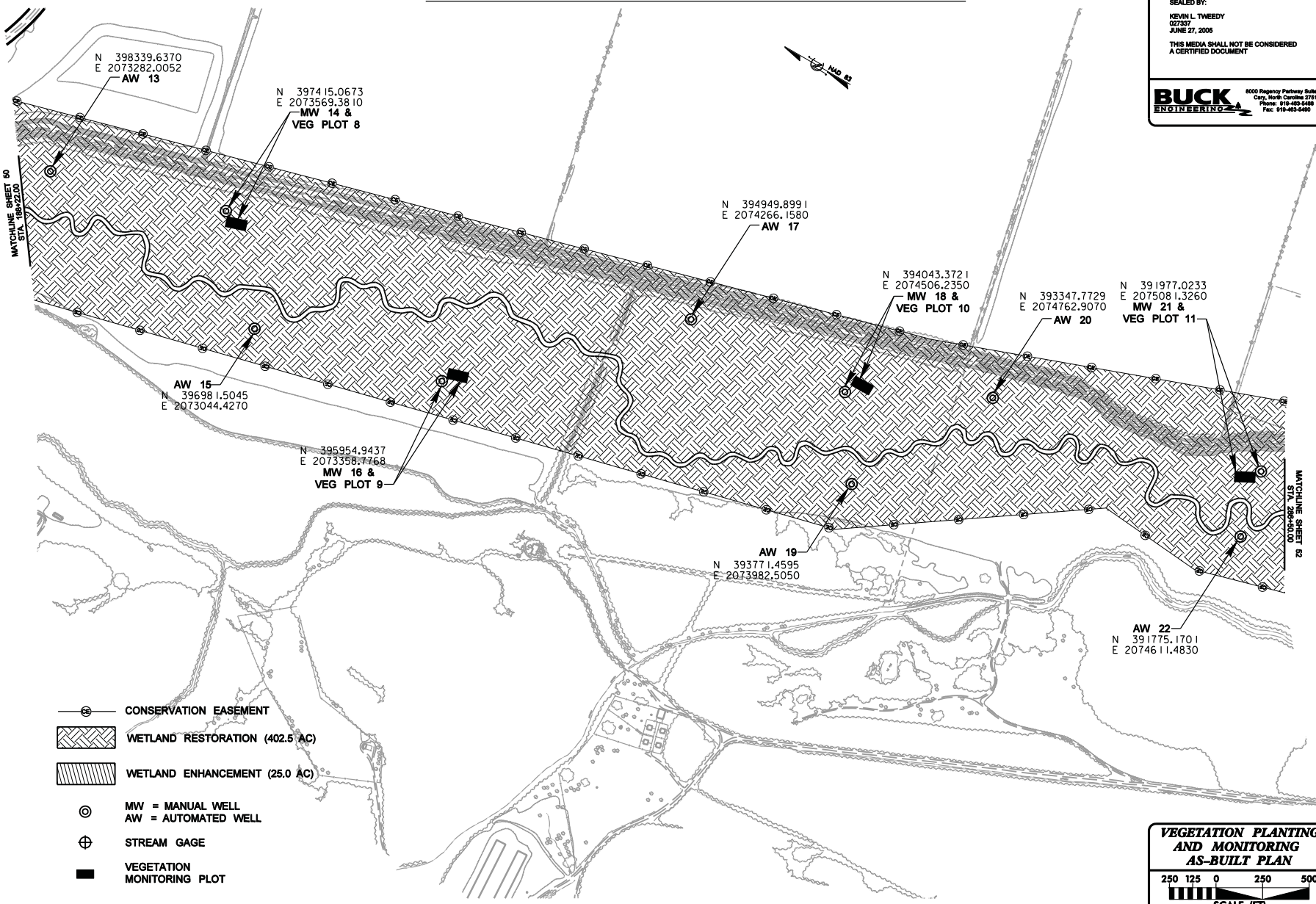
VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



PROJECT REFERENCE NO.	SHEET NO.
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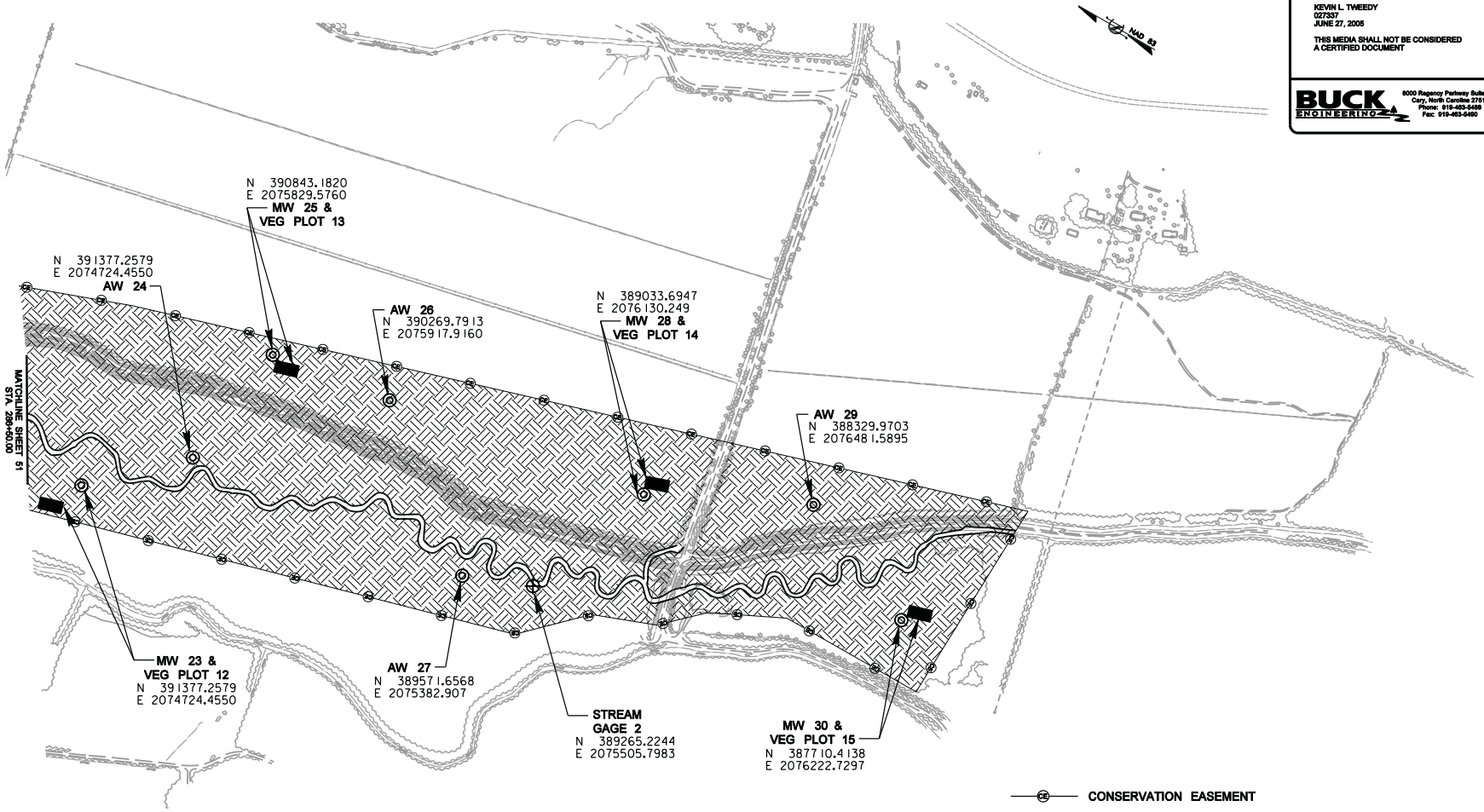
SCALE (FT)

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



CONSERVATION EASEMENT

WETLAND RESTORATION (402.5 AC)

WETLAND ENHANCEMENT (25.0 AC)

MW = MANUAL WELL
AW = AUTOMATED WELL

STREAM GAGE

VEGETATION
MONITORING PLOT

PROJECT REFERENCE NO.	SHEET NO.
0157	34

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VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

250 125 0 250 500
SCALE (FT)

2/26/03

11/10/2005
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The restoration plan for the Site specified that 15 vegetation plots, each 25 feet by 100 feet in size would be established across the restoration area. The initial planted density within each of the vegetation monitoring plots is given in Table 3. The average initial density of planted bare root stems, based on the data from the 15 monitoring plots, was 670 stems/ acre. The data from the end of the third growing season are presented in Table 3. The locations of the vegetation plots are shown in Figure 3a-3d.

Table 3
Density of Trees for the 15 Vegetation Sampling Plots.

Sampling Plot No.	Counted Stems per Plot			Stems per Acre (extrapolated)		
	Initial	Year 2	Year 3	Initial	Year 2	Year 3
1	38	33	30	662	575	523
2	40	38	36	697	662	627
3	39	37	31	680	645	540
4	33	31	32	575	540	558
5	42	42	39	732	732	680
6	37	33	32	645	575	558
7	43	40	36	749	697	627
8	31	31	26	540	540	453
9	35	27	26	610	470	453
10	35	30	30	610	523	523
11	39	18	19	680	314	331
12	36	29	27	627	505	470
13	35	16	16	610	279	279
14	49	16	16	854	279	279
15	45	37	33	784	645	575

2.1.1 Results and Discussion

Fifteen monitoring plots, each 0.057 acre in size, were used to predict survivability of the woody vegetation planted on-site. The vegetation monitoring for 2007 (Year 3) indicated an average survivability of 498 stems per acre, which is on a trajectory to achieve an average vegetation survival criteria of 320 stems per acre surviving after the fifth growing season.

2.1.2 Areas of Concern

Three monitoring plots had lower than expected survivability rates for Year 3. The survivability rates for Plots 11, 13, and 14 ranged from 33 to 49 percent and densities ranging from 279 to 331. The count for Plot 11 during Year 3 was one tree higher than the count for Year 2. This extra tree was most likely recorded as dead during Year 2 but was actually green at the base and re-sprouted during Year 3 growing season. The prevalence of volunteer species was also assessed to determine if natural recolonization is compensating for lower planted stem densities. Volunteer species were noted in Plots 8 and 14. Both of these plots demonstrated the presence of numerous *Acer rubrum* (red maple) saplings that were 3 inches to 1 foot in height. Plot 14 also showed *Liquidambar styraciflua* (sweet

gum) saplings growing within the plot boundary. These saplings were not counted during the Year 3 monitoring event.

The three vegetation plots that displayed lower than expected survivability (Plots 11, 13, and 14) will be monitored closely during the 2008 (Year 4) growing season. These three plots also displayed low survivability numbers for 2006 (Year 2), but showed no further decrease in survivability between Year 2 and Year 3. Therefore, it is possible that the plots will maintain their current numbers of surviving trees through the completion of the monitoring period.

2.2 Morphology

Drainage area strongly influences channel morphology. Watershed areas for the reconstructed channel increase from 1.0 square mile at the beginning of the project to 6.0 square miles at its downstream end (southern limit of the Site). The project was divided into five stream reaches, and the size of each restored channel reach was increased from upstream to downstream to reflect the increasing drainage area. Design ratios were kept the same for each design reach and were based on reference reach information.

Year 3 monitoring for stream stability included, the longitudinal profile, data on 67 permanent cross-sections, and data from two streamflow gauges. Data collection for the longitudinal profile was completed in May 2007 and cross-section data collection was completed in August 2007. The stream gauges are located on-site: one near the upstream limit of the project (stream gauge # 1) and one near the downstream limit of the project (stream gauge # 2). The locations of the gauges are shown in Figures 3a though 3d.

Permanent cross-sections are used to monitor channel dimension and bank erosion over time. Two permanent cross-sections were established per 1,000 LF of restored stream, with equal proportion of sections across riffles and pools. Each cross-section was marked on both banks with permanent pins that were surveyed relative to a common benchmark. This ensures use of the same transects through the entire monitoring period, facilitating easy comparison of year-to-year data. A complete longitudinal survey was completed in 2005 for the restored stream channel to provide a base-line for evaluating changes in bed conditions over time. A complete longitudinal survey was performed the Year 3 growing season.

The annual cross-section surveys include points measured at all breaks in slope, including top of bank, bankfull, inner berm, edge of water, and thalweg. The longitudinal profile includes the elevations of all grade control structures. The permanent cross-section and longitudinal profile data are provided in Appendices 2 and 3.

The stream gauges were installed on site to document continuous water level in the restored channel and record the occurrence of bankfull events. The gauges automatically record water depth every six hours, and have a continuous period of record extending from end of construction to present. The gauges are inspected and their water level data is retrieved every month.

Photographs were taken to visually document restoration success during Year 3 of monitoring. Each reference photograph station was marked with wooden stakes and bench-marked using a Global Positioning System (GPS). Reference photos of both streambanks were taken at each permanent cross-section. On each streambank photograph, the survey tape is centered and the water line is located along the lower edge of the frame, showing as much of the bank as possible.

2.2.1 Morphology Success Criteria

The stream restoration success criteria for the site include the following:

- *Cross-sections*: There should be little change in as-built cross-sections. Cross-sections shall be classified using the Rosgen stream classification method and all monitored cross-sections should fall within the quantitative parameters defined for “C” type channels.

- *Longitudinal Profiles*: The longitudinal profiles should show that the bedform features are remaining stable, e.g. they are not aggrading or degrading. Bedforms observed should be consistent with those observed in "C" type channels.
- *Photo Reference Stations*: 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 of excessive increases in channel depth.

2.2.2 Results and Discussion

On site streamflow gauges documented the occurrence of at least one bankfull flow event during Year 3 monitoring. The largest stream flow documented by the on site crest gauge occurred during the beginning of the month in February and was approximately 10 inches above the bankfull stage at stream gauge #2. During this event, stream gauge #2 registered a continuous out-of-bank flow for the lower end of the Site for a period of 11 days, from February 1 to February 11, 2007. For this same event, stream gauge #1 registered a continuous out-of-bank flow for the upper end of the Site for a period of 2 days, from February 2 to February 3, 2007.

Visual evidence of the out-of-bank flows observed during a subsequent site visit helped confirm the bankfull flow gauge readings. Based on observations of ponded water, debris lines, and deposited sediment on the floodplain, this bankfull event spread over a substantial portion of the restored wetland areas adjacent to the stream.

Due to electronic failure of stream gauge #2 in March 2007, the gauge was removed from the Site in April 2007. Prior to removal, stream gauge #2 had documented enough data to meet the success criteria of two bankfull events within the five year monitoring period. Stream gauge #1 is still in operation on the upper end of the Site and is functioning properly.

Cross-section data collected for Year 3 indicate very little adjustment in channel dimension has occurred since restoration of the stream channel, with all monitored cross-sections maintaining their design parameters within acceptable ranges. Some cross-sections indicate that minor bed scour features observed during Year 2 have filled back to as-built conditions during Year 3 (for example: Cross-sections 6, 7, 9, 16 and 22). Several pool cross-sections are beginning to show the formation of point bar features (Cross-sections 20, 32, 42, 44, 54). There are no cross-sections that indicate that presence of bank erosion, and no areas of bank erosion have been observed on the site during Year 3.

The longitudinal profile data for Year 3 indicate that minor adjustments in bed elevation are occurring along the design reaches, but changes are on the order of several tenths of a foot in most locations. This is attributed to the dense growth of vegetation along the channel toes that restricts flows near the center of the channel. This restriction under low flow conditions concentrates flows and provides for some scouring of the thalweg in certain reaches. However, this scouring is considered a normal bed adjustment process and has not been observed to cause channel instability. Log weir grade control structures were installed along all restored stream reaches for this purpose, and the longitudinal profile data indicate that these structures are maintaining grade.

In-stream structures installed within the restored stream included constructed riffles, log vanes, log weirs, and root wads. Visual observations of structures throughout the past growing season have indicated that the structures are functioning as designed.

Photographs were taken in October of the Year 3 growing season to document the evolution of the restored stream channel (see Appendix 1). Restored pools have maintained a variety of depths and habitat qualities, depending on the location and type of scour features (logs, root wads, etc.). Permanent vegetation seeded on the restored stream banks was noted.

2.2.3 Areas of Concern

No areas of concern have been identified for the restored stream channel segments.

2.3 Hydrology

The restoration plan for the Site specified that 30 monitoring wells (15 automated and 15 manual) would be established across the restored area. Thirty wells (15 automated and 15 manual) were installed initially during March 2005 to document water table hydrology in all required monitoring locations throughout the Site. The locations of the monitoring wells are shown on the as-built plan sheets in Figures 3a through 3d.

The reference wetland site identified for this project and described in the Monitoring Plan is also being monitored. Three automated monitoring wells were installed at the reference site during April 2005 to document variation in water table depth across the reference site. Data from these wells provide a base of comparison for water table hydrology between the Site and the established wetland areas.

Monthly photographs were taken during the Year 3 growing season to document vegetation growth throughout the restored wetland areas (see Appendix 1). The monitoring well locations will serve as the reference points from which photographs of vegetation growth will be taken over time.

As per the approved Privateer Farms Monitoring Plan, historic rainfall for Cumberland County was used to determine average rainfall and growing season dates for the Site. The automated weather station William O. Huske L&D (UCAN: 14405, COOP: 319427) in Bladen County, located within five miles of the Site, was used to determine rainfall over the Site during the 2007 growing season. Missing data are supplemented with data from the next closest weather station, Elizabethtown Lock 2 gauge (UCAN: 14082, COOP: 312732) in Bladen County.

For Year 3 monitoring, the automated weather station William O. Huske L&D (UCAN: 14405, COOP: 319427) measured total rainfall between March and September 2007 as 15.03 inches. A manual rainfall gauge on the Site was used to validate observations made at the automated weather station. Data collected on-site correlated well with the data from the weather stations. On-site rain gauge data measured total rainfall between March and September 2007 as 15.42 inches. There was a difference of 0.39 inches between the data collected on site and observations made at the automated weather stations for the Year 3 growing season.

2.3.1 Success Criteria

Successful restoration of wetland hydrology is defined in the project's Restoration Plan as achieving continuous inundation of the site or continuous saturation of its soil within 12 inches of soil surface for a minimum of 12.5 percent of the growing season, or 30 consecutive days. The day counts are based on the growing season for Cumberland County, which is 242 days long, beginning on March 18 and ending November 15, as calculated from National Weather Service Wetlands Determination Tables (WETS) for Cumberland County. Data on inundation height or depth of soil saturation line were obtained from the 15 automated monitoring wells and 15 manual monitoring wells in place throughout the site. Data defining successful hydrologic conditions must demonstrate that wetland conditions are present in normal or dryer than normal conditions.

If rainfall data for any given year during the monitoring period are not normal, and if the desired hydrology for the project site is not on a trajectory to achieve success, then data from the pre-defined reference wetland site for this project can be assessed to determine if there is a positive correlation between the underperformance of the restoration site and the natural hydrology of the reference site.

If the restored site is inundated or saturated within 12 inches of the soil surface for less than 12.5 percent of the growing season, but the post-restoration monitoring data reflect that the site meets applicable USACE criteria for wetlands and the site is performing with similar hydrology as the

monitored reference site, then the regulatory agencies may consider the site for mitigation of in-kind impacts on a case-by-case basis.

2.3.2 Results and Discussion

The total monthly rainfall for the 2007 growing season was below the approximated long-term average for the area. According to the automated weather station William O. Huske L&D, all months of the 2007 growing season experienced below average rainfall with the exception of April, which experienced normal conditions. For much of 2007, North Carolina was considered to be in severe drought conditions.

According to the automated weather station William O. Huske L&D, total rainfall for the 2007 growing season was more than 15 inches below the long-term average for total growing season rainfall. Year 3 may be considered an extremely dry year since the total monthly rainfall was half of the long-term average for the growing season. Table 4 and Figure 4 compare historic and average rainfall over the area with those observed during the 2007 growing season.

Data collected during Year 3 from the fifteen automatic monitoring well gauges at the Site showed that groundwater levels met hydrologic success criteria for only five of the gauges. The ten automatic gauges that did not meet the success criteria exhibited a continuous hydroperiod from 3.1 percent to 9.1 percent. However, the gauges did exhibit a cumulative hydroperiod from 10 to 58 days or 3.9 percent to 24.0 percent of the Year 3 growing season, indicating that the locations experience significant wetness, but the water table fluctuated rapidly, therefore, surface saturated conditions during the 2007 growing season were not present for long periods of time. Data collected from on-site gauges are presented in Appendix 4. The hydrologic monitoring results for the gauges are shown in Table 5.

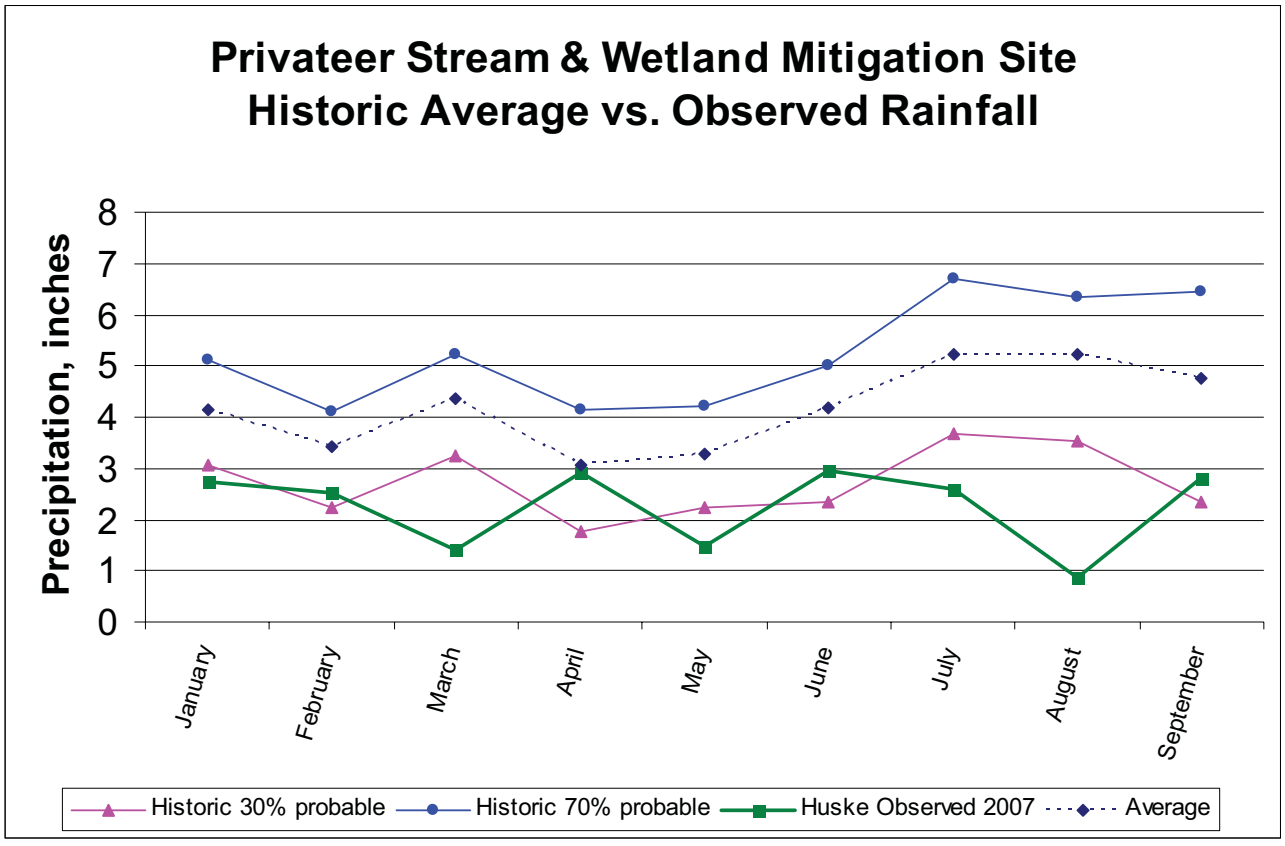
The three wells located in the reference site also indicated drier than normal conditions for 2007. The three automatic gauges exhibited a continuous hydroperiod from 2.5 to 16.5 days or 1 percent to 6.8 percent. The gauges exhibited a cumulative hydroperiod from 3 to 31 days or 1.0 percent to 12.8 percent of the Year 3 growing season. The REF3 gauge documented similar hydrologic conditions to areas of the Site, with a continuous hydroperiod of approximately 6.8 percent. The other two reference wells documented drier conditions, and it is suspected that these locations are experiencing a significant drainage effect from the nearby stream channel, especially during the drought conditions of 2007.

During Year 3 of the monitoring period AW6 and AW24 dataloggers were replaced due to communication errors. Also during Year 3, monitoring wells MW25, AW24, AW20, AW19, AW13 and AW8 were either damaged or destroyed. The site visits at these gauge locations showed signs of bear activity around the wells such as, bite marks on PVC and bent support posts. The gauges were all located at the downstream portion of the Site and were out of public view in thick vegetation. Due to these reasons, bear activity is attributed to the gauge destruction. All dataloggers or well casings have been either replaced or repaired and the aforementioned wells are now fully operational and collecting data at the time of this report preparation.

Table 4
Comparison of Historic Average Rainfall to Observed Rainfall (Inches).

Month	Average	30%	70%	Huske Observed 2007 Precipitation
January	4.16	3.06	5.13	2.75
February	3.43	2.22	4.11	2.54
March	4.37	3.24	5.22	1.42
April	3.06	1.77	4.13	2.91
May	3.29	2.25	4.2	1.46
June	4.18	2.36	5.02	2.95
July	5.21	3.69	6.7	2.61
August	5.21	3.54	6.36	0.88
September	4.77	2.36	6.46	2.8
October	3.15	1.73	3.76	N/A
November	2.88	1.75	3.76	N/A
December	3.24	2.3	3.81	N/A

Figure 4. Comparison of Observed Rainfall and Historic Average Rainfall.



Monitoring well data are shown in Figures 5 through 11 and in Appendix 4. A separate graph is presented for monitoring wells in each of the five reaches that comprise the project, except for data from Reach 1 which are included with Reach 2 data. Wherever there were more than 5 monitoring wells in a single reach, data for that reach are presented in two separate graphs: one for the upstream half of the reach and another for the downstream half of the same reach. Reference site well data are presented in Figure 12.

Table 5
Hydrologic Monitoring Results for 2007 (Year 3).

Monitoring Station	Most Consecutive Days Meeting Criteria[1]	Cumulative Days Meeting Criteria[2]	Number of Instances Meeting Criteria[3]
MW1[4]	48.5 (20.0%)	85 (34.9%)	2
MW2[5]	73.5 (30.4%)	128 (52.9%)	4
MW3[5]	73.5 (30.4%)	128 (52.9%)	4
AW4	73.5 (30.4%)	128 (52.9%)	4
MW5[5]	73.5 (30.4%)	128 (52.9%)	4
AW6	48.5 (20.0%)	85 (34.9%)	10
MW7[6]	48.5 (20.0%)	87 (36.0%)	8
AW8	138.5 (57.2%)	153 (63%)	4
AW9	48.5 (20.0%)	87 (36.0%)	8
MW10[6]	48.5 (20.0%)	87 (36.0%)	8
MW11[7]	47.5 (19.6%)	76 (31.2%)	8
AW12	47.5 (19.6%)	76 (31.2%)	8
AW13	21 (8.7%)	58 (24%)	9
MW14[9]	21 (8.7%)	58 (24%)	3
AW15	14 (5.8%)	40 (16.5%)	7
MW16[8]	14 (5.8%)	40 (16.5%)	7
AW17	9.5 (3.9%)	17 (7.0%)	4
MW18[10]	8.5 (3.5%)	13 (5.2%)	4
AW19	8.5 (3.5%)	13 (5.2%)	4
AW20	16.5 (6.8%)	32 (13.2%)	4
MW21[10]	8.5 (3.5%)	13 (5.2%)	4
AW22	15 (6.2%)	39 (16.1%)	9
MW23[10]	8.5 (3.5%)	13 (5.2%)	4
AW24	14.5 (6.0%)	35 (14.5%)	7
MW25[10]	8.5 (3.5%)	13 (5.2%)	4
AW26	7.5 (3.1%)	10 (3.9%)	2
AW27	7.5 (3.1%)	11 (4.3%)	3
MW28[10]	8.5 (3.5%)	13 (5.2%)	4

AW29	22 (9.1%)	55 (22.5%)	7
MW30[11]	22 (9.1%)	55 (22.5%)	7
REF1	2.5 (1.0%)	3 (1.0%)	1
REF2	3.5 (1.4%)	4 (1.4%)	1
REF3	16.5 (6.8%)	31 (12.8%)	2

[1] Indicates the most consecutive number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[2] Indicates the cumulative number of days within the monitored growing season with a water table less than 12 inches from the soil surface.

[3] Indicates the number of instances within the monitored growing season when the water table rose to less than 12 inches from the soil surface.

[4] Groundwater gauge MW1 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW6.

[5] Groundwater gauges MW2, MW3, and MW5 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW4.

[6] Groundwater gauges MW7 and MW10 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW9.

[7] Groundwater gauge MW11 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW12.

[8] Groundwater gauge MW16 is a manual gauges. Hydrologic parameters are estimated based on data from gauge AW15.

[9] Groundwater gauge MW14 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW13.

[10] Groundwater gauges MW18, MW21, MW23, MW25, and MW28 are manual gauges. Hydrologic parameters are estimated based on data from gauge AW19.

[11] Groundwater gauge MW30 is a manual gauge. Hydrologic parameters are estimated based on data from gauge AW29.

Figure 5. Well Data for Reach 1 and Reach 2 of the Privateer Restoration Project.

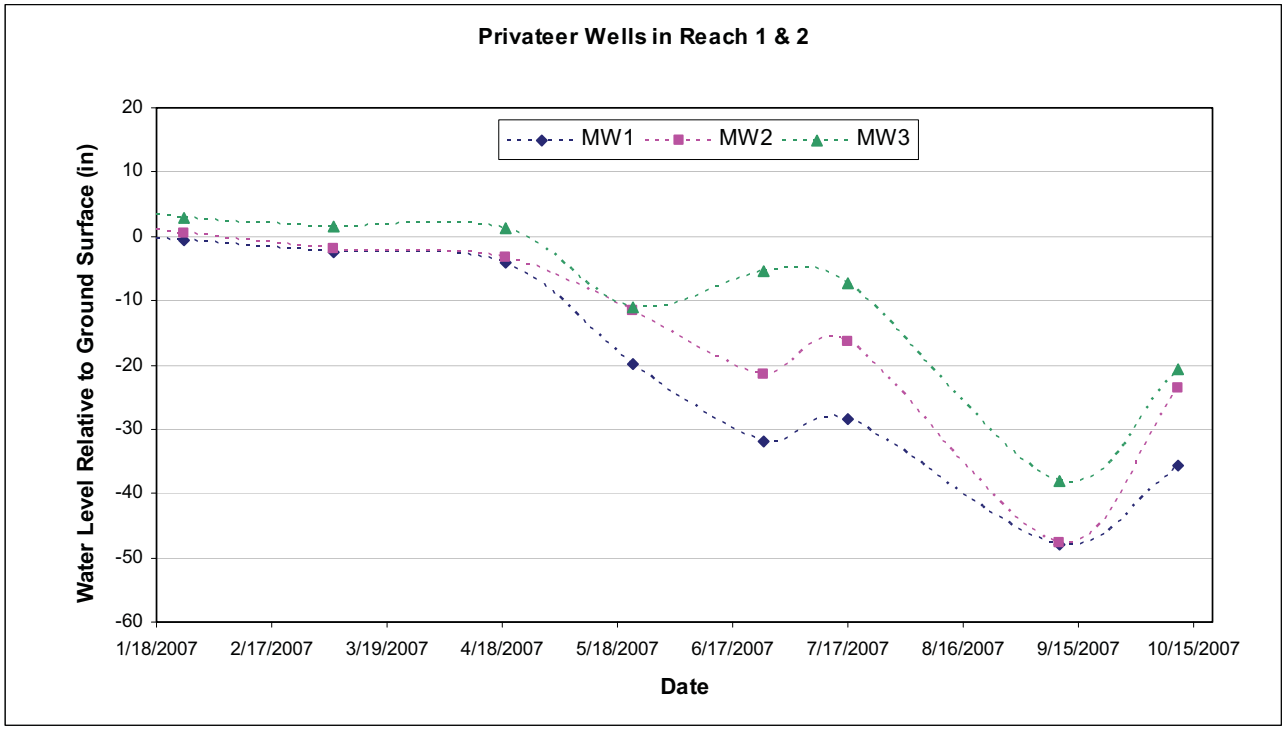


Figure 6. Well Data for Upstream Half of Reach 3 of the Privateer Restoration Project.

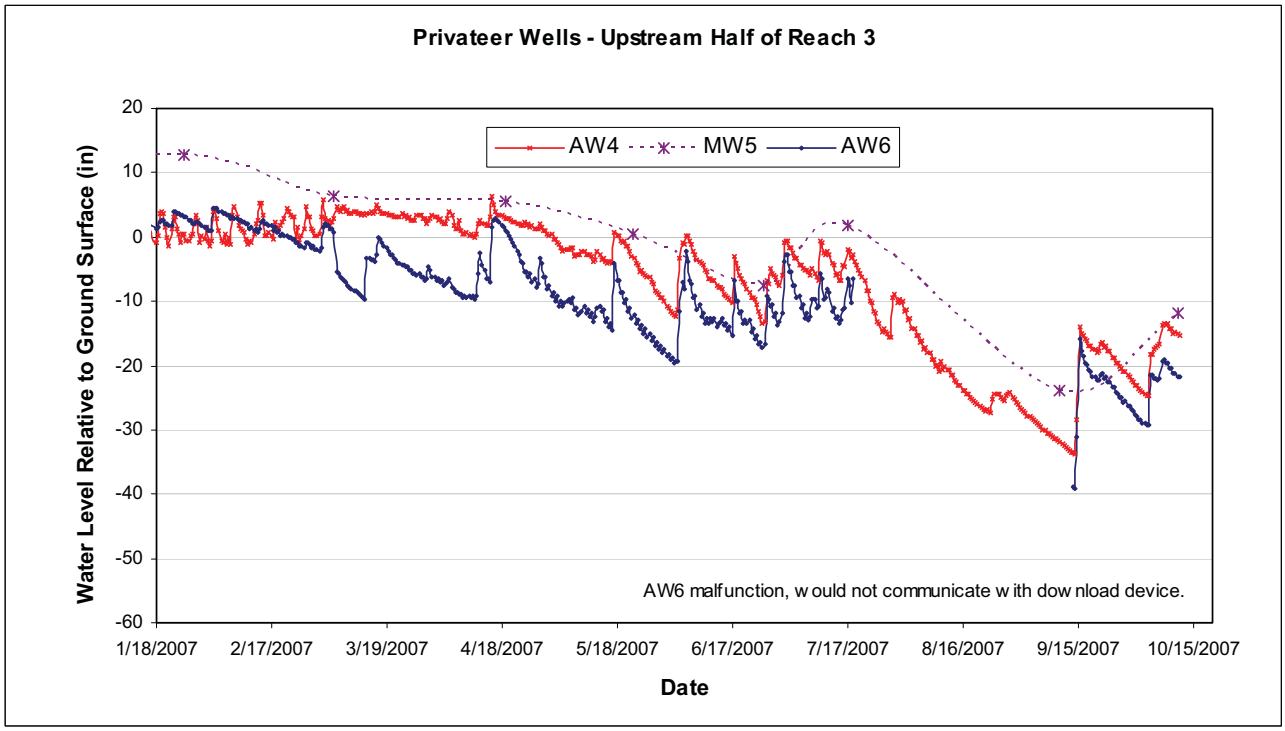


Figure 7. Well Data for Downstream Half of Reach 3 of the Privateer Restoration Project.

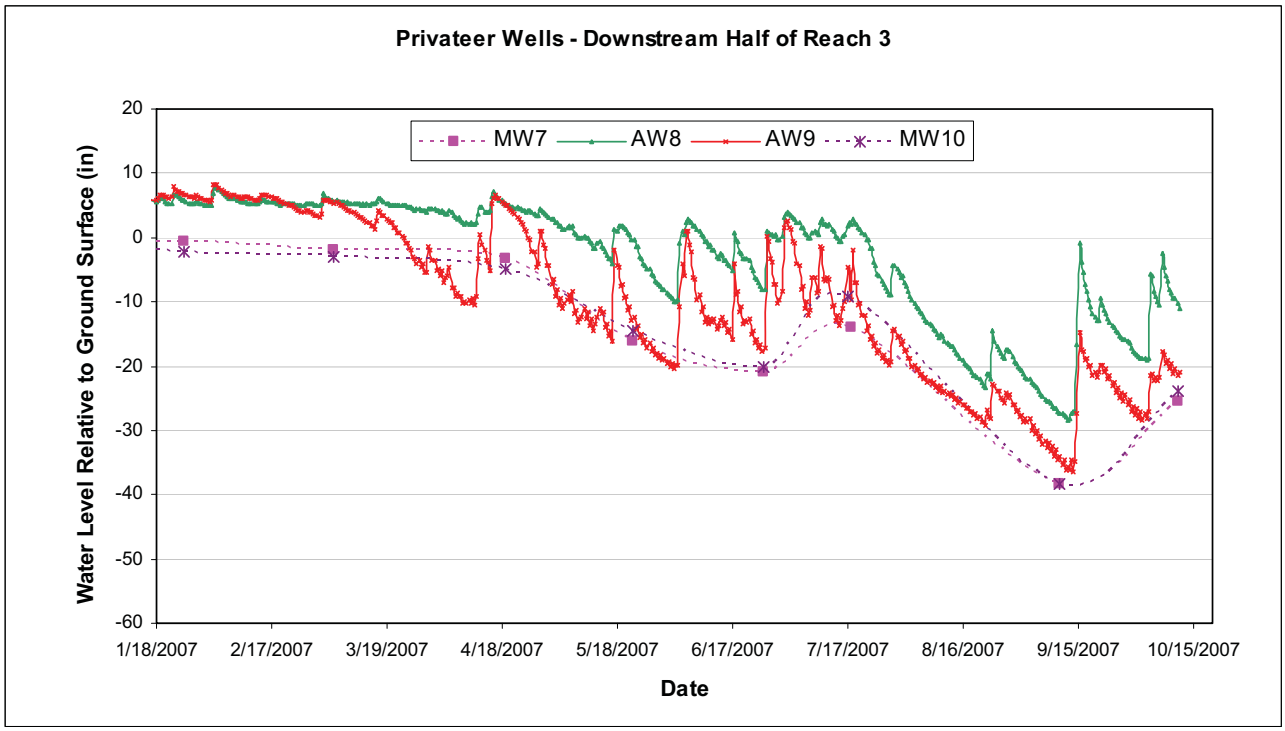


Figure 8. Well Data for Upstream Half of Reach 4 of the Privateer Restoration Project.

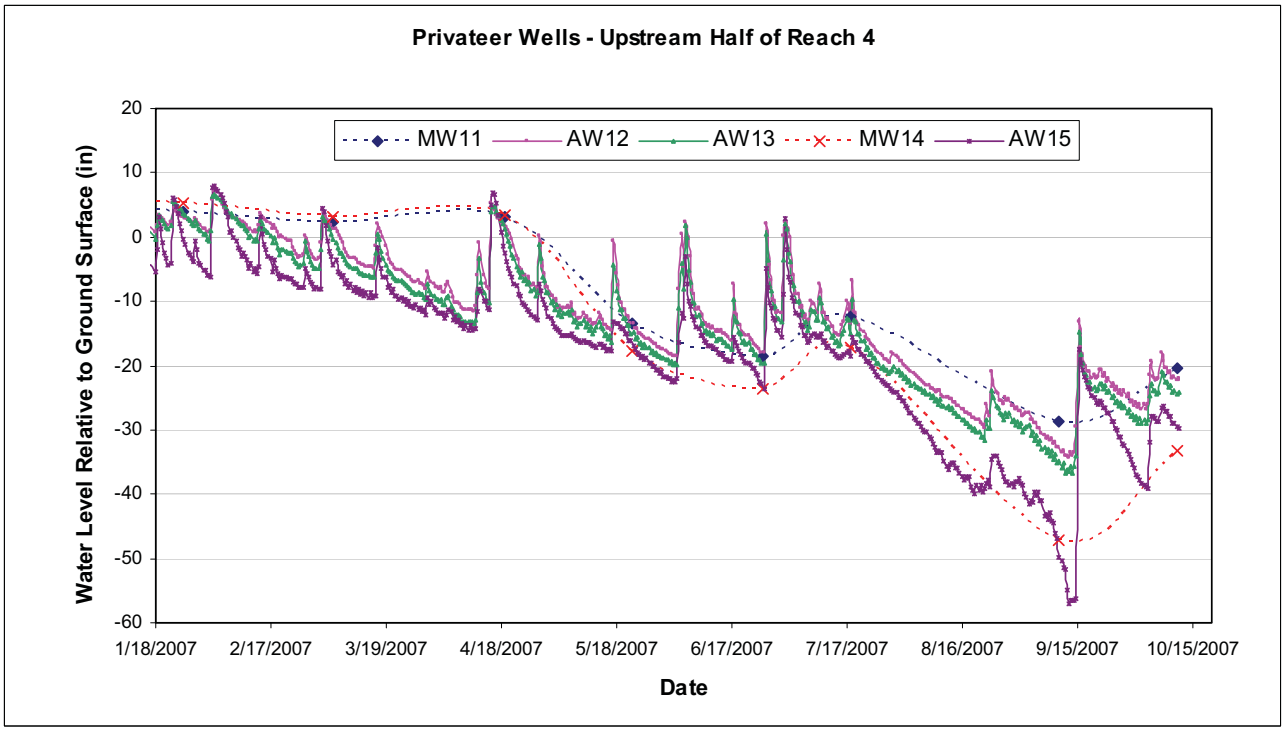


Figure 9. Well Data for Downstream Half of Reach 4 of the Privateer Restoration Project.

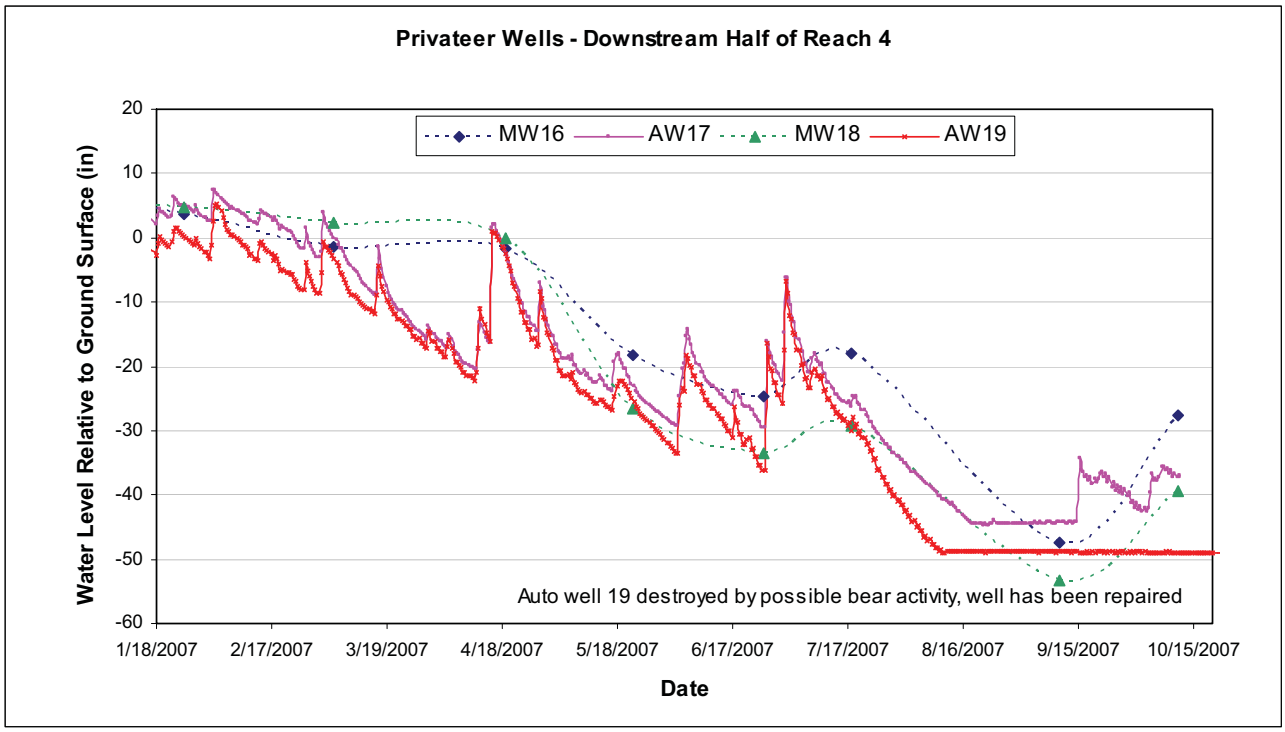


Figure 10. Well Data for Upstream Half of Reach 5 of the Privateer Restoration Project.

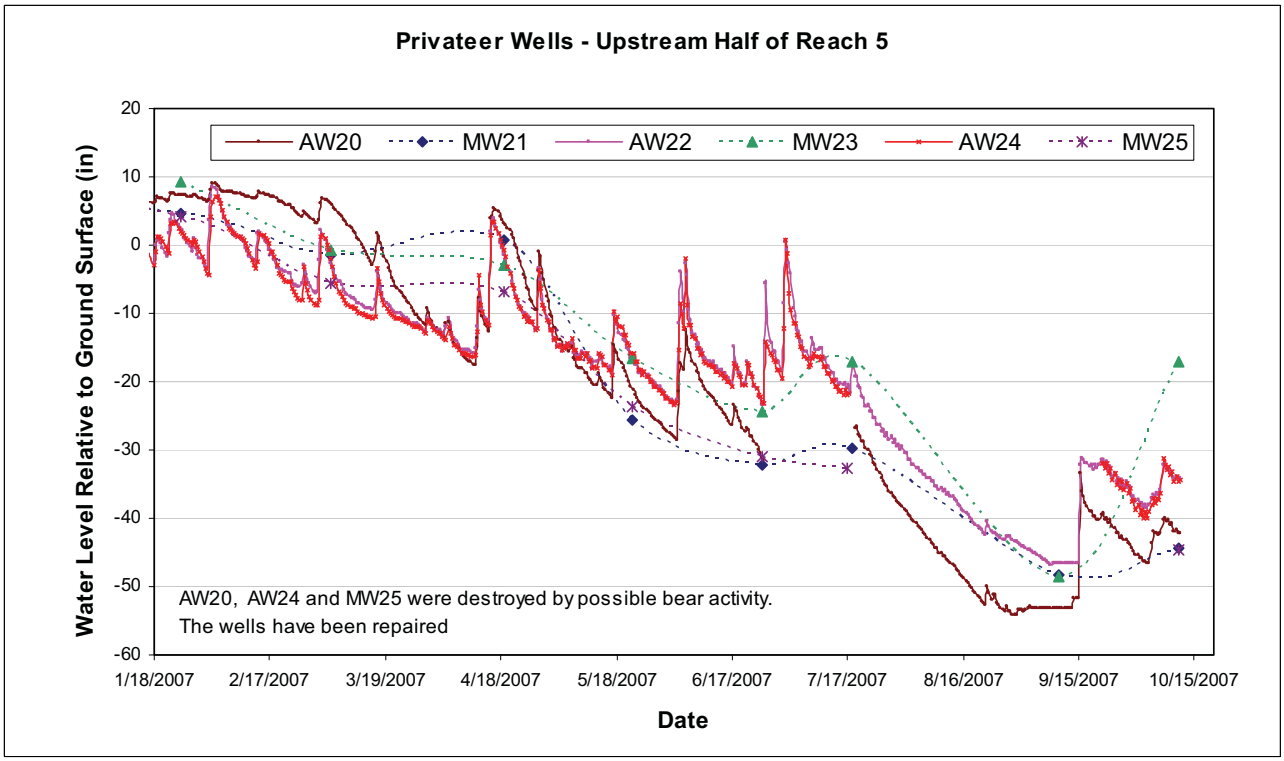


Figure 11. Well Data for Downstream Half of Reach 5 of the Privateer Restoration Project.

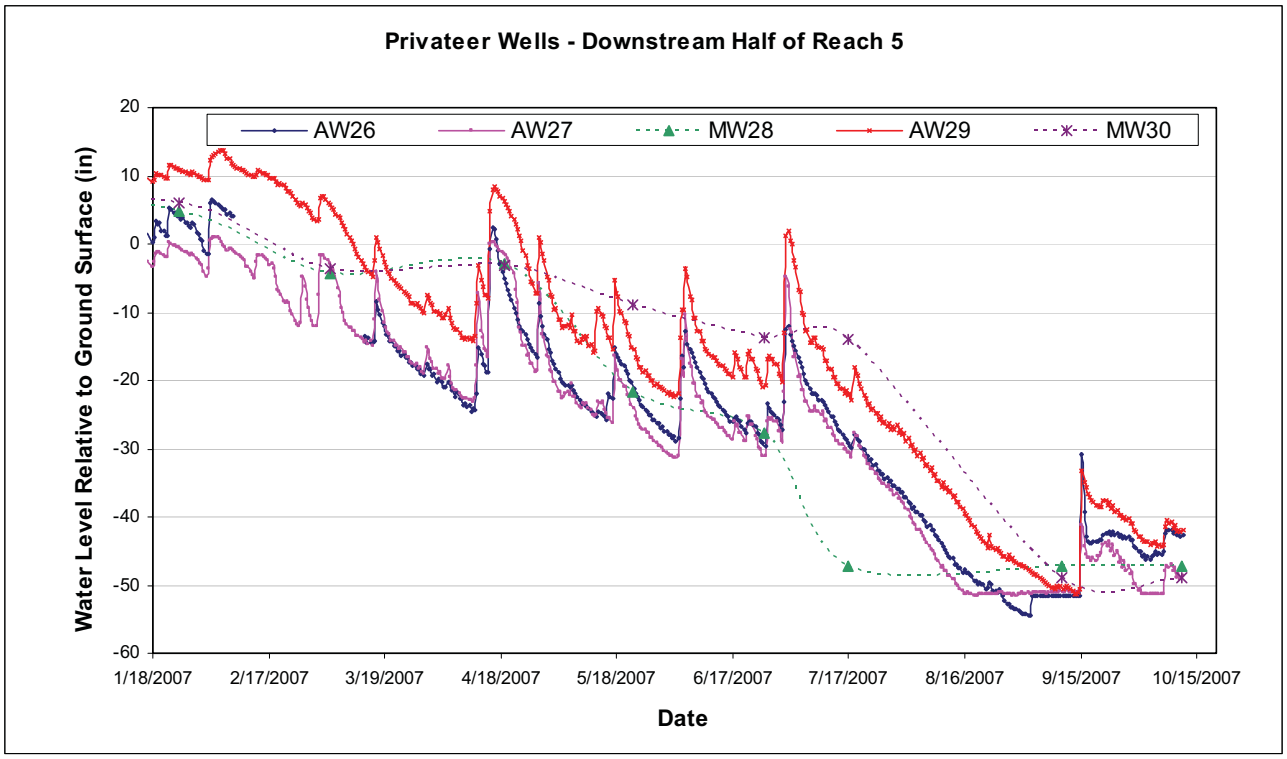
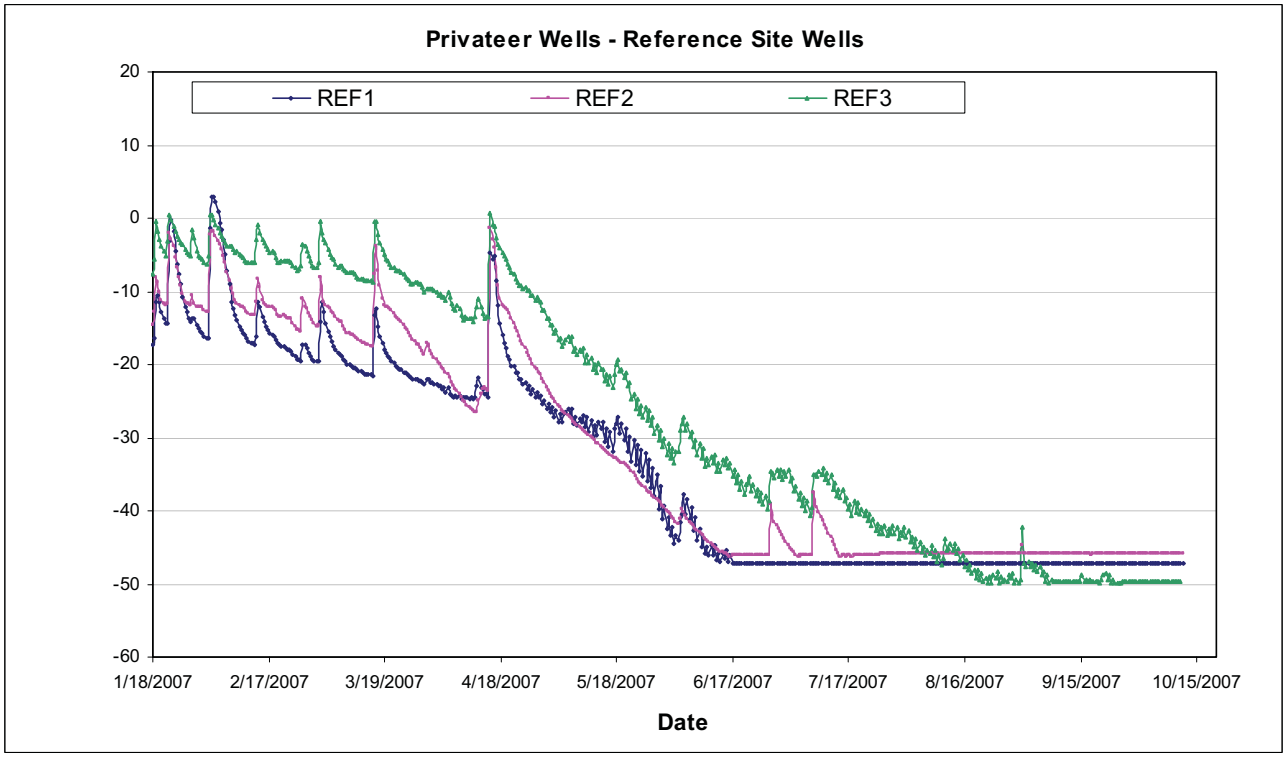


Figure 12. Well Data for Reference Site Wells - Privateer Restoration Project.



Due to the below average rainfall amounts during Year 3, ten automatic wells did not meet the success criteria of a continuous hydroperiod of at least 12.5 percent of the growing season. Although hydrologic success criteria were not met for many wells at the Site, the data show that 2007 hydrologic conditions at the Site were more favorable than those occurring at the reference site for the same year. The data correlates well with the type of wetland systems that are targeted in this project. Monitoring data from the reference site Well #3 demonstrate positive correlations between the Site and the natural hydrology of the target system. Based on these results, it was concluded that the Site is performing as designed and conditions are expected to improve if the Site experiences "normal" levels of rainfall in the future.

2.3.3 Areas of Concern

Ten automatic wells did not meet the success criteria. However, severe drought conditions were experienced during 2007. Data from monitoring Years 1 and 2, when rainfall conditions were closer to normal, indicated that the site did meet hydrologic success in those years. Therefore, Site is performing as designed and conditions are expected to improve.

2.4 Site Observations

Many different animal species were observed throughout the Site: white tail deer, wild turkey, great blue herons, wood ducks and many other birds. Turtles, several snake species and small fish in the stream were commonly observed on-site. No black bear sightings took place on-site during Year 3. However, evidence of bear activity at the Site was noted in the area of several destroyed gauges wells.

Thick, herbaceous vegetation nearly covered the Site. Observed species included rush (*Juncus* sp.), goldenrod (*Solidago* sp.), switchgrass (*Panicum virgatum*), lespedeza (*Lespedeza*), fennel (*Foeniculum vulgare*), tearthumb (*Polygonum sagittatum*), and various other grasses.