

Privateer Farms Restoration Site

Annual Monitoring Report for 2008 (Year 4)

December 2008



Prepared for:



NC Department of Transportation

Project Development and Environmental Analysis Branch

Office of Natural Environment

1598 Mail Service Center

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NC Ecosystem Enhancement Program

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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 linear feet (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 2008 growing season (Year 4 of the 5-year monitoring period).

| Table 1 Background Information. | |
|---|--|
| Project Name | Privateer Farms |
| Designer’s Name | Michal Baker Engineering, 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

| | |
|--|----------|
| 1.0 Background Information | 1 |
| 1.1 Goals and Objectives | 1 |
| 1.2 Project Location | 1 |
| 1.3 Project Description | 1 |
| 2.0 Monitoring Results – 2008 (Year 4) Data | 5 |
| 2.1 Vegetation | 5 |
| 2.2 Morphology | 12 |
| 2.3 Hydrology | 13 |
| 2.4 Site Observations | 23 |

Tables and Figures

| | |
|----------------------|---|
| Table 1 | Background Information |
| Table 2 | Bare-Root Tree Species Planted Across the Restoration Site |
| Table 3 | Density of Trees for the 15 Vegetation Sampling Plots |
| Table 4 | Comparison of Historic Average Rainfall to Observed Rainfall |
| Table 5 | Hydrologic Monitoring Results for 2008 (Year 4) |
| Figure 1 | Project Vicinity Map |
| Figure 2 | Watershed Map |
| Figure 3 – 3d | Overview As-Built Plan Sheets |
| Figure 4 | Comparison of Observed Rainfall and Historic Average Rainfall |
| 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 |

Appendices (Appendix materials are located on enclosed CD)

| | |
|-------------------|------------------------------|
| Appendix 1 | Selected Project Photographs |
| Appendix 2 | 2008 (Year 4) Cross-sections |
| Appendix 3 | Well Data |

1.0 Background Information

The Privateer Farms Restoration Site (Site) is located in Bladen and Cumberland Counties, North Carolina, approximately fourteen miles southeast of Fayetteville (Figure 1). Prior to restoration, land use on 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 33 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 was 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, which 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.

Figure 1. Project Vicinity Map

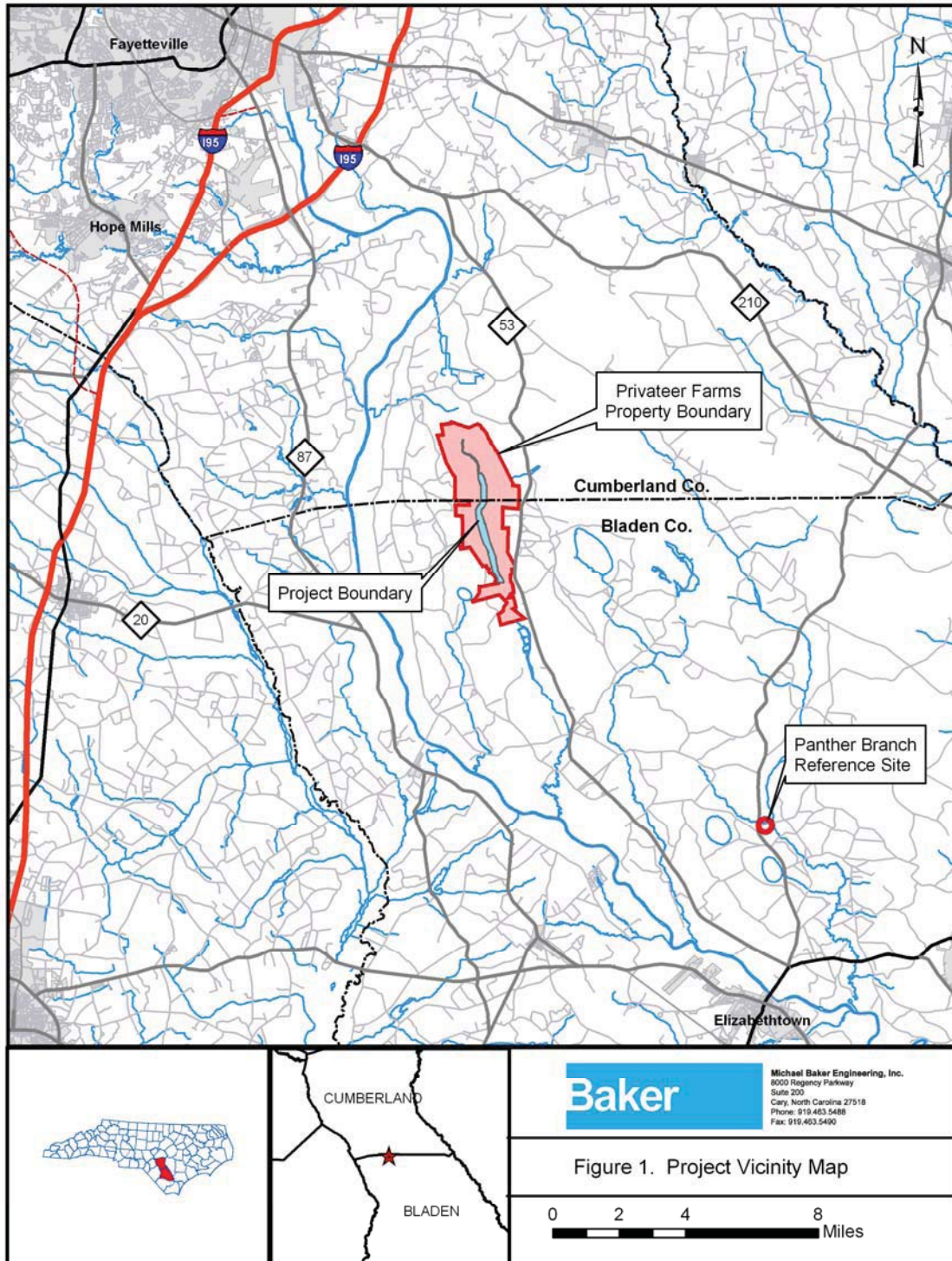
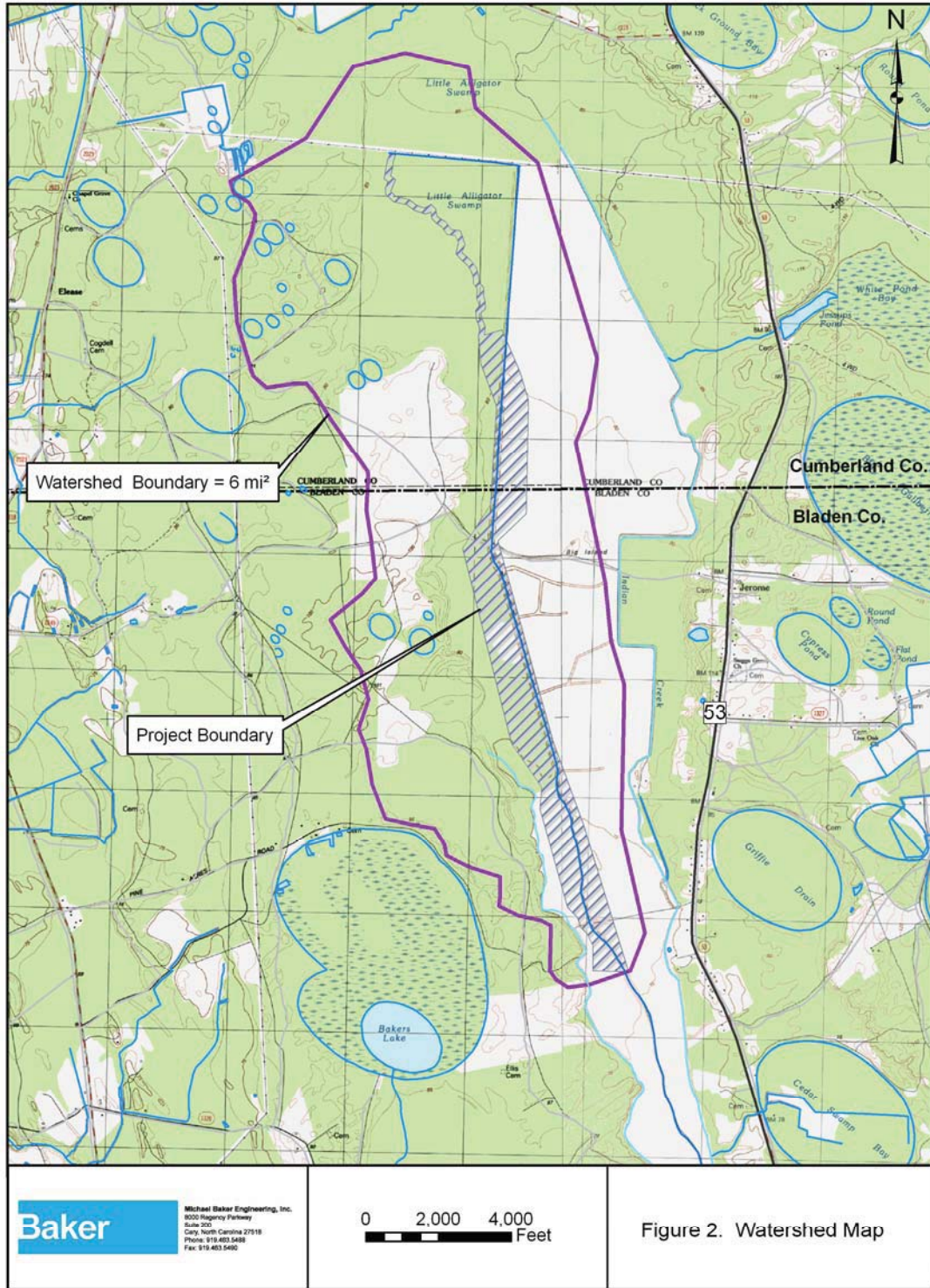


Figure 2. Watershed Map



2.0 Monitoring Results – 2008 (Year 4) 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.

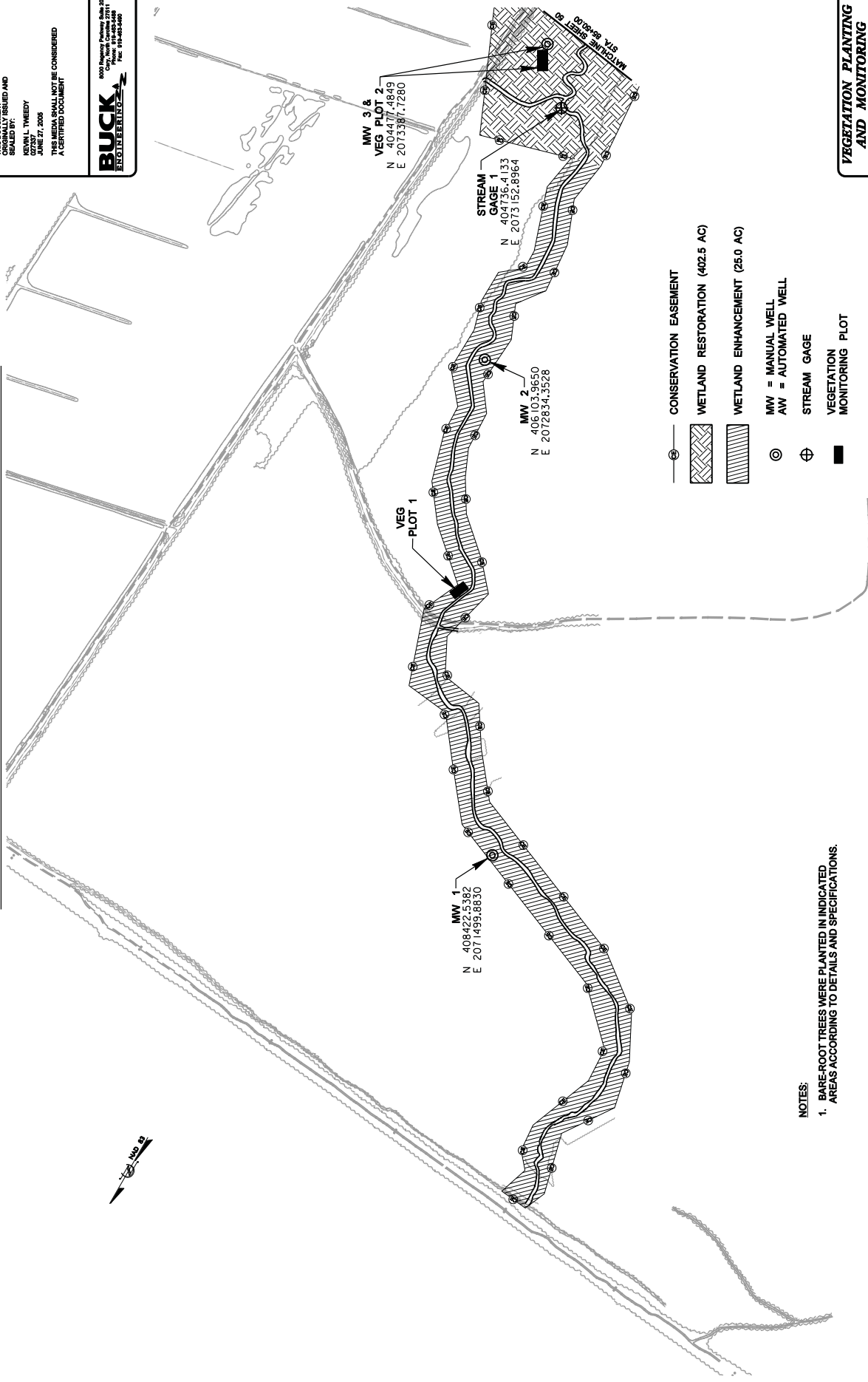
| Common Name | Scientific Name | Percent Planted by Species | Total Number of Stems | Wetness Tolerance ¹ |
|----------------|-------------------------------|----------------------------|-----------------------|--------------------------------|
| Willow oak | <i>Quercus phellos</i> | 8.6% | 23,300 |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

Notes:

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

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

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| PROJECT ENGINEER | | | |
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- CONSERVATION EASEMENT
- WETLAND RESTORATION (402.5 AC)
- WETLAND ENHANCEMENT (25.0 AC)
- MW = MANUAL WELL
- AW = AUTOMATED WELL
- STREAM GAGE
- VEGETATION MONITORING PLOT

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

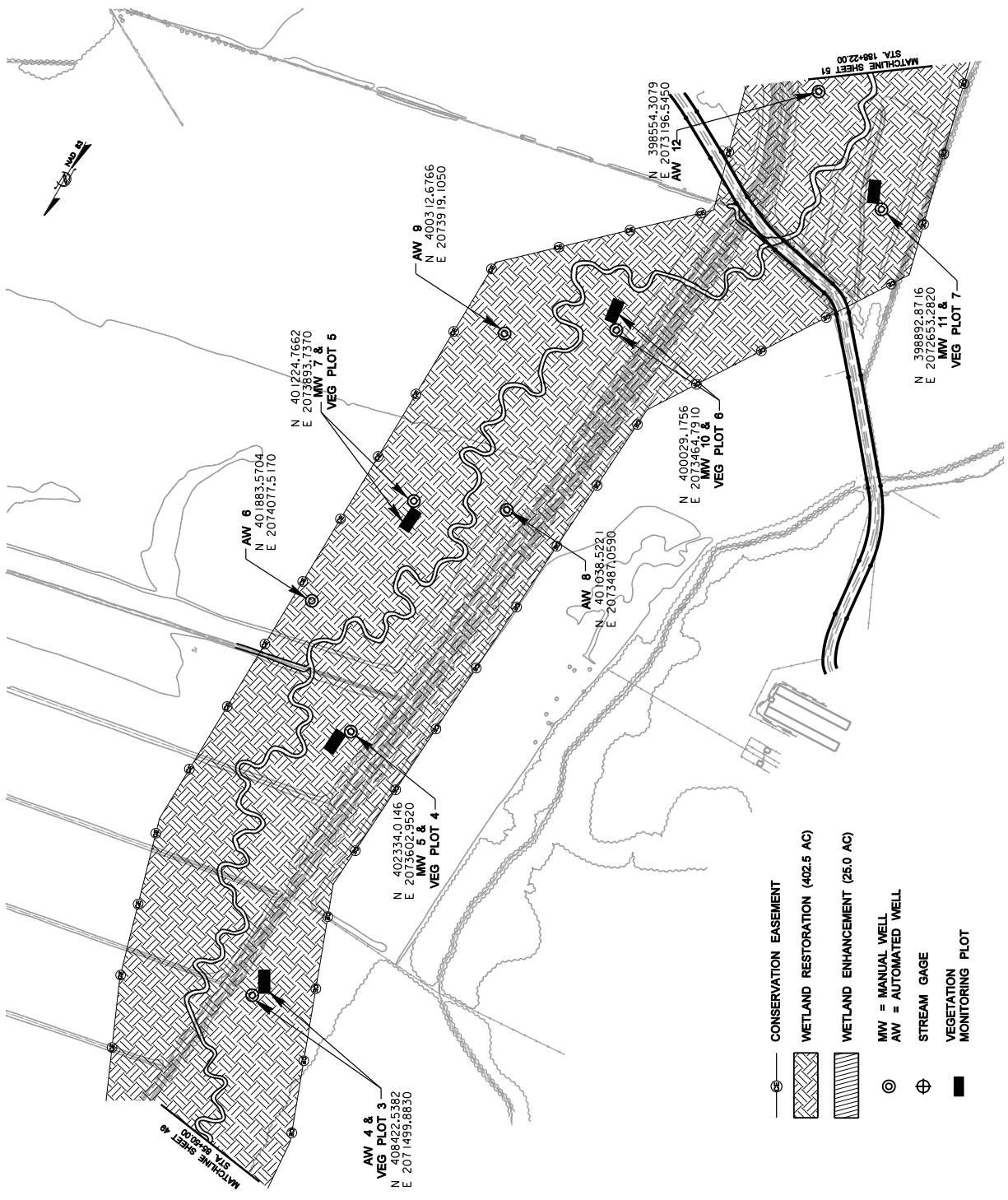
VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

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SCALE (FT)



VEGETATION PLANTING AND MONITORING AS-BUILT PLAN



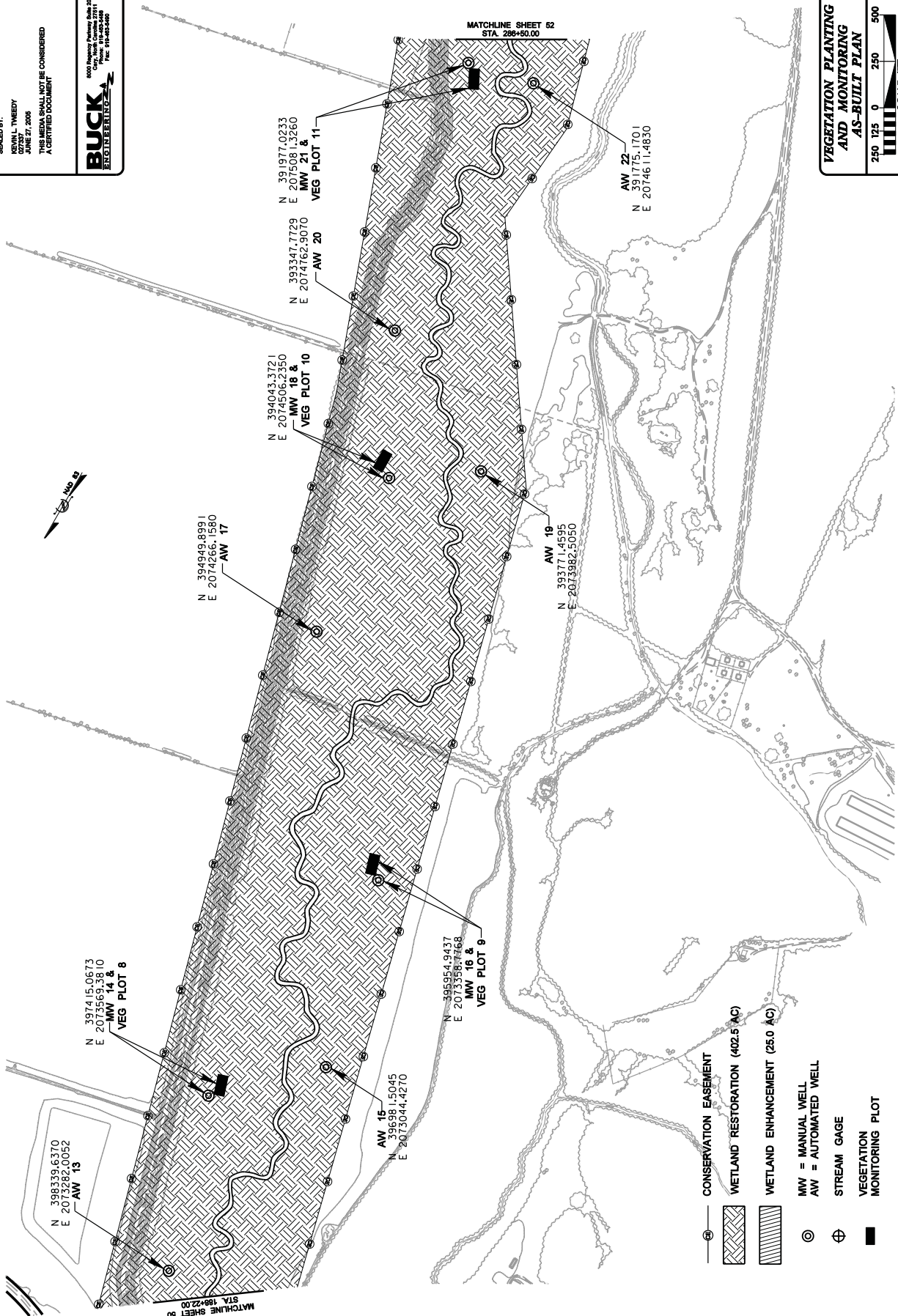
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- ⊕ AW = AUTOMATED WELL
- ⊕ STREAM GAGE
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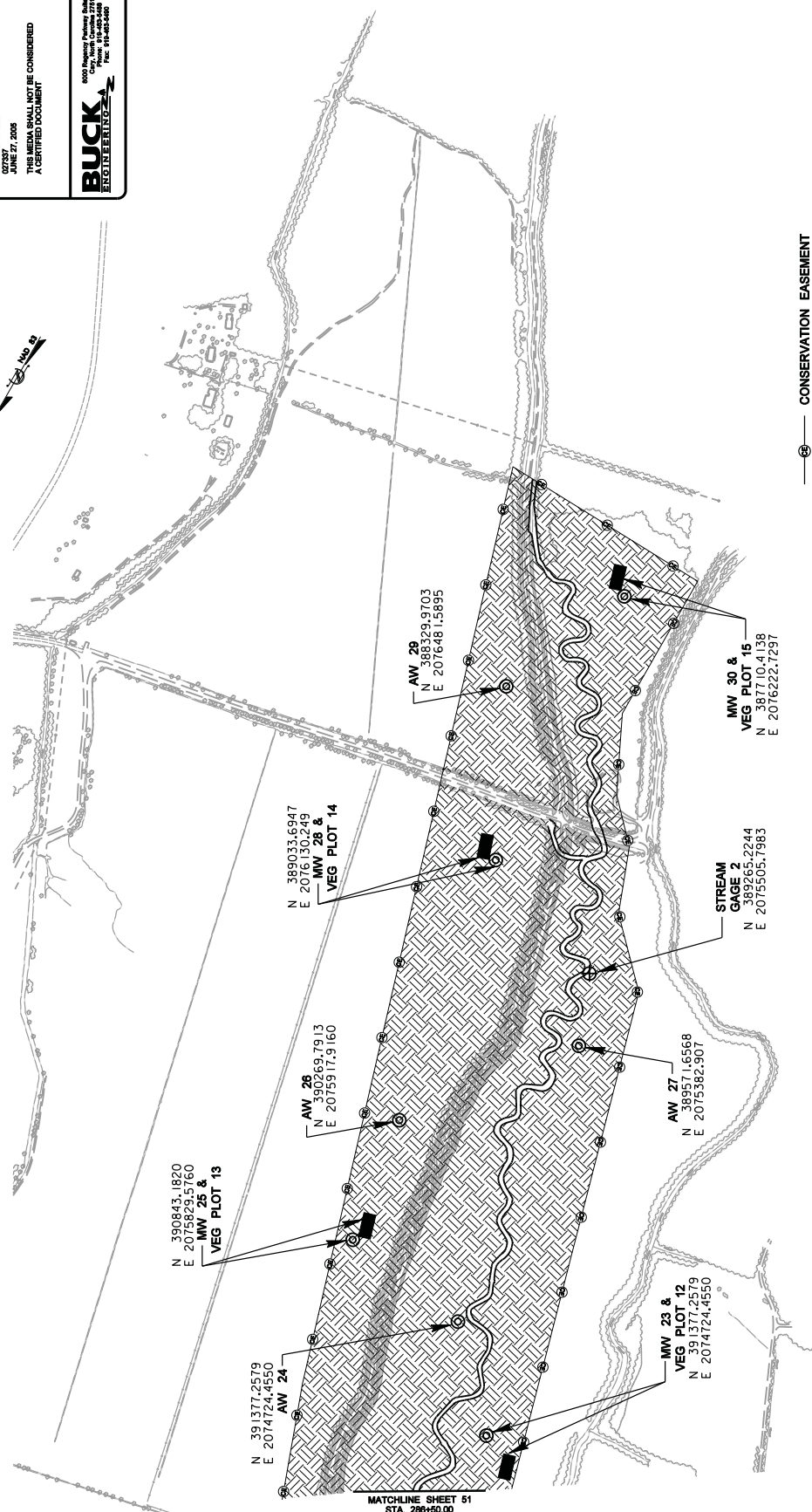
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VEGETATION PLANTING AND MONITORING AS-BUILT PLAN

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- STREAM GAGE
- VEGETATION MONITORING PLOT

VEGETATION PLANTING AND MONITORING AS-BUILT PLAN
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 SCALE (FT)

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. Data from the end of the fourth growing season are presented in Table 3. The locations of the vegetation plots are shown in Figure 3a-3d.

| Sampling Plot No. | Counted Stems per Plot | | | | Stems per Acre (extrapolated) | | | |
|-------------------|------------------------|--------|--------|--------|-------------------------------|--------|--------|--------|
| | Initial | Year 2 | Year 3 | Year 4 | Initial | Year 2 | Year 3 | Year 4 |
| 1 | 38 | 33 | 30 | 26 | 662 | 575 | 523 | 453 |
| 2 | 40 | 38 | 36 | 34 | 697 | 662 | 627 | 592 |
| 3 | 39 | 37 | 31 | 33 | 680 | 645 | 540 | 575 |
| 4 | 33 | 31 | 32 | 31 | 575 | 540 | 558 | 540 |
| 5 | 42 | 42 | 39 | 39 | 732 | 732 | 680 | 680 |
| 6 | 37 | 33 | 32 | 32 | 645 | 575 | 558 | 558 |
| 7 | 43 | 40 | 36 | 36 | 749 | 697 | 627 | 627 |
| 8 | 31 | 31 | 26 | 25 | 540 | 540 | 453 | 436 |
| 9 | 35 | 27 | 26 | 26 | 610 | 470 | 453 | 453 |
| 10 | 35 | 30 | 30 | 30 | 610 | 523 | 523 | 523 |
| 11 | 39 | 18 | 19 | 19 | 680 | 314 | 331 | 331 |
| 12 | 36 | 29 | 27 | 27 | 627 | 505 | 470 | 470 |
| 13 | 35 | 16 | 16 | 16 | 610 | 279 | 279 | 279 |
| 14 | 49 | 16 | 16 | 16 | 854 | 279 | 279 | 279 |
| 15 | 45 | 37 | 33 | 33 | 784 | 645 | 575 | 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 2008 (Year 4) indicated an average survivability of 491 stems per acre, which is on a trajectory to meet the average vegetation survival criteria of 260 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 4. The survivability rates for Plots 11, 13, and 14 ranged from 33 to 49 percent and densities ranging from 279 to 331. The densities for Plots 11, 13 and 14 have remained relatively unchanged since Year 2. The prevalence of volunteer species was also assessed to determine if natural recolonization is compensating for lower planted stem densities. Significant 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 has *Liquidambar styraciflua* (sweet gum) saplings growing within the plot boundary. These saplings were not counted during the Year 4 monitoring event.

The 3 vegetation plots that displayed lower than expected survivability in Year 4 (Plots 11, 13, and 14) will be monitored closely during the Year 5 growing season. Due to the stability of the vegetation plots during Year 3 and Year 4, it is most likely that all vegetation plots on the Site will maintain their current numbers of surviving trees through the completion of the monitoring period. Thus, all vegetation plots are currently on track to meet the final success criteria of 260 stems/acre after Year 5.

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 4 monitoring for stream stability included data on 67 permanent cross-sections, and data from one streamflow gauge. Data collection of the cross-sections was completed in December 2008. One stream gauge is located on-site near the upstream limit of the project (stream gauge # 1). The location of the gauge is shown in Figures 3a through 3d. Originally, a second stream gauge was installed on the site near the downstream end of the project. 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.

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 also performed during the Year 3 of the monitoring period. During Year 4 of the monitoring period, only annual cross-section surveys were performed.

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 permanent cross-section data are provided in Appendix 2.

Stream gauges were installed on-site to document continuous water levels in the restored channel and record the occurrence of bankfull events. The gauges were set to automatically record water depth every six hours, and have a continuous period of record extending from end of construction to present.

Photographs were taken to visually document restoration success during Year 4 of the monitoring period. 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

The on-site streamflow gauge documented the occurrence of at least one bankfull flow event during Year 4 monitoring. The largest stream flow documented by stream gauge #1 occurred during the beginning of the month in September and was 31.10 inches, which is approximately 7.1 inches above the bankfull stage at stream gauge #1. During this event, stream gauge #1 registered a continuous out-of-bank flow for the lower end of the Site for a period of 13 days, from September 6 to September 18, 2008.

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.

Cross-section data collected for during Year 4 indicates that 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. The cross-section data indicate that pools are maintaining their depth and riffles are remaining stable and holding grade. According to the data, there are no cross-sections that indicate presence of bank erosion and no areas of bank erosion were observed on the site during Year 4.

Per the approved restoration plan for the Site, a longitudinal profile for Year 4 was not surveyed during 2008. The final longitudinal survey for the Site is scheduled to take place during Year 5 (2009) monitoring.

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 all structures are functioning as designed.

Recent beaver activity was noted on the site during Year 4 of monitoring. During October 2008, two small beaver dams were observed across the restored channel on reach 2. The beaver dams are scheduled to be removed during the winter of 2008/2009.

Photographs were taken in October of the Year 4 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 4 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, is normally used to determine rainfall over the Site during each 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.

The 2008 data from the William O. Huske Station exhibited erroneous data recordings between January and November 2008. Therefore, rainfall data from the automated weather station, Elizabethtown Lock 2 were used. The manual rainfall gauge on the Site was used to validate observations made at the automated weather station. The on-site rain gauge measured total rainfall between March and November 2008 as 49.62 inches. For the same period, the Elizabethtown Lock 2 gauge measured 44.43 inches of rainfall.

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 2008 growing season was above the approximated long-term average for the area. According to the automated weather station at Elizabethtown Lock 2, the months of March, June and October of the 2008 growing season experienced below average rainfall. The months of April, May, July, August, September and November experienced normal or above normal conditions.

According to the automated weather station Elizabethtown Lock 2, total rainfall for the 2008 growing season was more than 8 inches above the long-term average for total growing season rainfall. Table 4 and Figure 4 compare historic and average rainfall over the area with the observed, during the 2008 growing season.

Data collected from the fifteen automatic monitoring well gauges at the Site showed that all gauges met the hydrologic success criteria for Year 4 monitoring. The fifteen automatic gauges that met the

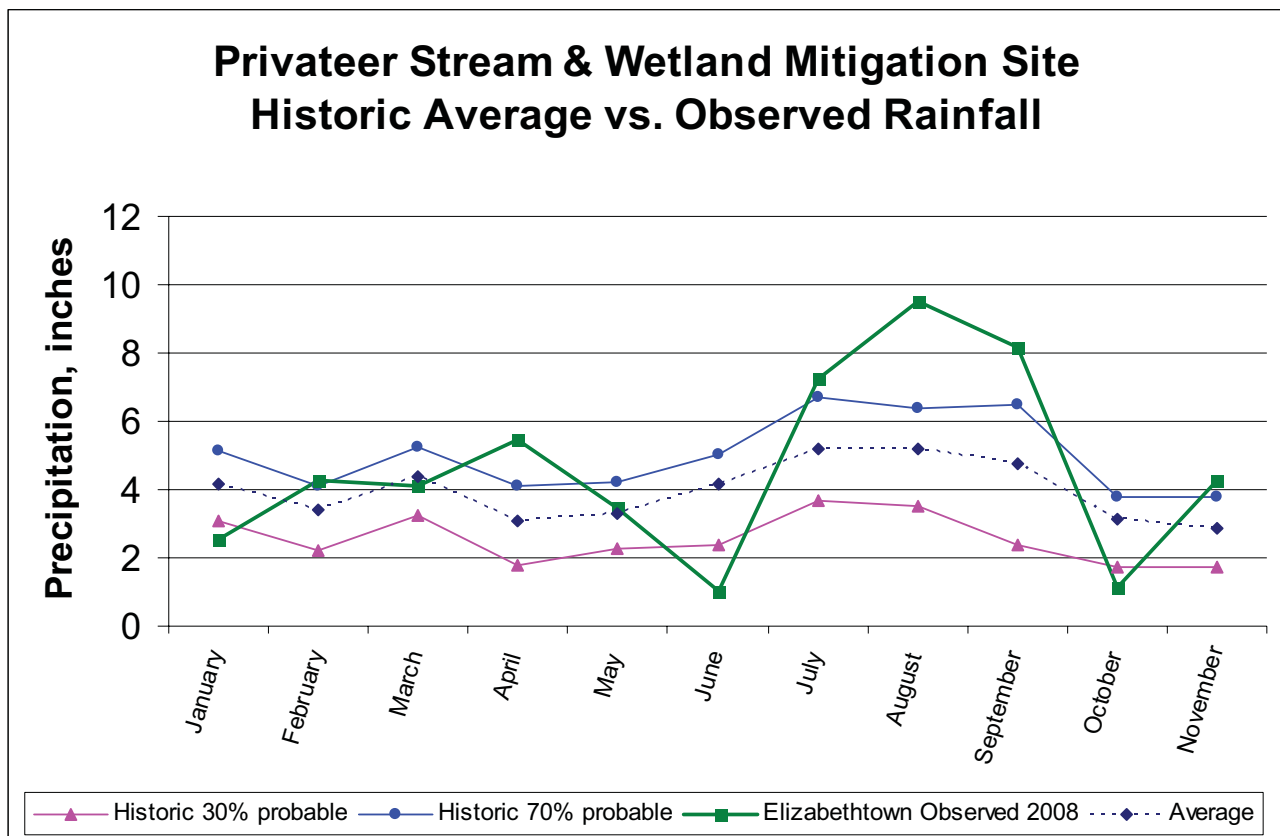
success criteria exhibited a continuous hydroperiod from 21.3 percent to 47.5 percent. The gauges exhibited a cumulative hydroperiod from 76 to 212 days or 31.8 percent to 88.7 percent of the Year 4 growing season. The data indicate that the locations experienced significant wetness and surface saturation conditions during the 2008 growing season. Data collected from on-site well gauges are presented in Appendix 3. The hydrologic monitoring results for the gauges are shown in Table 5.

The three wells located in the reference site indicated drier conditions than the Site for 2008. The three automatic gauges exhibited a continuous hydroperiod from 8 to 24.5 days or 3.3 percent to 10.3 percent. The reference gauges exhibited a cumulative hydroperiod from 15.5 to 75.5 days or 6.5 percent to 31.6 percent of the Year 3 growing season. The REF3 gauge documented hydrologic conditions most similar to areas of the restored site, with a continuous hydroperiod of approximately 10.3 percent. The other two reference wells, REF1 and REF2, documented somewhat drier conditions, and it is suspected that these locations are experiencing a significant drainage effect from the nearby stream channel.

During Year 4 of the monitoring period AW19, AW20, AW24 and MW21 sustained damage due to bear activity on the Site. Site visits at these gauge locations revealed signs of bear activity around the wells such as, bite marks on PVC, bent support posts and remnants of bear scat. 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.

| Month | Average | 30% | 70% | Elizabethtown Observed 2008 Precipitation |
|-----------|---------|------|------|--|
| January | 4.16 | 3.06 | 5.13 | 2.54 |
| February | 3.43 | 2.22 | 4.11 | 4.25 |
| March | 4.37 | 3.24 | 5.22 | 4.1 |
| April | 3.06 | 1.77 | 4.13 | 5.47 |
| May | 3.29 | 2.25 | 4.2 | 3.48 |
| June | 4.18 | 2.36 | 5.02 | 1.05 |
| July | 5.21 | 3.69 | 6.7 | 7.24 |
| August | 5.21 | 3.54 | 6.36 | 9.53 |
| September | 4.77 | 2.36 | 6.46 | 8.15 |
| October | 3.15 | 1.73 | 3.76 | 1.15 |
| November | 2.88 | 1.75 | 3.76 | 4.26 |
| 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 five 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 2008 (Year 4). | | | |
| Monitoring Station | Most Consecutive Days Meeting Criteria¹ | Cumulative Days Meeting Criteria² | Number of Instances Meeting Criteria³ |
| MW1 ⁴ | 79.5 (33.3%) | 172 (72%) | 11 |
| MW2 ⁵ | 98 (41.0%) | 158.5 (66.3) | 6 |
| MW3 ⁵ | 98 (41.0%) | 158.5 (66.3) | 6 |
| AW4 | 98 (41.0%) | 158.5 (66.3) | 6 |
| MW5 ⁵ | 98 (41.0%) | 158.5 (66.3) | 6 |
| AW6 | 79.5 (33.3%) | 172 (72%) | 11 |
| MW7 ⁶ | 80 (33.5%) | 180.5 (75.5%) | 5 |
| AW8 | 112 (46.9%) | 212 (88.7%) | 4 |
| AW9 | 80 (33.5%) | 180.5 (75.5%) | 5 |
| MW10 ⁶ | 80 (33.5%) | 180.5 (75.5%) | 5 |
| MW11 ⁷ | 79.5 (33.3%) | 179 (74.9%) | 5 |
| AW12 | 79.5 (33.3%) | 179 (74.9%) | 5 |
| AW13 | 79.5 (33.3%) | 161 (67.4%) | 7 |
| MW14 ⁹ | 79.5 (33.3%) | 161 (67.4%) | 7 |
| AW15 | 79.5 (33.3%) | 146.5 (61.3%) | 7 |
| MW16 ⁸ | 79.5 (33.3%) | 146.5 (61.3%) | 7 |
| AW17 | 79.5 (33.3%) | 156.5 (65.5%) | 9 |
| MW18 ¹⁰ | 79.5 (33.3%) | 155.5 (65.1%) | 7 |
| AW19 | 79.5 (33.3%) | 155.5 (65.1%) | 7 |
| AW20 | 58.5 (24.5%) | 76 (31.8%) | 5 |
| MW21 ¹⁰ | 79.5 (33.3%) | 155.5 (65.1%) | 7 |
| AW22 | 113.5 (47.5%) | 194 (81.2%) | 2 |
| MW23 ¹⁰ | 79.5 (33.3%) | 155.5 (65.1%) | 7 |
| AW24 | 79.5 (33.3%) | 151 (63.2%) | 2 |
| MW25 ¹⁰ | 79.5 (33.3%) | 155.5 (65.1%) | 7 |
| AW26 | 51 (21.3%) | 122.5 (51.3%) | 5 |
| AW27 | 79.5 (33.3%) | 151.5 (63.4%) | 6 |
| MW28 ¹⁰ | 79.5 (33.3%) | 155.5 (65.1%) | 7 |

| | | | |
|--------------------|--------------|---------------|---|
| AW29 | 80 (33.5%) | 165.5 (69.2%) | 9 |
| MW30 ¹¹ | 80 (33.5%) | 165.5 (69.2%) | 9 |
| REF1 | 8 (3.3%) | 15.5 (6.5%) | 4 |
| REF2 | 13.5 (5.6%) | 27 (11.3%) | 5 |
| REF3 | 24.5 (10.3%) | 75.5 (31.6%) | 9 |

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.

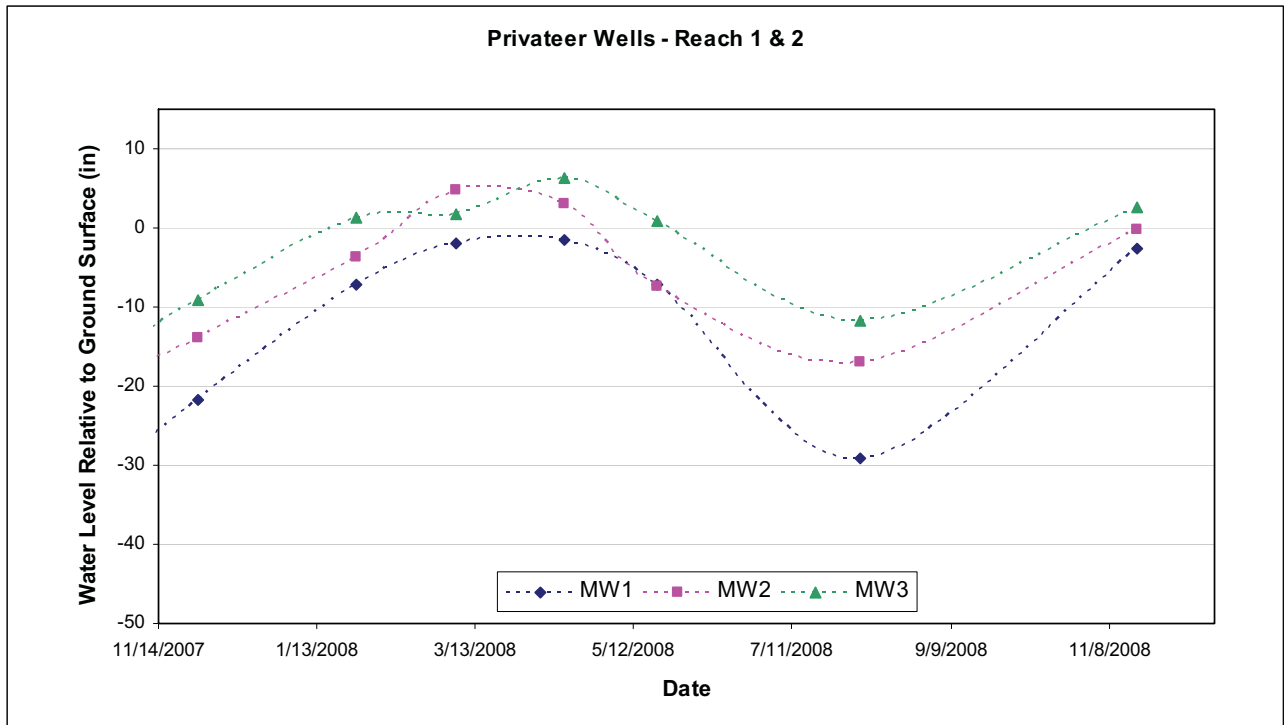


Figure 6. Well Data for Upstream Half of Reach 3 of the Privateer Restoration Project.

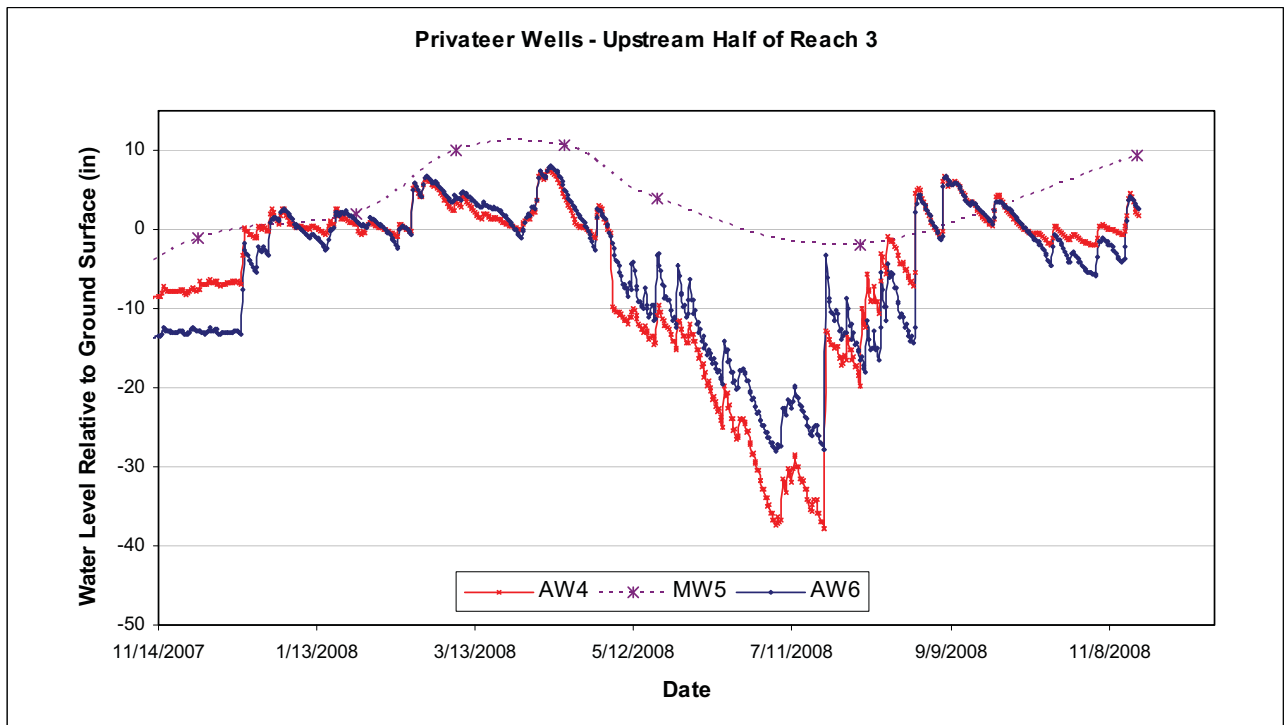


Figure 7. Well Data for Downstream Half of Reach 3 of the Privateer Restoration Project.

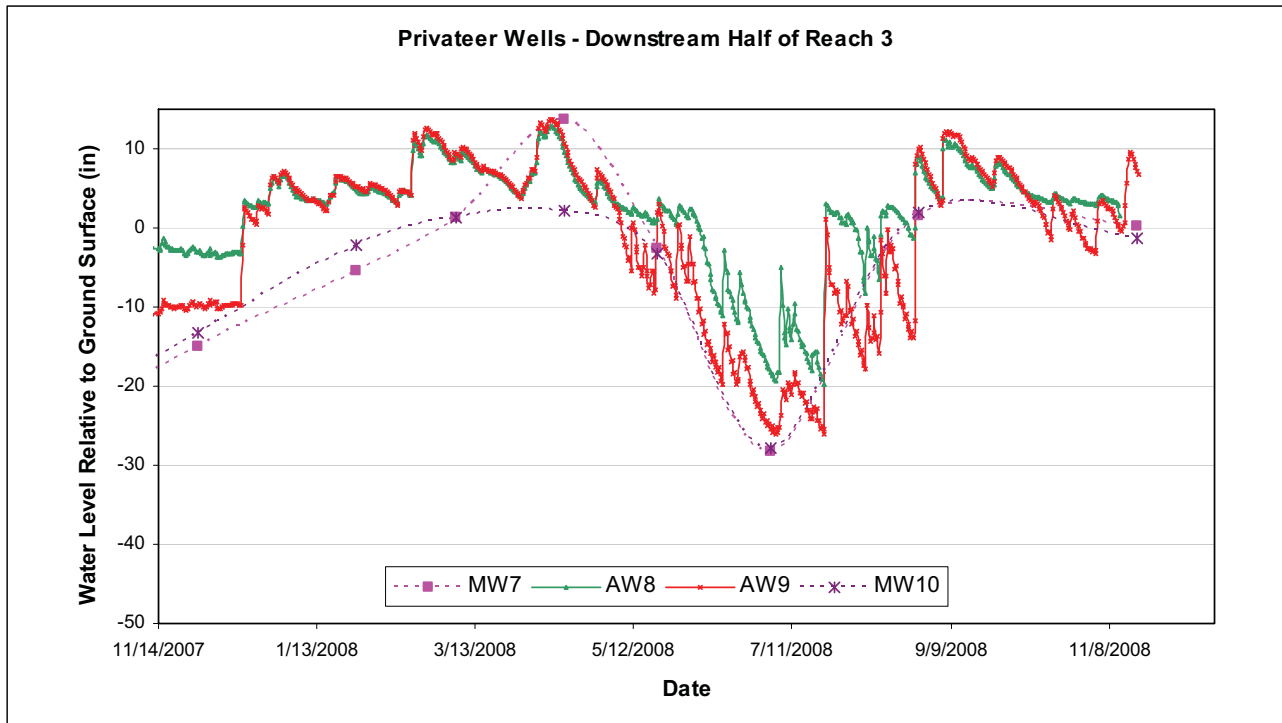


Figure 8. Well Data for Upstream Half of Reach 4 of the Privateer Restoration Project.

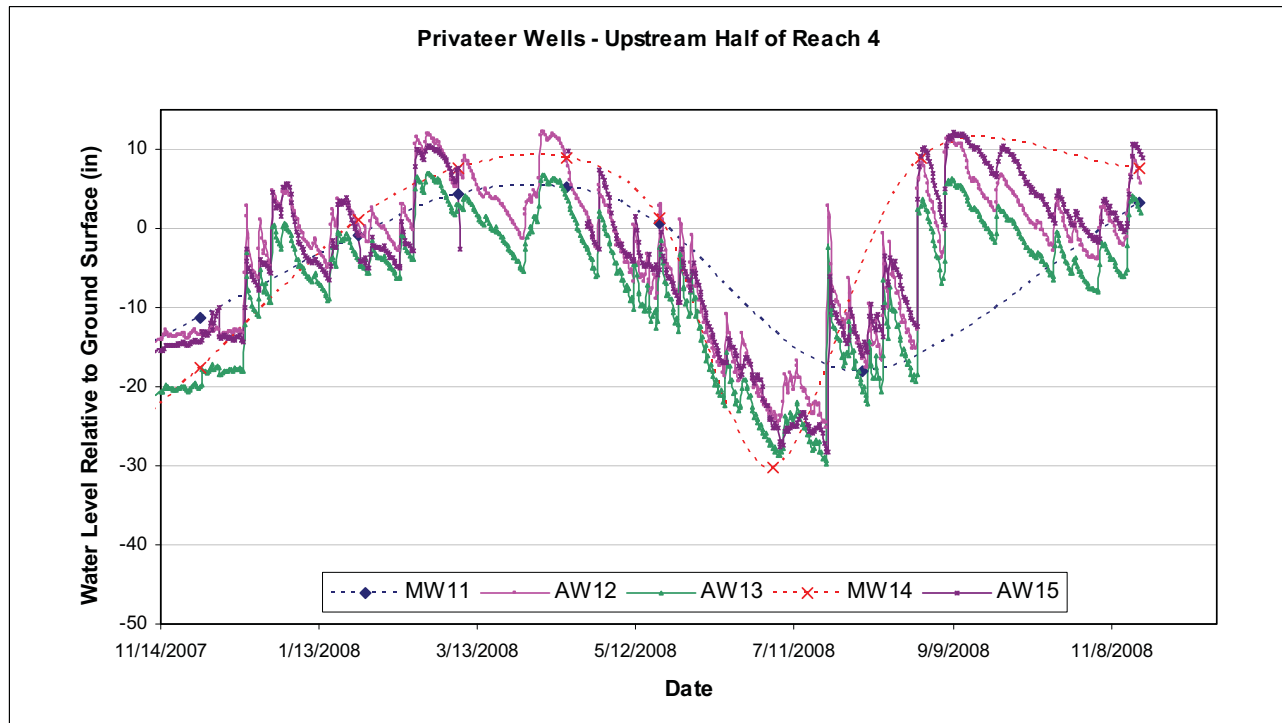


Figure 9. Well Data for Downstream Half of Reach 4 of the Privateer Restoration Project.

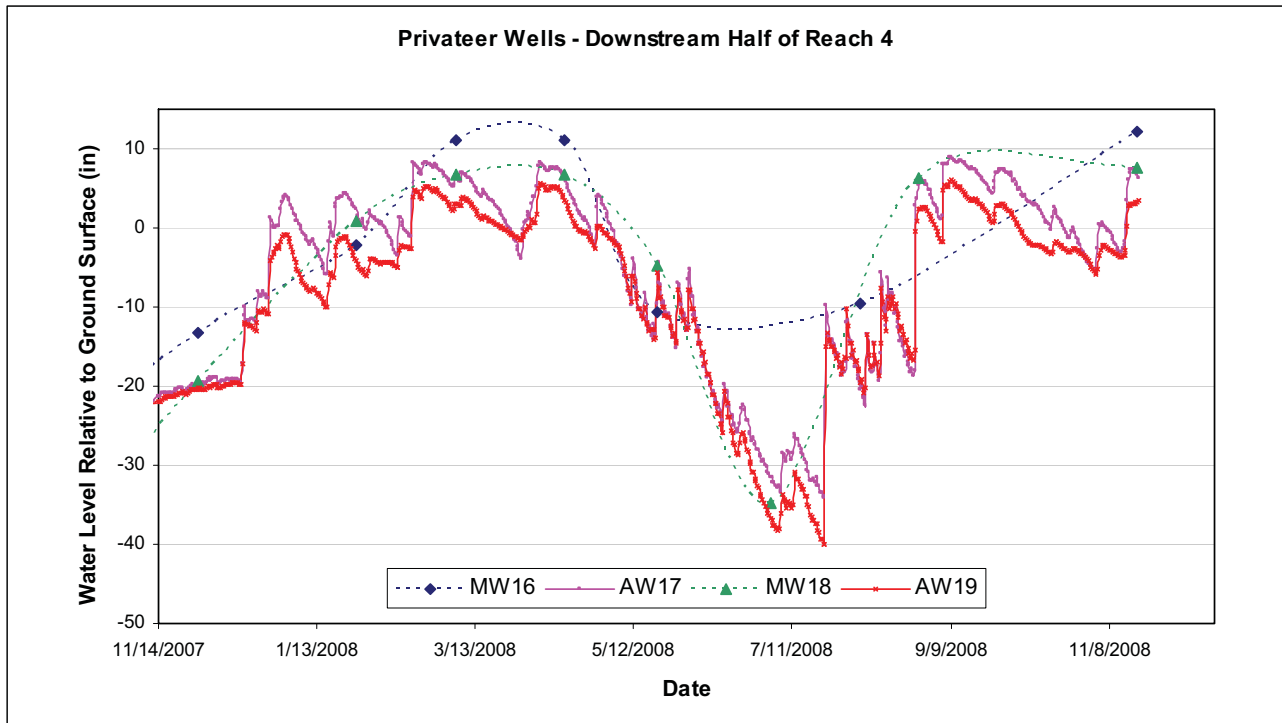


Figure 10. Well Data for Upstream Half of Reach 5 of the Privateer Restoration Project.

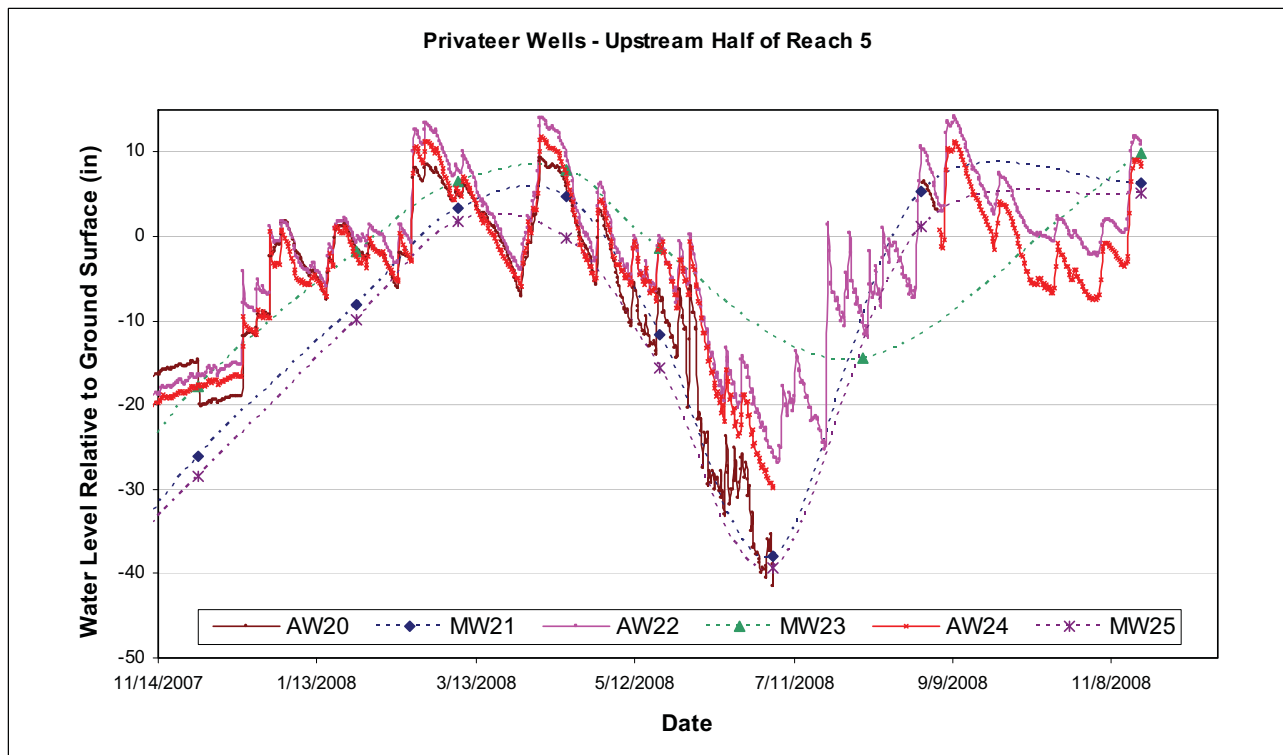


Figure 11. Well Data for Downstream Half of Reach 5 of the Privateer Restoration Project.

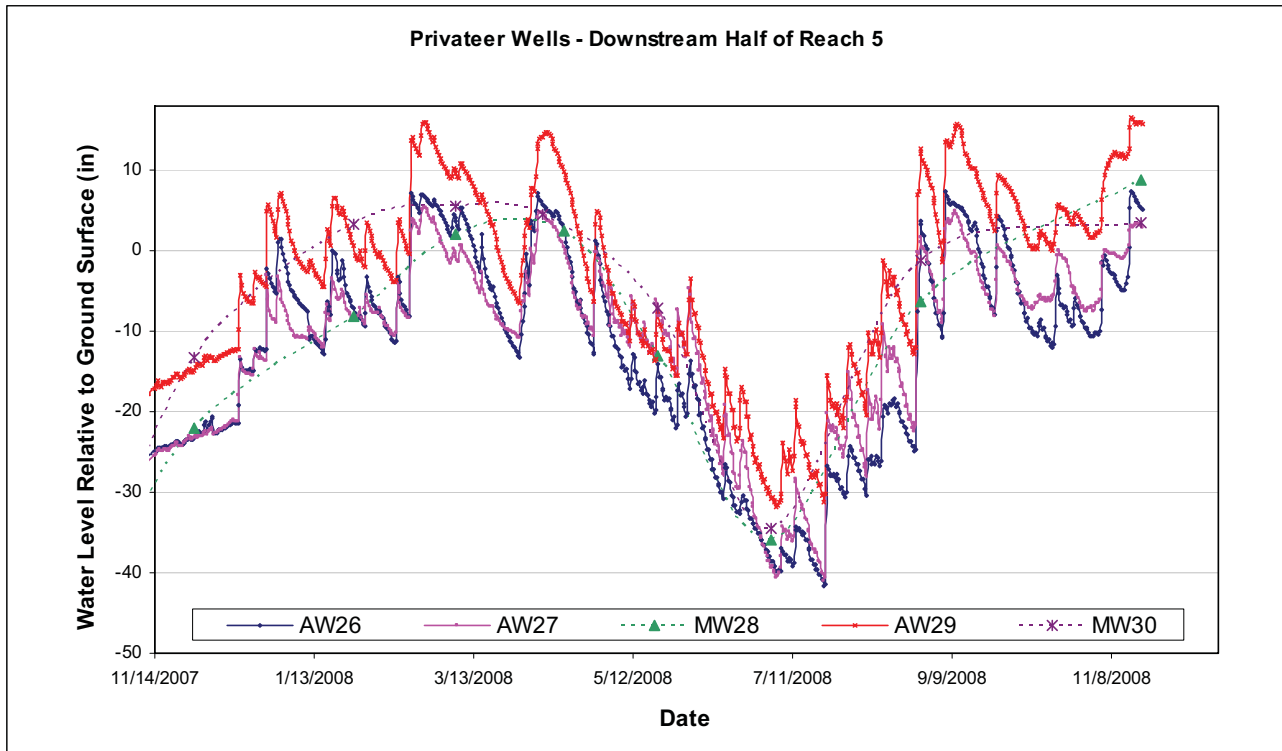
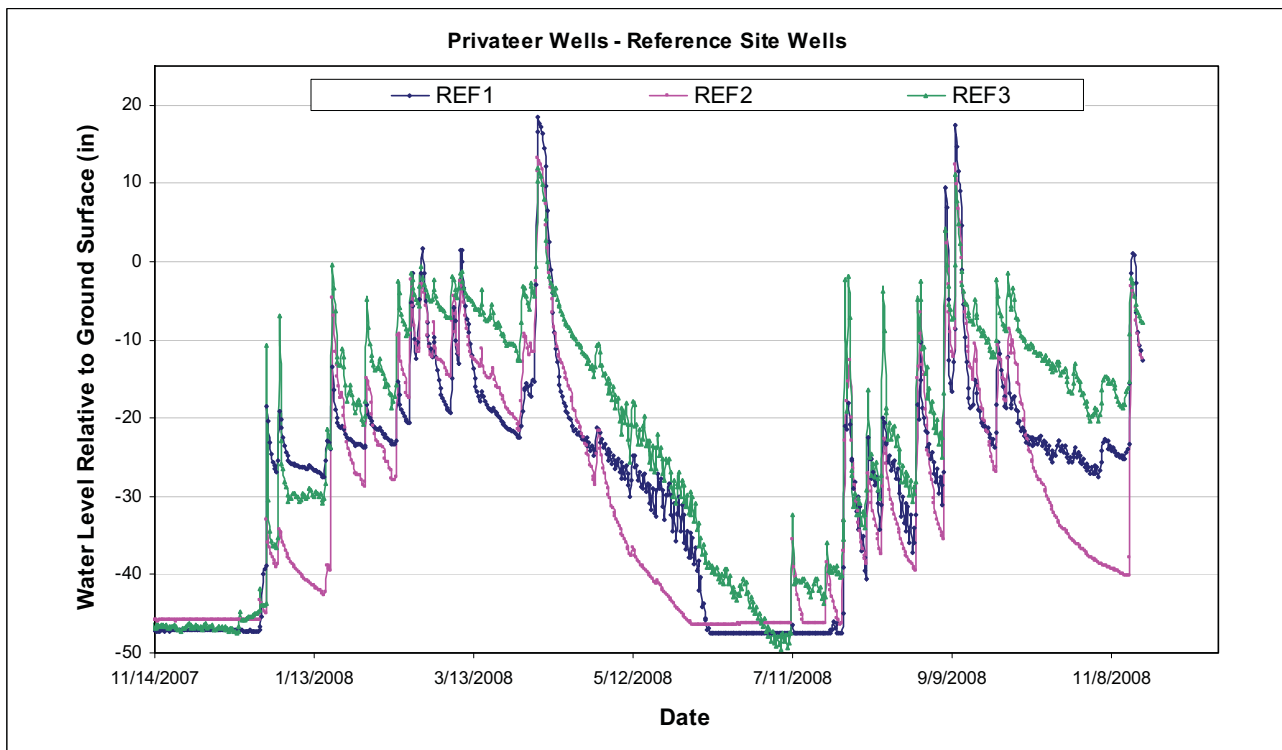


Figure 12. Well Data for Reference Site Wells - Privateer Restoration Project.



2.3.3 Areas of Concern

Based on these results, it was concluded that the Site is performing as designed. There are currently no areas of concern regarding the monitoring wells on the Site.

2.4 Site Observations

Many different animal species were observed throughout the Site: white tail deer, river otter, birds of prey, 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 the Site. However, evidence of bear scat was noted in several locations within the restoration area.

Thick, herbaceous vegetation nearly covers 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.