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Fernald Preserve, Ohio

Wetland Mitigation Monitoring Report

May 2012

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Abbreviations

ACOE	United State Army Corps of Engineers
AIBI	Amphibian Index of Biotic Integrity
BAP	Borrow Area Project
CC	coefficient of conservatism
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cm	centimeters
DOE	United States Department of Energy
EPA	United States Environmental Protection Agency
FPA	Former Production Area
FQAI	Floristic Quality Assessment Index
GIS	Graphical Information System
LM	Office of Legacy Management
m	meters
NPP	Northern Pine Plantation
NRRP	Natural Resource Restoration Plan
NRT	Natural Resource Trustee
ODNR	Ohio Department of Natural Resources
Ohio EPA	Ohio Environmental Protection Agency
OSU	Ohio State University
VIBI	Vegetation Index of Biotic Integrity
WMMP	*Fernald Preserve Wetland Mitigation Monitoring Plan*
WM1	Wetland Mitigation Phase I
WM2	Wetland Mitigation Phase II

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Executive Summary

The *Fernald Preserve, Ohio, Wetland Mitigation Monitoring Report* presents the results of a 3-year monitoring process to evaluate compensatory wetland mitigation projects at the Fernald Preserve. The Fernald Preserve is a former uranium-processing facility that operated from 1951 to 1991 as part of the United States Department of Energy (DOE) weapons complex. The site has since undergone remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), and the DOE Office of Legacy Management now maintains it. Wetland restoration projects were intended to satisfy wetland mitigation obligations as outlined in the Fernald Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE* (State of Ohio 2008). In November 2008, DOE and the Ohio Environmental Protection Agency (Ohio EPA) signed a Consent Decree that settled a long-standing natural resource damage claim under Section 107 of CERCLA. As a result, the Fernald Natural Resource Trustees (NRTs) (DOE, Ohio EPA, and the United States Department of the Interior) developed this wetland mitigation monitoring approach.

In 1993, 35.9 acres of jurisdictional wetlands were delineated at the Fernald site. According to the Operable Unit 5 Record of Decision, remediation activities would impact an estimated 10 acres of wetlands (primarily cattail marsh impoundments). Compensatory mitigation pursuant to Section 404 of the Clean Water Act was subsequently negotiated with regulators. In 1995, DOE committed to compensating for impacted wetlands on site at a 1.5-to-1 ratio. As remediation progressed, DOE became responsible for 17.85 acres of compensatory wetlands. Mitigation plans were incorporated into sitewide ecological restoration planning through the NRRP. DOE completed the NRRP wetland mitigation projects from 1999 through 2006.

The *Fernald Preserve Wetland Mitigation Monitoring Plan* (WMMP, DOE 2009) was developed using Ohio EPA performance standards and monitoring protocols. The size, type, and quality of site-impacted wetlands were estimated from historical information, which provided a basis for using Ohio EPA wetland mitigation performance standards. Monitoring objectives for the wetlands created on site were based on these standards. The WMMP designated 23 wetland basins within five project areas for mitigation monitoring from 2009 through 2011.

Performance standards include wetland acreage, basin morphometry, hydrology, vegetation, wildlife, and soil biogeochemistry. Mitigation wetland acreage was estimated via jurisdictional wetland delineation. The 1987 United States Army Corps of Engineers [ACOE] *Wetland Delineation Manual* and associated Midwest Regional supplement were used to delineate wetland boundaries within all wetland basins evaluated (ACOE 1987, 2008). Basin morphometry and perimeter-to-area ratio were estimated using Graphical Information System measurement and analytical tools. Performance standards associated with the hydrologic regime include the amount of time water is present in the root zone, the mean depth to water, and the Flashiness Index of mitigation wetlands. Subsurface water elevations were obtained via installation of shallow monitoring wells (piezometers). Vegetation parameters include Vegetation Index of Biotic Integrity (VIBI), percentage of native perennial hydrophytes, and percentage of invasive species. All vegetation data were obtained via fixed-plot sampling pursuant to Ohio EPA methodology (Mack 2007). Although there are no specific performance standards for evaluating wildlife parameters, the NRTs agreed that wildlife parameters would help with determining success. Field personnel collected amphibians and macroinvertebrates with funnel traps pursuant

to Ohio EPA protocols (Micacchion 2004), and the Amphibian Index of Biotic Integrity was calculated for the mitigation wetland basins. Migratory and breeding bird populations were also characterized as part of the Ohio Breeding Bird Atlas program. Reptile and small mammal populations were sampled via reptile coverboards. Soil samples were analyzed for solids, total organic carbon, and nitrogen content. Water samples were analyzed for inorganics (iron, magnesium, and potassium), general chemistry parameters (ammonia as nitrogen, total Kjeldahl nitrogen, total organic carbon, chloride, nitrate/nitrite, total phosphorous, total suspended solids, and total solids), and field parameters (pH, specific conductance, dissolved oxygen, and temperature).

A total of 31.33 acres of wetlands was delineated. Summary tables are provided for all data collected. Figures show wetland delineation boundaries, photograph locations, sample points, and basin morphometry. Basin-specific delineation forms, species lists, and photographs are provided as appendixes to this report. Results of monitoring efforts show much variability across the wetlands, but some generalizations can be made. Most areas met the standards for the hydrologic regime parameters. Nearly all basins failed to meet the standards for soil chemistry parameters. Results of vegetation monitoring varied greatly. Nearly half of the basins met the VIBI standards, including all basins within the Wetland Mitigation Phase II project and the North Pines Plantation project. Most basins met the standard for unvegetated open water. Only five basins met the standard for native perennial hydrophytes.

Although the monitoring results show mixed compliance with performance standards, the field data collected, along with wildlife observations and progress photographs, indicate that quality wetlands are forming. The approximately 31 acres of mitigation wetlands on the Fernald Preserve are likely of higher quality than the cattail marsh impoundments that were replaced. Therefore, for the purposes of compensatory mitigation, the 17.85-acre wetland creation goal has been met.

It is proposed that long-term monitoring of the wetlands continues at the Fernald Preserve. Monitoring activities provide pertinent data that are needed to make informed ecosystem management decisions and that are an important component of the adaptive management process. Wetland mitigation monitoring can be accomplished through continuance of the site functional monitoring program. This effort, which was also established in the NRRP, involves an ecosystem-level evaluation of major community types at the Fernald Preserve. Wetlands, prairies, and forest communities are evaluated on a 3-year rotation. Reporting would continue through annual Site Environmental Reports, with periodic updates to the NRTs and other stakeholders as needed.

1.0 Introduction

1.1 Background

The Fernald Preserve is a United States Department of Energy (DOE) site situated on a 1,050-acre tract of land, approximately 18 miles northwest of Cincinnati, Ohio. The site is near the unincorporated communities of Ross, Fernald, Shandon, and New Haven in Hamilton County. It is a former uranium-processing facility that was shut down in 1991. Since then, the site has undergone extensive remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). Remedial activities and subsequent ecological restoration have converted the site from an industrial production facility to an undeveloped park, encompassing wetlands, prairies, and forest. The Fernald site is now known as the Fernald Preserve. Several trails and the Fernald Preserve Visitors Center have been constructed on site for public use.

In addition to CERCLA Records of Decision that established remediation criteria, DOE and the Ohio Environmental Protection Agency (Ohio EPA) signed a Consent Decree, in November 2008, that settled a long-standing natural resource damage claim under Section 107 of CERCLA. As a result, the Fernald Natural Resource Trustees (NRTs) (DOE, Ohio EPA, and the United States Department of the Interior) finalized the Fernald Preserve Natural Resource Restoration Plan (NRRP), which is Appendix B of the *Consent Decree Resolving Ohio's Natural Resource Damage Claim against DOE* (State of Ohio 2008). The NRRP requires the NRTs to develop a process for resolving outstanding wetland mitigation obligations at the Fernald Preserve.

In June 1993, approximately 35.9 acres of jurisdictional wetlands and 8.9 acres of waters of the United States were identified and documented in the *Wetlands Delineation Report of the Fernald Environmental Management Project, Butler and Hamilton Counties, Ohio* (Ebasco Environmental 1993). The United States Army Corps of Engineers (ACOE) approved this delineation in August 1993.

Section 9.1.6 of the Operable Unit 5 Record of Decision identified approximately 10 acres of wetlands that would be impacted as a result of implementing Operable Unit 5 remedial actions (DOE 1996). The Record of Decision did not specifically define mitigation for wetland impacts, but it did indicate that mitigation would be consistent with Section 404(b)(1) of the Clean Water Act. Compensatory mitigation was also not specifically defined. The need for compensatory mitigation was to be determined after all practicable steps to avoid or minimize adverse impacts were applied.

In June 1995, DOE met with the United States Environmental Protection Agency (EPA), Ohio EPA, the United States Fish and Wildlife Service, and the Ohio Department of Natural Resources (ODNR) to discuss mitigation of impacted wetlands. DOE agreed to conduct on-property (if possible) mitigation and to replace 1.5 acres of wetlands for every acre of wetland dredged or filled. Section 3.2.4 of the NRRP recognizes this agreement.

DOE committed to compensating for 11.9 acres of wetlands, which consist of the original 1993 delineation of 10 acres that were initially anticipated to be impacted as well as an additional 1.9 acres of wetlands delineated during remediation. Figure 1 shows the location of impacted

jurisdictional wetlands. Based on the agreed-upon acreage and mitigation ratio, DOE is responsible for installing 17.85 acres of new wetlands.

Wetland compensation was incorporated into sitewide ecological restoration planning for the site through the NRRP. The NRRP established three separate ecological restoration projects to meet this requirement. Several other ecological restoration projects included a wetland-restoration or wetland-creation component. Also, approximately 26 acres of forested jurisdictional wetlands in the northern woodlot have been preserved on site. A combination of site mitigation projects implemented under the NRRP achieved the negotiated compensatory acreage. The *Fernald Preserve Wetland Mitigation Monitoring Plan* (WMMP, DOE 2009) established a comprehensive process for evaluating and accepting wetland mitigation projects at the Fernald Preserve. The NRTs established a 3-year period of performance for wetland mitigation monitoring, from 2009 through 2011. This *Fernald Preserve, Ohio, Wetland Mitigation Monitoring Report* presents the results of this monitoring effort.

1.2 Conceptual Approach

Based on the final site configuration following ecological restoration, the WMMP established 23 wetland basins within five project areas for mitigation monitoring (Figure 2). Table 1 lists the wetlands evaluated. These areas represent a range of communities and timeframes for ecological restoration at the site. Note that the WMMP originally designated 24 basins for evaluation. However, two basins (BAPW7 and BAPW8) were combined into one sampling unit due to proximity and hydrologic connectivity. This report designates these basins as BAPW7.

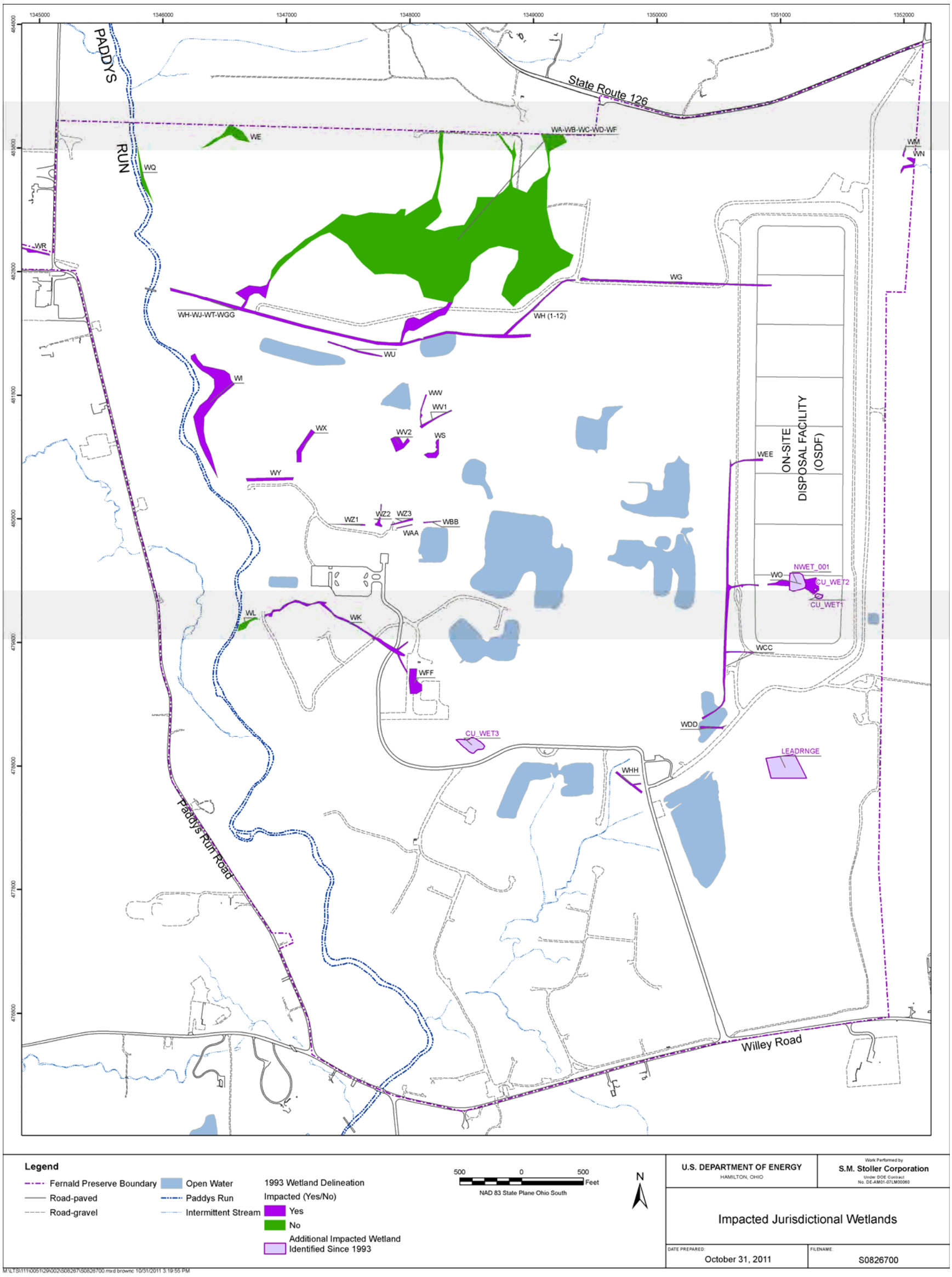

Figure 1. Impacted Jurisdictional Wetlands

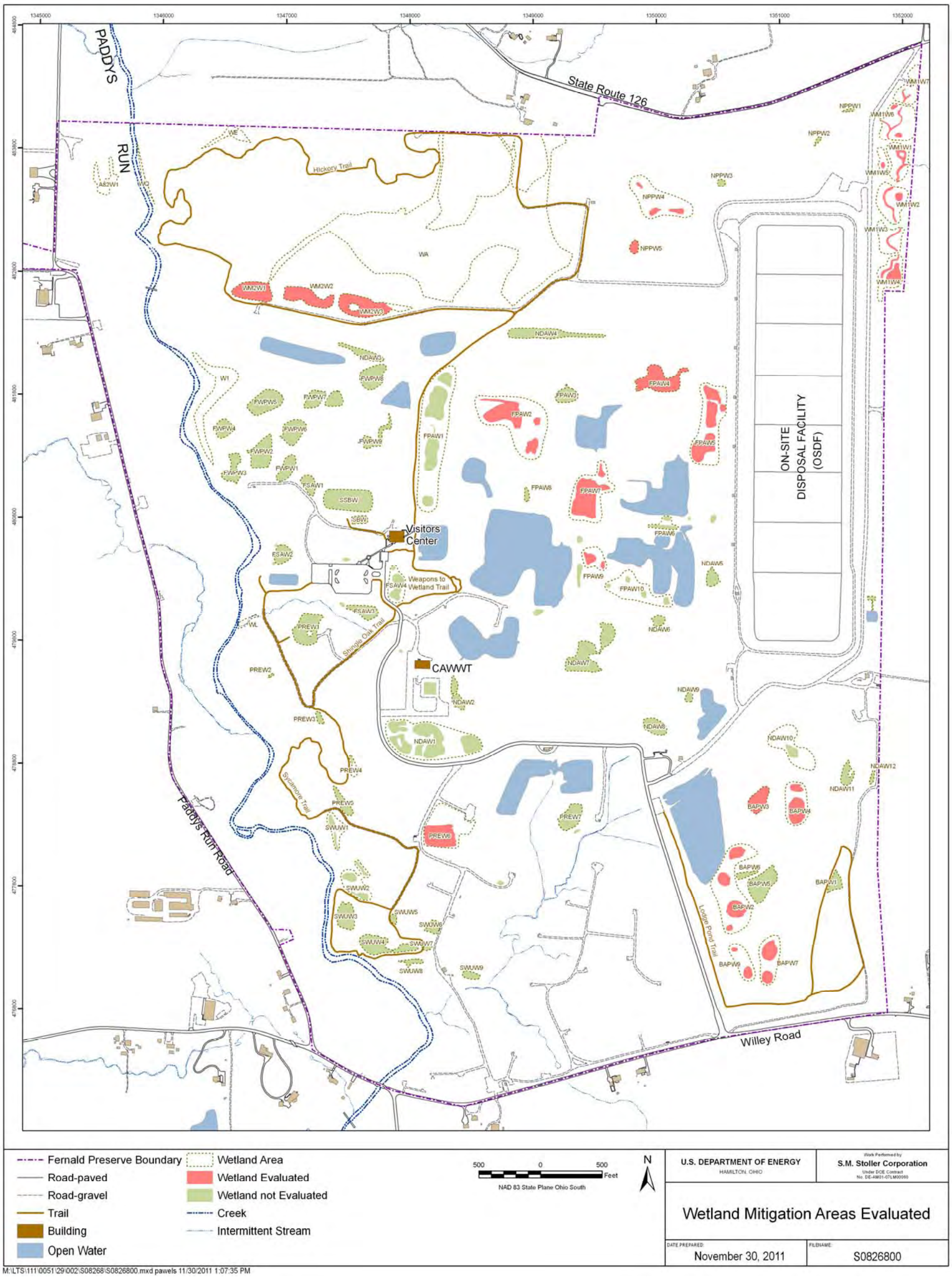

Figure 2. Wetland Mitigation Areas Evaluated

Table 1. Wetland Evaluation Areas

Restoration Project Area	Wetland Area	Approximate Size (acres)	Year Constructed
Borrow Area Project	BAPW2	3.35	2004
	BAPW3	0.56	2005
	BAPW4	1.30	2005
	BAPW7	1.24	2005
	BAPW9	0.83	2005
Former Production Area	FPAW2	4.25	2005
	FPAW4	1.20	2006
	FPAW5	2.91	2006
	FPAW7	2.47	2006
	FPAW9	2.51	2005
	PREW6	2.32	2005
Northern Pine Plantation Enhancement	NPPW4	2.24	2003
	NPPW5	0.14	2003
Wetland Mitigation Phase I	WM1W1	1.00	2000
	WM1W2	1.38	2000
	WM1M3	0.93	2000
	WM1W4	1.08	2000
	WM1W5	0.27	2000
	WM1W6	1.68	2000
	WM1W7	0.77	2000
Wetland Mitigation Phase II	WM2W1	0.94	2004
	WM2W2	0.94	2004
	WM2W3	1.19	2004

The NRTs agreed to adopt Ohio EPA wetland mitigation monitoring protocols as the means for compensatory wetland evaluation. Mack et al. (2004) established a set of monitoring protocols and performance standards for mitigation wetlands, which are designed to ensure that both the processes (functions) and ecological services (values) that an impacted wetland provided are sufficiently restored through the mitigation process. To do this, a multistep evaluation process has been developed to efficiently estimate the size, type, and quality of impacted wetlands. This evaluation results in a set of performance standards that subsequent mitigation wetlands must meet, to ensure that impacted wetlands are replaced with new wetlands that are similar to them in size, type, and quality.

For the Fernald Preserve, wetland impacts occurred years ago as part of remedial activities. The size and type of impacted wetlands can be approximated from the 1993 wetland delineation, but the quality of the wetlands must be inferred from this original jurisdictional delineation and subsequent discussions with regulators. The WMMP used existing information to estimate the size and type of wetlands impacted, as well as an approximation of impacted wetland quality at the site. Table 2 shows the estimates that this effort generated. Table 3 displays the performance standards for mitigation wetlands at the Fernald Preserve that have been established based on the estimates documented in Table 2.

Table 2. Representative Wetland Impact Estimate

Wetland Evaluation Parameter		Estimated Wetland Impact/Type
Size	Acres	11.9
Type	Hydrogeomorphic Class	Impoundment
	Class Modifier	(B) Human
	Plant Community Modifier	(2a) Emergent Marsh
	Dominant Plant Community	(iv) Cattail Marsh
Quality	Category	2

Table 3. Performance Standards for Mitigation Wetlands at the Fernald Preserve

Standard/Parameter	Value	Ohio EPA Standard Section	Comments
Acreage	17.85 acres	2.1.1	Total mitigation acreage that is required based on past impact
Basin morphometry	Less than or equal to 15:1 side slope (6.7%)	2.1.2	Not feasible in some areas, given remediation footprint
Perimeter-to-area ratio	Greater than or equal to 75% of impacted perimeter length	2.1.3	
Hydrologic regime		2.1.4	
Water in root zone (<30 cm)	53% of time		
Mean depth to water	29.4 cm		
Flashiness Index	2.0		
Unvegetated open water	<10%	2.2.1	Not feasible in some areas, given remediation footprint
Native perennial hydrophytes	>75%	2.2.2	
Invasive species	<5%	2.2.3	
Vegetation Index of Biotic Integrity	48–63	2.2.4	
Amphibian Index of Biotic Integrity	NA	2.3	No standard for emergent marsh impoundments
Other taxa groups	NA	2.4	Macroinvertebrates, wetland birds, and reptiles
Soil biogeochemistry		2.5	
% solids	<46.6%		
% total organic carbon	>3.9%		
% total N	>0.5%		

Adapted from Table 8 of the Ohio EPA wetland mitigation performance standards (Mack et al. 2004).
cm = centimeters
NA = not applicable

As discussed in the WMMP, a variety of wetlands have been created or preserved at the Fernald Preserve. A mosaic of open water, emergent marsh, wet prairie, scrub/shrub, and wet forest communities have provided and will continue to provide a number of ecological values and functions, regardless of monitoring and performance standards. Applying published performance

standards to projects that were not necessarily designed and constructed with the standards in mind is problematic. Mitigation wetlands at the Fernald Preserve were driven by the goals of the NRRP and generally aimed to establish native plant communities and promote wildlife use. As a result, some of the wetlands created or preserved at the Fernald Preserve fall within a different (and potentially higher-quality) hydrogeomorphic class and plant community than the impacted wetlands.

Instead of determining "pass/fail" compliance, the NRTs will use the Ohio EPA performance standards listed in Table 3 as a set of reference points for evaluating existing on-site mitigation wetlands. The performance standards form the basis for the monitoring program, and the NRTs will collectively evaluate the results. From this effort, the NRTs will determine the need for corrective action or the creation of additional wetlands. This process is conceptually similar to the functional monitoring approach for restored areas that is described in Section 5 of the NRRP (State of Ohio 2008). The performance standards serve as the "reference community" to which monitored on-site wetland areas are compared.

1.3 Monitoring Period

The WMMP established a 3-year monitoring period, from 2009 through 2011. Table 4 lists the implementation of specific monitoring activities by year. This schedule is slightly different from the one set forth in the WMMP, in that the jurisdictional wetland delineation was conducted in 2011 instead of 2010.

Table 4. Monitoring Schedule for Mitigation Wetlands at the Fernald Preserve

Monitoring Activity	Ohio EPA Standard Section	2009	2010	2011
Delineation	4.1.1			X
Basin morphometry	4.1.2			X
Perimeter-to-area ratio	4.1.3			X
Hydrologic monitoring	4.1.4		X	X
Vegetation sampling	4.2	X		X
Amphibian sampling	4.3	X	X	X
Soil and water sampling	4.5		X	X
Other taxa group sampling	4.4	X	X	X

Adapted from Table 6a of the Ohio EPA wetland mitigation performance standards (Mack 2004).

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2.0 Methods

Ohio EPA provides detailed guidance with respect to monitoring methods and data analysis for evaluation of performance standards (Mack et al. 2004). As Table 3 shows, the chosen performance standards cover a range of wetland functions and services. Evaluation criteria include parameters associated with design (e.g., size and shape), hydrologic regime, vegetation, wildlife, and biogeochemistry. Except where noted below, the Ohio EPA monitoring protocols were used at the Fernald Preserve.

2.1 Design Parameters

Design parameters for mitigation wetlands include acreage, basin morphometry, and perimeter-to-area ratio. Mitigation wetland acreage was estimated via a jurisdictional wetland delineation. The 1987 ACOE *Wetland Delineation Manual* and associated Midwest regional supplement were used to delineate wetland boundaries within all wetland basins evaluated (ACOE 1987, 2008). Fieldwork commenced in late May 2011 and continued through July. Field personnel identified major landscape or vegetation units within each of the 23 wetland areas to be evaluated. One or more sample points were selected from each basin. Two indicator tests were applied to determine the presence of hydrophytic vegetation and hydric soil in order to determine whether the sample point fell within a wetland area, thus determining the wetland boundary. Landscape-level photographs and photographs of vegetation and soil, were taken at each sample point. Each sample point was documented with a Midwest Region Wetland Determination Data Form. Pursuant to Ohio EPA monitoring protocols, net wetland acreage was calculated by subtracting the area of unvegetated open water (above 10 percent) from the total acreage within the delineation boundary. Appendix A–1 provides wetland delineation forms. Appendixes B–1 and B–2 provide, respectively, landscape-level and point-specific photographs. Appendix C includes aerial photographs of wetland basins. The photos are from July 2011. The combination of ground-level and aerial photography provides a good visual overview of wetlands created at the Fernald Preserve.

Basin morphometry and perimeter-to-area ratio were estimated using Graphical Information System (GIS) measurement and analytical tools. Delineation boundaries were used to calculate morphometry via slope histograms. Slope percentage was determined for all areas within the wetland boundary. Slopes less than or equal to 6.7 percent meet the 15:1 performance standard. Section 3.0 below presents the percentage of area that is less than or equal to 6.7 percent for each basin. Pursuant to the Ohio EPA monitoring protocols, the performance standard is met when greater than 50 percent of the wetland area has a slope of less than 6.8 percent. Section 3.0 also provides figures that show plan view depictions of slopes.

The perimeter-to-area ratio was also calculated using delineation boundaries. Ohio EPA protocol calls for a comparison of the mitigation basin to the impacted wetland basin. Considering the design approach described in Section 1.2, a “basin to basin” comparison is not possible. Instead, the perimeter-to-area ratio was calculated as a summed value across all wetland basins evaluated. Perimeter lengths for all impacted wetlands shown on Figure 1 were determined via GIS and summed. This value is then multiplied by 0.75 and compared to the total perimeter lengths of all mitigation wetlands evaluated.

2.2 Hydrologic Regime

Performance standards associated with the hydrologic regime include the amount of time water is present in the root zone, the mean depth to water, and the Flashiness Index of mitigation wetlands. These parameters were measured by installing shallow monitoring wells (piezometers). One piezometer was installed in each wetland basin. Piezometer locations are identified on the figures provided in Section 3.0. Pursuant to Ohio EPA guidance, piezometer locations were selected in the field based on soil types encountered, the boundary of the wetland, and the presence of standing water (Mack et al. 2004).

Piezometer boreholes were drilled using a 6-inch-diameter hand auger to a depth of approximately 3.5 feet below ground surface. The bottom 6 inches of the borehole was filled with sand. The wells were constructed using a 2.5-foot section of schedule 40 PVC 0.010 slot screen. For each piezometer, a friction fit cap with a ¼-inch hole drilled in the center (to act as a drain) was installed on the bottom of the well. The base of the screen was set at 3 feet below ground surface. A 5-foot riser was threaded to the screened section. Sand was then added to fill the annulus around the well up to 4 inches below ground surface. Bentonite pellets were used to top off the first 4 inches of the borehole. A lockable cap was placed on top of the riser to complete the installation. Transducers, which record and store water level data, were then installed in the piezometers. Figure 3 depicts the piezometer construction and the transducer placement.

Piezometers were installed in December 2009, and data collection began in January 2010. Transducers and data loggers allowed for hourly water level measurements. From these datasets, twice-daily readings were used to calculate performance standard values and develop hydrographs. Data are reported through October 15, 2011.

2.3 Vegetation Parameters

Vegetation parameters include Vegetation Index of Biotic Integrity (VIBI), percentage of native perennial hydrophytes, and percentage of invasive species. All vegetation data were obtained via fixed-plot sampling pursuant to Ohio EPA methodology (Mack 2007). Field personnel laid out a 1,000-square-meter grid across representative vegetation within each of the 23 wetland basins evaluated. The typical plot arrangement consisted of modules (which measured 10 meters [m] by 10 m) arranged in a 20-m-by-50-m grid (Figure 4). In order to ensure representative conditions, plots were sometimes arranged in a 10-m-by-100-m configuration. For each basin, 4 of the 10 modules were intensively surveyed, and species richness and cover estimates were collected. Biomass samples were also collected from each of the four intensive modules. The use of four biomass samples is a slight deviation from Ohio EPA protocols, which recommend eight samples. The number of samples was reduced due to the number of basins evaluated.

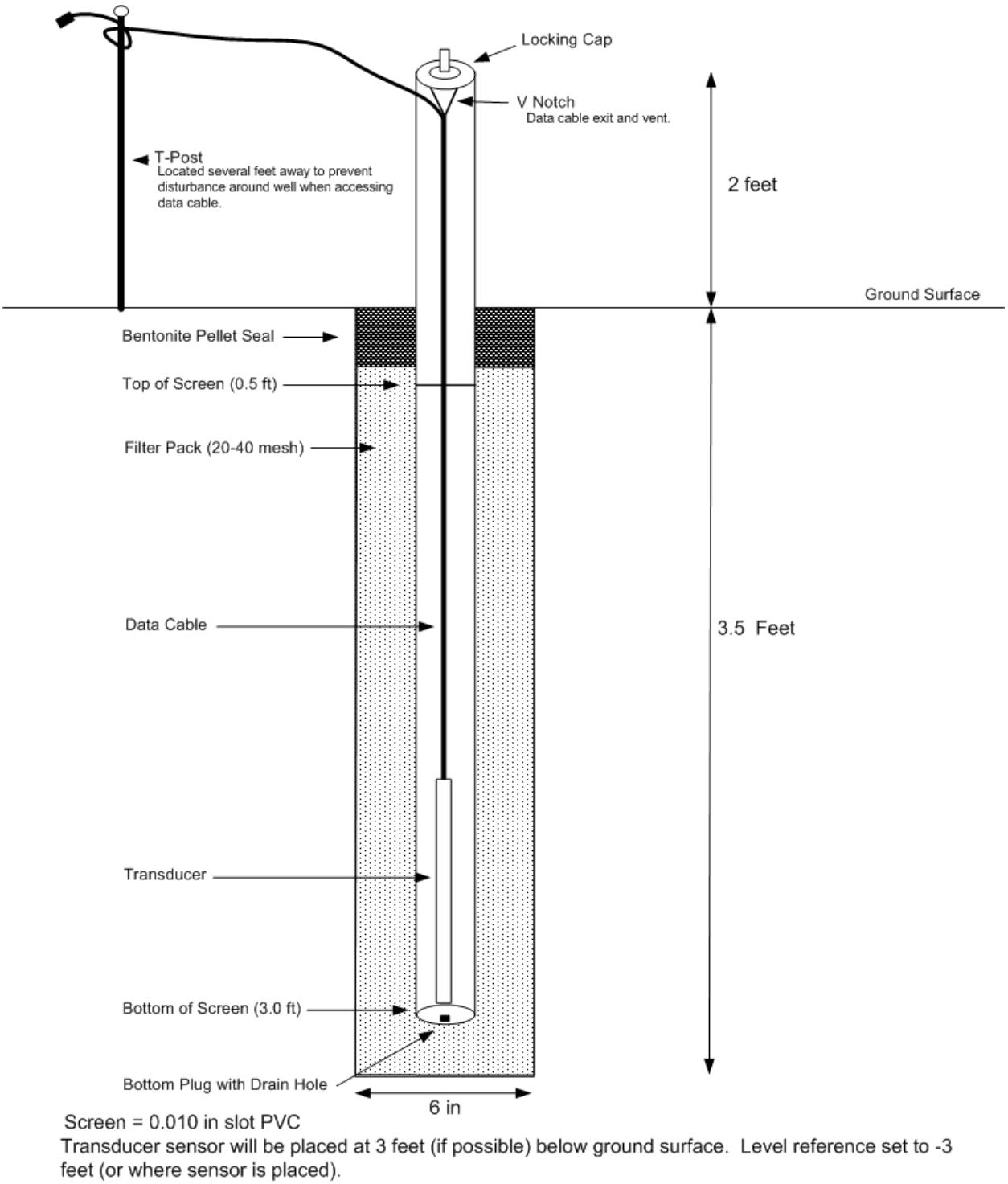

Figure 3. Schematic of Piezometer

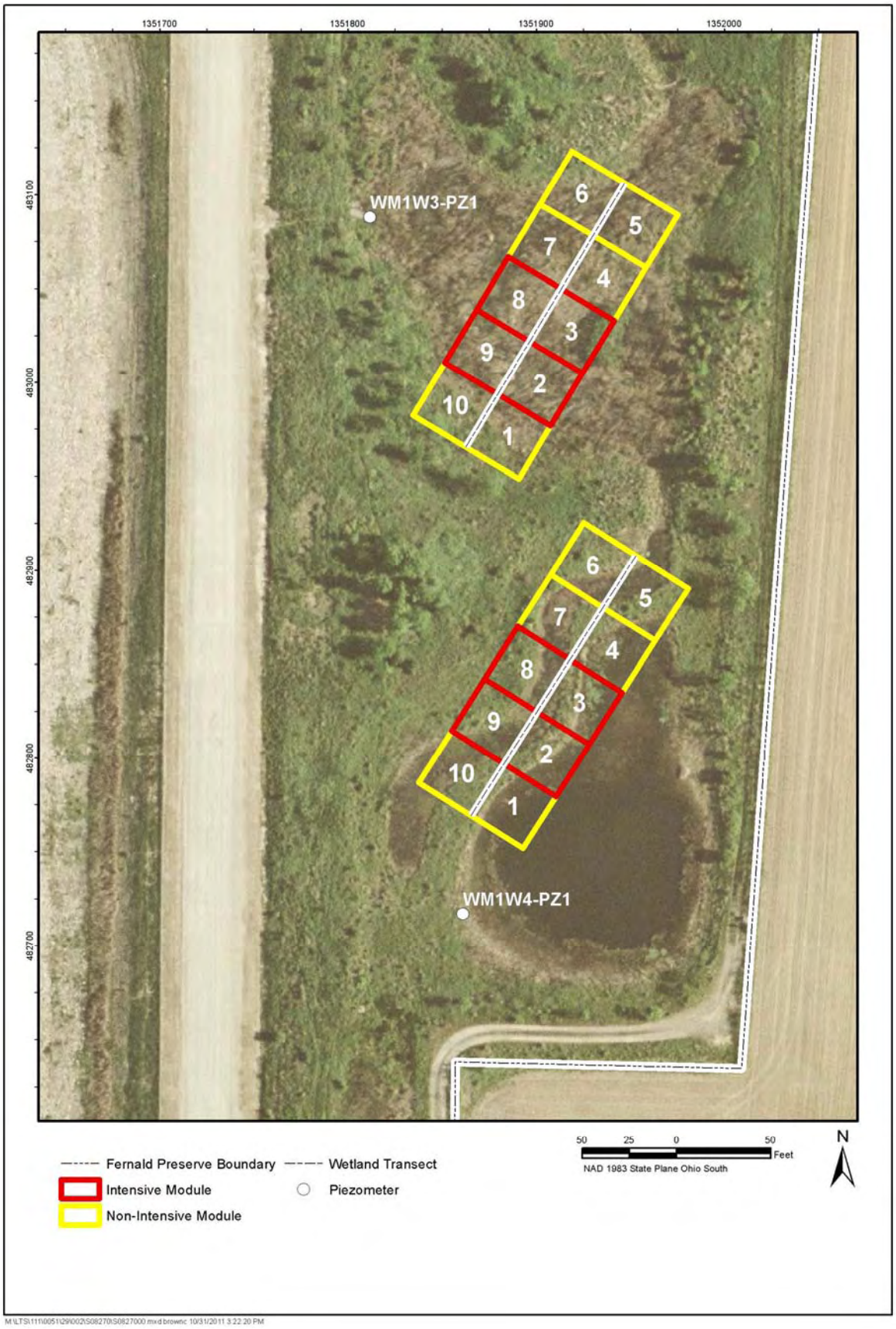

Figure 4. Typical Fixed-Plot VIBI Module

Vegetation monitoring took place between June and August in 2009 and 2011. The wetland communities were reassessed in 2011, so the locations of fixed plots were altered slightly in some instances. Figures in Section 3.0 depict fixed-plot locations for both years. All field data were entered into an Access database, and VIBI scores were calculated for emergent wetlands pursuant to Mack (2007). Section 3.0 provides, for each basin, all of the metrics that enter into the VIBI scoring system. Metrics include carex species richness, dicot species richness, shrub species richness, hydrophyte species richness, annual-to-perennial species ratio, Floristic Quality Assessment Index (FQAI), percentage of sensitive species, percentage of tolerant species, percentage of invasive species, and biomass. Percentages of native hydrophytes and invasive species were also calculated based on total species richness for each basin. Section 3.0 presents the results from 2009 and 2011. Appendix A–2 provides basin-specific species lists for 2011. Species lists from 2009 are available in the 2009 Site Environmental Report (DOE 2010). Appendix B–3 presents photographs of fixed-plot modules.

All vegetation characterization information was obtained from the Ohio FQAI database (Andreas et al. 2004). The percentage of sensitive species includes vegetation with a coefficient of conservatism (CC) of 6 or above, while tolerant species are plants with a CC of 3 or below.

2.4 Wildlife Parameters

As Table 3 shows, there are no specific performance standards for evaluating wildlife parameters. However, the NRTs agreed that wildlife parameters would help with determining success. Field personnel collected amphibians and macroinvertebrates with funnel traps pursuant to Ohio EPA protocols (Micacchion 2004). This process involves placing 10 funnel traps within a basin, at an interval to ensure complete coverage of the water's edge. The traps are retrieved after 24 hours and consolidated, and the amphibian species richness and abundance is recorded. Field personnel also determine richness and abundance for macroinvertebrates. Three monitoring events take place in the spring and early summer, in order to ensure that the full season of amphibian larval development is sampled.

Amphibian Index of Biotic Integrity (AIBI) was calculated for selected basins within each mitigation wetland area. Data were collected during spring 2010 and spring 2011. Section 3.0 presents summary data, and Appendix A–3 presents basin-specific results from 2011. Appendix B–3 includes photographs from 2011.

While the use of funnel traps is intended to gather amphibian and macroinvertebrate data, they collect other aquatic species as well. Fish and reptiles were also inventoried. This information is provided in Section 3.0 and Appendix A–3. Photographs from funnel trap sampling in 2011 are provided in Appendix B-4.

Several other wildlife characterization activities also took place. Migratory and breeding bird populations were characterized as part of the Ohio Breeding Bird Atlas program. The Ohio Breeding Bird Atlas program is a multiyear data-gathering effort that documents the distribution of breeding birds in Ohio, assesses changes in breeding distributions, identifies important habitats and breeding locations that support species of concern, and collects detailed information on the current status of the state's rare, threatened, and endangered species. Ohio State University (OSU) and ODNR directed the study. OSU prescribes methods for data collection, as documented in the *Atlas Volunteer Handbook* (OSU and ODNR 2011). Field data collection

involved canvassing habitat in the mornings during peak activity periods in June and July, using binoculars, spotting scopes, and knowledge of songs to identify nesting birds. Recordings were used on rare occasions in an attempt to confirm the presence of owls and certain wading birds such as American and least bitterns. Once a species was observed, the data were documented on the prescribed forms. Observation categories included species simply observed, possible and probable nesters, and confirmed nesters. Confirmed nesters were documented using a number of factors, such as nest building, carrying food, and the presence of fledged young.

Reptile and small mammal populations were sampled via reptile coverboards. Corrugated metal boards (2 feet by 4 feet) have been placed around wetland basins in the Borrow Area Project (BAP), Northern Pine Plantation (NPP), Wetland Mitigation Phase I (WM1), and Wetland Mitigation Phase II (WM2) wetlands. Field personnel check each coverboard biweekly from April to October and record reptile and small mammals observed. Section 3.0 presents species richness and abundance.

2.5 Soil and Water Chemistry

Soil and water samples were collected for each wetland basin in 2010 and 2011. A project-specific sampling plan was developed in accordance with standard sampling procedures at the Fernald Preserve (DOE 2011). The sampling plan was consistent with Ohio EPA monitoring protocols (Mack et al. 2004). Further detail is provided below.

2.5.1 Soil Biogeochemistry Sampling

Soil sampling locations depend on wetland morphometry and size. Five samples were collected from each wetland basin, in the pattern below (Figure 5):

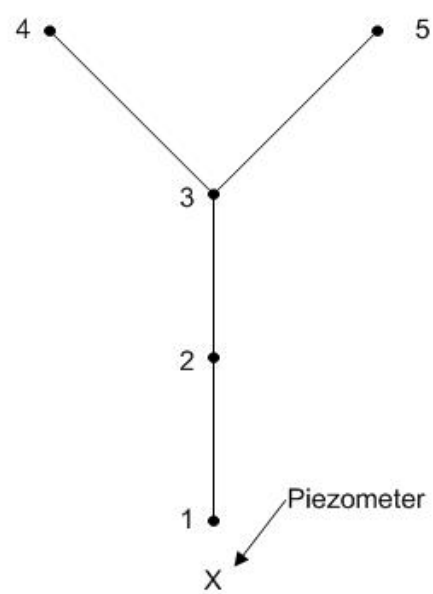

Figure 5. Typical Soil Sampling Pattern

- Sample 1 was collected approximately 10 m from the piezometer toward the center of the wetland.
- Sample 2 was collected halfway between location 1 and the approximate center of the wetland.
- Sample 3 was collected at the approximate center of the wetland.
- Samples 4 and 5 were collected halfway between the approximate center of the wetland and the far edge of the wetland, at a 45-degree angle from initial line (i.e., the line made by locations 1 through 3).
- A sixth soil sample was collected from the center of each of the fixed-plot vegetation sampling modules.

In several wetlands, Sample 1 was located near the edge of the wetland instead of 10 m from the piezometer. This decision was made because the sampling layout depends on the piezometer location, and some piezometers are near the center of the wetland. This change allows for better sampling coverage across the entire wetland. The affected wetlands are WM2W2, WM1W2, WM1W7, NPPW4, FPAW9, BAPW4, and BAPW9.

In addition, some sampling locations had to be moved because they were in areas where the water depth was greater than 3 feet or the location was obstructed (e.g., by shrubs or rocks). The sampling locations were moved to the left or right, on a line approximately perpendicular to the sampling location's original position. If the sampling location was moved greater than 3 feet, then the location was identified by adding the suffix "A" to the original sampling location identifier, and surveyed (Figure 6).

Soil sampling and fixed-plot locations are identified on the area-specific figures in Section 3.0. Samples were collected annually, between June 15 and August 30, from 0 to 4 inches below grade, per the *Fernald Preserve Environmental Monitoring Procedures* (DOE 2011). Samples were collected using a 3-inch stainless-steel core sampler with a butyrate liner. Samples collected below the water surface were collected so that the loose, saturated sediment at the surface was not lost while retrieving the liner from below the water. A photograph of the sampling location was taken standing 10 feet south of the location, facing north.

2.5.2 Water Sampling

Surface water samples were collected from the edge of each wetland basin, nearest the piezometer. Sampling locations are identified on the area-specific figures in Section 3.0. Samples were collected annually, in May, as close to the original sampling location as possible, per Section 6.0, "Liquids Sample Collection," of the *Fernald Preserve Environmental Monitoring Procedures* (DOE 2011). Samples were analyzed for inorganics (iron, magnesium, and potassium), general chemistry parameters (ammonia as N, total Kjeldahl nitrogen, total organic carbon, chloride, nitrate/nitrite, total phosphorous, total suspended solids, and total solids), and field parameters (pH, specific conductance, dissolved oxygen, and temperature).

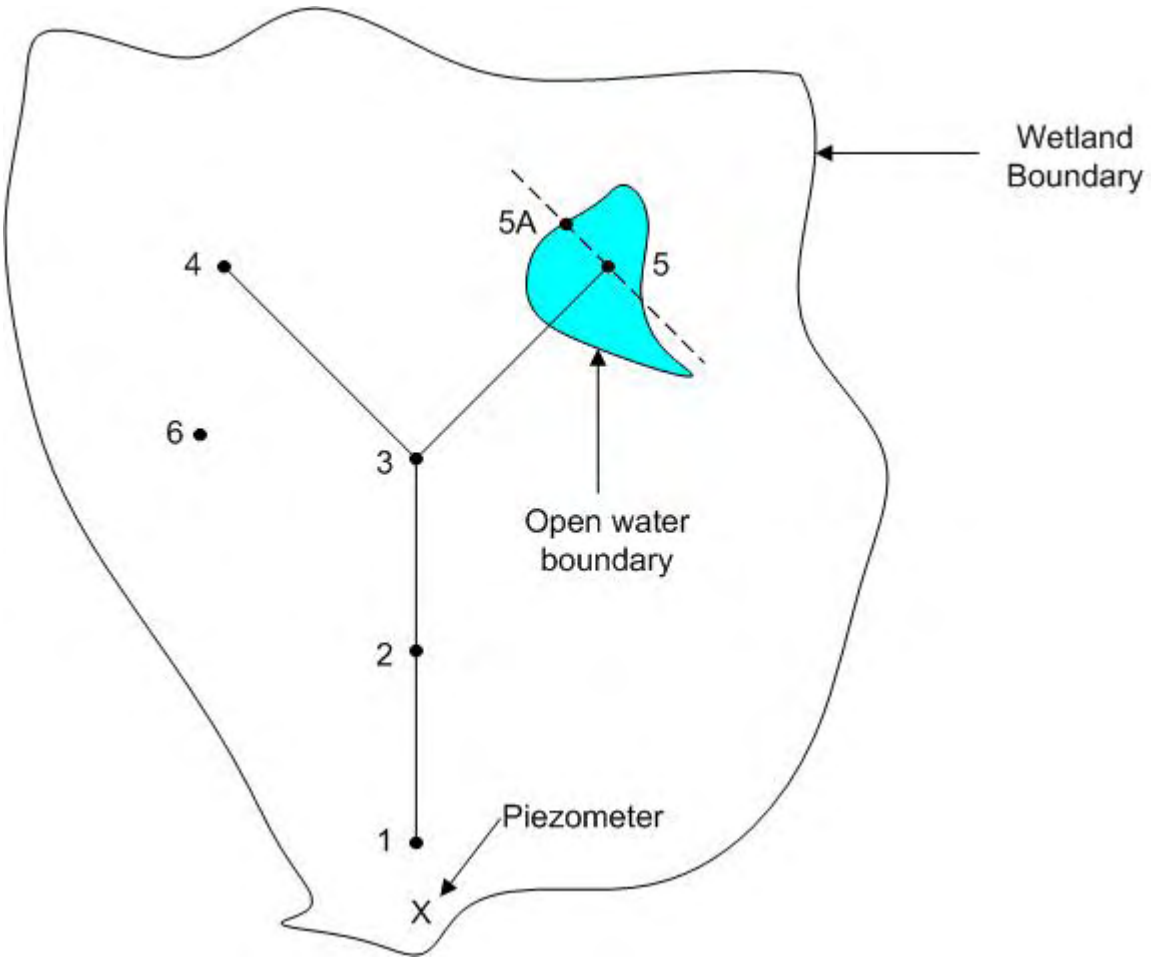

Figure 6. Typical Soil Sampling Pattern with Sample Point Relocation

3.0 Results and Discussion

Each of the five wetland areas is discussed below. Summary tables are provided for all data collected. Figures show wetland delineation boundaries, photograph locations, sample points, and basin morphometry. Appendixes to this report provide basin-specific delineation forms, species lists, and photographs. Each wetland area is briefly described below. However, the WMMP has a more detailed description of each restoration project (DOE 2009).

Most performance standards are compared on an area-specific or basin-specific basis. However, as discussed in Section 2.1, the perimeter-to-area ratio was required to be reviewed sitewide. The total perimeter length for impacted wetlands is 40,042 feet. The perimeter length for all mitigation wetlands is a combined 33,587 feet. The total mitigation length is approximately 84 percent of the total impacted wetland length. Therefore, the 75 percent performance standard is met.

3.1 Borrow Area Project

The BAP wetlands include a series of emergent basins and swales, surrounded by wet prairie communities. The basins and swales are all situated within the footprint of the former Borrow Area, from which clay was excavated and processed for use in the construction of the On-Site Disposal Facility. There is connectivity between the basins via periodic flooding and through several swales that were excavated between several of the basins. As stated in Table 1, basins were constructed from 2004 to 2005. The photographs provided in Appendix B–1 and B–3 show that the BAP wetlands consist of well-established herbaceous vegetation, with interspersed trees and shrubs that are both planted and naturally established.

3.1.1 BAP Design Parameter Results

A jurisdictional wetland delineation was conducted on each of the basins. Table 5 provides delineation acreages. The total delineated acreage for BAP is approximately 13 acres. Figure 7 presents mapped boundaries. Note that wetland communities expanded in the western portion of the basins, to the point that basins BAPW-2, BAPW-7, and BAPW-9 were combined into one area. This is primarily due to expanded stands of prairie cordgrass (*Spartina pectinata*) and switchgrass (*Panicum virgatum*). The delineation boundary on the northern edge of BAPW2 is estimated. It’s cut off as the area transitions into the open water Lodge Pond (Figure 7). Field personnel stopped mapping at the edge of emergent vegetation across the pond.

Table 5 provides basin morphometry calculations, and Figure 8 shows graphical information. These results indicate that all BAP basins meet the basin morphometry performance standard.

3.1.2 BAP Hydrologic Regime Results

Hydrology within BAP is characterized through data collected from five piezometers, as shown on Figure 9. Table 6 presents the results for each basin. Figures 10 through 14 show basin-specific hydrographs. All hydrologic performance standards were met in 2011. A faulty transducer prevented accurate data collection for BAPW2 in 2010. The 2011 results more accurately reflect the hydrology of BAPW2. The annual hydrographs in Figures 10 through 14 compare favorably to depression wetlands as described in Mack (2007).

Table 5. Borrow Area Project Design Parameter Summary

Basin	Parameter	Performance Standard	Result
BAPW2	Delineation Acreage	NA	*
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	*
	Morphometry	<15:1 side slope	*
BAPW3	Delineation Acreage	NA	2.75
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	2.75
	Morphology	<15:1 side slope	84%
BAPW4	Delineation Acreage	NA	3.03
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	3.03
	Morphometry	<15:1 side slope	86%
BAPW7	Delineation Acreage	NA	*
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	*
	Morphometry	<15:1 side slope	*
BAPW9	Delineation Acreage	NA	7.47
	Acreage of Unvegetated Open Water >10%	NA	0.15
	Actual Wetland Acreage	NA	7.32
	Morphometry	<15:1 side slope	76%

*BAPW2, BAPW7, and BAPW9 were combined into one delineation boundary.
NA = not applicable

Table 6. Borrow Area Project Hydrologic Regime Summary

Basin	Parameter	Performance Standard	2010	2011
BAPW2	Water in Root Zone (<30 cm)	>53%	6%	61%
	Mean Depth of Water	29.4 cm	66	25
	Flashiness Index	<2.0	0.74	0.58
BAPW3	Water in Root Zone (<30 cm)	>53%	71%	76%
	Mean Depth of Water	29.4 cm	25	13
	Flashiness Index	<2.0	0.45	0.81
BAPW4	Water in Root Zone (<30 cm)	>53%	73%	76%
	Mean Depth of Water	29.4 cm	14	17
	Flashiness Index	<2.0	0.53	0.8
BAPW7	Water in Root Zone (<30 cm)	>53%	68%	73%
	Mean Depth of Water	29.4 cm	32	26
	Flashiness Index	<2.0	0.41	0.41
BAPW9	Water in Root Zone (<30 cm)	>53%	67%	71%
	Mean Depth of Water	29.4 cm	28	18
	Flashiness Index	<2.0	0.67	0.89

cm = centimeters

Figure 7. Borrow Area Project Wetland Delineation Boundaries

Figure 8. Borrow Area Project Wetland Morphometry

Figure 9. Borrow Area Project Wetland Sampling Locations

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3.1.3 BAP Vegetation Parameter Results

Table 7 presents results from vegetation sampling, and Figure 9 shows fixed-plot module locations. The performance standard for unvegetated open water was obtained for all basins in both 2009 and 2011.

For percentage of native perennial hydrophytes, only BAPW2 met the performance standard in 2011. However, improvement was observed in three of the other four basins. BAPW7 was consistently the lowest performer in this category. A review of the species list in Appendix A–2 shows a relatively high percentage of cover for several nonnative species, including redtop (*Agrostis gigantea*) and Eurasian water-nymph (*Najas minor*).

Results were mixed for VIBI performance within BAP. Basins BAPW2 and BAPW7 met the performance standard in both 2009 and 2011. Improvement was observed in BAPW3, while BAPW4 and BAPW9 had lower VIBI scores in 2011. Figure 15 shows that VIBI scoring metrics varied considerably between 2009 and 2011. No specific trends are discernable at this time.

3.1.4 BAP Wildlife Parameter Results

Table 8 presents amphibian sampling results and calculations of AIBI. Only BAPW7 scored above zero. The species list in Appendix A–3 shows that a cricket frog (*Acris crepitans*) was collected in BAPW7. Cricket frogs are considered sensitive species, and thus they are assigned a CC of 7. These findings are not unexpected for BAP. The community is isolated from any forested communities. Also, as Table 9 shows, green sunfish (*Lepomus cyanellus*) have been observed in the connected Lodge Pond. These fish are known to heavily predate amphibian and macroinvertebrate populations. Previous informal sampling efforts within BAP have revealed severe predation impacts.

Other species listed in Table 9 show that the BAP wetlands support a diverse wildlife community. Migratory waterfowl are of particular interest, as the basins support a variety of dabbling ducks, diving ducks, and shorebirds. Local birders frequent the Lodge Pond Trail, which encircles BAP (Figure 7).

3.1.5 BAP Soil and Water Chemistry Results

Tables 10 and 11 summarize soil and water sampling in BAP. Soil biogeochemistry performance standards were not met for any of the basins. These results are generally consistent across all wetlands sampled. Water chemistry results in 2011 appear within expected ranges for all parameters sampled. Field measurements for pH appear high in 2010. After reviewing the 2011 results, which are more in line with expected values, it is suspected that there may have been an issue with the field instrumentation.

Table 7. Borrow Area Project Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
BAPW2	% Unvegetated Open Water	<10%	0.1%	NA	1.3%	NA
	% Native Perennial Hydrophytes	>75%	89.7%	NA	84.3%	NA
	VIBI	48–63	50	NA	46	NA
	Carex Richness	NA	3	3	2	3
	Dicot Richness	NA	26	10	11	3
	Shrub Richness	NA	1	0	1	0
	Hydrophyte Richness	NA	23	7	18	3
	Annual-to-Perennial Ratio	NA	0.40	3	0.37	3
	FQAI	NA	15.90	7	15.73	7
	% Sensitive Species	NA	1.7%	0	1.9%	0
	% Tolerant Species	NA	39.3%	0	33.9%	7
	% Invasive Species	<5%	0.2%	0	0.0%	10
	Biomass (g/m^2)	NA	561	3	136	10
BAPW3	% Unvegetated Open Water	<10%	0.1%	NA	2.0%	NA
	% Native Perennial Hydrophytes	>75%	81.2%	NA	67.2%	NA
	VIBI	48–63	32	NA	42	NA
	Carex Richness	NA	3	3	3	3
	Dicot Richness	NA	12	3	11	3
	Shrub Richness	NA	1	0	2	3
	Hydrophyte Richness	NA	20	3	24	7
	Annual-to-Perennial Ratio	NA	0.36	3	0.28	7
	FQAI	NA	12.82	3	12.50	3
	% Sensitive Species	NA	2.1%	0	1.6%	0
	% Tolerant Species	NA	43.7%	3	50.0%	3
	% Invasive Species	<5%	4.4%	7	19.0%	3
	Biomass (g/m^2)	NA	332	7	112	10
BAPW4	% Unvegetated Open Water	<10%	4.4%	NA	1.3%	NA
	% Native Perennial Hydrophytes	>75%	16.3%	NA	61.8%	NA
	VIBI	48–63	36	NA	23	NA
	Carex Richness	NA	4	7	4	7
	Dicot Richness	NA	17	3	10	0
	Shrub Richness	NA	1	0	1	0
	Hydrophyte Richness	NA	28	7	22	7
	Annual-to-Perennial Ratio	NA	0.42	3	0.36	3
	FQAI	NA	11.70	3	10.93	3
	% Sensitive Species	NA	5.3%	3	0.9%	0
	% Tolerant Species	NA	86.3%	0	60.6%	0
	% Invasive Species	<5%	19.9%	3	20.2%	3
	Biomass (g/m^2)	NA	449	7	99	0

Table 7 (continued). Borrow Area Project Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
BAPW7	% Unvegetated Open Water	<10%	3.3%	NA	1.8%	NA
	% Native Perennial Hydrophytes	>75%	52.4%	NA	55.5%	NA
	VIBI	48–63	50	NA	50	NA
	Carex Richness	NA	3	3	5	10
	Dicot Richness	NA	18	7	13	3
	Shrub Richness	NA	1	0	1	0
	Hydrophyte Richness	NA	26	7	27	7
	Annual-to-Perennial Ratio	NA	0.29	7	0.30	7
	FQAI	NA	12.36	3	11.88	3
	% Sensitive Species	NA	0.0%	0	5.5%	3
	% Tolerant Species	NA	58.3%	3	64.5%	0
	% Invasive Species	<5%	1.2%	10	1.7%	10
	Biomass (g/m^2)	NA	193	10	201	7
BAPW9	% Unvegetated Open Water	<10%	4.8%	NA	3.0%	NA
	% Native Perennial Hydrophytes	>75%	41.8%	NA	70.2%	NA
	VIBI	48–63	59	NA	29	NA
	Carex Richness	NA	4	7	3	3
	Dicot Richness	NA	21	7	11	3
	Shrub Richness	NA	1	0	1	0
	Hydrophyte Richness	NA	25	7	18	3
	Annual-to-Perennial Ratio	NA	0.22	7	0.30	7
	FQAI	NA	14.85	7	11.15	3
	% Sensitive Species	NA	0.0%	0	0.0%	0
	% Tolerant Species	NA	36.5%	7	61.3%	0
	% Invasive Species	<5%	0.0%	10	0.1%	10
	Biomass (g/m^2)	NA	441	7	98	0

g/m^2 = grams per square meter
NA = not applicable

Table 8. Borrow Area Project AIBI Summary

Basin	Parameter	2010	AIBI Score	2011	AIBI Score
BAPW2	AIBI	NA	**0**	NA	**0**
	Amphibian Quality Assessment Index	2.00	0	1.60	0
	% Relative Abundance of Sensitive Species	0%	0	0%	0
	% Relative Abundance of Tolerant Species	100%	0	100%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
BAPW4	AIBI	NA	**0**	NA	**0**
	Amphibian Quality Assessment Index	2.00	0	1.00	0
	% Relative Abundance of Sensitive Species	0%	0	0%	0
	% Relative Abundance of Tolerant Species	100%	0	100%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
BAPW7	AIBI	NA	**0**	NA	**13**
	Amphibian Quality Assessment Index	2.00	0	3.20	3
	% Relative Abundance of Sensitive Species	0%	0	20%	7
	% Relative Abundance of Tolerant Species	100%	0	60%	3
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0

NA = not applicable

Table 9. Borrow Area Project Other Wildlife Summary

Amphibian Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Acris crepitans*	cricket frog	NA	0	1
Funnel Traps	*Anaxyrus americanus*	American toad	NA	83	0
Funnel Traps	*Lithobates catesbeiana*	American bull frog	NA	38	13
Funnel Traps	*Lithobates clamitans*	green frog	NA	0	2
Funnel Traps	*Lithobates pipiens*	northern leopard frog	NA	0	1
Funnel Traps	*Lithobates species*	frog species	NA	4	22
Funnel Traps	*Pseudacris crucifer*	spring peeper	NA	0	1
Bird Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Actitis macularius*	spotted sandpiper	NA	NA	NA
Observation	*Agelaius phoeniceus*	red-winged black bird	NA	NA	NA
Observation	*Anas platyrhynchos*	mallard	NA	NA	NA
Observation	*Ardea herodias*	great blue heron	NA	NA	NA
Observation	*Aythya americana*	redhead duck	NA	NA	NA
Observation	*Aythya collaris*	ring necked duck	NA	NA	NA
Observation	*Aythya valisineria*	canvasback	NA	NA	NA
Observation	*Butorides virescens*	green heron	NA	NA	NA

Table 9 (continued). Borrow Area Project Other Wildlife Summary

Bird Summary (continued)			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Casmerodius albus*	great egret	NA	NA	NA
Observation	*Circus cyaneus*	northern harrier	NA	NA	NA
Observation	*Cygnus olor*	mute swan	NA	NA	NA
Observation	*Egretta thula*	snowy egret	NA	NA	NA
Observation	*Ixobrychus exilis*	least bittern	NA	NA	NA
Observation	*Megaceryle alcyon*	belted kingfisher	NA	NA	NA
Observation	*Molothrus ater*	brown-headed cowbird	NA	NA	NA
Observation	*Quiscalus quiscula*	common grackle	NA	NA	NA
Fish Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Lepomus cyanellus*	green sunfish	0	37	98
Macroinvertebrate Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Belostomatidae	giant waterbug	NA	0	10
Funnel Traps	Family: Calopterygidae	broad-winged damselfly	NA	0	19
Funnel Traps	Family: Coenagrionidae	narrow-winged damselfly	NA	0	13
Funnel Traps	Order: Coleoptera	beetle	NA	23	0
Funnel Traps	Family: Corydalidae	dobsonfly, fishfly	NA	1	0
Funnel Traps	Family: Corixidae	water boatman	NA	0	3
Funnel Traps	Family: Dytiscidae	predaceous diving beetle	NA	0	2
Funnel Traps	Order: Ephemeroptera	mayfly	NA	1	4
Funnel Traps	Family: Gammaridae	sideswimmer/scud	NA	0	1
Funnel Traps	Family: Haliplidae	crawling water beetle	NA	0	42
Funnel Traps	Order: Haplotaxida (Tubificina)	freshwater worm	NA	3	5
Funnel Traps	Family: Hirudinidae	leech	NA	2	0
Funnel Traps	Family: Hydrachnidiae	mite	NA	1	5
Funnel Traps	Family: Hydrophilidae	water scavanger	NA	0	13
Funnel Traps	Family: Lymnaeidae	pond snail	NA	23	8
Funnel Traps	Family: Naucoridae	creeping water bug	NA	0	3
Funnel Traps	Family: Nepidae	water scorpian	NA	0	8
Funnel Traps	Family: Notonectidae	backswimmer	NA	3	1
Funnel Traps	Order:Odonata,Sub-Order:Anisoptera	dragonfly	NA	1	18
Funnel Traps	Order: Odonata, Sub-Order: Zygoptera	damselfly	NA	0	19
Funnel Traps	Family: Perlidae	stonefly	NA	1	0
Funnel Traps	Family: Physidae	pouch snail	NA	209	567
Funnel Traps	Family: Planorbidae	ramhorn snail	NA	29	140
Funnel Traps	Order: Trichoptera	caddisfly	NA	0	2
Funnel Traps	Order: Unionoida	clam	NA	0	1

Table 9 (continued). Borrow Area Project Other Wildlife Summary

Reptile Summary			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Thamnophis sirtalis*	eastern garter snake	6	47	45
Small Mammal Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Blarina brevicauda*	short-tailed shrew	0	2	0
Coverboards	*Cryptotis parva*	least-tailed shrew	0	1	0
Coverboards	*Microtus pennsylvanicus*	meadow vole	33	17	3
Coverboards	*Mus musculus*	field mouse	0	0	6
Coverboards	*Peromyscus maniculatus*	deer mouse	140	74	15
Coverboards	*Synaptomys cooperi*	bog lermming	1	0	0

NA = not applicable

Table 10. Borrow Area Project Soil Sampling Summary

Basin	Parameter	Performance Standard (%)	2010				2011			
			N	Median (%)	Q_1 (%)	Q_2 (%)	N	Median (%)	Q_1 (%)	Q_2 (%)
BAPW2	% Solids	<46.6	6	76.6	70.6	86.4	6	75.4	62.3	88.3
	% Total Organic Carbon	>3.9	6	0.748	0.705	0.815	6	1.16	1.11	1.22
	% Total Nitrogen	>0.5	6	0.105	0.0695	0.113	6	0.185	0.125	0.252
BAPW3	% Solids	<46.6	6	66.4	58.5	74	6	74.3	73.8	75.8
	% Total Organic Carbon	>3.9	6	1.01	0.945	1.24	6	0.536	0.45	0.76
	% Total Nitrogen	>0.5	6	0.105	0.0787	0.129	6	0.101	0.0947	0.11
BAPW4	% Solids	<46.6	6	76.1	72.6	80	6	74.6	70.1	78.9
	% Total Organic Carbon	>3.9	6	0.919	0.586	1.65	6	0.865	0.677	0.951
	% Total Nitrogen	>0.5	6	0.0704	0.0649	0.116	6	0.09	0.0721	0.0955
BAPW7	% Solids	<46.6	6	72.9	68.5	79.3	6	67.3	63	76.7
	% Total Organic Carbon	>3.9	6	1.62	1.12	2.68	6	1.59	1.35	1.89
	% Total Nitrogen	>0.5	6	0.12	0.0987	0.135	6	0.222	0.2	0.278
BAPW9	% Solids	<46.6	6	80.1	72.9	84.9	6	85.7	71.8	90.4
	% Total Organic Carbon	>3.9	6	1.48	1.16	1.87	6	1.52	1.39	1.76
	% Total Nitrogen	>0.5	6	0.235	0.189	0.285	6	0.41	0.383	0.446

Table 11. Borrow Area Project Water Sampling Summary

Basin	Parameter	Units	2010	2011
BAPW2	Ammonia Total as Nitrogen	mg/L	0.269	0.228
	Chloride	mg/L	1.63	0.534
	Dissolved Oxygen	mg/L	5.85	11.54
	Iron	mg/L	0.828	0.872
	Magnesium	mg/L	18.6	14.7
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	1.25
	Oxidation Reduction Potential	mV	82	5.5
	pH	unitless	8.38	7.66
	Phosphorous	mg/L	0.342	0.3
	Potassium	mg/L	4.03	3.37
	Specific Conductance	umhos/cm	399	294
	Temperature	C	27.62	26.67
	Total Kjeidahl Nitrogen	mg/L	1.52	1.78
	Total Organic Carbon	mg/L	21.6	16.6
	Total Solids	mg/L	287	438
	Total Suspended Solids	mg/L	208	184
	Turbidity	NTU	8.09	2.65
BAPW3	Ammonia Total as Nitrogen	mg/L	0.055	0.278
	Chloride	mg/L	1.68	0.624
	Dissolved Oxygen	mg/L	11.15	3.35
	Iron	mg/L	4.18	19.1
	Magnesium	mg/L	19.1	17.6
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.127
	Oxidation Reduction Potential	mV	78.5	-67
	pH	unitless	8.85	7.06
	Phosphorous	mg/L	<0.189	0.3
	Potassium	mg/L	2.92	3.47
	Specific Conductance	umhos/cm	387	407
	Temperature	C	28.38	27.62
	Total Kjeidahl Nitrogen	mg/L	0.104	1.07
	Total Organic Carbon	mg/L	26.3	22.1
	Total Solids	mg/L	445	463
	Total Suspended Solids	mg/L	113	217
	Turbidity	NTU	58.7	4.25
BAPW4	Ammonia Total as Nitrogen	mg/L	0.063	0.212
	Chloride	mg/L	4.72	1.21
	Dissolved Oxygen	mg/L	6.58	10.04
	Iron	mg/L	1.47	1.71
	Magnesium	mg/L	23.9	17.9
	Nitrate + Nitrite as Nitrogen	mg/L	0.108	<0.01
	Oxidation Reduction Potential	mV	101	24
	pH	unitless	8.48	7.79
	Phosphorous	mg/L	<0.135	<0.1
	Potassium	mg/L	3.06	0.745
	Specific Conductance	umhos/cm	483	502
	Temperature	C	25.13	29.22

Table 11 (continued). Borrow Area Project Water Sampling Summary

Basin	Parameter	Units	2010	2011
BAPW4 (Cont)	Total Kjeidahl Nitrogen	mg/L	0.102	1.27
	Total Organic Carbon	mg/L	17.3	16.9
	Total Solids	mg/L	467	223
	Total Suspended Solids	mg/L	84	18.8
	Turbidity	NTU	28.4	6.99
BAPW7	Ammonia Total as Nitrogen	mg/L	0.246	0.193
	Chloride	mg/L	0.823	0.353
	Dissolved Oxygen	mg/L	7.65	7.5
	Iron	mg/L	0.642	2.25
	Magnesium	mg/L	17.7	11.8
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.05
	Oxidation Reduction Potential	mV	73.1	-104
	pH	unitless	9.48	6.95
	Phosphorous	mg/L	0.452	0.3
	Potassium	mg/L	1.73	1.4
	Specific Conductance	umhos/cm	308	392
	Temperature	C	26.36	23.73
	Total Kjeidahl Nitrogen	mg/L	1.41	1.19
	Total Organic Carbon	mg/L	19.9	15.7
	Total Solids	mg/L	266	297
	Total Suspended Solids	mg/L	44	96
	Turbidity	NTU	23	6.16
BAPW9	Ammonia Total as Nitrogen	mg/L	0.305	0.226
	Chloride	mg/L	0.503	0.405
	Dissolved Oxygen	mg/L	10.4	10.59
	Iron	mg/L	2.74	0.768
	Magnesium	mg/L	12.1	6.99
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	1.99
	Oxidation Reduction Potential	mV	71	2
	pH	unitless	10.27	8.09
	Phosphorous	mg/L	0.382	0.6
	Potassium	mg/L	1.39	2.05
	Specific Conductance	umhos/cm	203	160
	Temperature	C	28.19	27.52
	Total Kjeidahl Nitrogen	mg/L	1.78	2.76
	Total Organic Carbon	mg/L	20.7	13.7
	Total Solids	mg/L	212	350
	Total Suspended Solids	mg/L	85.2	222
	Turbidity	NTU	25.5	2.65

C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
umhos/cm = micromhos per centimeter

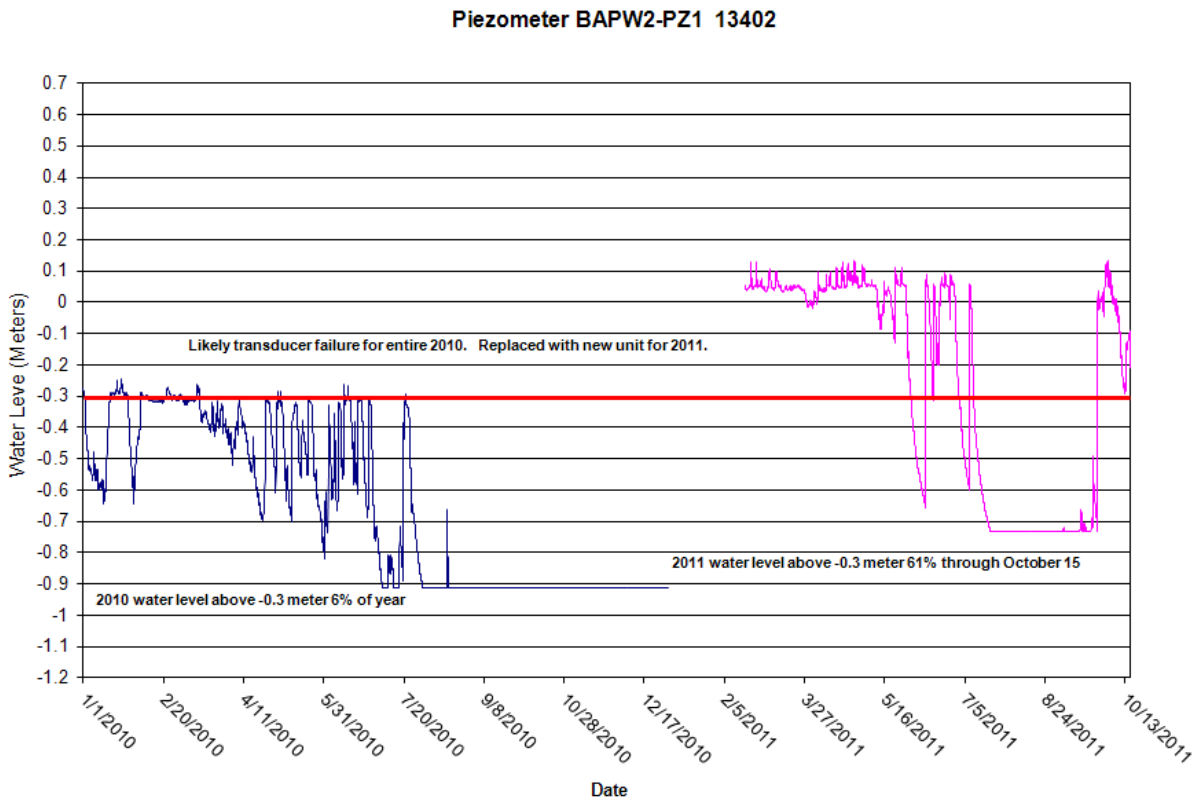

Figure 10. Borrow Area Project BAPW2 Hydrograph

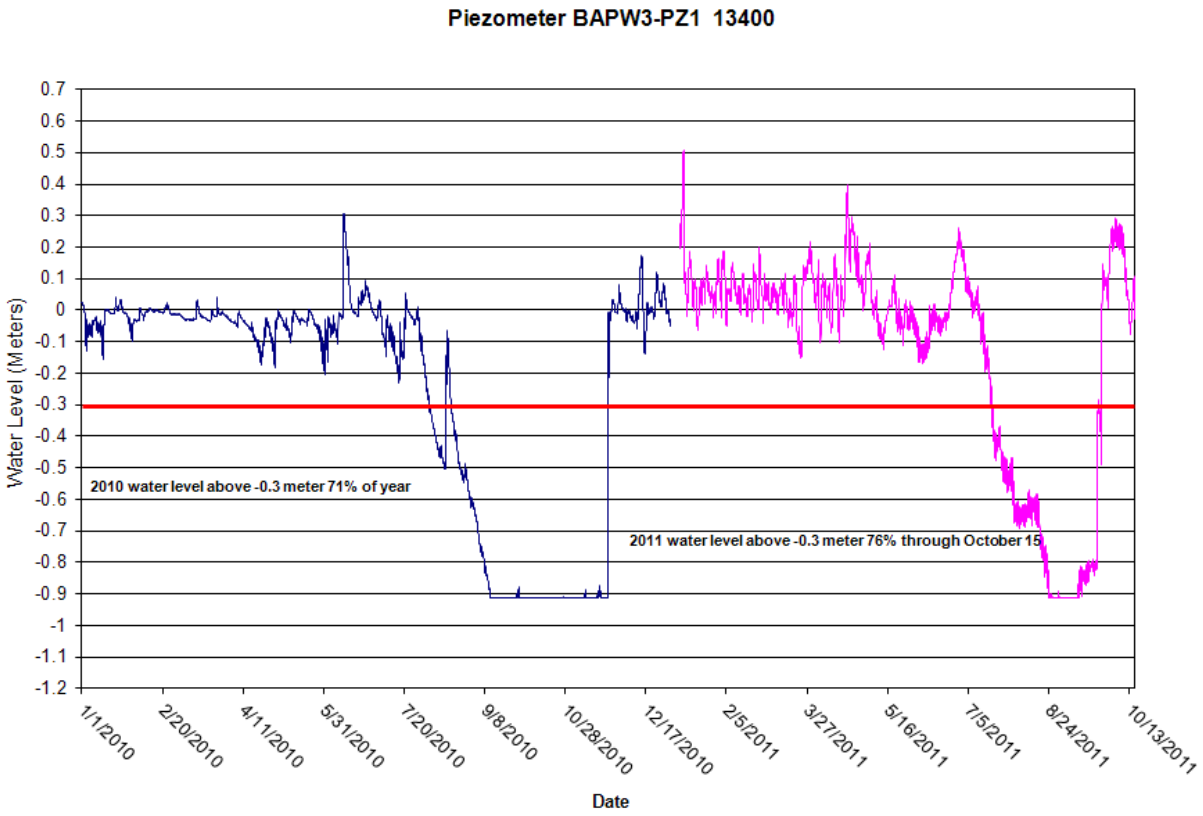

Figure 11. Borrow Area Project BAPW3 Hydrograph

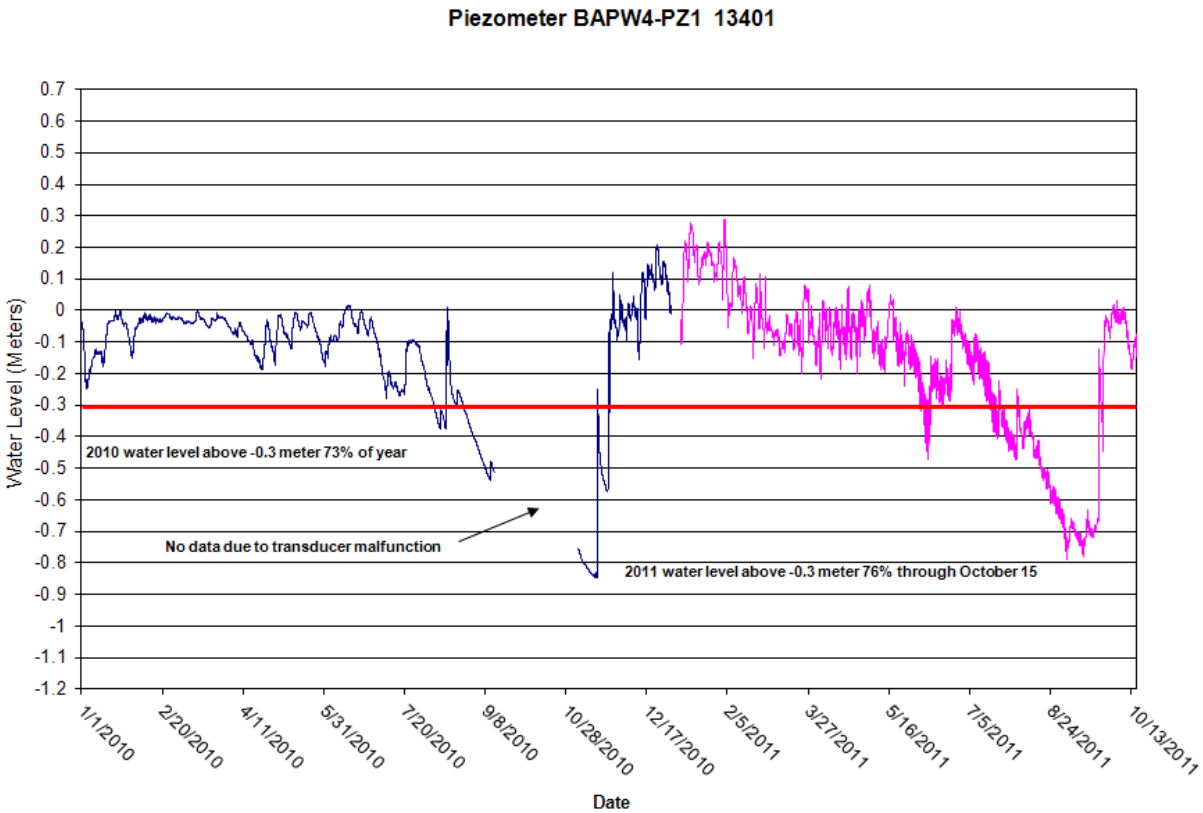

Figure 12. Borrow Area Project BAPW4 Hydrograph

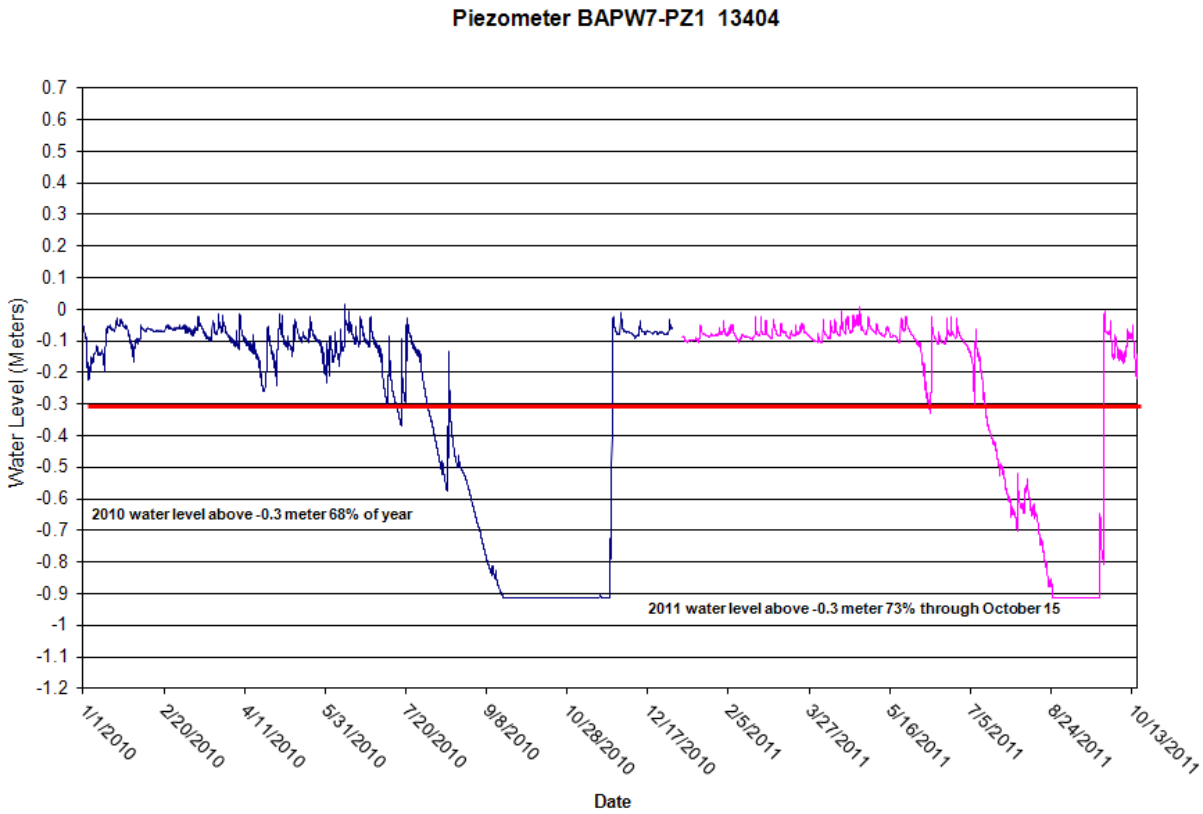

Figure 13. Borrow Area Project BAPW7 Hydrograph

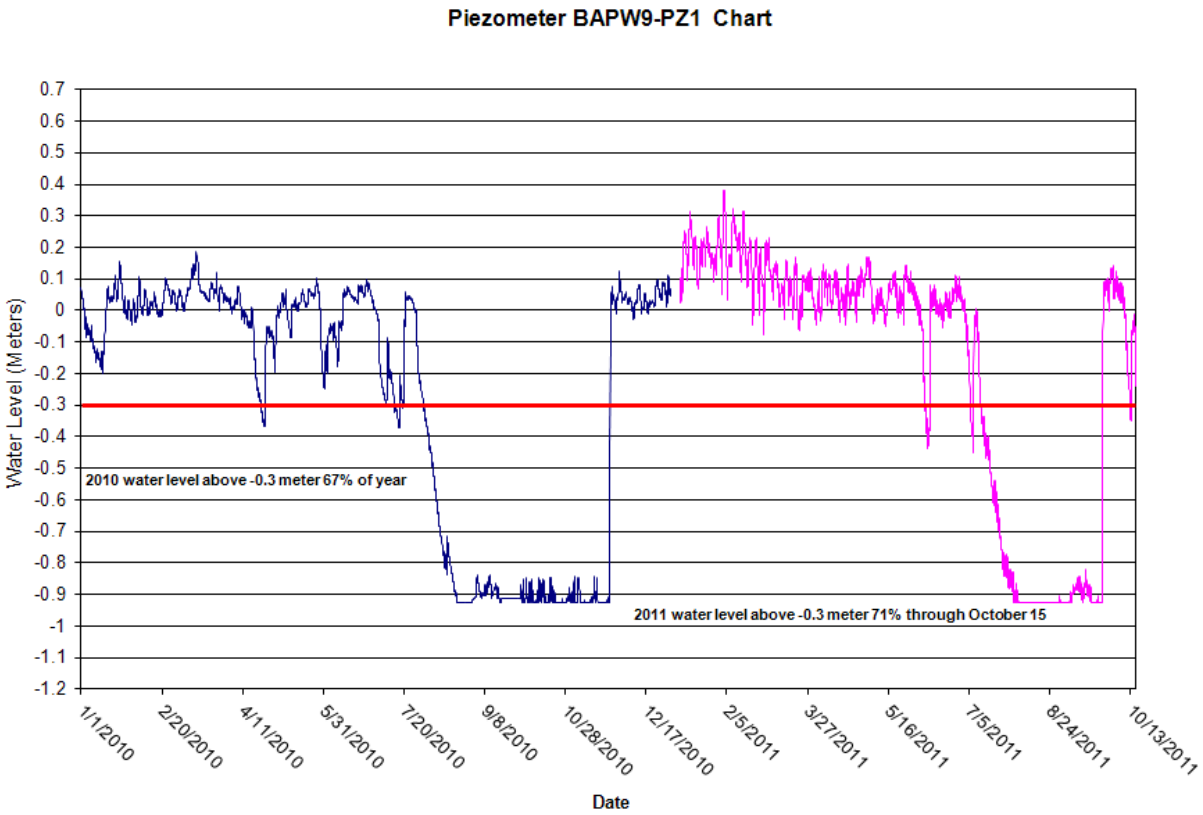

Figure 14. Borrow Area Project BAPW9 Hydrograph

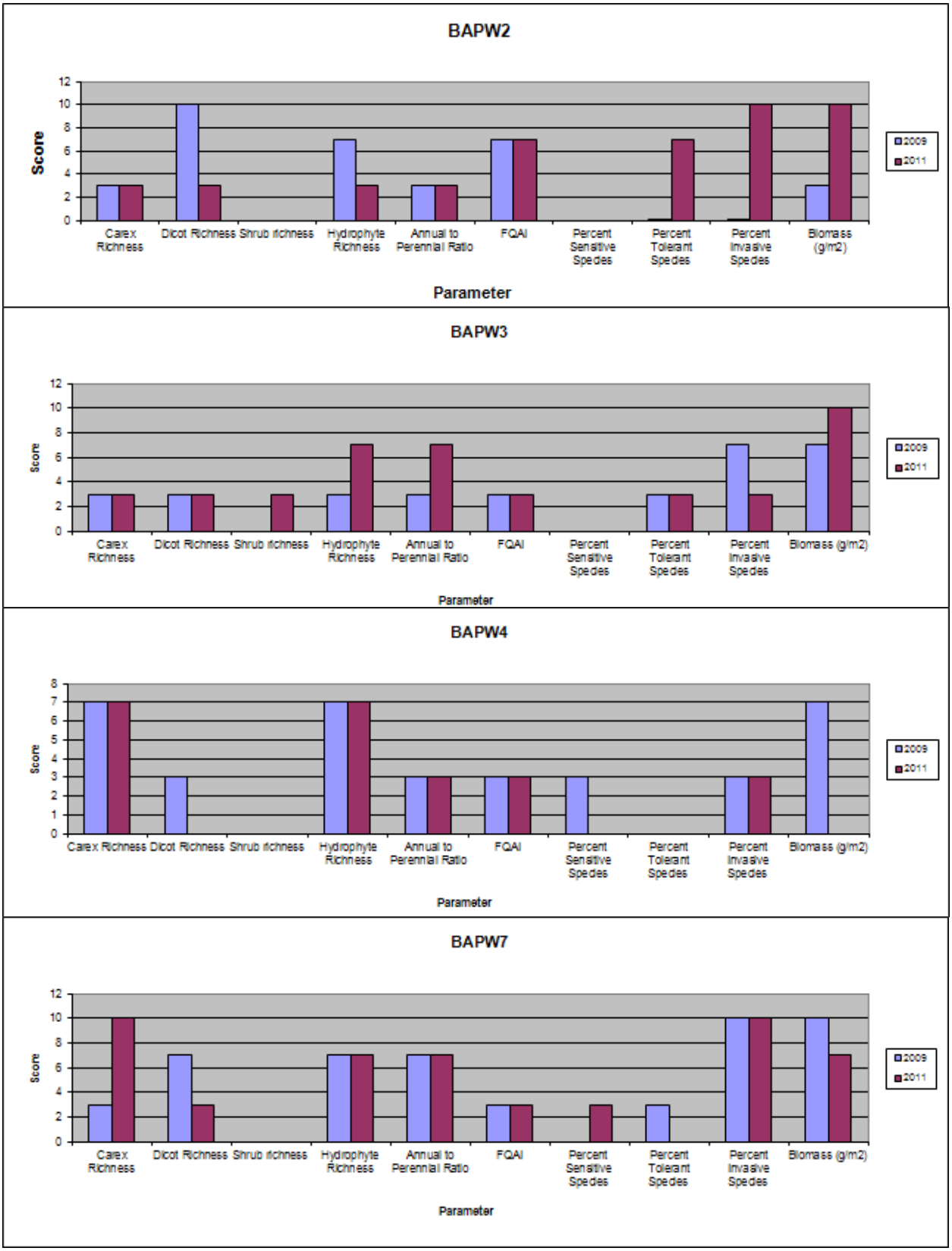

Figure 15. Borrow Area Project VIBI Chart

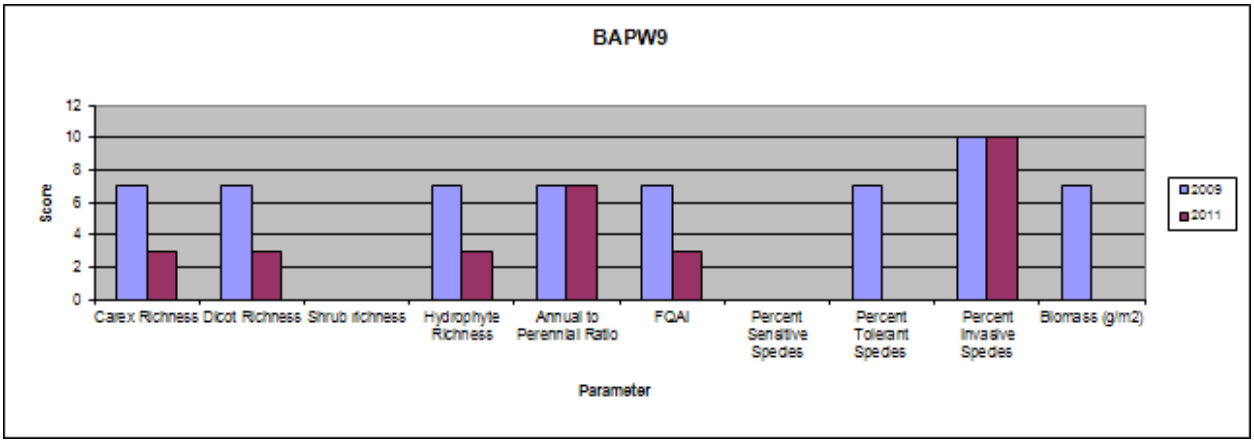

Figure 15 (continued). Borrow Area Project VIBI Chart

3.2 Former Production Area

The FPA wetlands consist of a series of ponds, emergent wetlands, swales, and drainage ditches that are surrounded by seeded mesic tallgrass prairie. Several shrub stands have been established within FPA as well. The wetlands evaluated in FPA are mostly isolated from each other. While they are not connected hydrologically, the FPA wetlands share a common baseline condition. All of the FPA wetlands are within a formerly industrialized area. Extensive excavation and building demolition left most of FPA devoid of organic matter. Restoration activities often required the need for large amounts of soil amendments, in the form of yard waste compost. Wetland PREW6 is not within the footprint of FPA. However, it is included with the FPA wetlands because its design and construction are similar in scope. As Table 1 shows, the FPA wetlands were constructed in 2005 and 2006. These are some of the most recent mitigation wetlands constructed. Nevertheless, the photographs in Appendixes B–1 and B–3 demonstrate extensive vegetation establishment across the project area.

3.2.1 FPA Design Parameter Results

The jurisdictional wetland delineation for FPA resulted in 9.34 wetland acres identified. Figure 16 shows the sample points and subsequent mapped boundaries. Basin-specific wetland acreages are provided in Table 12. Most delineation boundaries appear consistent with the original design intent. The wetland acreage in PREW6 has expanded since establishment in 2005. This is due to an altered drainage pattern following construction of a gravel drive in 2006. The road appears to act as a dam, impeding water flow to the north. Therefore, the wetland boundary has been expanded to the road edge along most of PREW6.

Figure 17 shows basin morphometry, and Table 12 provides calculated percentages. All but one basin (FPAW7) met the performance standard for basin morphometry. This is most likely an artifact of the way that morphometry is determined. Since site contours stop at water surfaces, the blue “Wetland Basin” shape on Figure 17 is excluded from the area calculation. In reality, most of this basin consists of a level, emergent community. Photographs in Appendix B–1 show the extent of vegetation establishment. Therefore, the amount of FPAW7 that has a slope of less than 15:1 is much greater than 48 percent.

3.2.2 FPA Hydrologic Regime Results

Hydrology within FPA is characterized through data collected from six piezometers, as shown on Figure 18. Table 13 presents the results for each basin. Figures 19 through 24 show basin-specific hydrographs. With the exception of FPAW9, all hydrologic performance standards were met in 2011. The mean depth to water in FPAW9 was calculated to be just above the 29.4-centimeter (cm) performance standard. While the 30 cm mean depth is above the performance standard, it is a marked improvement over the mean depth in 2010 (53 cm). Hydrographs appear as expected, with lower water levels recorded in the fall of 2010 and 2011. This is typical of depressions with a seasonal hydroperiod, where basins dry up for a portion of the year (Mack et al. 2004).

3.2.3 FPA Vegetation Parameter Results

Table 14 presents vegetation sampling results for the FPA wetlands. Figure 18 shows fixed quadrat locations for each basin. Results show limited success with meeting vegetation performance standards so far. VIBI performance was met for only FPAW5 and FPAW9. However, the VIBI scoring metrics on Figure 25 do not demonstrate any noticeable trends through 2011.

3.2.4 FPA Wildlife Parameter Results

Table 15 provides the AIBI summary for FPA. Several basins scored well. This appears to be due to the presence of cricket frogs and spring peepers (*Pseudacris crucifer*) collected in several basins (Table 16). As with the BAP wetlands, no Ambystomatid salamander species have been observed in FPA. This is likely due to the isolated nature of these wetlands, with no existing salamander habitat nearby. Table 16 shows that green sunfish are an issue in FPA as well.

3.2.5 FPA Soil and Water Chemistry Results

Tables 17 and 18 present soil and water sampling results. As with other areas, most soil biogeochemistry performance standards were not met. FPAW2 and FPAW7 did meet the performance standard for total organic carbon in both 2010 and 2011. These are the only soil parameters met within any basin. This finding may be due to the increased use of yard waste compost across FPA, as compared to other areas.

Water sampling results demonstrated expected values across FPA (Table 18). Several instances of high pH in 2010 appear normal in 2011. These differences between 2010 and 2011 are similar to the differences found in other basins sampled.

Table 12. Former Production Area Design Parameter Summary

Basin	Parameter	Performance Standard	Result
FPAW2	Delineation Acreage	NA	2.01
	Acreage of Unvegetated Open Water >10%	NA	0
	Actual Wetland Acreage	NA	2.01
	Morphometry	<15:1 side slope	84%
FPAW4	Delineation Acreage	NA	1.43
	Acreage of Unvegetated Open Water >10%	NA	0
	Actual Wetland Acreage	NA	1.43
	Morphometry	<15:1 side slope	76%
FPAW5	Delineation Acreage	NA	1.87
	Acreage of Unvegetated Open Water >10%	NA	0.67
	Actual Wetland Acreage	NA	1.20
	Morphometry	<15:1 side slope	85%
FPAW7	Delineation Acreage	NA	1.72
	Acreage of Unvegetated Open Water >10%	NA	0.33
	Actual Wetland Acreage	NA	1.39
	Morphometry	<15:1 side slope	48%
FPAW9	Delineation Acreage	NA	0.54
	Acreage of Unvegetated Open Water >10%	NA	0.01
	Actual Wetland Acreage	NA	0.53
	Morphometry	<15:1 side slope	68%
PREW6	Delineation Acreage	NA	2.78
	Acreage of Unvegetated Open Water >10%	NA	0
	Actual Wetland Acreage	NA	2.78
	Morphometry	<15:1 side slope	75%

NA = not applicable

Table 13. Former Production Area Hydrologic Regime Summary

Basin	Parameter	Performance Standard	2010	2011
FPAW2	Water in Root Zone (<30 cm)	>53%	67%	73%
	Mean Depth of Water	29.4 cm	32	27
	Flashiness Index	<2.0	0.6	0.39
FPAW4	Water in Root Zone (<30 cm)	>53%	78%	81%
	Mean Depth of Water	29.4 cm	19	16
	Flashiness Index	2	0.4	0.31
FPAW5	Water in Root Zone (<30 cm)	>53%	71%	73%
	Mean Depth of Water	29.4 cm	15	23
	Flashiness Index	<2.0	0.6	0.43
FPAW7	Water in Root Zone (<30 cm)	>53%	77%	78%
	Mean Depth of Water	29.4 cm	22	20
	Flashiness Index	2	0.40	0.91
FPAW9	Water in Root Zone (<30 cm)	>53%	30%	76%
	Mean Depth of Water	29.4 cm	53	30
	Flashiness Index	<2.0	0.58	0.31
PREW6	Water in Root Zone (<30 cm)	>53%	75%	80%
	Mean Depth of Water	29.4 cm	13	7
	Flashiness Index	<2.0	0.31	0.47

Table 14. Former Production Area Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
FPAW2	% Unvegetated Open Water	<10%	0.0%	NA	40.0%	NA
	% Native Perennial Hydrophytes	>75%	63.4%	NA	96.1%	NA
	VIBI	48–63	25	NA	40	NA
	Carex Richness	NA	0	0	2	3
	Dicot Richness	NA	17	3	5	0
	Shrub richness	NA	0	0	0	0
	Hydrophyte Richness	NA	16	3	17	3
	Annual to Perennial Ratio	NA	0.38	3	0.27	0
	FQAI	NA	11.83	3	9.82	0
	% Sensitive Species	NA	0.0%	0	0.0%	7
	% Tolerant Species	NA	41.4%	3	36.2%	10
	% Invasive Species	<5%	0.0%	10	0.1%	10
	Biomass (g/m^2)	NA	1334	0	103	10

Table 14 (continued). Former Production Area Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
FPAW4	% Unvegetated Open Water	<10%	9.4%	NA	26.0%	NA
	% Native Perennial Hydrophytes	>75%	53.2%	NA	42.0%	NA
	VIBI	48–63	50	NA	18	NA
	Carex Richness	NA	2	3	3	3
	Dicot Richness	NA	27	10	13	3
	Shrub richness	NA	0	0	0	0
	Hydrophyte Richness	NA	21	7	16	3
	Annual to Perennial Ratio	NA	0.44	3	0.43	3
	FQAI	NA	15.44	7	11.67	3
	% Sensitive Species	NA	4.6%	3	0.0%	0
	% Tolerant Species	NA	24.1%	7	68.8%	0
	% Invasive Species	<5%	1.0%	10	24.3%	3
	Biomass (g/m^2)	NA	0	0	98	0
FPAW5	% Unvegetated Open Water	<10%	25.0%	NA	11.5%	NA
	% Native Perennial Hydrophytes	>75%	46.9%	NA	56.0%	NA
	VIBI	48–63	51	NA	54	NA
	Carex Richness	NA	3	3	5	10
	Dicot Richness	NA	25	7	23	7
	Shrub richness	NA	0	0	0	0
	Hydrophyte Richness	NA	22	7	21	7
	Annual to Perennial Ratio	NA	0.32	7	0.34	3
	FQAI	NA	15.63	7	15.80	7
	% Sensitive Species	NA	3.2%	3	1.1%	0
	% Tolerant Species	NA	67.9%	0	46.3%	3
	% Invasive Species	<5%	2.4%	10	5.1%	7
	Biomass (g/m^2)	NA	220	7	145	10
FPAW7	% Unvegetated Open Water	<10%	0.0%	NA	1.0%	NA
	% Native Perennial Hydrophytes	>75%	55.3%	NA	29.1%	NA
	VIBI	48–63	34	NA	13	NA
	Carex Richness	NA	2	3	2	3
	Dicot Richness	NA	10	0	0	0
	Shrub richness	NA	0	0	0	0
	Hydrophyte Richness	NA	23	7	10	0
	Annual to Perennial Ratio	NA	0.31	7	0.20	10
	FQAI	NA	13.69	3	8.37	0
	% Sensitive Species	NA	0.4%	0	0.0%	0
	% Tolerant Species	NA	60.6%	0	79.3%	0
	% Invasive Species	<5%	3.4%	7	43.0%	0
	Biomass (g/m^2)	NA	379	7	98	0

Table 14 (continued). Former Production Area Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
FPAW9	% Unvegetated Open Water	<10%	0.0%	NA	2.8%	NA
	% Native Perennial Hydrophytes	>75%	23.6%	NA	58.3%	NA
	VIBI	48–63	50	NA	56	NA
	Carex Richness	NA	2	3	2	3
	Dicot Richness	NA	28	10	17	3
	Shrub richness	NA	2	3	5	10
	Hydrophyte Richness	NA	28	7	21	7
	Annual to Perennial Ratio	NA	0.29	7	0.32	7
	FQAI	NA	17.40	7	16.36	7
	% Sensitive Species	NA	3.3%	3	60.7%	3
	% Tolerant Species	NA	75.7%	0	52.5%	3
	% Invasive Species	<5%	1.0%	10	23.3%	3
	Biomass (g/m^2)	NA	0	0	126	10
PREW6	% Unvegetated Open Water	<10%	0.4%	NA	17.3%	NA
	% Native Perennial Hydrophytes	>75%	55.9%	NA	46.2%	NA
	VIBI	48–63	43	NA	25	NA
	Carex Richness	NA	2	3	2	3
	Dicot Richness	NA	23	7	16	3
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	23	7	19	3
	Annual to Perennial Ratio	NA	0.43	3	0.38	3
	FQAI	NA	13.42	3	10.25	3
	% Sensitive Species	NA	0.0%	0	0.8%	0
	% Tolerant Species	NA	74.1%	0	74.7%	0
	% Invasive Species	<5%	1.9%	10	23.1%	3
	Biomass (g/m^2)	NA	187	10	217	7

NA = not applicable

Table 15. Former Production Area AIBI Summary

Basin	Parameter	2010	AIBI Score	2011	AIBI Score
FPAW2	AIBI	NA	**0**	NA	**13**
	Amphibian Quality Assessment Index	2.00	0	3.50	3
	% Relative Abundance of Sensitive Species	0%	0	25%	7
	% Relative Abundance of Tolerant Species	100%	0	75%	3
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
FPAW7	AIBI	NA	**0**	NA	**0**
	Amphibian Quality Assessment Index	0.00	0	1.09	0
	% Relative Abundance of Sensitive Species	0%	0	0%	0
	% Relative Abundance of Tolerant Species	0%	0	100%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
FPAW9	AIBI	NA	**0**	NA	**10**
	Amphibian Quality Assessment Index	1.80	0	2.28	0
	% Relative Abundance of Sensitive Species	0%	0	29%	7
	% Relative Abundance of Tolerant Species	100%	0	71%	3
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
PREW6	AIBI	NA	**13**	NA	**13**
	Amphibian Quality Assessment Index	3.54	3	4.18	3
	% Relative Abundance of Sensitive Species	23%	7	45%	7
	% Relative Abundance of Tolerant Species	77%	3	55%	3
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0

NA = not applicable

Table 16. Former Production Area Other Wildlife Summary

Amphibian Summary			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Acris crepitans*	cricket frog	NA	19	23
Funnel Traps	*Anaxyrus species*	toad species	NA	0	1
Funnel Traps	*Lithobates catesbeiana*	American bull frog	NA	14	41
Funnel Traps	*Lithobates clamitans*	green frog	NA	1	2
Funnel Traps	*Lithobates species*	lithobates species	NA	97	4
Funnel Traps	*Pseudacris crucifer*	spring peeper	NA	31	1
Bird Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Actitis macularius*	spotted sandpiper	NA	NA	NA
Observation	*Aix sponsa*	wood duck	NA	NA	NA
Observation	*Ammodramus henslowii*	Henslow's sparrow	NA	NA	NA
Observation	*Ammodramus savannarum*	grasshoper sparrow	NA	NA	NA
Observation	*Anas discors*	blue winged teal	NA	NA	NA
Observation	*Anas platyrhynchos*	mallard	NA	NA	NA
Observation	*Asio flammeus*	short eared owl	NA	NA	NA
Observation	*Botaurus lentiginosus*	American bittern	NA	NA	NA
Observation	*Butorides virescens*	green heron	NA	NA	NA
Observation	*Charadrius vociferous*	killdeer	NA	NA	NA
Observation	*Circus cyaneus*	northern harrier	NA	NA	NA
Observation	*Cygnus olor*	mute swan	NA	NA	NA
Observation	*Dolichonyx oryzivorus*	bobolink	NA	NA	NA
Observation	*Gallinago gallinago*	common snipe	NA	NA	NA
Observation	*Gallinula chloropus*	common moorhen	NA	NA	NA
Observation	*Hirundo rustica*	barn swallow	NA	NA	NA
Observation	*Lophodytes cucullatus*	hooded merganser	NA	NA	NA
Observation	*Passerina caerulea*	blue grosbeak	NA	NA	NA
Observation	*Porzana carolina*	sora	NA	NA	NA
Observation	*Riparia riparia*	bank swallow	NA	NA	NA
Observation	*Spiza americana*	dickcissel	NA	NA	NA
Observation	*Tachycineta bicolor*	tree swallow	NA	NA	NA
Fish Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Cyprinidae	minnow species	0	20	0
Funnel Traps	*Lepomus cyanellus*	green sunfish	0	244	38
Macroinvertebrate Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Asellidae	aquatic sowbug	NA	0	1
Funnel Traps	Family: Belostomatidae	giant waterbug	NA	0	2
Funnel Traps	Order: Coleoptera	beetle	NA	262	0
Funnel Traps	Family: Corixidae	water boatman	NA	19	82
Funnel Traps	Family: Corydalidae	dobsonfly, fishfly	NA	4	0
Funnel Traps	Family: Culicidae	mosquito	NA	1	0

Table 16 (continued). Former Production Area Other Wildlife Summary

Macroinvertebrate Summary (continued)			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Dytiscidae	predaceous diving beetle	NA	1	12
Funnel Traps	Order: Ephemeroptera	mayfly	NA	8	30
Funnel Traps	Family: Gammaridae	sideswimmer/scud	NA	0	5
Funnel Traps	Family: Gerridae	water strider	NA	0	3
Funnel Traps	Family: Haliplidae	crawling water beetle	NA	0	68
Funnel Traps	Order: Haplotaxida (Tubificina)	freshwater worm	NA	2	4
Funnel Traps	Family: Hirudinidae	leech	NA	70	2
Funnel Traps	Family: Hydrachnidiae	mite	NA	6	4
Funnel Traps	Family: Hydrophilidae	water scavanger	NA	0	35
Funnel Traps	Order: Isopoda	isopod	NA	0	1
Funnel Traps	Family: Lymnaeidae	pond snail	NA	126	12
Funnel Traps	Family: Naucoridae	creeping water bug	NA	33	34
Funnel Traps	Family: Nepidae	water scorpion	NA	1	1
Funnel Traps	Family: Notonectidae	backswimmer	NA	166	29
Funnel Traps	Order:Odonata,Sub-Order:Anisoptera	dragonfly	NA	75	25
Funnel Traps	Order: Odonata, Sub-Order: Zygoptera	damselfly	NA	29	93
Funnel Traps	Family: Physidae	pouch snail	NA	279	259
Funnel Traps	Family: Planorbidae	ramhorn snail	NA	104	109
Funnel Traps	Order: Trichoptera	caddisfly	NA	0	7
Reptile Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Thamnophis sirtalis*	eastern garter snake	8	9	2
Small Mammal Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Microtus pennsylvanicus*	meadow vole	6	0	0
Coverboards	*Peromyscus maniculatus*	deer mouse	3	0	0

NA = not applicable

Table 17. Former Production Area Soil Sampling Summary

Basin	Parameter	Performance Standard	2010				2011			
			N	Median (%)	Q_1 (%)	Q_2 (%)	N	Median (%)	Q_1 (%)	Q_2 (%)
FPAW2	% Solids	<46.6%	6	56.6	51	61.1	6	75	59.7	82.2
	% Total Organic Carbon	>3.9%	6	5.71	5.02	6.28	6	5.96	2.96	6.57
	% Total Nitrogen	>0.5%	6	0.274	0.225	0.335	6	0.247	0.176	0.305
FPAW4	% Solids	<46.6%	6	69.5	59.9	77.8	6	60	56.9	70
	% Total Organic Carbon	>3.9%	6	2.92	2.39	4.35	6	4.54	1.92	7.77
	% Total Nitrogen	>0.5%	6	0.116	0.0991	0.413	6	0.0855	0.066	0.16
FPAW5	% Solids	<46.6%	6	77.6	75.2	79.9	6	55.3	36.1	81.5
	% Total Organic Carbon	>3.9%	6	3.6	2.35	4.01	6	3.29	0.715	9.78
	% Total Nitrogen	>0.5%	6	0.0606	0.0454	0.107	6	0.199	0.0251	0.408
FPAW7	% Solids	<46.6%	6	65.1	58.9	69.2	6	79.6	70.9	88.6
	% Total Organic Carbon	>3.9%	6	5.32	3.52	6.41	6	5.71	3.75	6.18
	% Total Nitrogen	>0.5%	6	0.288	0.187	0.516	6	0.201	0.099	0.223
FPAW9	% Solids	<46.6%	6	73.2	62.6	79.5	6	85.9	82.1	87.8
	% Total Organic Carbon	>3.9%	6	1.69	1.13	2.71	6	4.28	2.86	5.68
	% Total Nitrogen	>0.5%	6	0.131	0.0565	0.182	6	0.117	0.0917	0.137
PREW6	% Solids	<46.6%	6	70.3	65.1	70.5	6	74.9	69.3	77.9
	% Total Organic Carbon	>3.9%	6	0.472	0.256	2.37	6	0.354	0.265	1.39
	% Total Nitrogen	>0.5%	6	0.0528	0.045	0.115	6	0.0788	0.0409	0.125

Table 18. Former Production Area Water Sampling Summary

Basin	Parameter	Units	2010	2011
FPAW2	Ammonia Total as Nitrogen	mg/L	0.118	1.2
	Chloride	mg/L	4.05	8.35
	Dissolved Oxygen	mg/L	3.61	3.57
	Iron	mg/L	8.12	7.04
	Magnesium	mg/L	36.3	43.9
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	83.1	-86.7
	pH	unitless	7.51	7.03
	Phosphorous	mg/L	0.428	0.4
	Potassium	mg/L	14.7	12.1
	Specific Conductance	umhos/cm	597	578
	Temperature	C	22.07	21.37
	Total Kjeidahl Nitrogen	mg/L	0.177	10.3
	Total Organic Carbon	mg/L	68.4	62.2
	Total Solids	mg/L	939	783
	Total Suspended Solids	mg/L	445	198
	Turbidity	NTU	26.9	96
FPAW4	Ammonia Total as Nitrogen	mg/L	<.016	0.295
	Chloride	mg/L	2.03	0.955
	Dissolved Oxygen	mg/L	12.12	3.23
	Iron	mg/L	1.33	1.36
	Magnesium	mg/L	26	15.4
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	157	-15
	pH	unitless	9.91	7.87
	Phosphorous	mg/L	13.1	<0.111
	Potassium	mg/L	13.1	6.27
	Specific Conductance	umhos/cm	487	330
	Temperature	C	38.58	21.11
	Total Kjeidahl Nitrogen	mg/L	<0.033	2.16
	Total Organic Carbon	mg/L	44.8	24.6
	Total Solids	mg/L	414	241
	Total Suspended Solids	mg/L	30.4	18.4
	Turbidity	NTU	7.92	10.3
FPAW5	Ammonia Total as Nitrogen	mg/L	0.068	0.513
	Chloride	mg/L	6.66	12.8
	Dissolved Oxygen	mg/L	7.26	1.24
	Iron	mg/L	0.757	2.53
	Magnesium	mg/L	81.5	57.3
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	135	-159
	pH	unitless	9.15	7.2
	Phosphorous	mg/L	<0.107	0.4
	Potassium	mg/L	19.2	37.8
	Specific Conductance	umhos/cm	1131	1024
	Temperature	C	27.82	20.66

Table 18 (continued). Former Production Area Water Sampling Summary

Basin	Parameter	Units	2010	2011
FPAW5 (Cont)	Total Kjeidahl Nitrogen	mg/L	0.124	9.61
	Total Organic Carbon	mg/L	17.2	37.5
	Total Solids	mg/L	973	928
	Total Suspended Solids	mg/L	18.2	198
	Turbidity	NTU	11.8	9.35
FPAW7	Ammonia Total as Nitrogen	mg/L	0.148	0.641
	Chloride	mg/L	2	0.367
	Dissolved Oxygen	mg/L	1.02	5.84
	Iron	mg/L	5.38	8.03
	Magnesium	mg/L	42.3	36.4
	Nitrate + Nitrite as Nitrogen	mg/L	0.078	1.83
	Oxidation Reduction Potential	mV	-36	-115
	pH	unitless	8.03	6.93
	Phosphorous	mg/L	0.44	0.8
	Potassium	mg/L	15.8	6.57
	Specific Conductance	umhos/cm	762	874
	Temperature	C	21.87	18.35
	Total Kjeidahl Nitrogen	mg/L	0.278	6.77
	Total Organic Carbon	mg/L	86.8	50.6
	Total Solids	mg/L	847	968
	Total Suspended Solids	mg/L	220	352
	Turbidity	NTU	27.9	22.7
FPAW9	Ammonia Total as Nitrogen	mg/L	0.646	0.31
	Chloride	mg/L	9.59	1.49
	Dissolved Oxygen	mg/L	2.58	4.83
	Iron	mg/L	3.58	0.995
	Magnesium	mg/L	22.8	11.5
	Nitrate + Nitrite as Nitrogen	mg/L	<.05	0.178
	Oxidation Reduction Potential	mV	30.4	-31.5
	pH	unitless	8.31	7.55
	Phosphorous	mg/L	0.275	0.1
	Potassium	mg/L	23.2	7.87
	Specific Conductance	umhos/cm	537	321
	Temperature	C	23.51	22.82
	Total Kjeidahl Nitrogen	mg/L	0.719	2.05
	Total Organic Carbon	mg/L	38.7	19.9
	Total Solids	mg/L	411	269
	Total Suspended Solids	mg/L	12.4	75
	Turbidity	NTU	26.9	6.24
PREW6	Ammonia Total as Nitrogen	mg/L	<0.016	0.263
	Chloride	mg/L	0.403	0.456
	Dissolved Oxygen	mg/L	5.5	5.3
	Iron	mg/L	1.98	3.43
	Magnesium	mg/L	15.3	8.62
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.259
	Oxidation Reduction Potential	mV	129	185
	pH	unitless	7.37	7.6

Table 18 (continued). Former Production Area Water Sampling Summary

Basin	Parameter	Units	2010	2011
PREW6 (Cont)	Phosphorous	mg/L	0.288	0.7
	Potassium	mg/L	0.356	0.515
	Specific Conductance	umhos/cm	322	162
	Temperature	C	27.37	22.11
	Total Kjeidahl Nitrogen	mg/L	0.18	2.05
	Total Organic Carbon	mg/L	20.3	16.5
	Total Solids	mg/L	256	229
	Total Suspended Solids	mg/L	33.2	63
	Turbidity	NTU	12.6	8.08

C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
umhos/cm = micromhos per centimeter

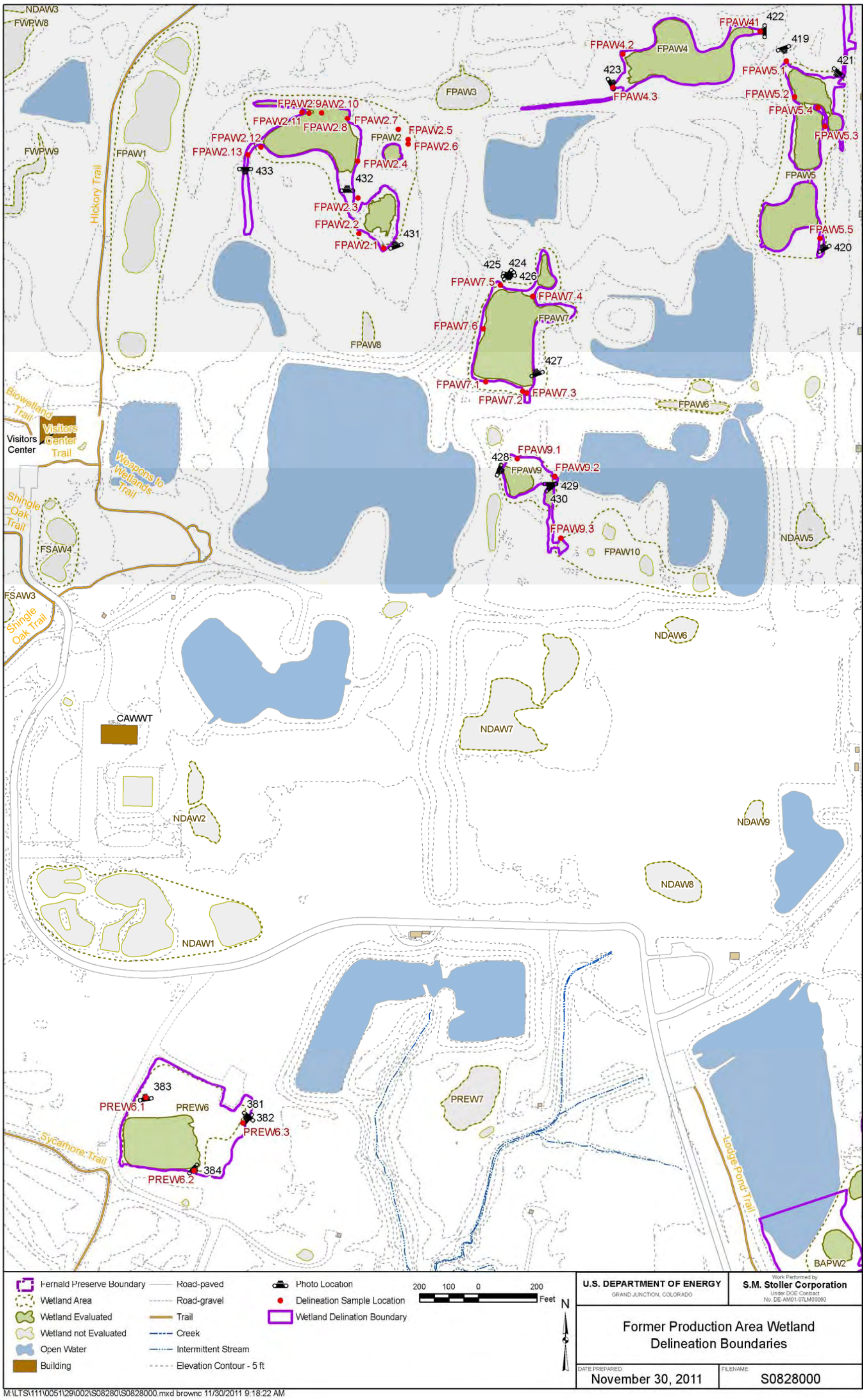

Figure 16. Former Production Area Wetland Delineation Boundaries

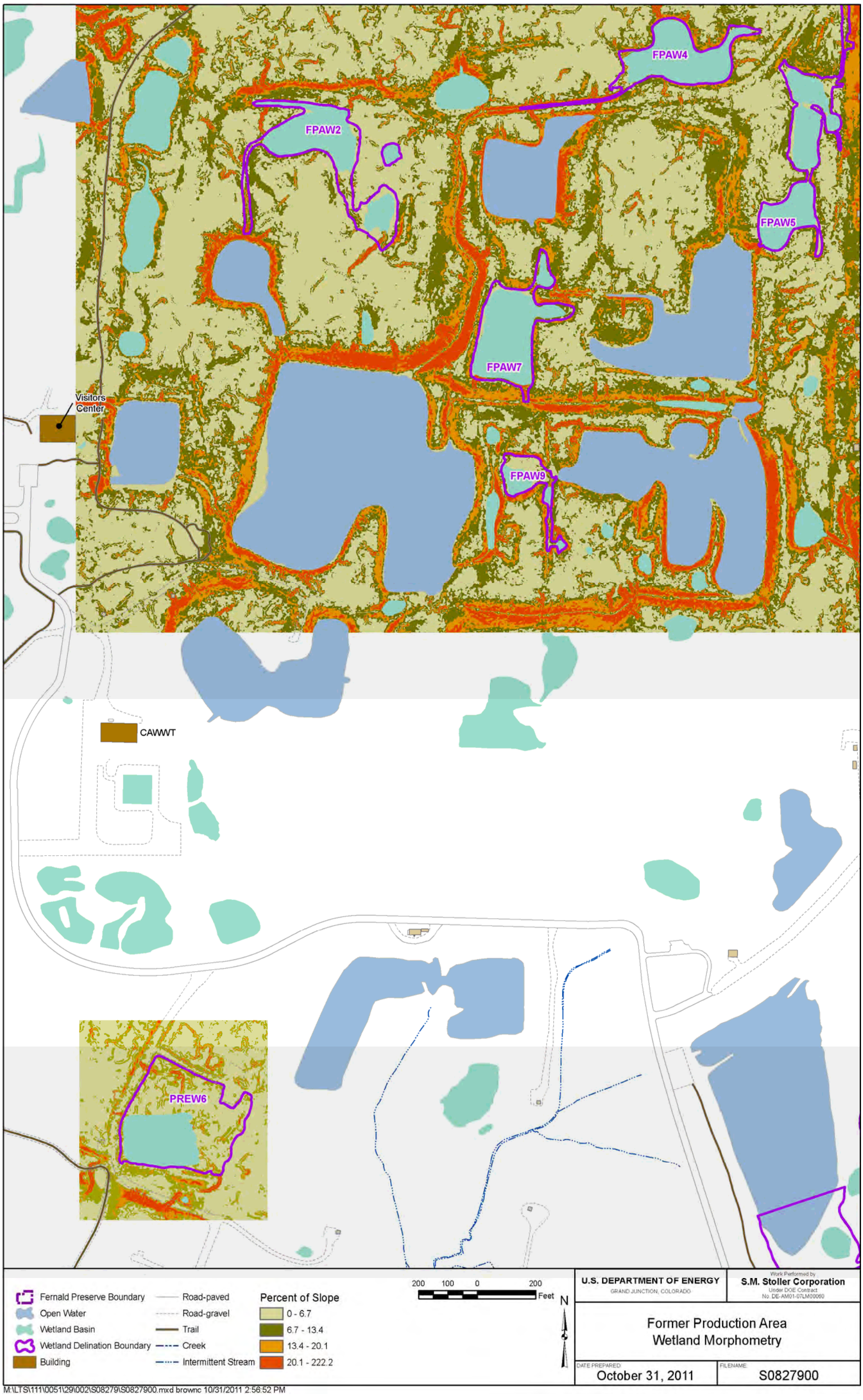

Figure 17. Former Production Area Wetland Morphometry

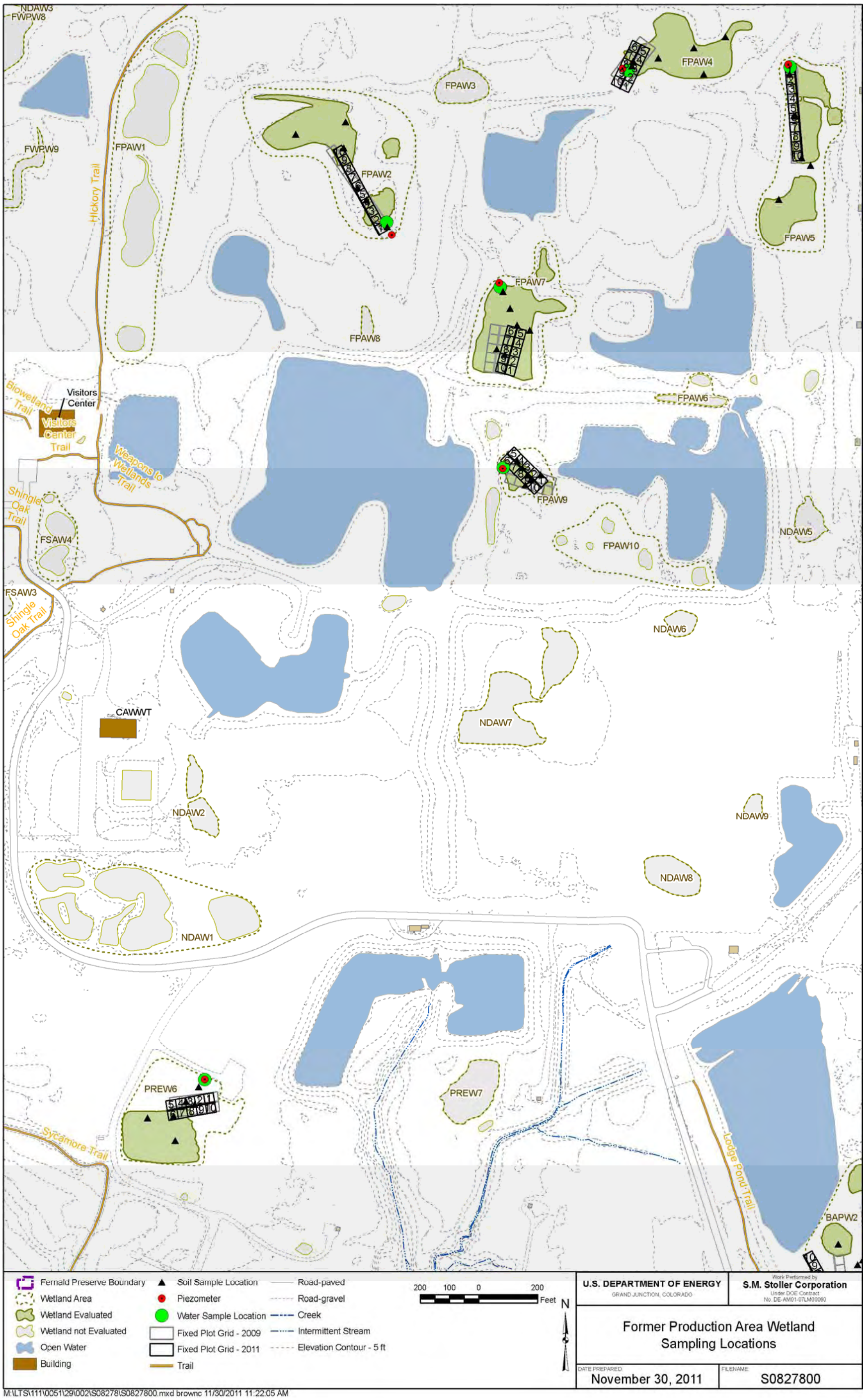

Figure 18. Former Production Area Wetland Sampling Locations

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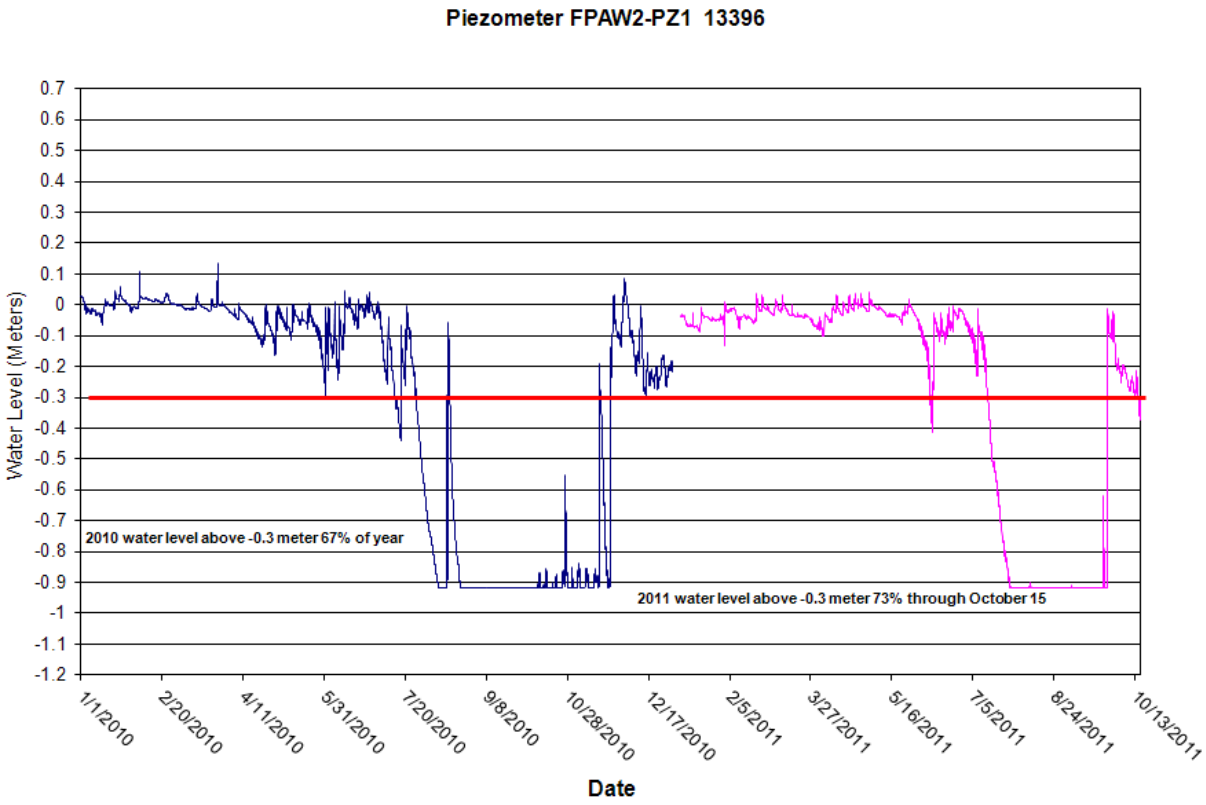

Figure 19. Former Production Area FPAW2 Hydrograph

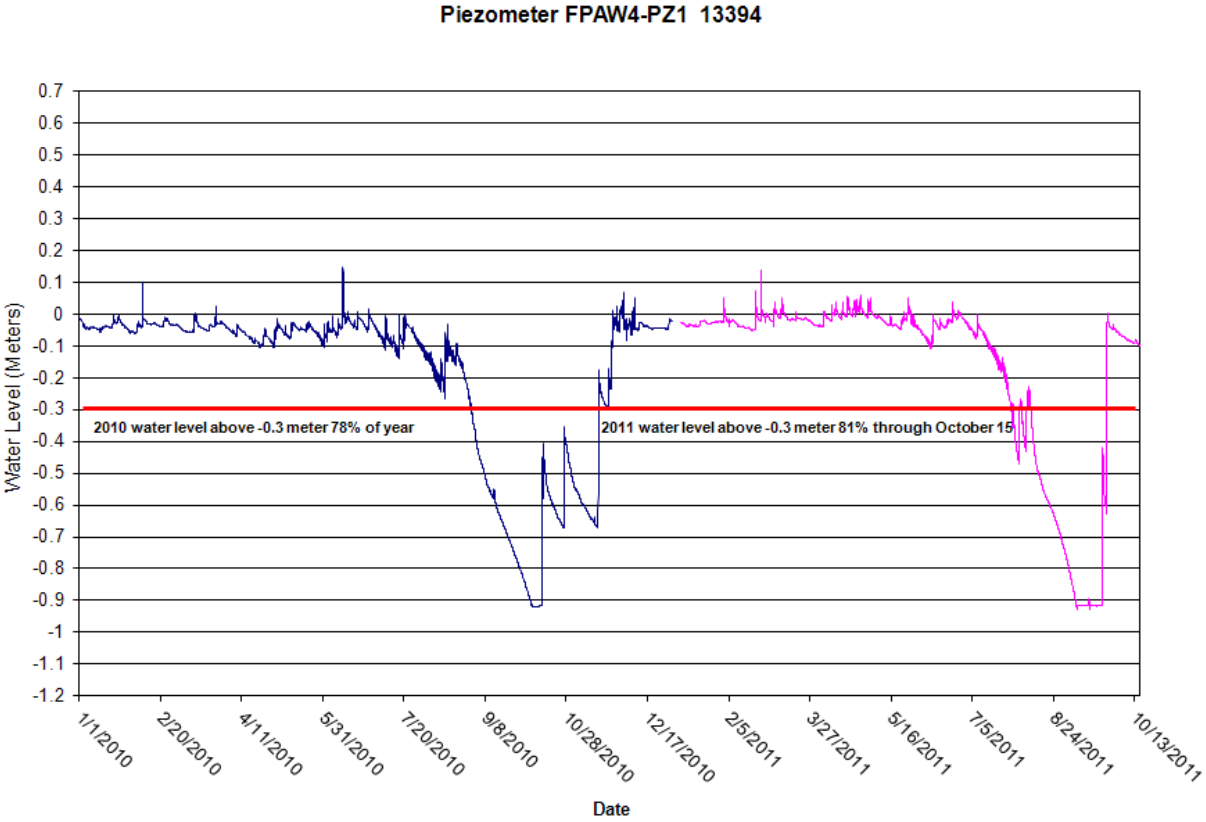

Figure 20. Former Production Area FPAW4 Hydrograph

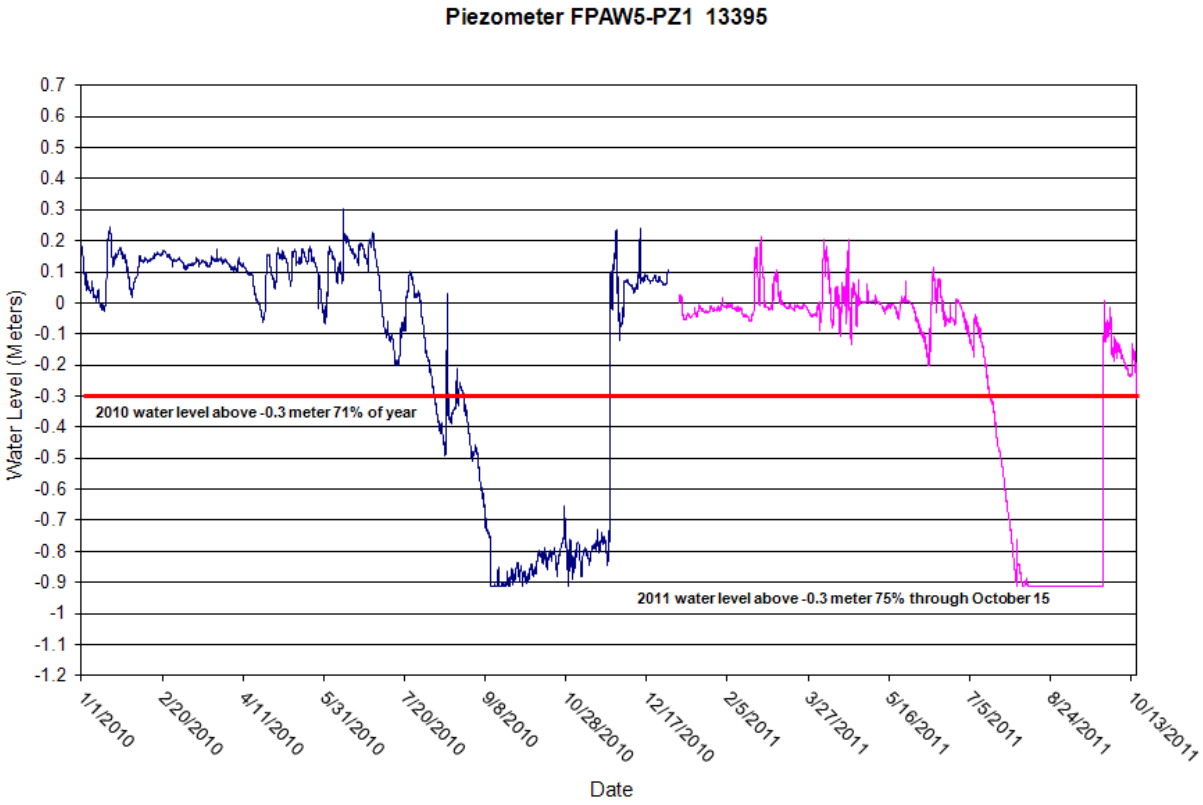

Figure 21. Former Production Area FPAW5 Hydrograph

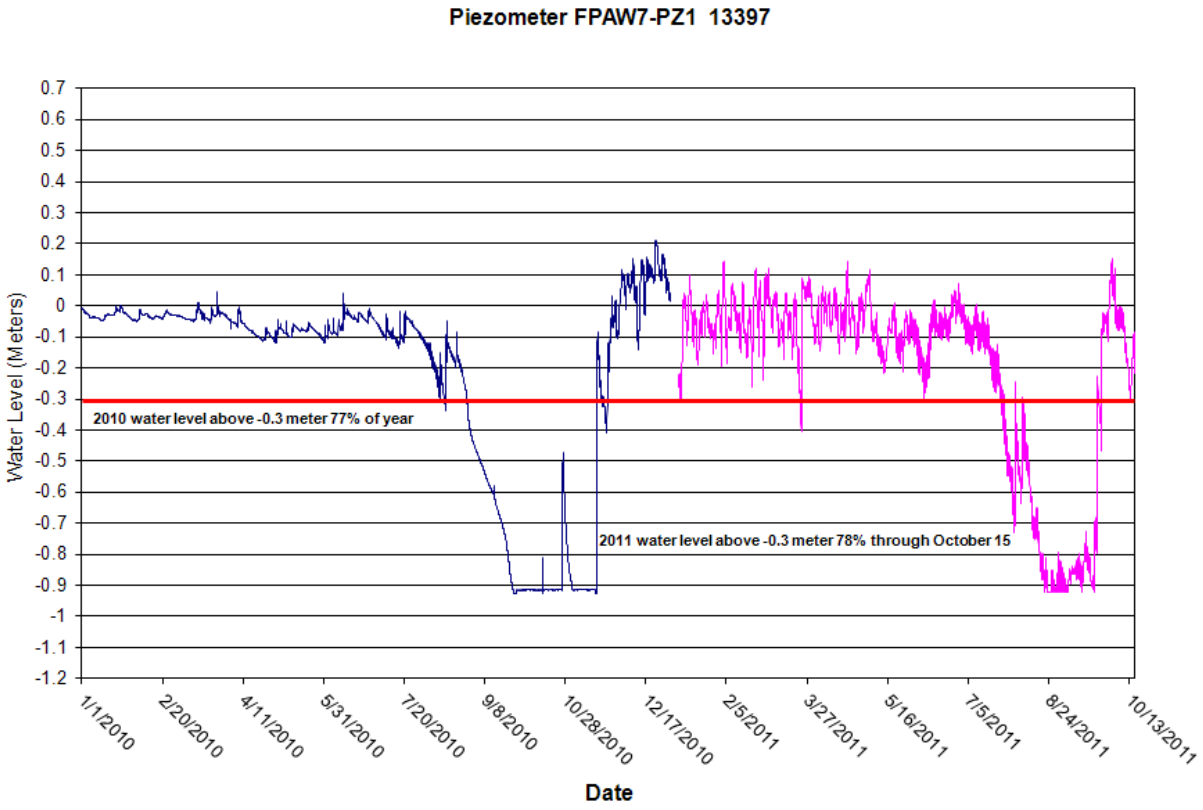

Figure 22. Former Production Area FPAW7 Hydrograph

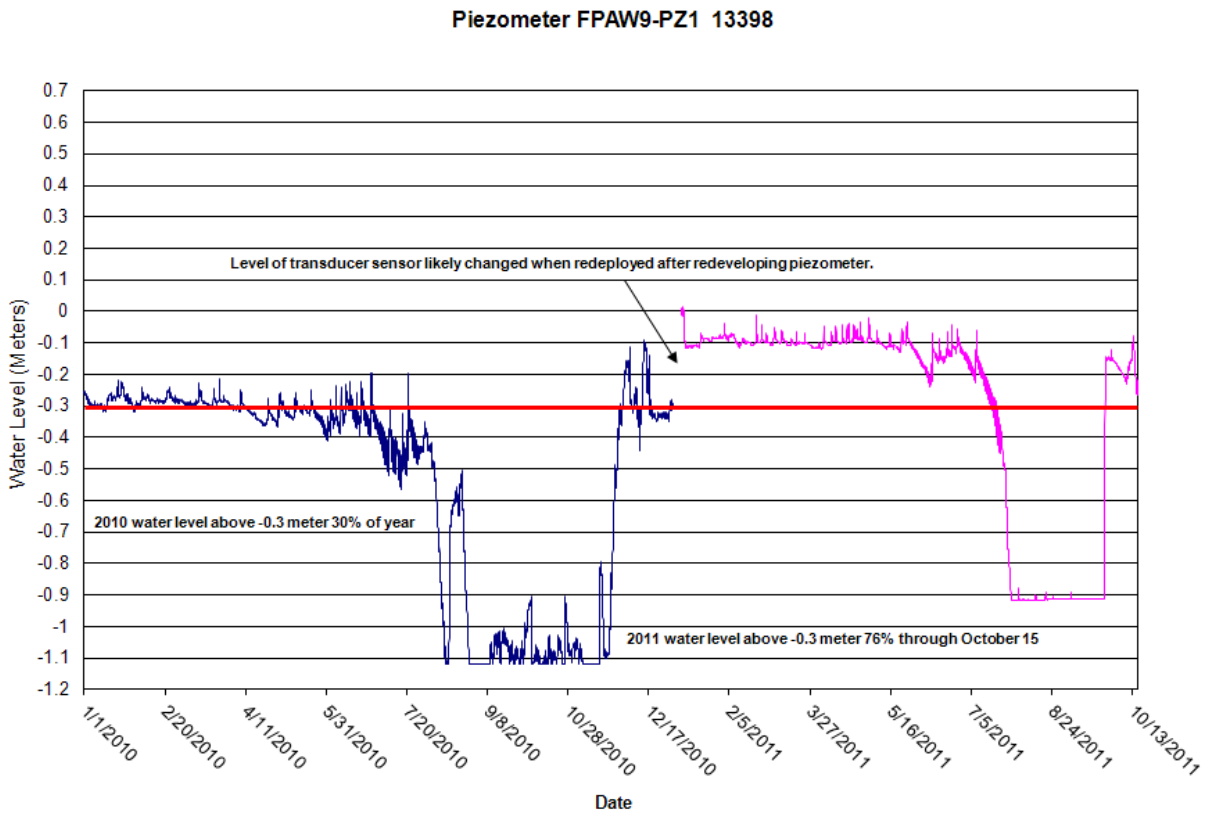

Figure 23. Former Production Area FPAW9 Hydrograph

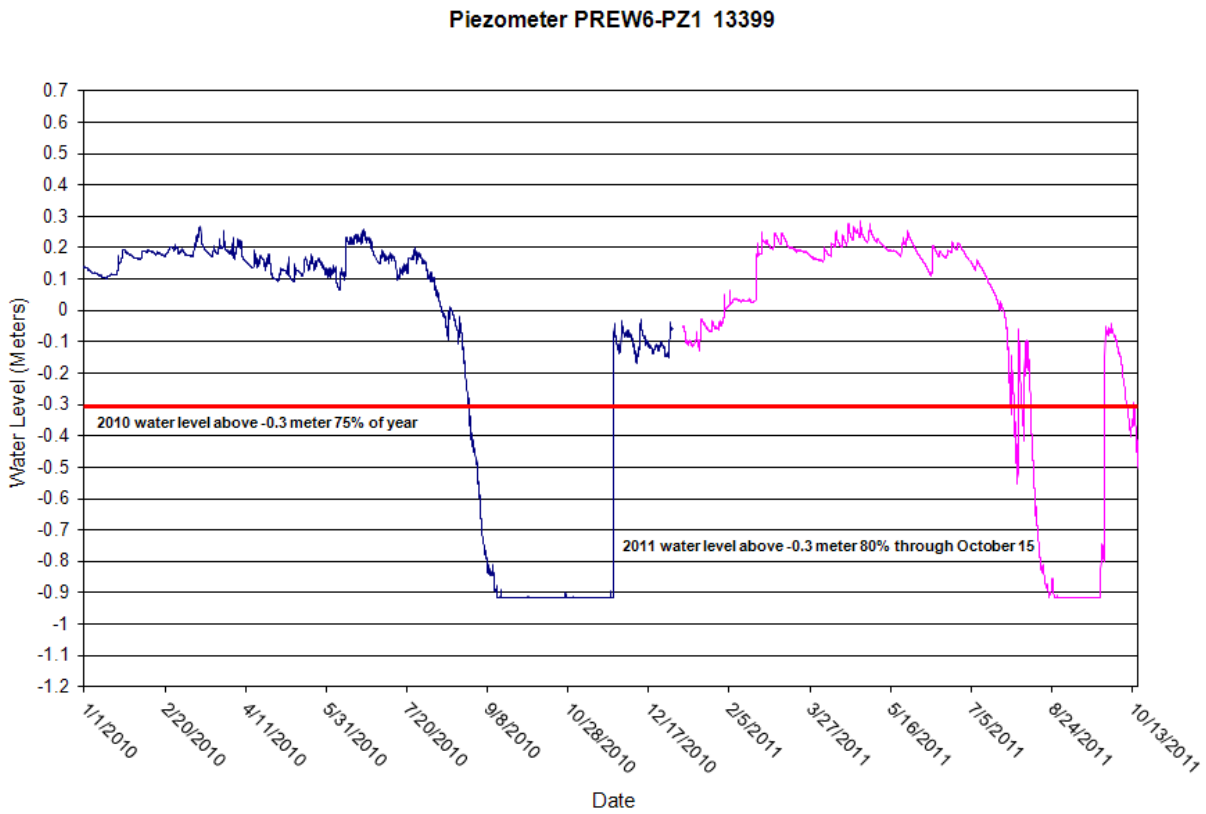

Figure 24. Former Production Area PREW6 Hydrograph

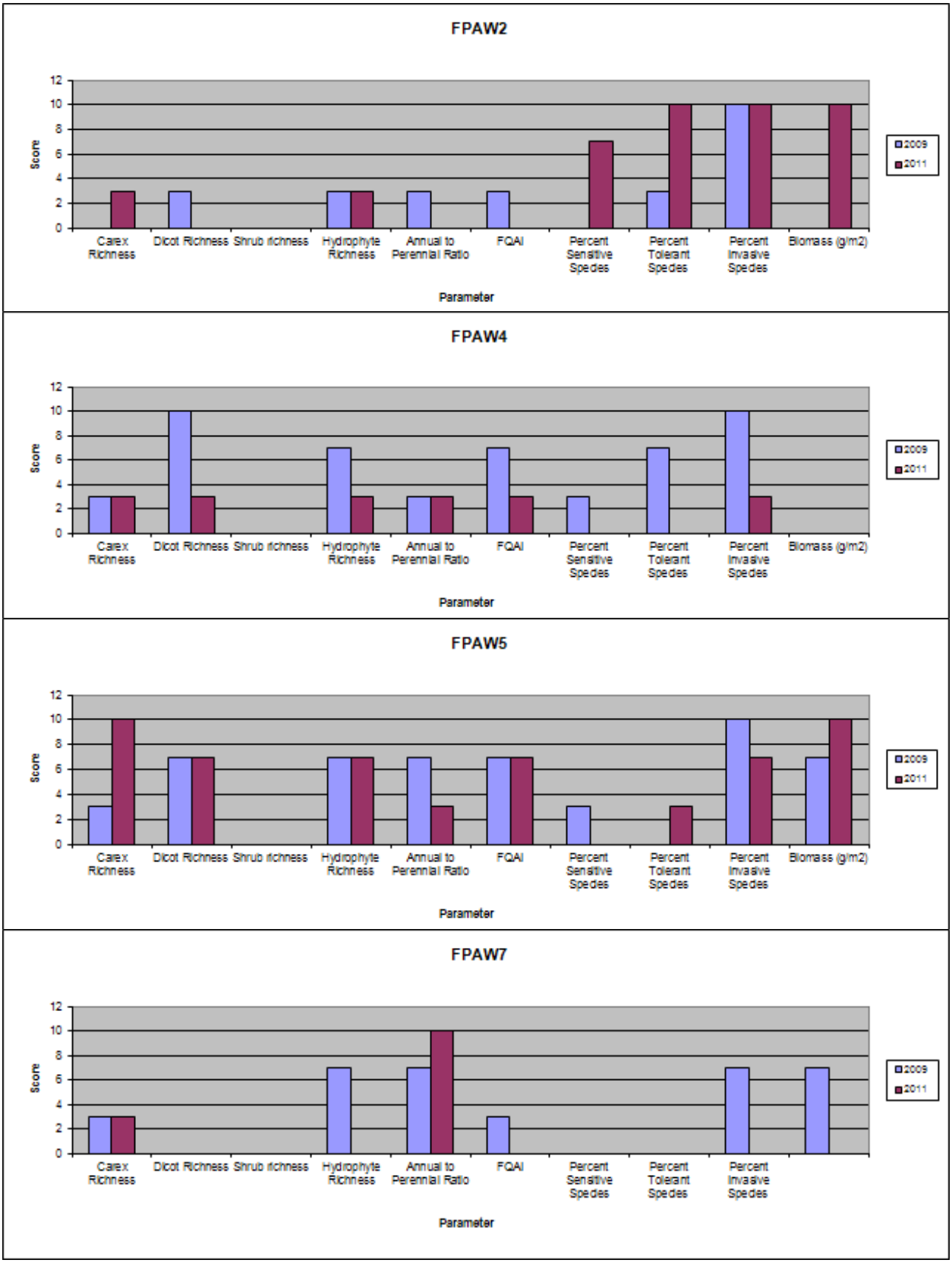

Figure 25. Former Production Area VIBI Chart

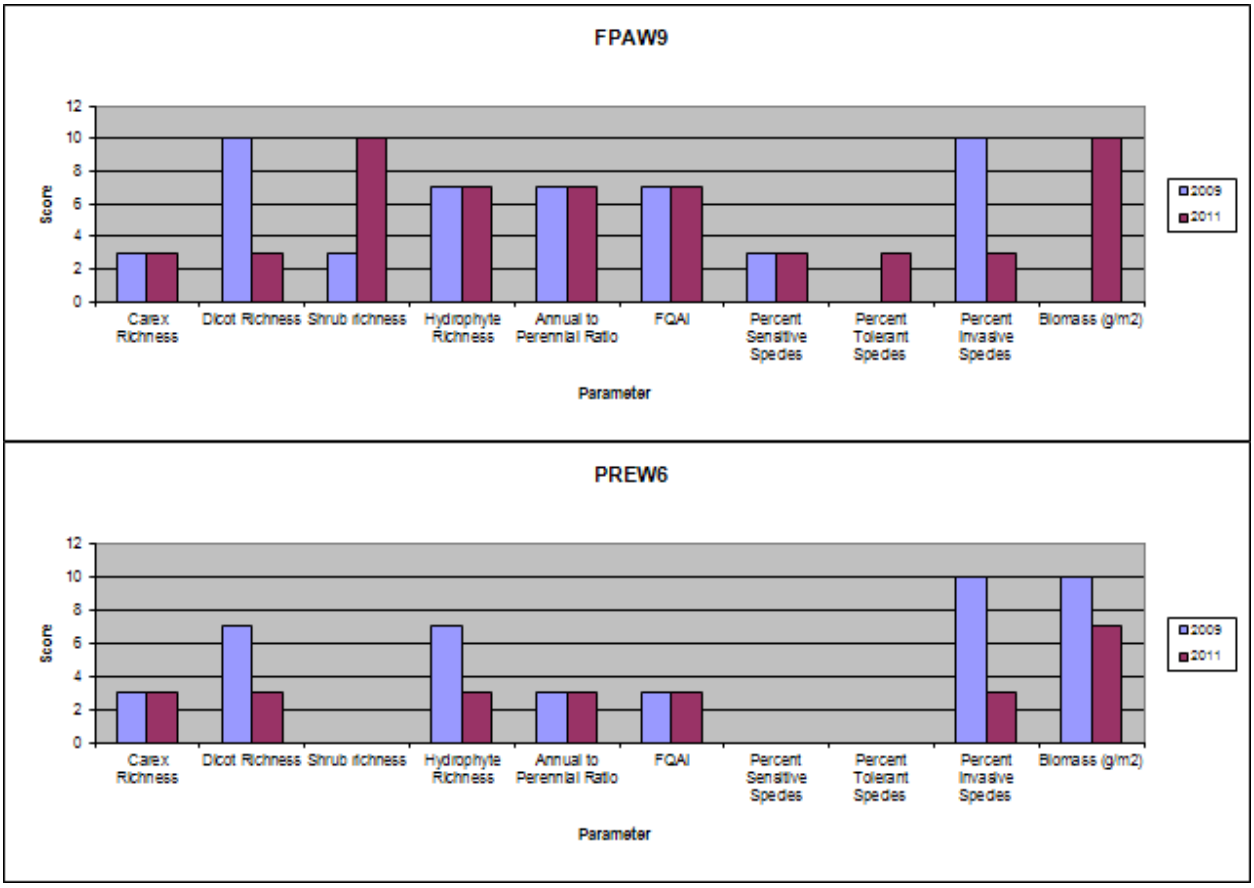

Figure 25 (continued). Former Production Area VIBI Chart

3.3 Northern Pines Plantation

The NPP wetlands lie within what used to be a monoculture evergreen woodlot. Restoration of this area took place in 2003 and consisted primarily of replacing the conifers with a deciduous forest community. Due to surface water hydrology of this area and several old agricultural drain tiles found during restoration, several wet prairies and emergent wetlands were created. Today, there are several distinct basins that exhibit hydrologic connectivity. Wetland types include vernal pool, sedge meadow, and emergent communities.

3.3.1 NPP Design Parameter Results

Jurisdictional wetland boundaries total 0.89 acre. Figure 26 displays the wetland boundaries and the sample points used to identify wetland areas. Table 19 provides basin-specific wetland acreage. The wetland boundaries are consistent with the design intent. Hydric soils were actually present across much of the larger NPP project area, suggesting that jurisdictional wetlands may eventually be expanding.

The basin morphometry standard was met for both NPPW4 and NPPW5 (Table 19). Figure 27 shows some gradient from the northern vernal pool to the two other basins that make up NPPW4.

3.3.2 NPP Hydrologic Regime Results

Hydrology within NPP is characterized through data collected from two piezometers, as shown on Figure 28. Table 20 presents the results for each basin. Figures 29 and 30 show basin-specific hydrographs. All hydrologic performance standards were met in both 2010 and 2011.

3.3.3 NPP Vegetation Parameter Results

Table 21 presents results from vegetation sampling. Figure 28 shows fixed-plot module locations. Results show improvement in vegetation composition and quality. Although only NPPW5 passed the native perennial hydrophyte parameter in 2011, the percentage of native hydrophytes in each basin increased by at least 30 percent from 2009. Both basins passed the VIBI standard in 2009 and in 2011, with higher scores seen in 2011. Figure 31 shows that VIBI metrics are fairly consistent between 2009 and 2011, with the exception of biomass.

The performance standard for unvegetated open water was obtained in both 2009 and 2011. NPPW4 is of particular note. Photographs in Appendix B–3 show a sedge meadow community developing between the northern vernal pool and the emergent wetlands to the south.

3.3.4 NPP Wildlife Parameter Results

Amphibian sampling results and calculation of AIBI values are presented in Table 22, with basin-specific data provided in Appendix A–3. NPPW4 is particularly noteworthy because of the number of salamander species identified within this wetland. During AIBI monitoring, both streamside salamanders (*Ambystoma barbouri*) and tiger salamanders (*Ambystoma tigrinum*) were identified. The wildlife summary shown in Table 23 indicates that a spotted salamander (*Ambystoma maculatum*) was also collected during species inventory sampling efforts. Spotted salamanders are good indicators of relatively undisturbed conditions (Micacchion 2004). The northern portion of NPPW4 is a vernal pool, which is subject to drying conditions annually in the summer and early fall. The hydrograph for NPPW4 demonstrates this pattern (Figure 29). The vernal pool hydrology, coupled with its location adjacent to an existing forest community, makes the NPPW4 basin an ideal system for wetland wildlife. In addition to the Ambystomatid salamanders, fairy shrimp (family *Chirocephalidae*) have been collected in NPPW4 as well (Table 23).

3.3.5 NPP Soil and Water Chemistry Results

Tables 24 and 25 show soil and water sampling results. As with most other wetlands, the soil biogeochemistry and water performance standards were not met. Regardless, the delineation results discussed in Section 3.3.1 suggest that the development of hydric soils is progressing.

Table 19. Northern Pine Plantation Design Parameter Summary

Basin	Parameter	Performance Standard	Result
NPPW4	Delineation Acreage	NA	0.80
	Acreage of Unvegetated Open Water >10%	NA	0.09
	Actual Wetland Acreage	NA	0.71
	Morphometry	<15:1 side slope	73%
NPPW5	Delineation Acreage	NA	0.19
	Acreage of Unvegetated Open Water >10%	NA	0.01
	Actual Wetland Acreage	NA	0.18
	Morphometry	<15:1 side slope	98%

NA = not applicable

Table 20. Northern Pine Plantation Hydrologic Regime Summary

Basin	Parameter	Performance Standard	2010	2011
NPPW4	Water in Root Zone (<30 cm)	>53%	65%	70%
	Mean Depth of Water	29.4 cm	28	18
	Flashiness Index	<2.0	0.33	0.65
NPPW5	Water in Root Zone (<30 cm)	>53%	67%	67%
	Mean Depth of Water	29.4 cm	28	24
	Flashiness Index	<2.0	0.53	0.62

Table 21. Northern Pine Plantation Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
NPPW4	% Unvegetated Open Water	<10%	0.0%	NA	5.3%	NA
	% Native Perennial Hydrophytes	>75%	42.0%	NA	72.1%	NA
	VIBI	48–63	51	NA	58	NA
	Carex Richness	NA	5	10	6	10
	Dicot Richness	NA	25	7	20	7
	Shrub richness	NA	1	0	0	0
	Hydrophyte Richness	NA	28	7	29	7
	Annual to Perennial Ratio	NA	0.26	7	0.14	10
	FQAI	NA	16.83	7	16.05	7
	% Sensitive Species	NA	0.4%	0	0.6%	0
	% Tolerant Species	NA	48.3%	3	72.8%	0
	% Invasive Species	<5%	0.0%	10	1.9%	10
	Biomass (g/m^2)	NA	99	0	263	7

Table 21 (continued). Northern Pine Plantation Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
NPPW5	% Unvegetated Open Water	<10%	0.3%	NA	3.8%	NA
	% Native Perennial Hydrophytes	>75%	32.2%	NA	79.6%	NA
	VIBI	48–63	51	NA	61	NA
	Carex Richness	NA	8	10	6	10
	Dicot Richness	NA	25	7	23	7
	Shrub richness	NA	0	0	0	0
	Hydrophyte Richness	NA	24	7	21	7
	Annual to Perennial Ratio	NA	0.17	10	0.12	10
	FQAI	NA	14.58	7	14.97	7
	% Sensitive Species	NA	0.2%	0	0.6%	0
	% Tolerant Species	NA	79.3%	0	66.4%	0
	% Invasive Species	<5%	0.0%	10	0.0%	10
	Biomass (g/m^2)	NA	0	0	184	10

g/m^2 = grams per square meter
NA = not applicable

Table 22. Northern Pine Plantation AIBI Summary

Basin	Parameter	2010	AIBI Score	2011	AIBI Score
NPPW4	AIBI	NA	**16**	NA	**33**
	Amphibian Quality Assessment Index	3.81	3	6.26	10
	% Relative Abundance of Sensitive Species	33%	7	85.11%	10
	% Relative Abundance of Tolerant Species	65%	3	14.83%	10
	Number of Pond-Breeding Salamanders	2	3	1	3
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
NPPW5	AIBI	NA	**24**	NA	**0**
	Amphibian Quality Assessment Index	5.30	7	2.82	0
	% Relative Abundance of Sensitive Species	65%	10	0%	0
	% Relative Abundance of Tolerant Species	35%	7	100%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0

Table 23. Northern Pine Plantation Other Wildlife Summary

Amphibian Summary			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Acris crepitans*	cricket frog	0	31	40
Funnel Traps*	*Ambystoma barbouri*	streamside salamander	0	10	0
Coverboards*	*Ambystoma barbouri*	streamside salamander	0	0	1
Funnel Traps*	*Ambystoma jeffersonianum*	Jefferson salamander	0	1	0
Funnel Traps*	*Ambystoma maculatum*	spotted salamander	0	2	0
Funnel Traps	*Ambystoma species*	salamander species	0	1	0
Funnel Traps	*Ambystoma tigrinum*	tiger salamander	0	0	1
Funnel Traps	*Anaxyrus americanus*	American toad	0	26	0
Funnel Traps	*Lithobates catesbeiana*	American bull frog	10	19	7
Funnel Traps	*Lithobates clamitans*	green frog	1	1	2
Funnel Traps	*Lithobates pipiens*	northern leopard frog	0	0	1
Funnel Traps	*Lithobates species*	Lithobates species	0	3	0
Funnel Traps	*Pseudacris crucifer*	spring peeper	90	6	14
Bird Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Aix sponsa*	wood duck	NA	NA	NA
Observation	*Dendroica petechia*	kentucky warbler	NA	NA	NA
Observation	*Dendroica pinus*	pine warbler	NA	NA	NA
Observation	*Hirundo rustica*	barn swallow	NA	NA	NA
Observation	*Icteria virens*	yellow chat	NA	NA	NA
Observation	*Passerina cyanea*	indigo bunting	NA	NA	NA
Observation	*Riparia riparia*	bank swallow	NA	NA	NA
Observation	*Spiza americana*	dickcissel	NA	NA	NA
Observation	*Sturnella magna*	eastern meadowlark	NA	NA	NA
Observation	*Tachycineta bicolor*	tree swallow	NA	NA	NA
Macroinvertebrate Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Asellidae	aquatic sowbug	0	0	38
Funnel Traps	Family: Notonectidae	backswimmer	34	85	77
Funnel Traps	Order: Coleoptera	beetle	172	177	0
Funnel Traps	Family: Ceratopogonidae	biting midge, no-see-um, punkin	0	1	0
Funnel Traps	Order: Trichoptera	caddisfly	0	0	1
Funnel Traps	Family: Haliplidae	crawling water beetle	0	0	17
Funnel Traps	Family: Cambaridae	crayfish	0	3	4
Funnel Traps	Family: Naucoridae	creeping water bug	0	169	11
Funnel Traps	Order: Odonata, Sub-Order: Zygoptera	damselfly	0	0	5
Funnel Traps	Family: Corydalidae	dobsonfly, fishfly	2	0	0
Funnel Traps	Order:Odonata,Sub-Order:Anisoptera	dragonfly	20	10	14
Funnel Traps	Family: Chirocephalidae	fairy shrimp	16	3	34
Funnel Traps	Order: Isopoda	isopods	18	6	0

Table 23 (continued). Northern Pine Plantation Other Wildlife Summary

Macroinvertebrate Summary (continued)			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Hirudinidae	leech	1	1	2
Funnel Traps	Family: Physidae	pouch snail	290	266	215
Funnel Traps	Order: Ephemeroptera	mayfly	1	33	4
Funnel Traps	Family: Hydrachnidiae	mite	2	2	0
Funnel Traps	Family: Dytiscidae	predaceous diving beetle	38	0	4
Funnel Traps	Family: Lymnaeidae	pond snail	65	38	5
Funnel Traps	Family: Gammaridae	sideswimmer/scud	0	11	27
Funnel Traps	Family: Planorbidae	ramhorn snail	166	109	54
Funnel Traps	Family: Corixidae	water boatman	2	74	17
Funnel Traps	Family: Hydrophilidae	water scavanger	0	0	27
Funnel Traps	Family: Nepidae	water scorpian	0	3	1
Funnel Traps	Family: Gerridae	water strider	1	30	1
Reptile Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Nerodia sipedon*	northern water snake	0	2	1
Coverboards	*Thamnophis sirtalis*	eastern garter snake	9	11	10
Small Mammal Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Blarina brevicauda*	short-tailed shrew	2	12	0
Coverboards	*Cryptotis parva*	least-tailed shrew	0	1	0
Coverboards	*Microtus pennsylvanicus*	meadow vole	20	2	1
Coverboards	*Peromyscus maniculatus*	deer mouse	15	1	0
Coverboards	*Scalopus aquaticus*	eastern mole	0	1	0
Coverboards	*Synaptomys cooperi*	bog lemming	1	0	0
Coverboards	Unknown	unknown mammal	0	0	2

*Collected for species inventory, not AIBI.

Table 24. Northern Pine Plantation Soil Sampling Summary

Basin	Parameter	Performance Standard (%)	2010				2011			
			N	Median (%)	Q_1 (%)	Q_2 (%)	N	Median (%)	Q_1 (%)	Q_2 (%)
NPPW4	% Solids	<46.6	6	62	56.5	73.5	6	78.4	70.2	80.9
	% Total Organic Carbon	>3.9	6	2.69	1.58	3.69	6	0.847	0.771	0.904
	% Total Nitrogen	>0.5	6	0.163	0.137	0.192	6	0.0992	0.0778	0.116
NPPW5	% Solids	<46.6	6	68.6	68.1	71	6	71.2	69.2	71.6
	% Total Organic Carbon	>3.9	6	0.815	0.576	0.959	6	0.573	0.331	0.706
	% Total Nitrogen	>0.5	6	0.0671	0.0484	0.114	6	0.0756	0.0639	0.0997

Table 25. Northern Pine Plantation Water Sampling Summary

Basin	Parameter	Units	2010	2011
NPPW4	Ammonia Total as Nitrogen	mg/L	0.114	0.236
	Chloride	mg/L	34.1	21.7
	Dissolved Oxygen	mg/L	7.15	4.26
	Iron	mg/L	0.712	18.1
	Magnesium	mg/L	18.8	17.6
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	1.04
	Oxidation Reduction Potential	mV	232	-30
	pH	unitless	7.36	6.87
	Phosphorous	mg/L	0.234	<0.1
	Potassium	mg/L	1.67	2.64
	Specific Conductance	umhos/cm	566	255
	Temperature	C	26.8	28.0
	Total Kjeidahl Nitrogen	mg/L	0.21	2.29
	Total Organic Carbon	mg/L	10.2	16.3
	Total Solids	mg/L	622	532
	Total Suspended Solids	mg/L	156	189
	Turbidity	NTU	10.1	9.48
NPPW5	Ammonia Total as Nitrogen	mg/L	<0.016	0.174
	Chloride	mg/L	23.5	19.8
	Dissolved Oxygen	mg/L	7.75	9.9
	Iron	mg/L	1.23	1.14
	Magnesium	mg/L	27.5	24.3
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.286
	Oxidation Reduction Potential	mV	232	56
	pH	unitless	7.76	7.66
	Phosphorous	mg/L	<0.108	0.2
	Potassium	mg/L	2.53	1.92
	Specific Conductance	umhos/cm	578	606
	Temperature	C	28.19	25.22
	Total Kjeidahl Nitrogen	mg/L	<0.033	0.312
	Total Organic Carbon	mg/L	8.76	9.47
	Total Solids	mg/L	608	452
	Total Suspended Solids	mg/L	195	50.8
	Turbidity	NTU	27.6	13.6

C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
umhos/cm = micromhos per centimeter

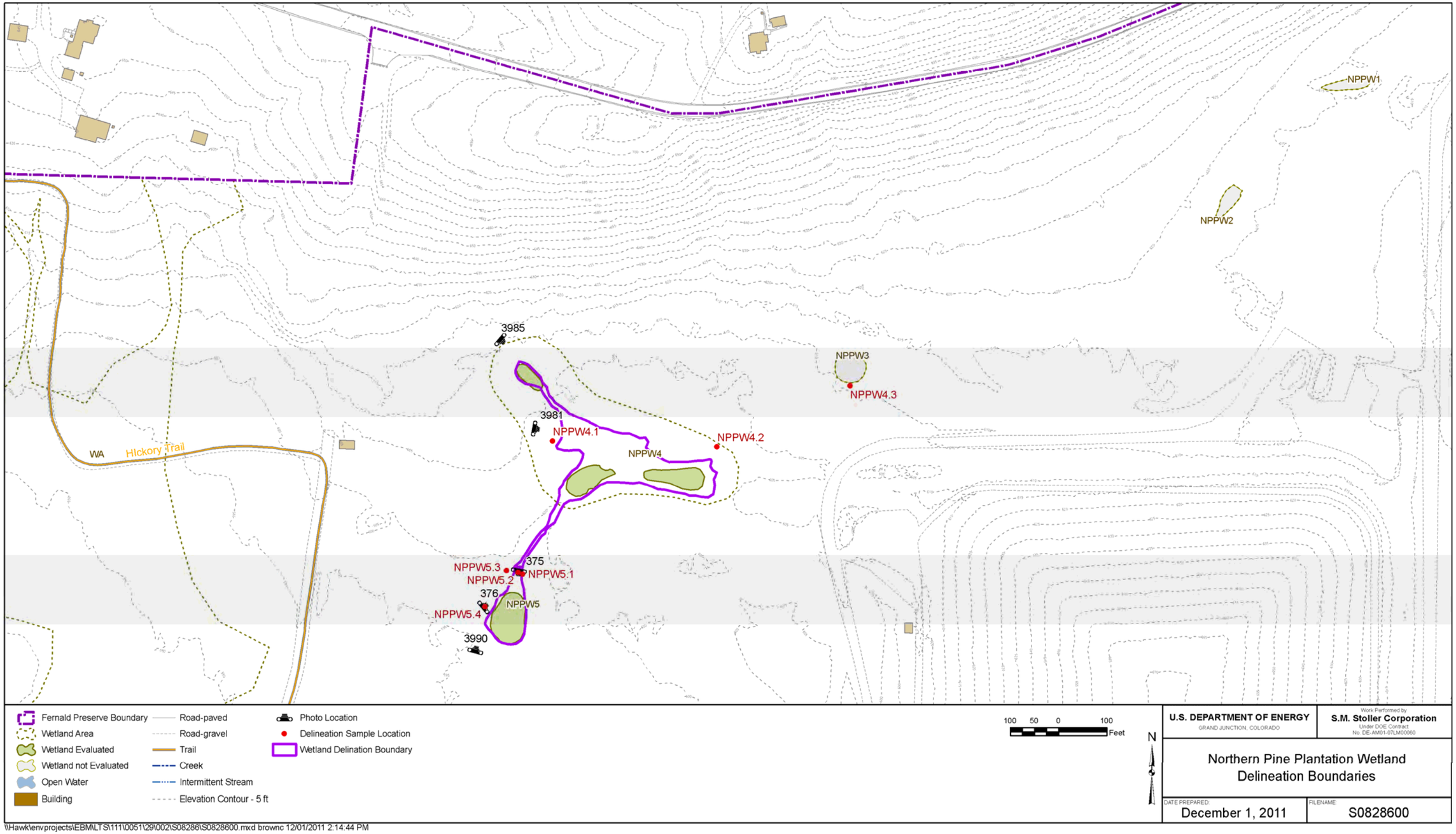

Figure 26. Northern Pine Plantation Wetland Delineation Boundaries

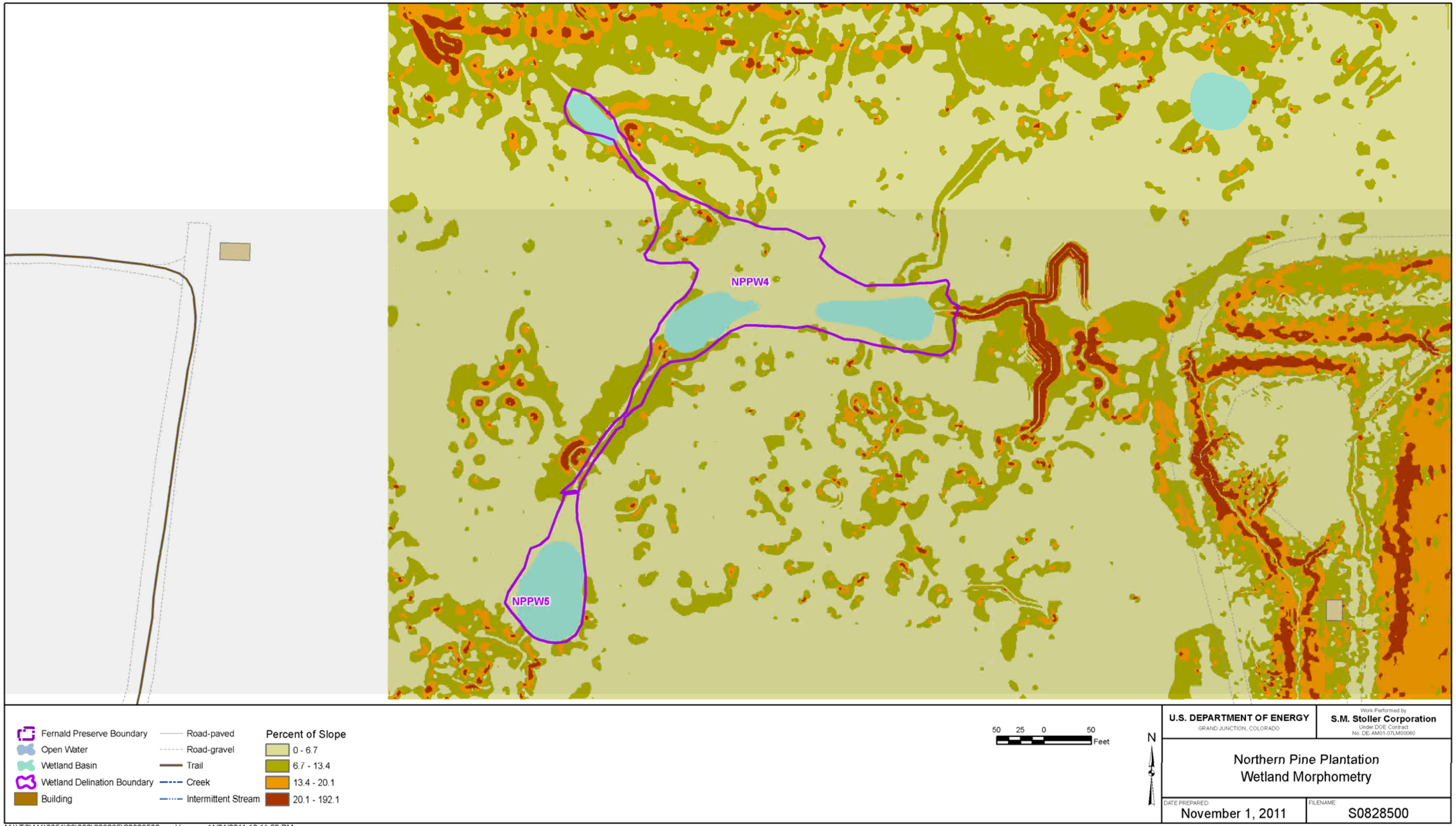

Figure 27. Northern Pine Plantation Wetland Morphometry

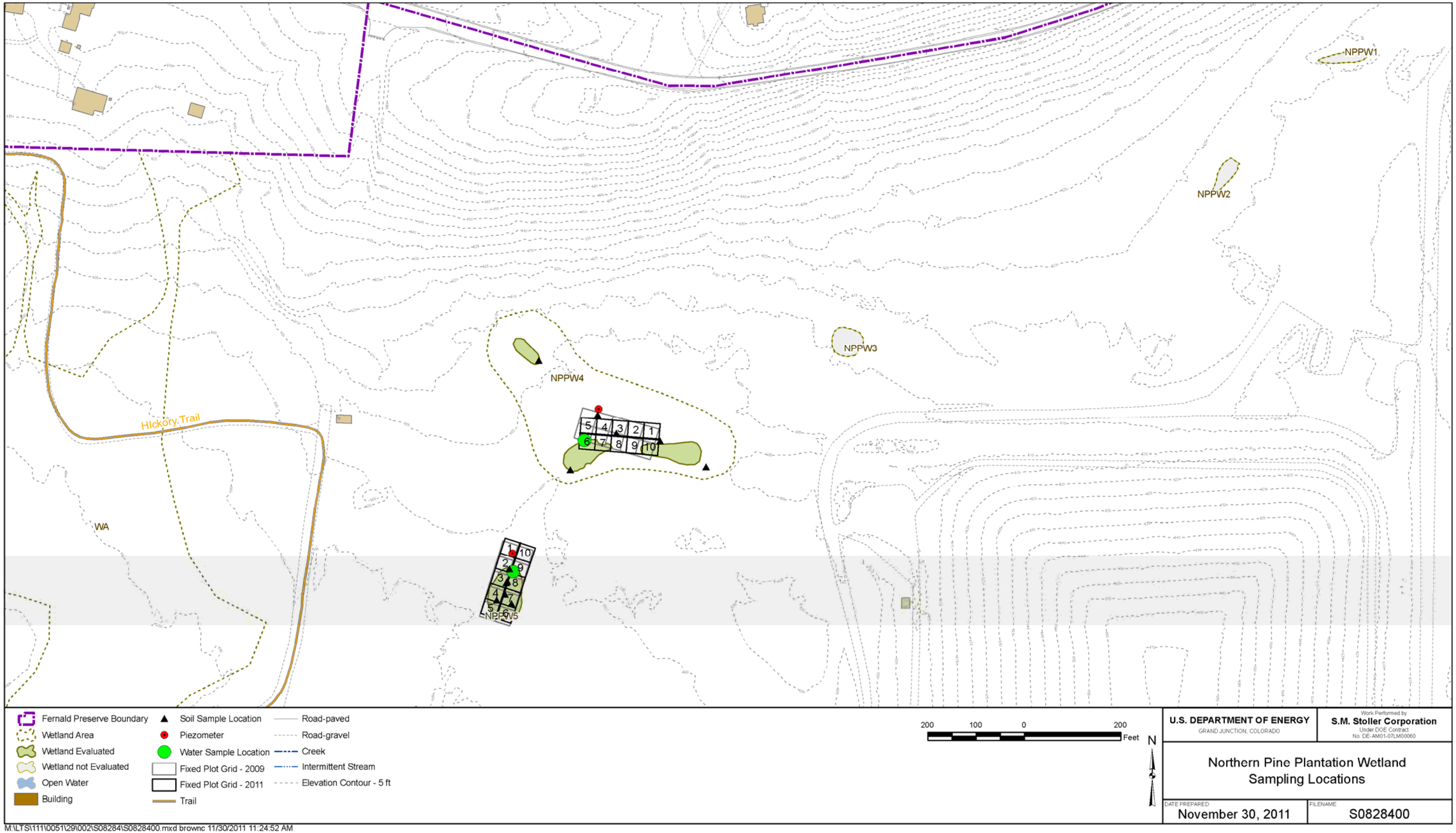

Figure 28. Northern Pine Plantation Wetland Sampling Locations

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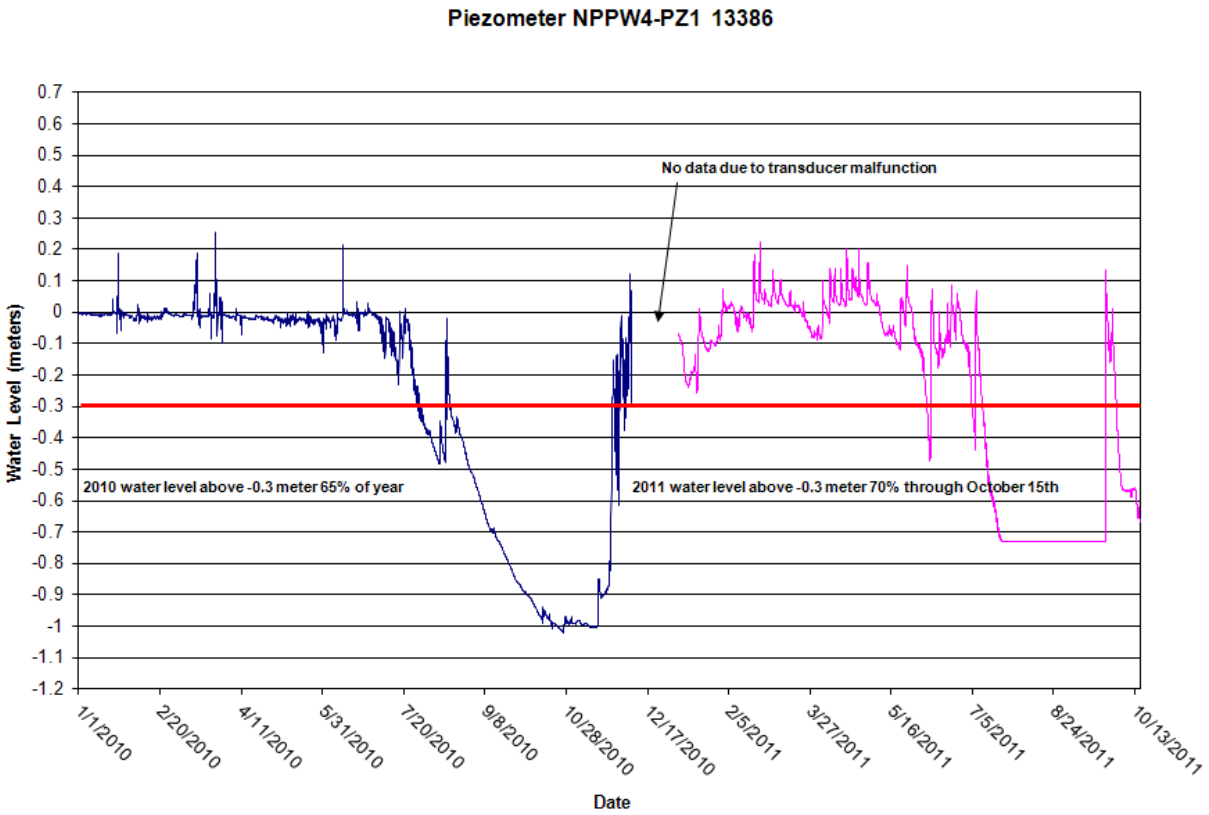

Figure 29. Northern Pine Plantation NPPW4 Hydrograph

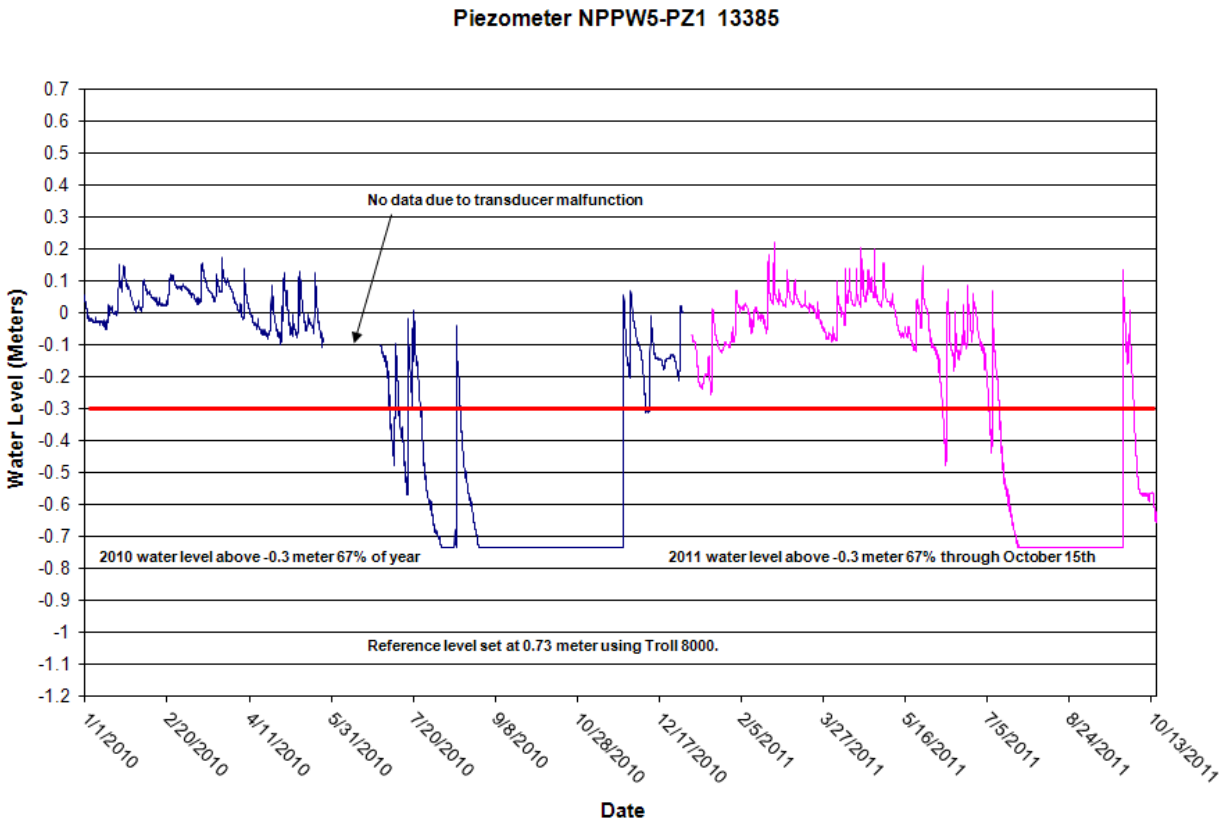

Figure 30. Northern Pine Plantation NPPW5 Hydrograph

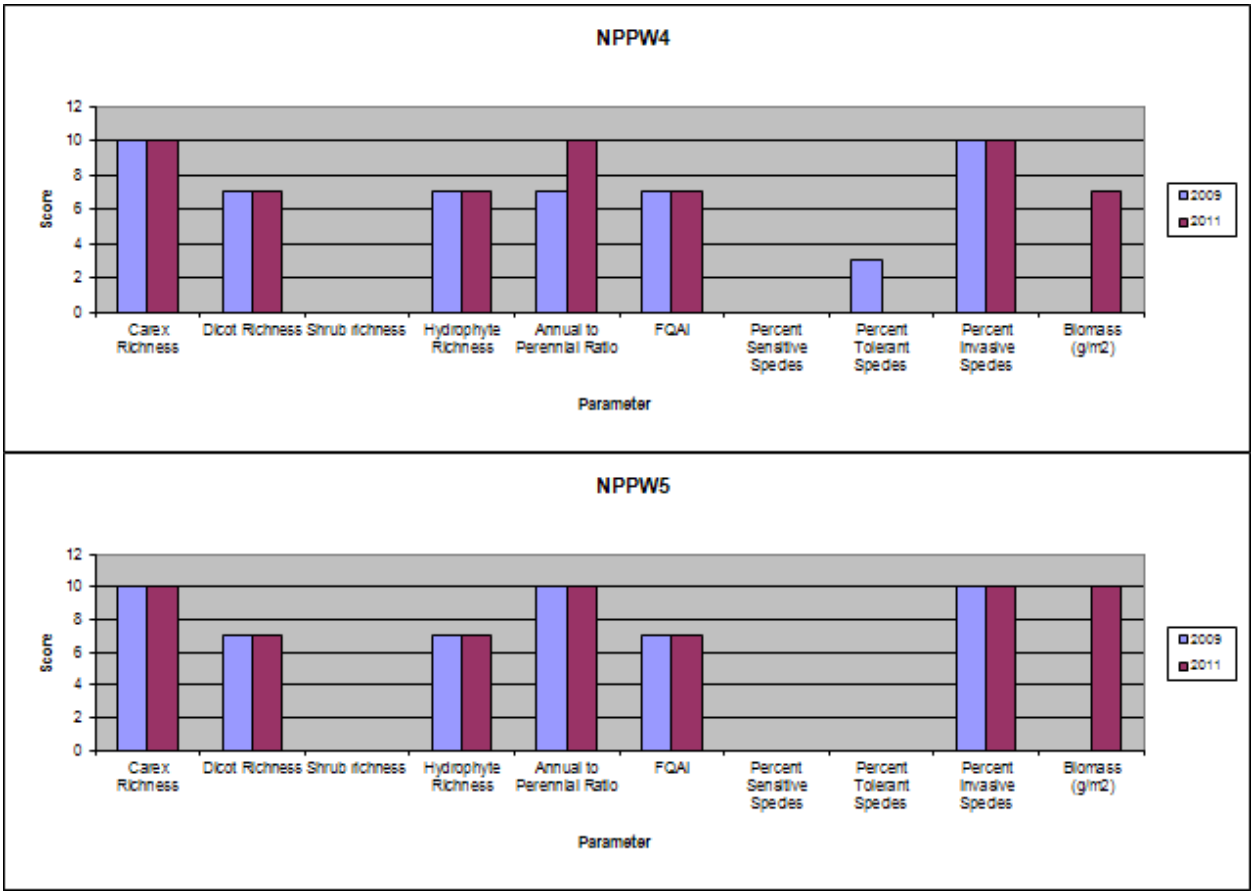

Figure 31. Northern Pine Plantation VIBI Chart

3.4 Wetland Mitigation Phase I

The WM1 wetlands are composed of a series of eight basins across approximately 12 acres. The basins are hydrologically connected through a series of swales and include a variety of emergent, wet meadow, scrub/shrub, and open water areas, surrounded by upland prairie and forest patches. Note that for the NRRP, WM1W7 was originally two separate basins (Basins 7 and 8). The hydrologic connectivity between Basins 7 and 8 was sufficient to combine the two. As Table 1 shows, this area was one of the first to be completed at the Fernald site. Appendix B–1 and B–3 provide photographs that show well-established vegetation and a maturing tree population. The WM1 project was previously monitored for several years from 2000 through 2004. Progress photographs were included as part of this effort. New photographs were taken from the same vantage points in 2011to assess progress. These comparison photographs are also included in Appendix B–1.

3.4.1 WM1 Design Parameters

The jurisdictional wetland delineation for WM1 resulted in a total of 5.82 acres of identified wetland area. Table 26 shows basin-specific acreage. Figure 32 shows the wetland boundaries and the sample points used to identify wetland areas. A previous wetland delineation conducted

in 2004 showed 5.34 acres of wetlands, so the 2011 delineation boundaries remain consistent with the original design intent.

Basin morphometry performance was met for all basins (Table 26, Figure 33). The wetland design plan lends to ample areas of level ground.

3.4.2 WM1 Hydrologic Regime Results

Hydrology within WM1 is characterized through data collected from seven piezometers, as shown on Figure 34. Table 27 presents the results for each basin. Figures 35 through 41 show basin-specific hydrographs. All basins met the standard for the Flashiness Index, and with the exception of WM1W1, all basins were within the criteria for water in the root zone. Only three of the seven basins achieved the standard for the mean depth to water. The basin designs of WM1 allowed for a larger sedge meadow community that extends well beyond emergent wetland borders. The locations of piezometers reflect this design and are, thus, further removed from the surface water impoundments (Figure 34). This is particularly true in Basins WM1W1 and WM1W3, which did not meet the mean water depth performance standard.

3.4.3 WM1 Vegetation Parameter Results

Table 28 presents results from vegetation sampling. Figure 34 shows fixed-plot module locations. Figure 42 provides VIBI metric charts. Results show a general decrease in the percentage of native perennial hydrophytes, with the exception of WM1W6, as well as a general decrease in the VIBI score, with the exception of WM1W5. These lower percentages and scores are likely due to the implementation of a new field protocol in 2011, which identifies all *Typha* species as the hybrid *Typha X glauca* instead of differentiating between the native *Typha latifolia* and the nonnative *Typha angustifolia*. Section 4.1 discusses these findings further.

Both the 2009 and 2011 unvegetated open water results met the performance standard in all basins.

3.4.4 WM1 Wildlife Parameter Results

Table 29 shows amphibian sampling results and the calculation of AIBI values. Wetlands WM1W1, WM1W4, and WM1W7 were evaluated. The basins in WMI generally result in low AIBI scores. This is to be expected as there is no established salamander population nearby. However, the first breeding Ambystomatid salamander was found in 2011 in WMIW1. Table 30 presents the results of all wildlife surveying efforts. As with other wetlands at the Fernald Preserve, a diverse assemblage of wildlife is present.

3.4.5 WM1 Soil and Water Chemistry Results

Tables 31 and 32 summarizes results for soil and water sampling. Consistent with results across all wetlands sampled, soil biogeochemistry performance standards were not met. As with other basins, the soil biogeochemistry results are mitigated somewhat by the wetland delineation findings. The delineation effort demonstrates the establishment of hydric soils across all basins. Water chemistry results are generally within typical ranges.

Table 26. Wetland Mitigation Phase I Design Parameter Summary

Basin	Parameter	Performance Standard	Result
WM1W1	Delineation Acreage	NA	0.94
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	0.94
	Morphometry	<15:1 side slope	68%
WM1W2	Delineation Acreage	NA	1.13
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	1.13
	Morphometry	<15:1 side slope	91%
WM1W3	Delineation Acreage	NA	0.80
	Acreage of Unvegetated Open Water >10%	NA	0.04
	Actual Wetland Acreage	NA	0.76
	Morphometry	<15:1 side slope	80%
WM1W4	Delineation Acreage	NA	1.00
	Acreage of Unvegetated Open Water >10%	NA	0.22
	Actual Wetland Acreage	NA	0.78
	Morphometry	<15:1 side slope	88%
WM1W5	Delineation Acreage	NA	0.23
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	0.23
	Morphometry	<15:1 side slope	71%
WM1W6	Delineation Acreage	NA	1.45
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	1.45
	Morphometry	<15:1 side slope	83%
WM1W7	Delineation Acreage	NA	0.54
	Acreage of Unvegetated Open Water >10%	NA	0.01
	Actual Wetland Acreage	NA	0.53
	Morphometry	<15:1 side slope	76%

NA = not applicable

Table 27. Wetland Mitigation Phase I Hydrologic Regime Summary

Basin	Parameter	Performance Standard	2010	2011
WM1W1	Water in Root Zone (<30 cm)	>53%	34%	52%
	Mean Depth of Water	29.4 cm	49	41
	Flashiness Index	<2.0	0.71	0.72
WM1W2	Water in Root Zone (<30 cm)	>53%	67%	68%
	Mean Depth of Water	29.4 cm	36	32
	Flashiness Index	2	0.48	0.36
WM1W3	Water in Root Zone (<30 cm)	>53%	63%	63%
	Mean Depth of Water	29.4 cm	41	38
	Flashiness Index	<2.0	0.54	0.71
WM1W4	Water in Root Zone (<30 cm)	>53%	77%	77%
	Mean Depth of Water	29.4 cm	24	22
	Flashiness Index	2	0.39	0.39
WM1W5	Water in Root Zone (<30 cm)	>53%	53%	61%
	Mean Depth of Water	29.4 cm	38	29
	Flashiness Index	<2.0	1.17	1.33
WM1W6	Water in Root Zone (<30 cm)	>53%	66%	50%
	Mean Depth of Water	29.4 cm	30	52
	Flashiness Index	<2.0	0.38	0.64
WM1W7	Water in Root Zone (<30 cm)	>53%	61%	58%
	Mean Depth of Water	29.4 cm	37	25
	Flashiness Index	<2.0	0.77	0.61

Table 28. Wetland Mitigation Phase I Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
WM1W1	% Unvegetated Open Water	<10%	0.0%	NA	1.3%	NA
	% Native Perennial Hydrophytes	>75%	62.9%	NA	47.2%	NA
	VIBI	48–63	40	NA	39	NA
	Carex Richness	NA	4	7	4	7
	Dicot Richness	NA	19	7	13	3
	Shrub richness	NA	2	3	1	0
	Hydrophyte Richness	NA	29	7	27	7
	Annual to Perennial Ratio	NA	0.18	10	0.15	10
	FQAI	NA	13.57	3	12.53	3
	% Sensitive Species	NA	2.3%	0	6.0%	3
	% Tolerant Species	NA	89.1%	0	72.8%	0
	% Invasive Species	<5%	21.7%	3	24.7%	3
	Biomass (g/m^2)	NA	1229	0	556	3
WM1W2	% Unvegetated Open Water	<10%	0.1%	NA	2.1%	NA
	% Native Perennial Hydrophytes	>75%	65.9%	NA	60.6%	NA
	VIBI	48–63	71	NA	61	NA
	Carex Richness	NA	6	10	9	10
	Dicot Richness	NA	31	10	27	10
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	32	10	27	7
	Annual to Perennial Ratio	NA	0.16	10	0.19	10
	FQAI	NA	17.56	7	16.01	7
	% Sensitive Species	NA	34.3%	10	12.1%	7
	% Tolerant Species	NA	37.6%	7	46.2%	3
	% Invasive Species	<5%	10.2%	7	8.6%	7
	Biomass (g/m^2)	NA	97	0	84	0
WM1W3	% Unvegetated Open Water	<10%	0.0%	NA	3.8%	NA
	% Native Perennial Hydrophytes	>75%	95.6%	NA	75.6%	NA
	VIBI	48–63	61	NA	46	NA
	Carex Richness	NA	5	10	5	10
	Dicot Richness	NA	18	7	17	3
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	27	7	20	3
	Annual to Perennial Ratio	NA	0.27	7	0.38	3
	FQAI	NA	12.12	3	11.07	3
	% Sensitive Species	NA	18.8%	10	12.0%	7
	% Tolerant Species	NA	73.5%	0	69.5%	0
	% Invasive Species	<5%	1.3%	10	0.9%	10
	Biomass (g/m^2)	NA	448	7	299	7

Table 28 (continued). Wetland Mitigation Phase I Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
WM1W4	% Unvegetated Open Water	<10%	1.1%	NA	8.0%	NA
	% Native Perennial Hydrophytes	>75%	67.9%	NA	60.2%	NA
	VIBI	48–63	61	NA	54	NA
	Carex Richness	NA	6	10	8	10
	Dicot Richness	NA	26	10	29	10
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	26	7	30	7
	Annual to Perennial Ratio	NA	0.17	10	0.26	7
	FQAI	NA	15.28	7	13.44	3
	% Sensitive Species	NA	13.1%	7	14.6%	7
	% Tolerant Species	NA	64.8%	0	62.9%	1
	% Invasive Species	<5%	0.7%	10	2.6%	10
	Biomass (g/m^2)	NA	875	0	77	0
WM1W5	% Unvegetated Open Water	<10%	0.0%	NA	0.0%	NA
	% Native Perennial Hydrophytes	>75%	71.7%	NA	71.0%	NA
	VIBI	48–63	26	NA	32	NA
	Carex Richness	NA	0	0	0	0
	Dicot Richness	NA	23	7	11	3
	Shrub richness	NA	2	3	2	3
	Hydrophyte Richness	NA	19	3	13	3
	Annual to Perennial Ratio	NA	0.30	7	0.17	10
	FQAI	NA	12.57	3	8.22	0
	% Sensitive Species	NA	0.9%	0	0.0%	0
	% Tolerant Species	NA	96.7%	0	88.4%	0
	% Invasive Species	<5%	46.4%	0	18.2%	3
	Biomass (g/m^2)	NA	622	3	128	10
WM1W6	% Unvegetated Open Water	<10%	0.0%	NA	1.3%	NA
	% Native Perennial Hydrophytes	>75%	35.2%	NA	43.3%	NA
	VIBI	48–63	67	NA	48	NA
	Carex Richness	NA	6	10	9	10
	Dicot Richness	NA	27	10	19	7
	Shrub richness	NA	2	3	1	0
	Hydrophyte Richness	NA	30	7	24	7
	Annual to Perennial Ratio	NA	0.16	10	0.19	10
	FQAI	NA	15.50	7	14.7	7
	% Sensitive Species	NA	15.6%	10	2.2%	0
	% Tolerant Species	NA	68.1%	0	66.1%	0
	% Invasive Species	<5%	3.5%	7	4.4%	7
	Biomass (g/m^2)	NA	602	3	21	0

Table 28 (continued). Wetland Mitigation Phase I Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
WM1W7	% Unvegetated Open Water	<10%	0.1%	NA	2.9%	NA
	% Native Perennial Hydrophytes	>75%	79.4%	NA	64.0%	NA
	VIBI	48–63	54	NA	42	NA
	Carex Richness	NA	4	7	2	3
	Dicot Richness	NA	13	3	5	0
	Shrub richness	NA	2	3	0	0
	Hydrophyte Richness	NA	21	7	19	9
	Annual to Perennial Ratio	NA	0.10	10	0.08	10
	FQAI	NA	12.17	3	10.39	3
	% Sensitive Species	NA	0.3%	0	0.4%	0
	% Tolerant Species	NA	24.0%	7	66.7%	0
	% Invasive Species	<5%	4.1%	7	1.1%	10
	Biomass (g/m^2)	NA	247	7	272	7

g/m^2 = grams per square meter
NA = not applicable

Table 29. Wetland Mitigation Phase I AIBI Summary

Basin	Parameter	2010	AIBI Score	2011	AIBI Score
WM1W1	AIBI	NA	**0**	NA	**3**
	Amphibian Quality Assessment Index	2.00	0	2.00	0
	% Relative Abundance of Sensitive Species	0%	0	0%	0
	% Relative Abundance of Tolerant Species	100%	0	80%	0
	Number of Pond-Breeding Salamanders	0	0	1	3
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
WM1W4	AIBI	NA	**13**	NA	**3**
	Amphibian Quality Assessment Index	3.14	3	1.51	0
	% Relative Abundance of Sensitive Species	23%	7	2%	3
	% Relative Abundance of Tolerant Species	77%	3	98%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
WM1W7	AIBI	NA	**0**	NA	**0**
	Amphibian Quality Assessment Index	2.14	0	3.00	0
	% Relative Abundance of Sensitive Species	0%	0	0%	0
	% Relative Abundance of Tolerant Species	88%	0	100%	0
	Number of Pond-Breeding Salamanders	0	0	0	0
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0

NA = not applicable

Table 30. Wetland Mitigation Phase I Other Wildlife Summary

Amphibian Summary			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Acris crepitans*	cricket frog	NA	8	1
Funnel Traps	*Ambystoma species*	salamander species	NA	0	1
Funnel Traps	*Lithobates catesbeiana*	american bull frog	NA	42	16
Funnel Traps	*Lithobates clamitans*	green frog	NA	2	10
Funnel Traps	*Lithobates pipiens*	northern leopard frog	NA	1	0
Funnel Traps	*Lithobates species*	frog species	NA	4	19
Funnel Traps	*Pseudacris crucifer*	spring peeper	NA	0	40
Bird Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Agelaius phoeniceus*	red winged black bird	NA	NA	NA
Observation	*Aix sponsa*	wood duck	NA	NA	NA
Observation	*Ardea herodias*	great blue heron	NA	NA	NA
Observation	*Butorides virescens*	green heron	NA	NA	NA
Observation	*Empidonax traillii*	willow flycatcher	NA	NA	NA
Observation	*Megaceryle alcyon*	belted kingfisher	NA	NA	NA
Observation	*Nycticorax nycticorax*	black cap night heron	NA	NA	NA
Observation	*Riparia riparia*	bank swallow	NA	NA	NA
Observation	*Spiza americana*	dickcissel	NA	NA	NA
Observation	*Tachycineta bicolor*	tree swallow	NA	NA	NA
Observation	*Tyrannus tyrannus*	eastern king bird	NA	NA	NA
Observation	*Zenaida macroura*	morning dove	NA	NA	NA
Fish Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Cyprinella spiloptera*	spotfin shiner	0	0	5
Funnel Traps	*Pimephales notatus*	bluntnose minnow	0	0	70
Macroinvertebrate Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Asellidae	aquatic sowbug	NA	0	13
Funnel Traps	Family: Belostomatidae	giant waterbug	NA	0	9
Funnel Traps	Family: Chirocephalidae	fairy shrimp	NA	51	3
Funnel Traps	Order: Coleoptera	beetle	NA	65	0
Funnel Traps	Family: Corixidae	water boatman	NA	3	3
Funnel Traps	Family: Dytiscidae	predaceous diving beetle	NA	1	5
Funnel Traps	Order: Ephemeroptera	mayfly	NA	2	1
Funnel Traps	Family: Gammaridae	sideswimmer/scud	NA	22	14
Funnel Traps	Family: Gerridae	water strider	NA	0	1
Funnel Traps	Family: Haliplidae	crawling water beetle	NA	0	16
Funnel Traps	Order: Haplotaxida (Tubificina)	freshwater worm	NA	10	0
Funnel Traps	Family: Hirudinidae	leech	NA	5	2
Funnel Traps	Family: Hydrachnidiae	mite	NA	3	0
Funnel Traps	Family: Hydrophilidae	water scavanger	NA	0	9
Funnel Traps	Order: Isopoda	isopod	NA	68	1

Table 30 (continued). Wetland Mitigation Phase I Other Wildlife Summary

Macroinvertebrate Summary (continued)			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Lymnaeidae	pond snail	NA	0	1
Funnel Traps	Family: Naucoridae	creeping water bug	NA	3	1
Funnel Traps	Family: Nepidae	water scorpian	NA	1	2
Funnel Traps	Family: Notonectidae	backswimmer	NA	29	25
Funnel Traps	Order:Odonata, Sub-Order:Anisoptera	dragonfly	NA	7	20
Funnel Traps	Order: Odonata, Sub-Order: Zygoptera	damselfly	NA	2	0
Funnel Traps	Family: Physidae	pouch snail	NA	577	388
Funnel Traps	Family: Planorbidae	ramhorn snail	NA	28	90
Funnel Traps	Family: Psephenidae	water penny beetle	NA	0	1
Funnel Traps	Order: Trichoptera	caddisfly	NA	2	2
Funnel Traps	Order: Unionoida	clam	NA	0	1
Reptile Coverboard			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Nerodia sipedon*	northern water snake	6	2	0
Coverboards	*Pantherophis alleghaniensis*	eastern black rat snake	0	0	2
Coverboards	*Thamnophis sirtalis*	garter snake	16	13	14
Small Mammal Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Blarina brevicauda*	short-tailed shrew	1	3	3
Coverboards	*Cryptotis parva*	least-tailed shrew	0	1	0
Coverboards	*Microtus pennsylvanicus*	meadow vole	17	11	2
Coverboards	*Mus musculus*	field mouse	0	0	1
Coverboards	*Peromyscus maniculatus*	deer mouse	23	1	7
Coverboards	Unknown	unknown mammal	0	0	2

NA = not applicable

Table 31. Wetland Mitigation Phase I Soil Sampling Summary

Basin	Parameter	Performance Standard	2010				2011			
			N	Median (%)	Q_1 (%)	Q_2 (%)	N	Median (%)	Q_1 (%)	Q_2 (%)
WM1W1	% Solids	<46.6%	6	67	58.3	72.4	6	78.2	76.3	82
	% Total Organic Carbon	>3.9%	6	2.49	2.2	2.83	6	1.65	1.03	2.27
	% Total Nitrogen	>0.5%	6	0.173	0.108	0.322	6	0.11	0.0926	0.12
WM1W2	% Solids	<46.6%	6	69.1	62.1	73.9	6	77.8	71	83.5
	% Total Organic Carbon	>3.9%	6	1.01	0.716	2.96	6	1.14	0.686	1.19
	% Total Nitrogen	>0.5%	6	0.109	0.0916	0.147	5*	0.344	0.184	0.428
WM1W3	% Solids	<46.6%	6	71.8	69	76	6	83.8	82.8	85
	% Total Organic Carbon	>3.9%	6	1.3	1.26	1.51	6	1.3	0.93	1.63
	% Total Nitrogen	>0.5%	6	0.104	0.0831	0.115	6	0.246	0.224	0.316
WM1W4	% Solids	<46.6%	6	72.8	69.5	74.3	6	76.3	72	77.8
	% Total Organic Carbon	>3.9%	6	1.8	1.11	2.19	6	0.563	0.316	1.21
	% Total Nitrogen	>0.5%	6	0.0497	0.0327	0.128	6	0.109	0.07	0.318
WM1W5	% Solids	<46.6%	6	73.4	64	78	6	79.5	76.9	81.4
	% Total Organic Carbon	>3.9%	6	2.25	1.84	2.63	6	1.45	1.26	1.61
	% Total Nitrogen	>0.5%	6	0.148	0.0925	0.255	6	0.109	0.0924	0.155
WM1W6	% Solids	<46.6%	6	67.5	66.4	72.1	6	85.5	81.9	86.2
	% Total Organic Carbon	>3.9%	6	1.1	0.711	1.2	6	1.1	0.999	1.33
	% Total Nitrogen	>0.5%	6	0.128	0.0631	0.251	6	0.0804	0.0635	0.124
WM1W7	% Solids	<46.6%	6	69.2	63.3	76.3	6	84.3	82.3	85.1
	% Total Organic Carbon	>3.9%	6	3.8	2.66	4.11	6	1.91	1.38	2.11
	% Total Nitrogen	>0.5%	6	0.277	0.26	0.434	6	0.129	0.107	0.16

* One of the total nitrogen samples from the wetland was broken at the laboratory. Therefore, there are only five samples for this wetland.

Table 32. Wetland Mitigation Phase I Water Sampling Summary

Basin	Parameter	Units	2010	2011
WM1W1	Ammonia Total as Nitrogen	mg/L	<0.016	0.153
	Chloride	mg/L	5.13	2.68
	Dissolved Oxygen	mg/L	5.75	9.61
	Iron	mg/L	4.02	3.52
	Magnesium	mg/L	23.5	16.3
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	175	11.2
	pH	unitless	7.65	7.07
	Phosphorous	mg/L	<0.21	<0.1
	Potassium	mg/L	2.83	3.08
	Specific Conductance	umhos/cm	644	453
	Temperature	C	25.19	19.67
	Total Kjeidahl Nitrogen	mg/L	<0.033	0.237
	Total Organic Carbon	mg/L	18.1	13.4
	Total Solids	mg/L	524	400
	Total Suspended Solids	mg/L	123	91.2
	Turbidity	NTU	34	50.9
WM1W2	Ammonia Total as Nitrogen	mg/L	0.02	0.156
	Chloride	mg/L	0.31	1.01
	Dissolved Oxygen	mg/L	7.86	5.01
	Iron	mg/L	0.818	3.69
	Magnesium	mg/L	22.5	16.6
	Nitrate + Nitrite as Nitrogen	mg/L	0.186	<0.01
	Oxidation Reduction Potential	mV	247	116.4
	pH	unitless	7.78	7.26
	Phosphorous	mg/L	<0.118	<0.1
	Potassium	mg/L	1.02	4.22
	Specific Conductance	umhos/cm	555	450
	Temperature	C	27.58	20.24
	Total Kjeidahl Nitrogen	mg/L	0.121	0.988
	Total Organic Carbon	mg/L	14.0	15.7
	Total Solids	mg/L	391	352
	Total Suspended Solids	mg/L	68.4	73
	Turbidity	NTU	10.3	23.8
WM1W3	Ammonia Total as Nitrogen	mg/L	0.134	0.148
	Chloride	mg/L	0.357	0.674
	Dissolved Oxygen	mg/L	7.85	4.75
	Iron	mg/L	1.2	2.0
	Magnesium	mg/L	21.7	20.4
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.311
	Oxidation Reduction Potential	mV	171.2	103
	pH	unitless	8.21	7.28
	Phosphorous	mg/L	<0.128	<0.1
	Potassium	mg/L	3.54	4.36
	Specific Conductance	umhos/cm	522	494
	Temperature	C	27.68	20.41

Table 32 (continued). Wetland Mitigation Phase I Water Sampling Summary

Basin	Parameter	Units	2010	2011
WM1W3 (Cont)	Total Kjeidahl Nitrogen	mg/L	0.129	0.253
	Total Organic Carbon	mg/L	18.0	15.6
	Total Solids	mg/L	281	314
	Total Suspended Solids	mg/L	64	5.6
	Turbidity	NTU	8.8	13
WM1W4	Ammonia Total as Nitrogen	mg/L	0.166	0.113
	Chloride	mg/L	4.04	0.908
	Dissolved Oxygen	mg/L	7.05	6.06
	Iron	mg/L	3.34	2.01
	Magnesium	mg/L	8.65	6.49
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	2.03
	Oxidation Reduction Potential	mV	200	57.9
	pH	unitless	7.86	7.53
	Phosphorous	mg/L	0.747	0.2
	Potassium	mg/L	2.76	4.19
	Specific Conductance	umhos/cm	186	190
	Temperature	C	27.51	20.53
	Total Kjeidahl Nitrogen	mg/L	0.312	1.7
	Total Organic Carbon	mg/L	13.3	9.64
	Total Solids	mg/L	230	369
	Total Suspended Solids	mg/L	165	215
	Turbidity	NTU	76.5	29.9
WM1W5	Ammonia Total as Nitrogen	mg/L	0.368	0.36
	Chloride	mg/L	33.6	19.4
	Dissolved Oxygen	mg/L	13.83	6.22
	Iron	mg/L	7.19	2.67
	Magnesium	mg/L	26.7	19.6
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	275	63.3
	pH	unitless	7.96	7.05
	Phosphorous	mg/L	0.255	0.5
	Potassium	mg/L	22.8	22.8
	Specific Conductance	umhos/cm	749	540
	Temperature	C	26.05	18.58
	Total Kjeidahl Nitrogen	mg/L	0.37	2.1
	Total Organic Carbon	mg/L	35.3	28.6
	Total Solids	mg/L	1128	508
	Total Suspended Solids	mg/L	676	108
	Turbidity	NTU	115	179

Table 32 (continued). Wetland Mitigation Phase I Water Sampling Summary

Basin	Parameter	Units	2010	2011
WM1W6	Ammonia Total as Nitrogen	mg/L	<0.016	0.136
	Chloride	mg/L	91	78.6
	Dissolved Oxygen	mg/L	7.3	3.91
	Iron	mg/L	7.57	1.24
	Magnesium	mg/L	27.7	19.8
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.166
	Oxidation Reduction Potential	mV	172	-25.6
	pH	unitless	7.23	6.97
	Phosphorous	mg/L	<0.097	0.2
	Potassium	mg/L	2.7	1.56
	Specific Conductance	umhos/cm	1089	763
	Temperature	C	24.88	19.21
	Total Kjeidahl Nitrogen	mg/L	<0.033	0.39
	Total Organic Carbon	mg/L	11.9	10.6
	Total Solids	mg/L	1006	615
	Total Suspended Solids	mg/L	382	150.8
	Turbidity	NTU	29.3	24.5
WM1W7	Ammonia Total as Nitrogen	mg/L	0.169	0.183
	Chloride	mg/L	187	140
	Dissolved Oxygen	mg/L	6.7	7.62
	Iron	mg/L	0.778	1.37
	Magnesium	mg/L	26.1	21.7
	Nitrate + Nitrite as Nitrogen	mg/L	0.144	0.396
	Oxidation Reduction Potential	mV	311	83.5
	pH	unitless	7.56	7.23
	Phosphorous	mg/L	<0.165	0.4
	Potassium	mg/L	1.09	2.18
	Specific Conductance	umhos/cm	1216	900
	Temperature	C	26.26	19.61
	Total Kjeidahl Nitrogen	mg/L	0.222	0.359
	Total Organic Carbon	mg/L	13.4	17.4
	Total Solids	mg/L	868	698
	Total Suspended Solids	mg/L	25.2	35.6
	Turbidity	NTU	9.44	22.2

C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
umhos/cm = micromhos per centimeter

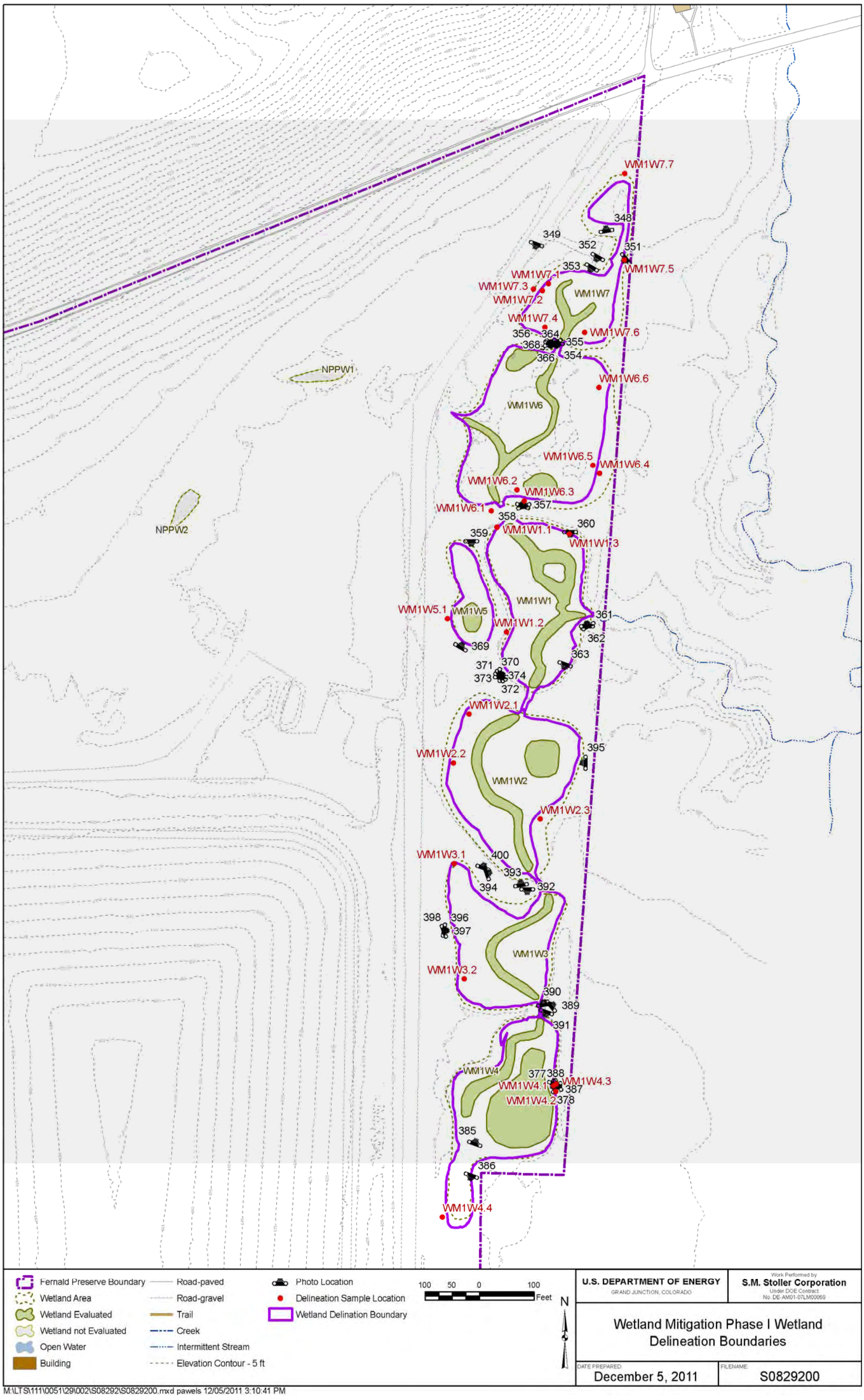

Figure 32. Wetland Mitigation Phase I Wetland Delineation Boundaries

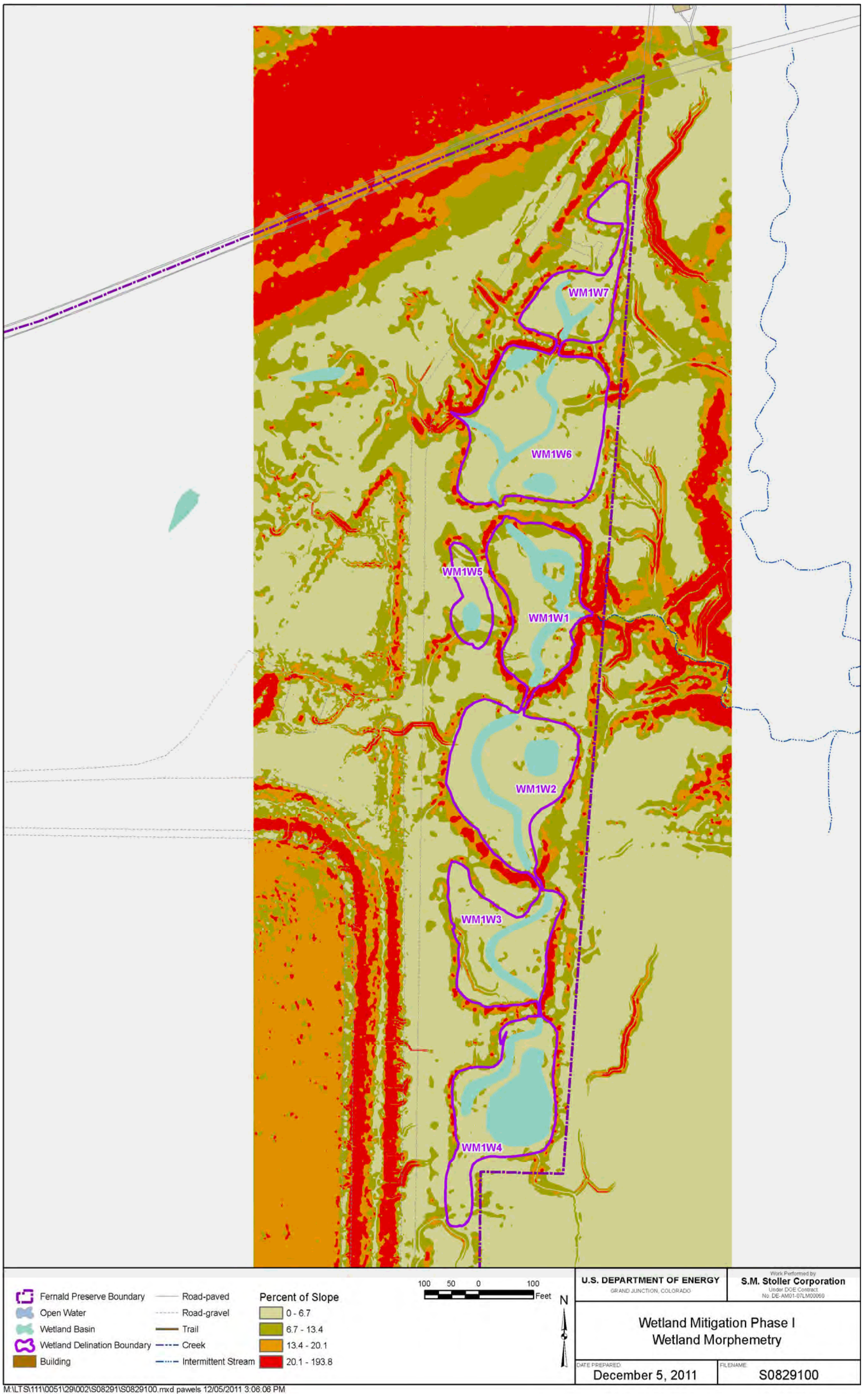

Figure 33. Wetland Mitigation Phase I Wetland Morphometry

Figure 34. Wetland Mitigation Phase I Wetland Sampling Locations

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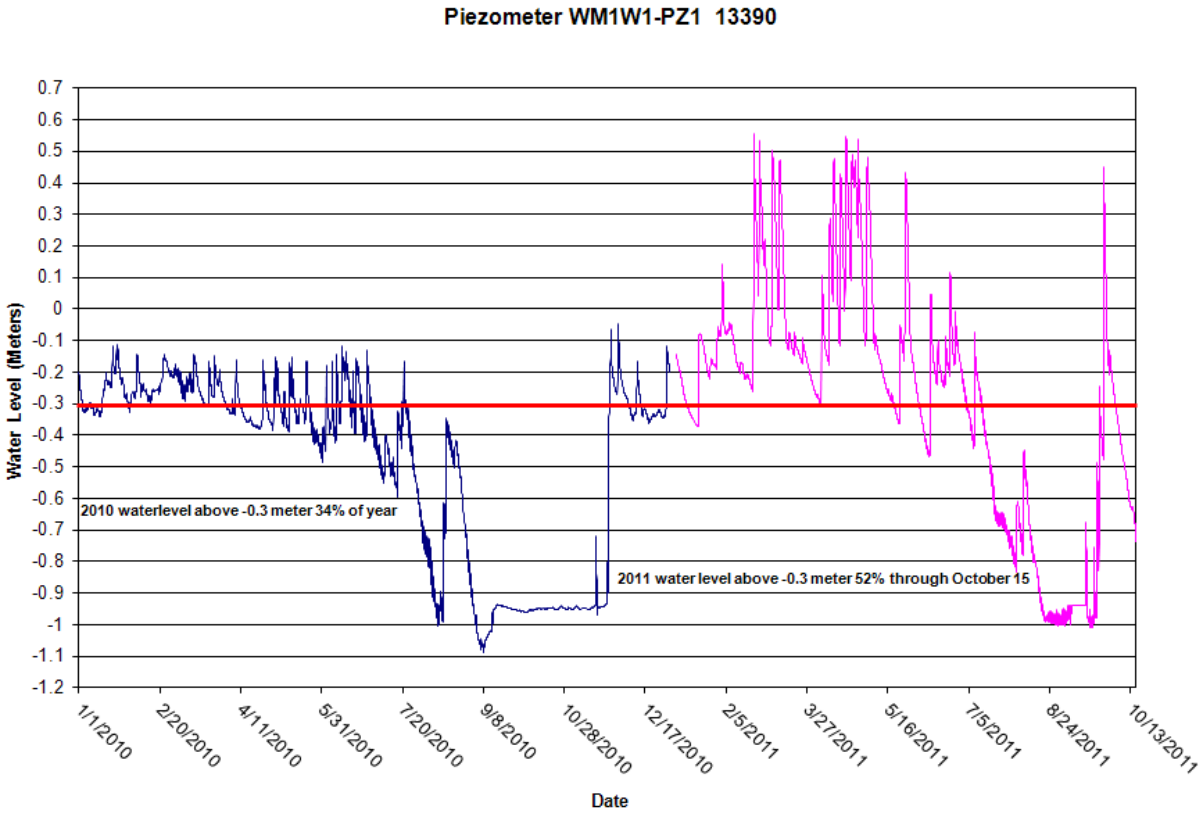

Figure 35. Wetland Mitigation Phase I WM1W1 Hydrograph

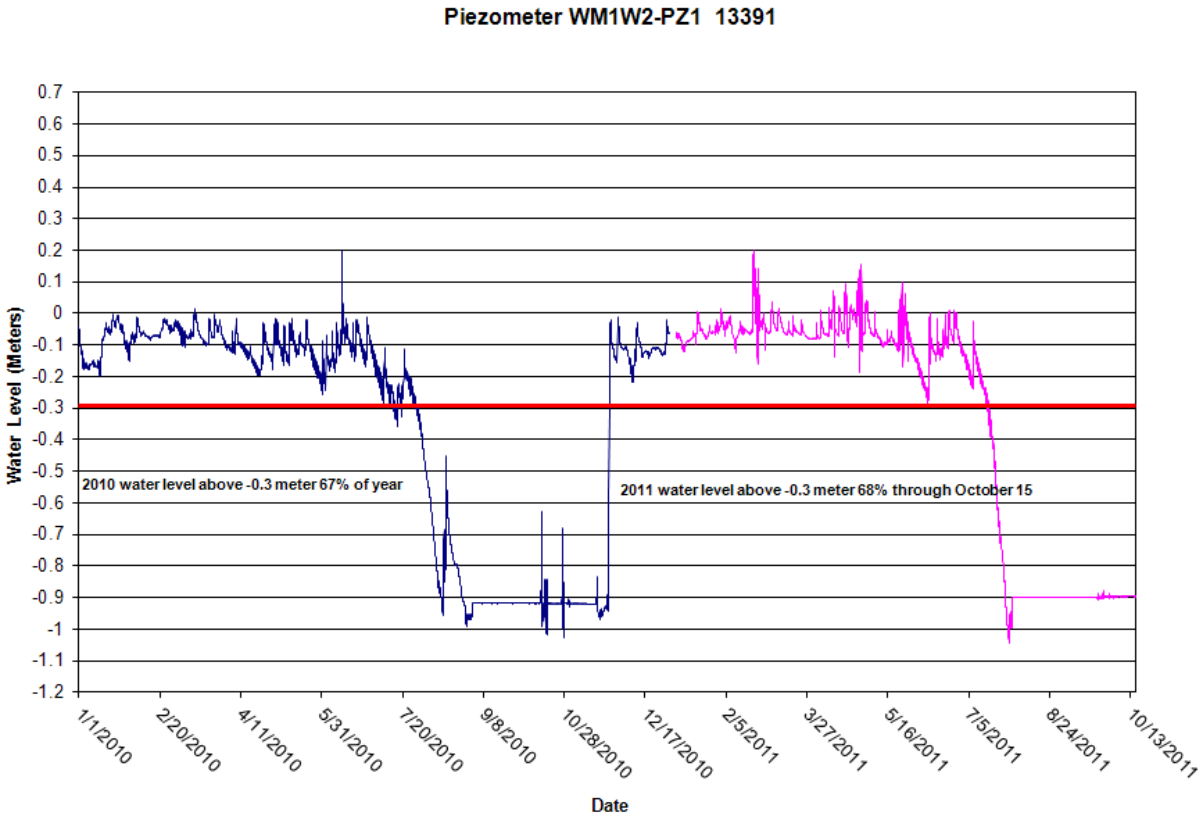

Figure 36. Wetland Mitigation Phase I WM1W2 Hydrograph

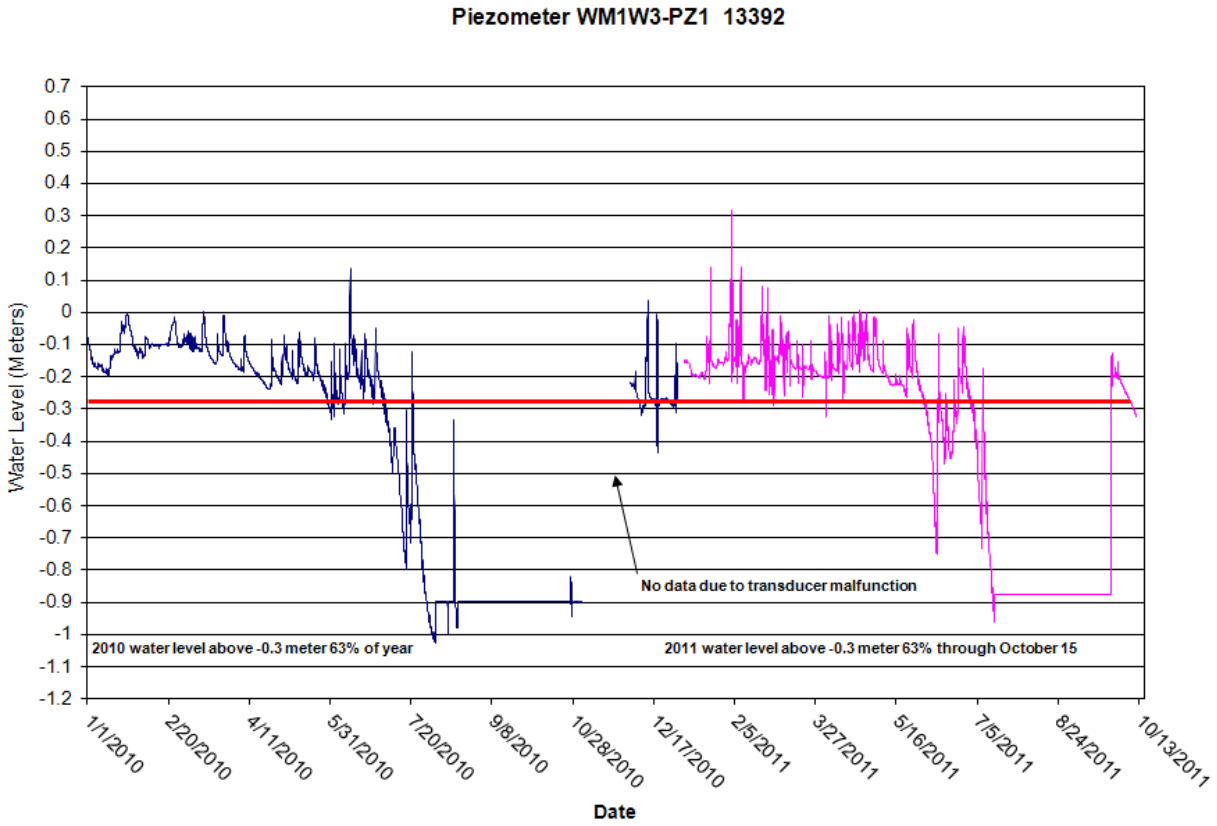

Figure 37. Wetland Mitigation Phase I WM1W3 Hydrograph

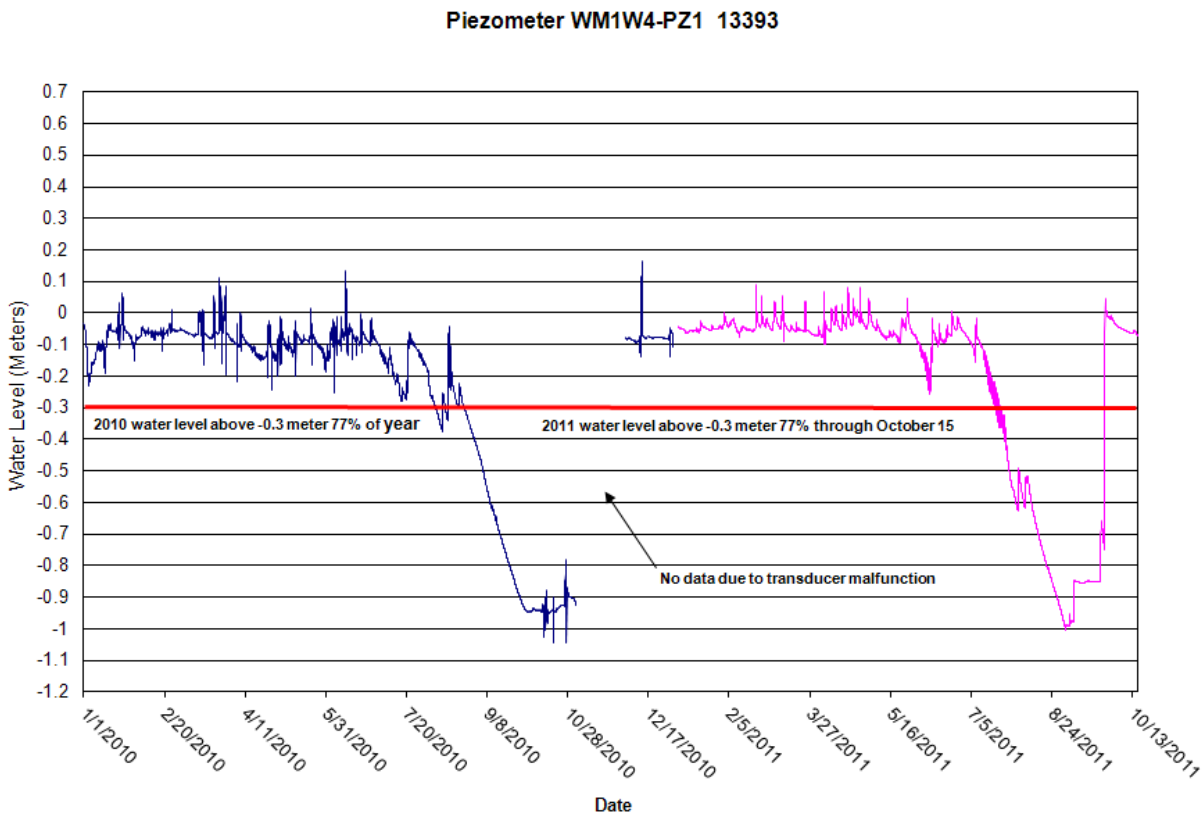

Figure 38. Wetland Mitigation Phase I WM1W4 Hydrograph

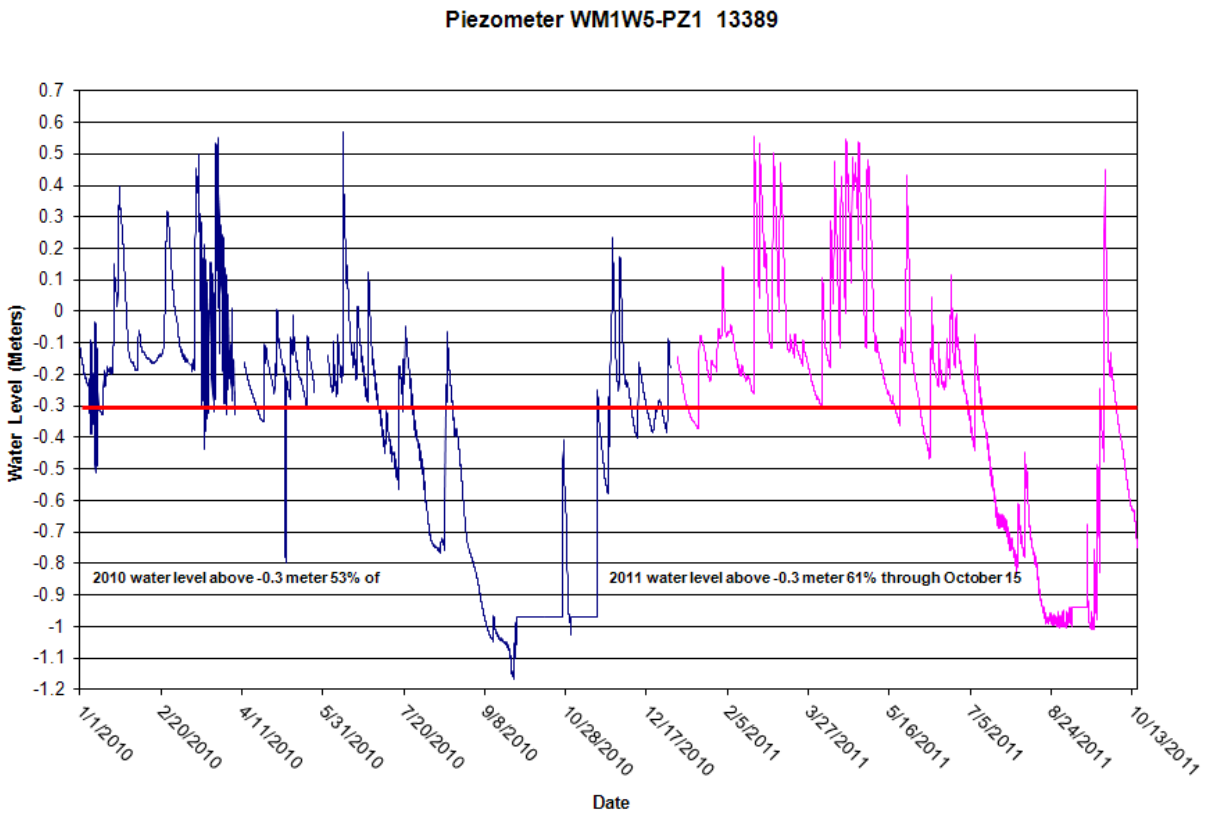

Figure 39. Wetland Mitigation Phase I WM1W5 Hydrograph

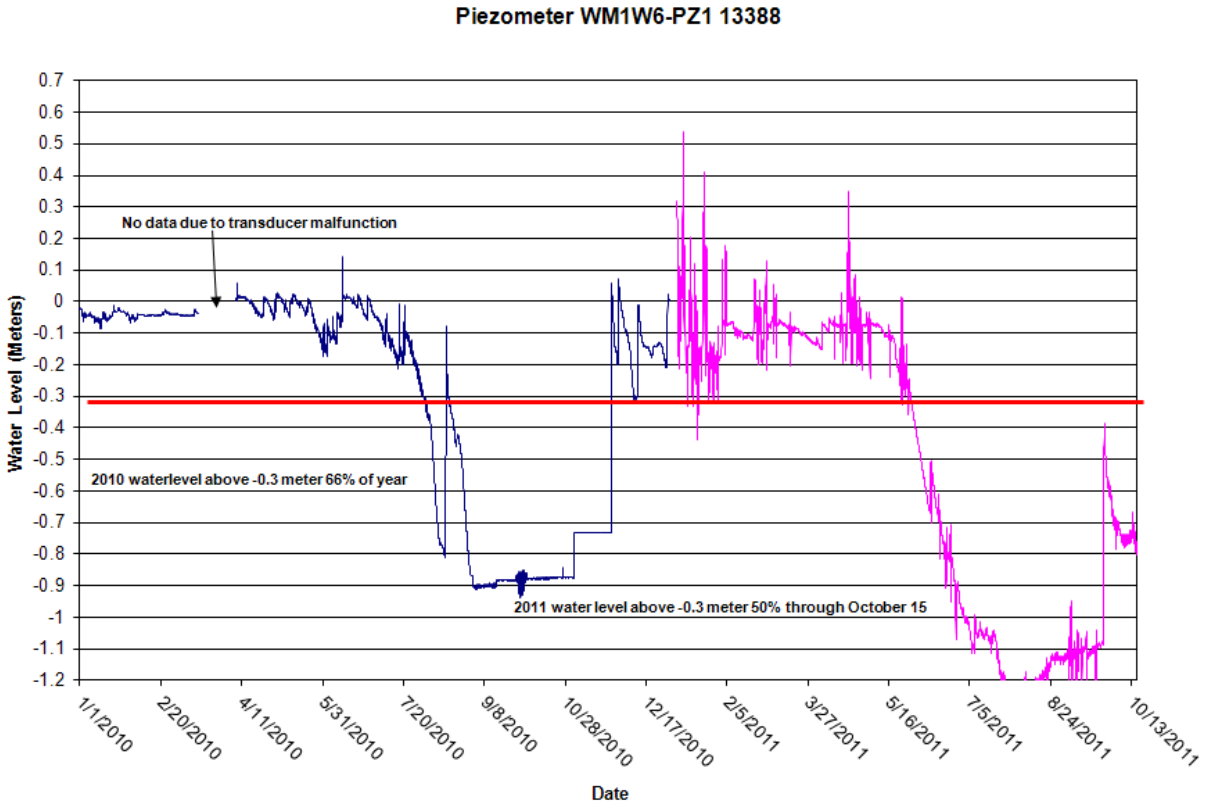

Figure 40. Wetland Mitigation Phase I WM1W6 Hydrograph

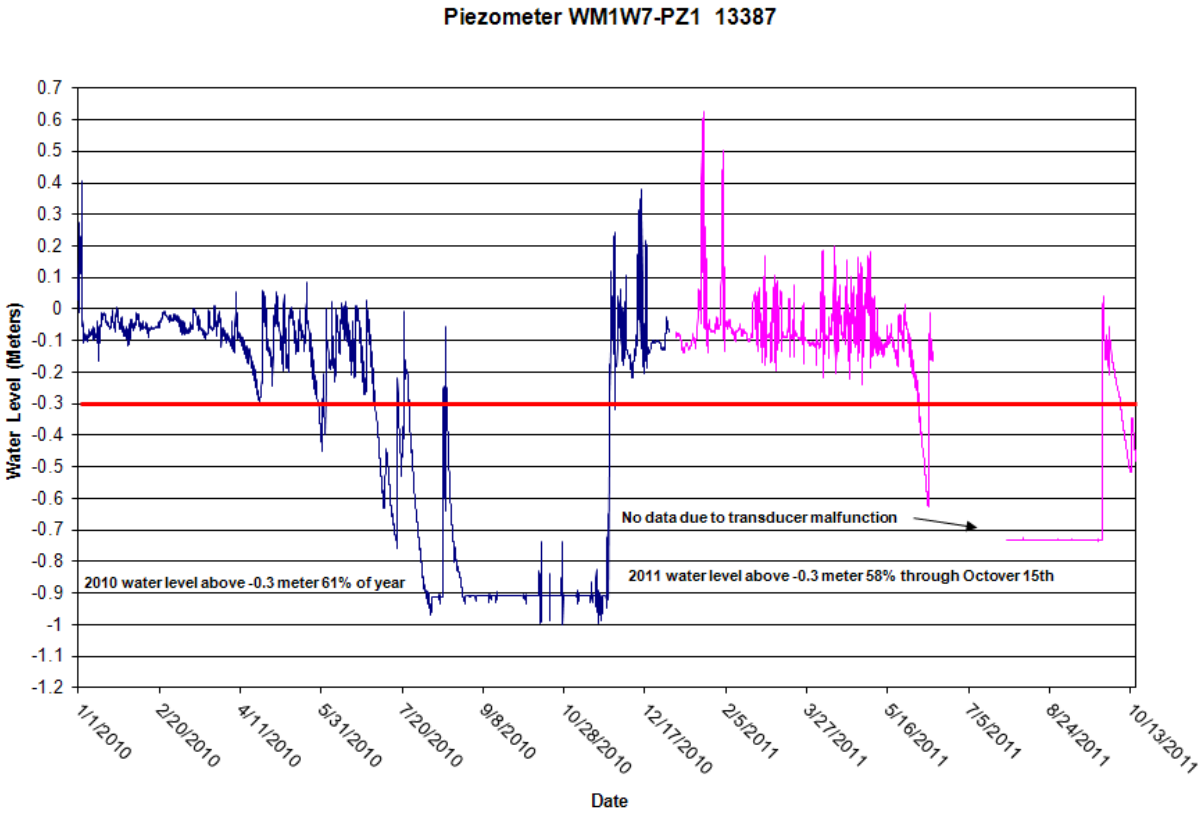

Figure 41. Wetland Mitigation Phase I WM1W7 Hydrograph

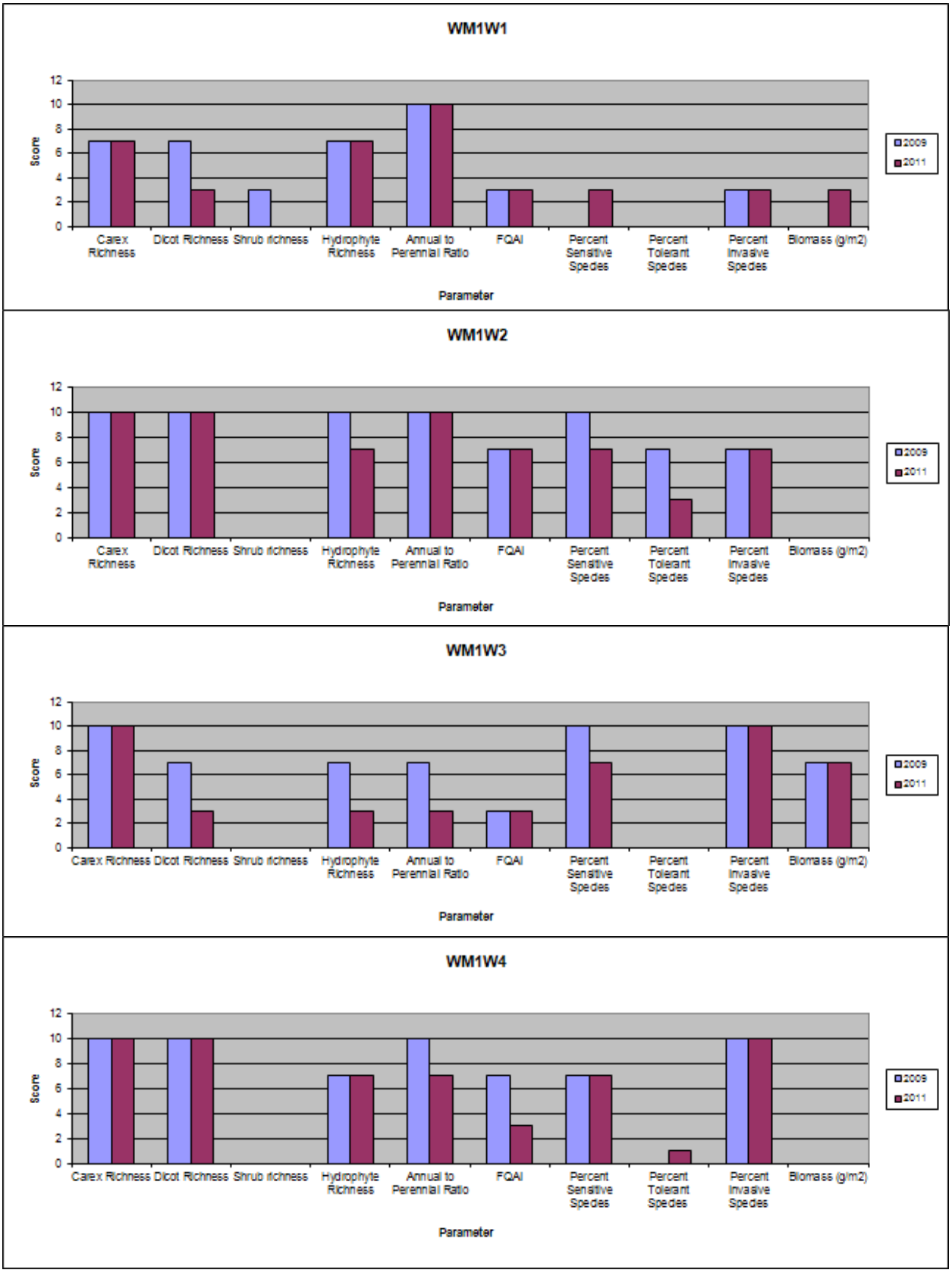

Figure 42. Wetland Mitigation Phase I VIBI Chart

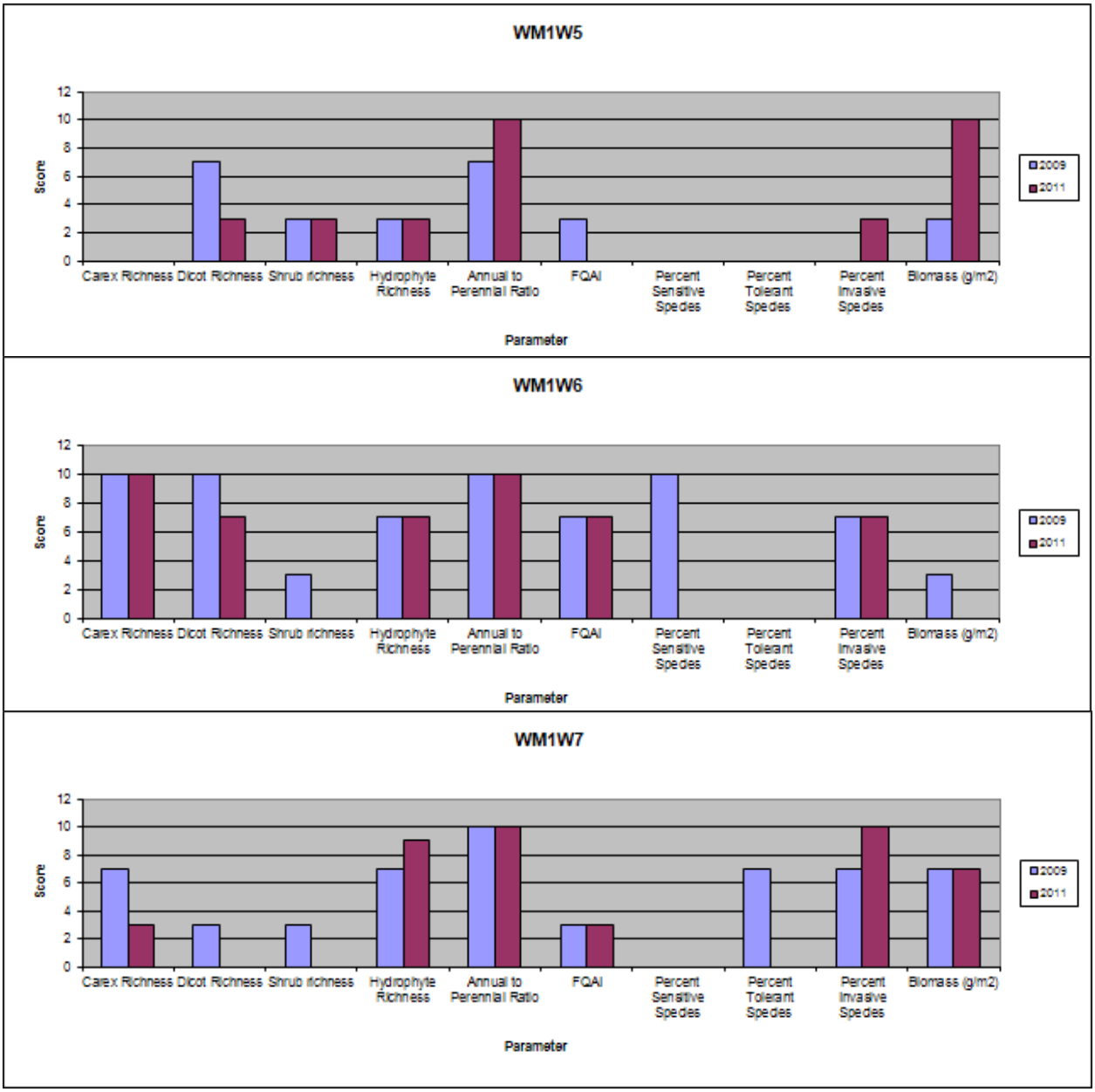

Figure 42 (continued). Wetland Mitigation Phase I VIBI Chart

3.5 Wetland Mitigation Phase II

The WM2 wetlands consist of three basins on 8 acres just south of an established woodlot. The basins are fed by surface water that drains from an existing 26-acre wetland system. The wetland restoration project was completed in 2005. Photographs in Appendix B–1 show an established wetland system composed of a mix of open water and emergent and forested wetland communities.

3.5.1 WM2 Design Parameter Results

A jurisdictional wetland delineation was conducted on each of the three basins. The total delineated acreage for WM2 is 2.18 acres. Table 33 provides basin-specific acreages, and Figure 43 identifies boundaries. The total acreage is less the original design intended, primarily due to areas of unvegetated open water in WM2W2 and WM2W3. The delineation boundary for WM2W1 expanded upslope to the east. This appears to be due to several factors. A swale that runs adjacent to the access road just south of the project area drains into WM2W1 at the southeastern corner of the basin. In addition, some seepage from upgradient WM2W2 may be occurring. This portion of WM2W1 does not meet the 15:1 morphometry standard (Figure 44). However, the overall basin morphometry standard is met (Table 33).

3.5.2 WM2 Hydrologic Regime Results

Hydrology within WM2 is characterized through data collected from three piezometers, as shown on Figure 45. Results presented in Table 34 show that all basins met the hydrologic performance standards. Figures 46 through 48 show basin-specific hydrographs. Hydrographs for WM2W2 and WM2W3 are consistent with depressional wetlands with a strong seasonal hydroperiod. WM2W1 is more closely associated with permanently inundated depression wetlands (Mack 2007). The piezometer location is within the expanded wetland boundary discussed above, so there may be some additional influence due to these factors.

3.5.3 WM2 Vegetation Parameter Results

Table 35 presents results from vegetation sampling. Figure 45 shows fixed-plot module locations. All three basins in WM2 achieved VIBI performance standards. WM2W1 and WM2W2 both saw their scores improve since 2009. The WM2W2 plot was adjusted to the north in 2011 because of increased water depth at the western end of the basin (Figure 44).

While all three basins passed the performance standard for native perennial hydrophytes in 2009, only WM2W2 met the greater-than-75-percent mark in 2011. These lower percentages are likely due to the implementation of a new field protocol in 2011, which identifies all *Typha* species as the hybrid *Typha X glauca* instead of differentiating between the native *Typha latifolia* and the nonnative *Typha angustifolia*. Section 4.1 discusses the new field protocol in more detail. These findings are reflected in the VIBI metrics chart in Figure 49.

WM2 achieved mixed results for the standard for unvegetated open water in both survey years. As discussed in Section 1.2, the WM2 basin design was completed before the Ohio EPA monitoring protocols were adopted. The large open water basins used in WM2 would not be implemented today.

3.5.4 WM2 Wildlife Parameter Results

Table 36 displays results for AIBI. Scores are not particularly high for these basins primarily due to an abundance of tolerant species, including bull frogs (*Lithobates catesbeiana*) and green frogs (*Lithobates clamitans*). However, the presence of sensitive species, such as cricket frogs, spring peepers, and a salamander population (*Ambystoma spp.*), show promising developments in the amphibian community.

Table 37 presents specific species that were identified during sampling efforts from 2009 through 2011. Of particular note, two species of salamanders were found in these basins. The recurrent presence of these salamanders suggests an established population most likely originating from the existing forested wetlands that drain into the WM2 wetlands.

3.5.5 WM2 Soil and Water Chemistry Results

Tables 38 and 39 present soil and water sampling results. As with most other areas, soil biogeochemistry performance standards were not met. Again, the presence of hydric soils sampled during wetland delineation efforts indicates that wetland soil is developing. Water sampling results in Table 39 are within normal ranges.

Table 33. Wetland Mitigation Phase II Design Parameter Summary

Basin	Parameter	Performance Standard	Result
WM2W1	Delineation Acreage	NA	1.17
	Acreage of Unvegetated Open Water >10%	NA	0.00
	Actual Wetland Acreage	NA	1.17
	Morphometry	<15:1 side slope	55%
WM2W2	Delineation Acreage	NA	1.00
	Acreage of Unvegetated Open Water >10%	NA	0.45
	Actual Wetland Acreage	NA	0.55
	Morphometry	<15:1 side slope	89%
WM2W3	Delineation Acreage	NA	1.65
	Acreage of Unvegetated Open Water >10%	NA	1.19
	Actual Wetland Acreage	NA	0.46
	Morphometry	<15:1 side slope	53%

NA = not applicable

Table 34. Wetland Mitigation Phase II Hydrologic Regime Summary

Basin	Parameter	Performance Standard	2010	2011
WM2W1	Water in Root Zone (<30 cm)	>53%	97%	96%
	Mean Depth of Water	29.4 cm	15	4
	Flashiness Index	<2.0	0.46	0.88
WM2W2	Water in Root Zone (<30 cm)	>53%	73%	71%
	Mean Depth of Water	29.4 cm	18	20
	Flashiness Index	2	0.47	0.68
WM2W3	Water in Root Zone (<30 cm)	>53%	66%	76%
	Mean Depth of Water	29.4 cm	31	0
	Flashiness Index	<2.0	0.54	0.61

Table 35. Wetland Mitigation Phase II Vegetation Parameter Summary

Basin	Parameter	Performance Standard	2009	VIBI Score	2011	VIBI Score
WM2W1	% Unvegetated Open Water	<10%	12.5%	NA	1.0%	NA
	% Native Perennial Hydrophytes	>75%	78.7%	NA	63.8%	NA
	VIBI	48–63	50	NA	53	NA
	Carex Richness	NA	5	10	6	10
	Dicot Richness	NA	16	3	20	7
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	21	7	16	3
	Annual to Perennial Ratio	NA	0.13	10	0.12	10
	FQAI	NA	12.49	3	11.63	3
	% Sensitive Species	NA	0.2%	0	24.0%	0
	% Tolerant Species	NA	33.2%	7	53.4%	3
	% Invasive Species	<5%	22.5%	3	10.7%	7
	Biomass (g/m^2)	NA	364	7	143	10
WM2W2	% Unvegetated Open Water	<10%	4.5%	NA	13.8%	NA
	% Native Perennial Hydrophytes	>75%	89.4%	NA	81.0%	NA
	VIBI	48–63	43	NA	49	NA
	Carex Richness	NA	3	3	5	10
	Dicot Richness	NA	19	7	16	3
	Shrub richness	NA	1	0	1	0
	Hydrophyte Richness	NA	25	7	19	3
	Annual to Perennial Ratio	NA	0.38	3	0.18	10
	FQAI	NA	14.15	3	12.75	3
	% Sensitive Species	NA	0.8%	0	2.1%	0
	% Tolerant Species	NA	15.7%	10	31.5%	7
	% Invasive Species	<5%	1.7%	10	16.3%	3
	Biomass (g/m^2)	NA	87	0	112	10
WM2W3	% Unvegetated Open Water	<10%	13.3%	NA	20.5%	NA
	% Native Perennial Hydrophytes	>75%	82.7%	NA	55.6%	NA
	VIBI	48–63	57	NA	51	NA
	Carex Richness	NA	5	10	7	10
	Dicot Richness	NA	14	3	18	7
	Shrub richness	NA	1	0	2	3
	Hydrophyte Richness	NA	22	7	24	7
	Annual to Perennial Ratio	NA	0.19	10	0.13	10
	FQAI	NA	12.65	3	14.76	7
	% Sensitive Species	NA	0.6%	0	1.0%	0
	% Tolerant Species	NA	34.9%	7	72.0%	0
	% Invasive Species	<5%	12.2%	7	37.5%	0
	Biomass (g/m^2)	NA	125	10	234	7

g/m^2 = grams per square meter
NA = not applicable

Table 36. Wetland Mitigation Phase II AIBI Summary

Basin	Parameter	2010	AIBI Score	2011	AIBI Score
WM2W1	Amphibian Index of Biotic Integrity	NA	**3**	NA	**6**
	Amphibian Quality Assessment Index	2.06	0	2.31%	0
	% Relative Abundance of Sensitive Species	1%	3	7.44%	3
	% Relative Abundance of Tolerant Species	99%	0	90.91%	0
	Number of Pond-Breeding Salamanders	0	0	1	3
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
WM2W2	Amphibian Index of Biotic Integrity	NA	**3**	NA	**6**
	Amphibian Quality Assessment Index	2.07	0	1.66	0
	% Relative Abundance of Sensitive Species	1%	3	1%	3
	% Relative Abundance of Tolerant Species	99%	0	99%	0
	Number of Pond-Breeding Salamanders	0	0	2	3
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0
WM2W3	Amphibian Index of Biotic Integrity	NA	**16**	NA	**12**
	Amphibian Quality Assessment Index	4.19	3	3.61	3
	% Relative Abundance of Sensitive Species	42%	7	2%	3
	% Relative Abundance of Tolerant Species	58%	3	65%	3
	Number of Pond-Breeding Salamanders	1	3	1	3
	Presence of Spotted Salamanders or Wood Frogs	no	0	no	0

NA = not applicable

Table 37. Wetland Mitigation Phase II Other Wildlife Summary

Amphibian Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Acris crepitans*	cricket frog	4	29	1
Funnel Traps	*Ambystoma barbouri*	streamside salamander	0	1	3
Funnel Traps	*Ambystoma opacum*	marbled salamander	0	0	1
Funnel Traps	*Ambystoma species*	salamander species	1	0	23
Funnel Traps	*Ambystoma tigrinum*	tiger salamander	5	0	0
Funnel Traps	*Anaxyrus americanus*	American toad	0	1274	0
Funnel Traps	*Anaxyrus species*	toad species	0	0	223
Funnel Traps	*Lithobates catesbeiana*	American bull frog	26	31	101
Funnel Traps	*Lithobates clamitans*	green frog	1	2	2
Funnel Traps	*Pseudacris crucifer*	spring peeper	22	7	30
Funnel Traps	*Lithobates pipiens*	northern leopard frog	0	0	1
Funnel Traps	*Lithobates species*	frog species	0	0	136
Bird Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Aix sponsa*	wood duck	NA	NA	NA
Observation	*Anas discors*	blue winged teal	NA	NA	NA
Observation	*Anas platyrhynchos*	mallard	NA	NA	NA
Observation	*Buteo jamaicensis*	red tail hawk	NA	NA	NA
Observation	*Carduelis tristis*	American gold finch	NA	NA	NA
Observation	*Cyanocitta cristata*	blue jay	NA	NA	NA

Table 37 (continued). Wetland Mitigation Phase II Other Wildlife Summary

Bird Summary (continued)			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Observation	*Hirundo rustica*	barn swallow	NA	NA	NA
Observation	*Icterus spurius*	orchard orioles	NA	NA	NA
Observation	*Ixobrychus exilis*	least bittern	NA	NA	NA
Observation	*Megaceryle alcyon*	belted king fisher	NA	NA	NA
Observation	*Passerina cyanea*	indigo bunting	NA	NA	NA
Observation	*Poecile carolinensis*	carolina chickadee	NA	NA	NA
Observation	*Rallus limicola*	Virginia rail	NA	NA	NA
Observation	*Riparia riparia*	bank swallow	NA	NA	NA
Observation	*Tachycineta bicolor*	tree swallow	NA	NA	NA
Fish Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	*Lepomus cyanellus*	green sunfish	0	0	1
Macroinvertebrate Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Funnel Traps	Family: Notonectidae	backswimmer	53	222	81
Funnel Traps	Family: Belostomatidae	giant waterbug	0	1	48
Funnel Traps	Family: Cambaridae	crayfish	0	0	3
Funnel Traps	Order: Coleoptera	beetle	110	108	0
Funnel Traps	Family: Corixidae	water boatman	4	85	53
Funnel Traps	Family: Corydalidae	dobsonfly, fishfly	1	1	0
Funnel Traps	Family: Dytiscidae	predaceous diving beetle	11	1	33
Funnel Traps	Order: Ephemeroptera	mayfly	2	64	10
Funnel Traps	Family: Gammaridae	sideswimmer/scud	0	4	1
Funnel Traps	Family: Gerridae	water strider	0	2	0
Funnel Traps	Family: Haliplidae	crawling water beetle	0	0	60
Funnel Traps	Order: Haplotaxida (Tubificina)	freshwater worm	0	3	7
Funnel Traps	Family: Hirudinidae	leech	4	19	1
Funnel Traps	Family: Hydrachnidiae	mite	21	5	10
Funnel Traps	Family: Hydrophilidae	water scavanger	0	0	43
Funnel Traps	Order: Isopoda	isopod	3	22	4
Funnel Traps	Family: Lymnaeidae	pond snail	1	131	13
Funnel Traps	Family: Naucoridae	creeping water bug	0	9	16
Funnel Traps	Family: Nepidae	water scorpian	1	0	9
Funnel Traps	Order:Odonata, Sub-Order:Anisoptera	dragonfly	16	33	26
Funnel Traps	Order: Odonata, Sub-Order: Zygoptera	damselfly	59	20	15
Funnel Traps	Family: Perlidae	stonefly	1	0	0
Funnel Traps	Family: Physidae	pouch snail	182	461	150
Funnel Traps	Family: Planorbidae	ramhorn snail	113	112	167
Funnel Traps	Family: Tipulidae	cranefly	0	2	0
Funnel Traps	Order: Trichoptera	caddisfly	2	2	5
Funnel Traps	Order: Unionoida	clam	0	6	1

Table 37 (continued). Wetland Mitigation Phase II Other Wildlife Summary

Reptile Summary			Abundance		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Nerodia sipedon*	northern water snake	11	13	6
Coverboards	*Thamnophis sirtalis*	eastern garter snake	59	78	26
Small Mammal Summary			**Abundance**		
Collection Method	**Taxa**	**Common Name**	**2009**	**2010**	**2011**
Coverboards	*Blarina brevicauda*	short-tailed shrew	3	3	1
Coverboards	*Cryptotis parva*	least-tailed shrew	0	2	0
Coverboards	*Microtus pennsylvanicus*	meadow vole	28	0	8
Coverboards	*Peromyscus maniculatus*	deer mouse	24	0	1
Coverboards	*Scalopus aquaticus*	eastern mole	3	0	0
Coverboards	*Synaptomys cooperi*	bog lemming	2	0	0

NA = not applicable

Table 38. Wetland Mitigation Phase II Soil Sampling Summary

Basin	Parameter	Performance Standard	2010				2011			
			N	Median (%)	Q_1 (%)	Q_2 (%)	N	Median (%)	Q_1 (%)	Q_2 (%)
WM2W1	Percent Solids	<46.6%	6	70.7	67.2	74	6	73.9	73.4	76
	Percent Total Organic Carbon	>3.9%	6	3.44	2.81	3.57	6	0.51	0.497	0.733
	Percent Total Nitrogen	>0.5%	6	0.0918	0.0591	0.119	6	0.0362	0.0342	0.0438
WM2W2	Percent Solids	<46.6%	6	77.9	74.9	79.7	6	85	76	87.7
	Percent Total Organic Carbon	>3.9%	6	1.06	0.482	2.38	6	0.503	0.317	0.863
	Percent Total Nitrogen	>0.5%	6	0.0557	0.0258	0.137	6	0.0818	0.0512	0.135
WM2W3	Percent Solids	<46.6%	6	80.1	73.8	82	6	78.6	71.4	81.4
	Percent Total Organic Carbon	>3.9%	6	1.52	0.934	2.99	6	0.348	0.273	0.407
	Percent Total Nitrogen	>0.5%	6	0.0256	0.0148	0.033	6	0.035	0.0272	0.0499

Table 39. Wetland Mitigation Phase II Water Sampling Summary

Basin	Parameter	Units	2010	2011
WM2W1	Ammonia Total as Nitrogen	mg/L	<0.016	0.146
	Chloride	mg/L	24.3	12.9
	Dissolved Oxygen	mg/L	6.44	6.75
	Iron	mg/L	6.12	3.62
	Magnesium	mg/L	31.5	22.7
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	0.095
	Oxidation Reduction Potential	mV	401.4	-21.1
	pH	unitless	7.22	7.08
	Phosphorous	mg/L	<0.13	<0.2
	Potassium	mg/L	2.01	1.48
	Specific Conductance	umhos/cm	562	384
	Temperature	C	22.95	27.08
	Total Kjeidahl Nitrogen	mg/L	<0.033	1.69
	Total Organic Carbon	mg/L	14.3	8.83
	Total Solids	mg/L	1074	310
	Total Suspended Solids	mg/L	728	17.2
	Turbidity	NTU	59.9	7.23
WM2W2	Ammonia Total as Nitrogen	mg/L	<0.016	0.129
	Chloride	mg/L	25	11.5
	Dissolved Oxygen	mg/L	8.44	7.28
	Iron	mg/L	0.877	2
	Magnesium	mg/L	13.8	12.2
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	251	125
	pH	unitless	9.08	7.73
	Phosphorous	mg/L	<0.131	<0.1
	Potassium	mg/L	1.32	2.28
	Specific Conductance	umhos/cm	305	295
	Temperature	C	27.15	26.86
	Total Kjeidahl Nitrogen	mg/L	<0.033	0.991
	Total Organic Carbon	mg/L	10.4	12.2
	Total Solids	mg/L	226	266
	Total Suspended Solids	mg/L	30.8	31.2
	Turbidity	NTU	18.1	34.2
WM2W3	Ammonia Total as Nitrogen	mg/L	<0.016	0.132
	Chloride	mg/L	46.6	26.8
	Dissolved Oxygen	mg/L	5.88	8.04
	Iron	mg/L	6.14	1.88
	Magnesium	mg/L	33.3	18.5
	Nitrate + Nitrite as Nitrogen	mg/L	<0.05	<0.01
	Oxidation Reduction Potential	mV	223	113
	pH	unitless	7.67	7.61
	Phosphorous	mg/L	<0.105	0.3
	Potassium	mg/L	1.91	2.94
	Specific Conductance	umhos/cm	745	482
	Temperature	C	26.54	28.68

Table 39 (continued). Wetland Mitigation Phase II Water Sampling Summary

Basin	Parameter	Units	2010	2011
WM2W3 (Cont)	Total Kjeidahl Nitrogen	mg/L	<0.033	0.783
	Total Organic Carbon	mg/L	13.6	14.3
	Total Solids	mg/L	616	507
	Total Suspended Solids	mg/L	156.5	171
	Turbidity	NTU	12.5	22.5

C = degrees Celsius
mg/L = milligrams per liter
mV = millivolts
NTU = nephelometric turbidity units
umhos/cm = micromhos per centimeter

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Figure 43. Wetland Mitigation Phase II Wetland Delineation Boundaries

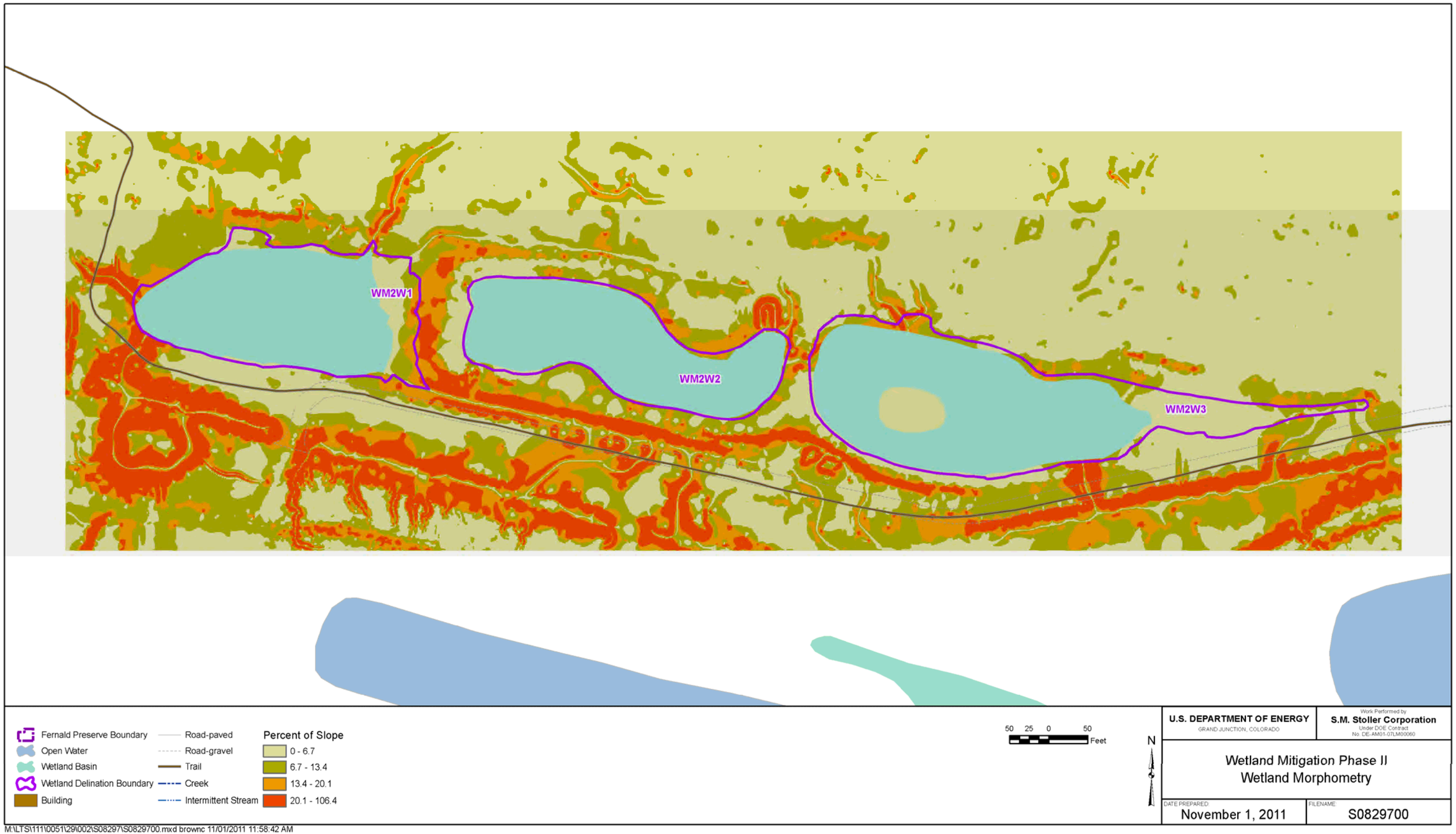

Figure 44. Wetland Mitigation Phase II Wetland Morphometry

Figure 45. Wetland Mitigation Phase II Wetland Sampling Locations

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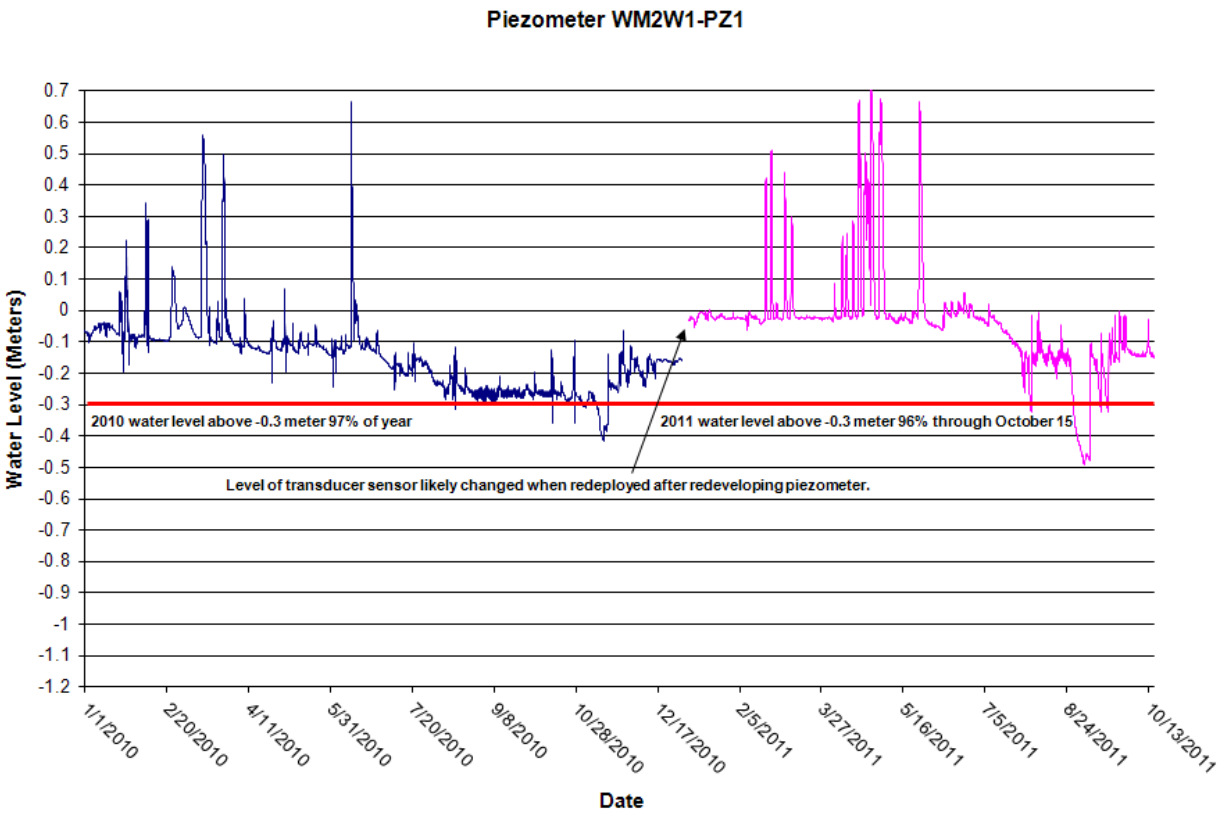

Figure 46. Wetland Mitigation Phase II WM2W1 Hydrograph

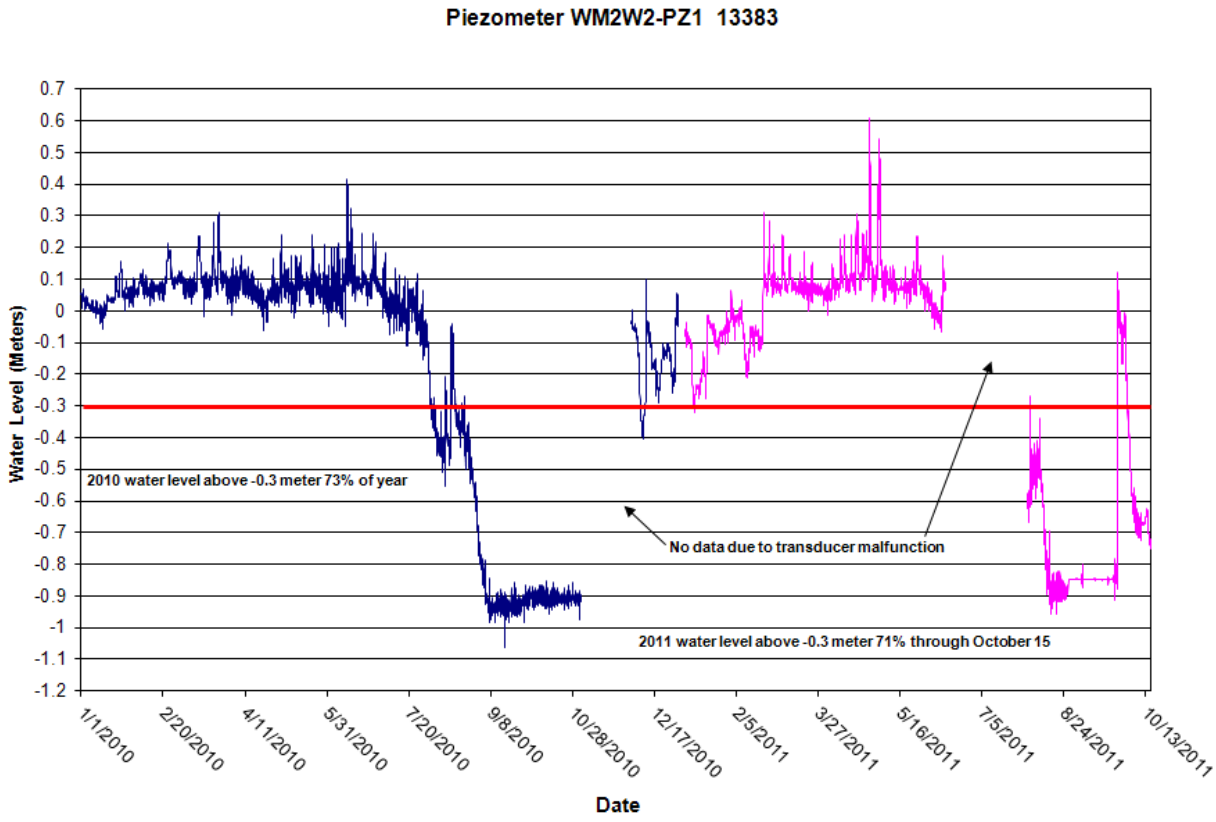

Figure 47. Wetland Mitigation Phase II WM2W2 Hydrograph

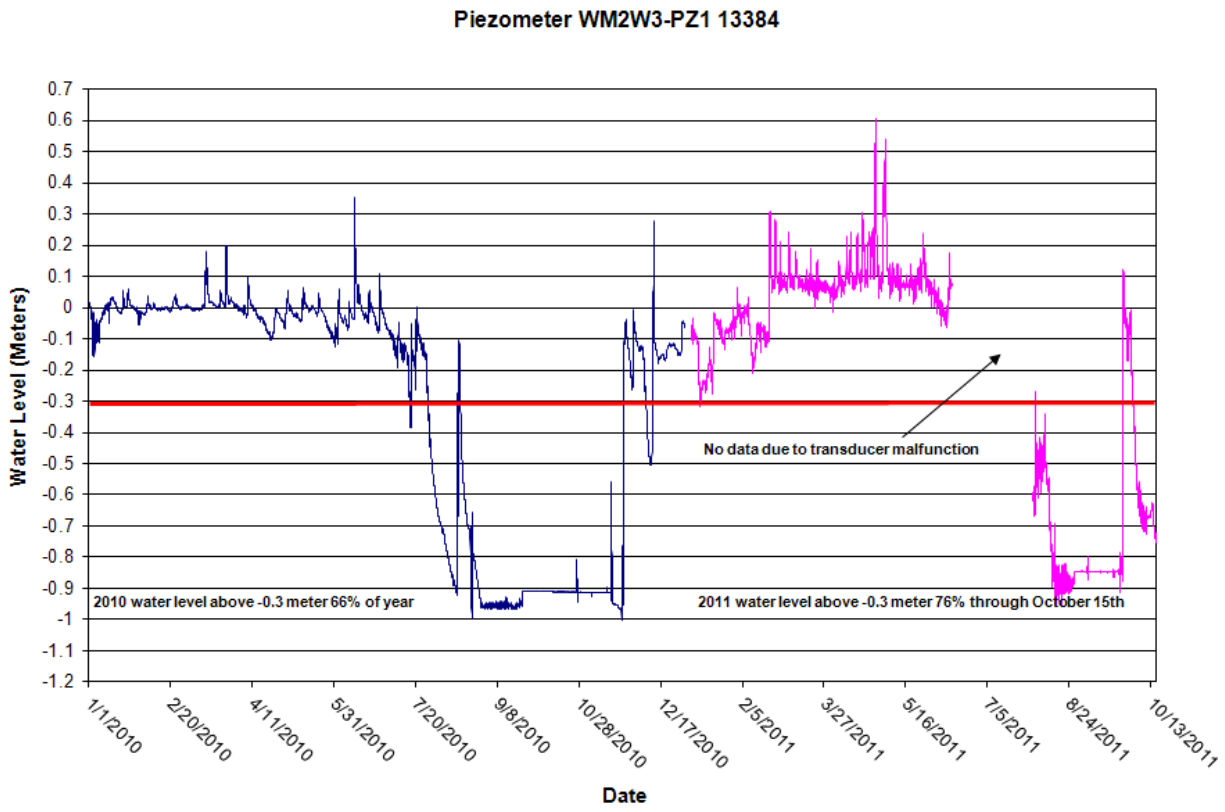

Figure 48. Wetland Mitigation Phase II WM2W3 Hydrograph

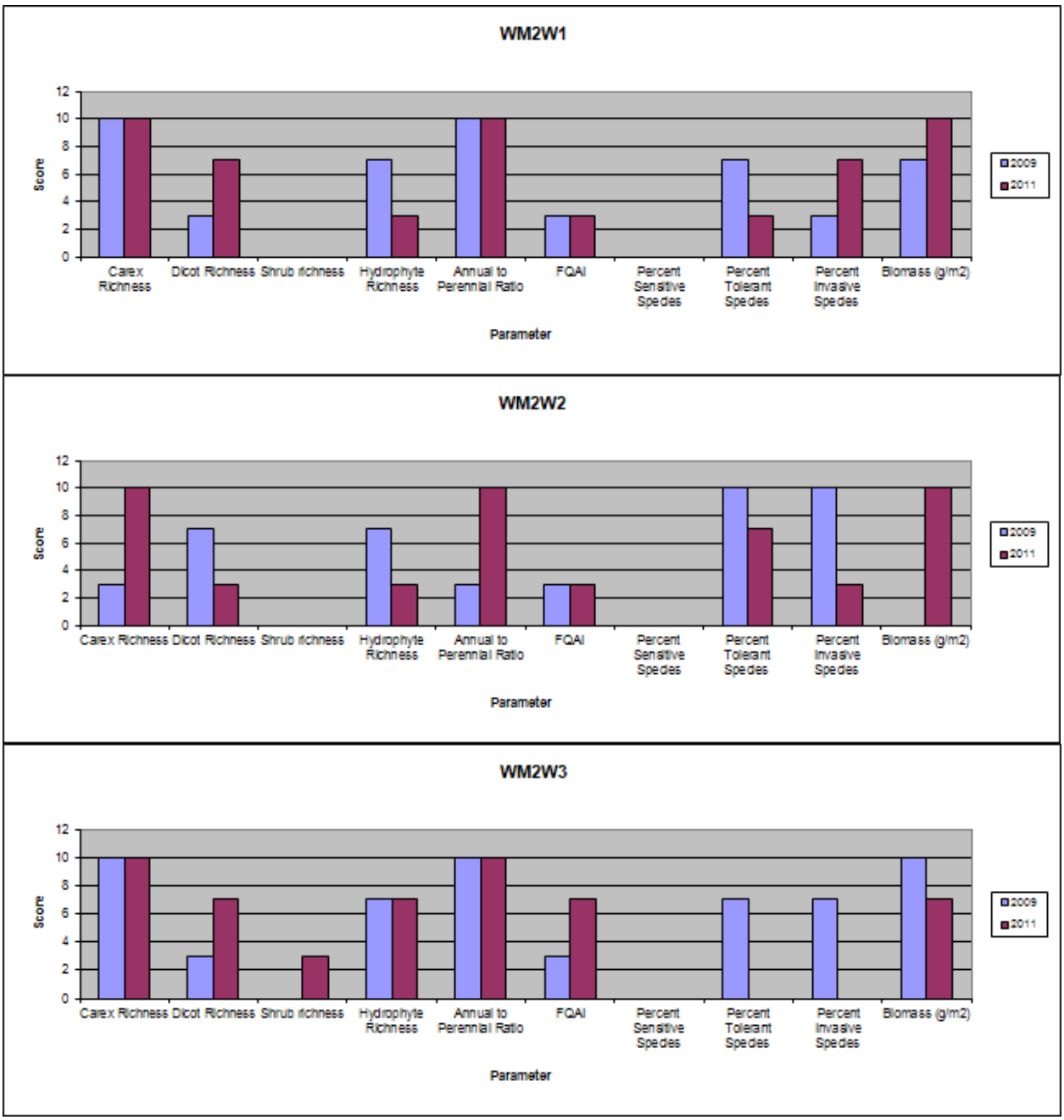

Figure 49. Wetland Mitigation Phase I VIBI Chart

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4.0 Conclusions

The data presented in the previous section represents a great effort to characterize basin-specific conditions. While a variety of results were observed across the Fernald Preserve, some general observations and trends can be discussed. Conclusions presented in this section attempt to discuss compliance in a sitewide context.

4.1 Performance Standards

Comparing wetland areas to the Ohio EPA performance standards shows mixed results. Table 40 provides a "Performance Matrix" across all basins and years. Results generally indicate that hydrologic conditions are sufficient, vegetation parameters are varied, and most soil parameters are not met. Results of soil biogeochemical sampling are consistent with other mitigation wetland evaluations in Ohio (Fennessy et al. 2004). The hard clay pan that is typically constructed to retain surface water limits the establishment of a loose, organic soil column. Field sampling often showed strong stratification, with a relatively thin organic layer sitting on a very dense, low organic clay horizon. It is interesting to note that the FPA wetlands came closest to meeting the performance standard for both percentage of solids and percentage of total organic carbon. It could be argued that the construction of these wetlands was the most challenging on site, since remediation activities left large stretches of subsoil as the starting point for restoration. The resulting use of yard waste compost as a soil amendment in FPA may have provided a good base for a buildup of organic soils in wetland basins.

Soil biogeochemistry is expected to improve over time. Monitoring of the hydrologic regime and vegetation was consistent across site wetlands and showed that basins are sufficiently inundated and supporting diverse wetland communities. The presence of vegetation and anoxic conditions due to prolonged periods of inundation will result in a buildup of organic matter, less bulk density, and a lessoning of the line of distinction between organic layer and mineral layer (Hammer 1997). Indeed, the jurisdictional wetland delineation conducted in 2011 demonstrated that hydric soils have developed within all of the wetlands evaluated.

Comparison to vegetation parameters is best within wetlands that are near existing forested communities. Both the NPP and WM2 wetland basins met the VIBI standard in 2011. A review of species lists in Appendix A–2 shows a relatively low amount of adventive vegetation establishment. Perhaps the location of these wetlands in perimeter areas provided a higher-quality base of soil and seedbank for vegetation establishment. Also, several basins are exhibiting a high frequency of volunteer woody vegetation establishment. This may further act as a deterrent for undesirable vegetation. It should be noted that the location of the WM2 and NPP wetlands also appears to be a factor in amphibian community development. The two highest AIBI scores across all wetland basins were from WM2W3 and NPPW4 (Appendix A–3). Ambystomatid salamander larvae and adults have been observed in both the WM2 and NPP wetlands in recent years. These observations are consistent with GIS-based evaluations that Ohio EPA conducted, where the presence of existing amphibian habitat (specifically vernal pools) is an important factor in mitigation site selection (Gara and Micacchion 2010).

For other wetland basins, it is difficult to discern a pattern for vegetation at this time. Portions of all other wetland areas (BAP, FPA, and WM1) met the vegetation VIBI performance standard in 2011. Data show some reduction in native perennial hydrophytes across a number of basins (Table 40). However, field observations did not indicate any major shift in vegetation

community structure. Instead, the results are most likely due to changes in field data collection technique. In 2009, field personnel differentiated between the native broad-leaved cattail (*Typha latifolia*) and the adventive narrow-leaved cattail (*Typha angustifolia*). Species lists for all but three basins (BAPW9, FPAW2, and NPPW5) included one or both cattail species (DOE 2010). These species often hybridize, making a positive identification difficult. Following discussions with several botanists, the decision was made to list all cattail species observed in 2011 as hybrid cattail (*Typha X glauca*). This species is considered nonnative, and with the high relative covers observed in most basins, it would significantly reduce the calculations for percentage of native perennial hydrophytes. Indeed, the three basins listed above that did not have *Typha* species in 2009 had similar findings in 2011, with no or very little relative cover for *Typha X glauca* (Appendix A–2). All three of these basins showed improved percentage of native perennial hydrophyte composition in 2011 (Table 40).

The 2011 VIBI scores compare favorably with Ohio EPA's recent investigations of mitigation wetlands. Researchers characterized 26 mitigation wetland projects across Ohio in 2010, via VIBI and AIBI (Micacchion et al. 2010). The mean 2011 VIBI score for the basins at the Fernald Preserve (43, Table 40) is higher than mean VIBI scores for the mitigation projects Ohio EPA evaluated (34.35, Micacchion et al. 2010). Amphibian monitoring shows a similar trend. The mean 2011 AIBI score (7.47, Table 40) is over twice as high as the mitigation average (3.50) and very similar to the natural emergent wetlands evaluated (7.48, Micacchion et al. 2010).

The entirety of monitoring results indicates successful establishment of created wetlands at the Fernald Preserve. While not all performance standards were met, the data show that hydrology is supporting wetland vegetation establishment and hydric soil development. As stated in Section 1.2, the performance standards are not intended to be "pass/fail" criteria. They are instead reference points for use in making decisions regarding future monitoring and maintenance.

4.2 Trends and Adaptive Management

In addition to the performance standards discussed above, several other trends have been observed from 2009 to 2011. Field personnel use findings from data collection to drive wetland management and maintenance activities. This "adaptive management" process of planning and implementation following monitoring activities is discussed in the NRRP (State of Ohio 2008). Specific examples resulting from wetland mitigation monitoring are provided below.

Several species are expanding their range at the Fernald Preserve. First, the Ambystomatid salamander population is expanding. A marbled salamander (*Ambystoma opacum*) was collected in WM1W1 in 2011. This is the first Ambystomid salamander observed outside of the NPP and WM2 wetlands. One negative species expansion that has been observed is the green sunfish into wetland basins. Green sunfish predate amphibian and macroinvertebrate communities, to the point of total denudation. They were first observed in 2008 at BAP (the Lodge Pond) and FPA. More fish species have since been collected in additional FPA basins as well as in WM2W2. Management efforts for wetland basins involve drawdown in late summer to simulate vernal pool conditions. The WM2 wetlands were drained in August 2011.

Planted and woody vegetation continues to expand across a number of wetland basins. Photographs in Appendix B demonstrate large stands of cottonwood (*Populus deltoides*) and willow (*Salix spp.*) in several basins. Buttonbush (*Cephalanthus occidentalis*) and swamp rose

(*Rosa palustris*) shrubs were observed to be expanding in a number of basins as well. Wetland communities were compared against the emergent depression hydrogeomorphic class, so woody vegetation characterization was not a component of the monitoring program. However, it is possible that a long-term shift to a forested wetland community may take place in some basins. In addition to native woody vegetation establishment, several nonnative species are expanding as well. Callery pear (*Pyrus calleryana*) and amur honeysuckle (*Lonicera maackii*) have been recorded in the WM1 basins. Honeysuckle infestation is well documented across the site. However, the presence of callery pear is a newer phenomenon that is being observed regionally. Field personnel have adopted control measures similar to that of amur honeysuckle (i.e., physical removal and spot herbicide application).

A nonnative bulrush has appeared in several basins recently. Ricefield bulrush (*Schoenoplectus mucronatus*) is a nonnative wetland species that was observed in 8 of 23 basins in 2009 (DOE 2010). Herbarium records show its Ohio presence from only four counties (Homer and Decker 2010). Field personnel have adopted a "pull on site" policy for ricefield bulrush. It is physically removed whenever it is observed. Field personnel observed ricefield bulrush within seven basins in 2011 (Appendix A–2).

4.3 Recommendations and Path Forward

The 3-year monitoring effort at the Fernald Preserve has shown that mitigation wetlands are established and being sustained. The jurisdictional wetland delineation in 2011 yielded approximately 31 acres of jurisdictional wetlands. This is well in excess of the 17.85 acres required. While compliance with performance standards shows mixed results, the field data collection effort, wildlife observations, and progress photographs indicate that quality wetlands are forming. These mitigation wetlands are likely of a higher quality than the cattail marsh impoundments that were replaced. Therefore, for the purposes of compensatory mitigation, the 17.85-acre wetland creation goal has been met.

Monitoring activities are an important component of the adaptive management process. Field personnel at the Fernald Preserve need quality data from which to make informed decisions regarding ecosystem management. In addition, long-term trends in wetland development can provide valuable information for future restoration efforts. For these reasons, some form of long-term monitoring effort is proposed. This can be accomplished through continuing the site functional monitoring program. Functional monitoring, which was also established in the NRRP, involves an ecosystem-level evaluation of major community types at the Fernald Preserve. Wetlands, prairies, and forest communities are evaluated on a 3-year rotation. Vegetation in restored communities is characterized and compared to pre-remediation baseline conditions as well as reference sites.

VIBI characterization can take place on a 3-year rotation, starting in 2012. In addition, the program could be expanded to include AIBI characterization. Hydrologic monitoring (i.e., water levels) can also continue, given that piezometers are already in place to collect data with little effort. This review of vegetation and wildlife can provide a quality dataset that can drive management decisions and make it possible to report long-term trend analysis. Reporting would continue through annual Site Environmental Reports, with periodic updates to the NRTs and other stakeholders as needed. Prairie and forest functional monitoring would continue on a 3-year rotation as well.

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Table 40. Wetland Mitigation Performance Matrix

	Design Parameters		Hydrologic Regime Parameters						Vegetation Parameters						Soil Chemistry Parameters						Other Wildlife Parameters	
Performance Standard	Delineation	Morphometry	Water in Root Zone		Mean Depth to Water		Flashiness Index		Unvegetated Open Water		Native Perennial Hydrophytes		VIBI		% Solids		% Total Organic Carbon		% Total Nitrogen		AIBI	
	17.85 Acres	>15:1 side slope	>53%		29.4 cm		<2.0		<10%		>75%		48–63		<46.6%		>3.9%		>0.5%		NA	
Basin/Year	**2011**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2009**	**2011**	**2009**	**2011**	**2009**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**	**2010**	**2011**
BAPW2	NA	NA	6%	61%	66	25	0.7	0.6	0.1%	1.3%	89.7%	84.3%	50	46	76.6%	**75.4%**	0.7%	**1.2%**	0.1%	**0.2%**	0	0
BAPW3	2.75	84%	71%	76%	25	13	0.5	0.8	0.1%	2.0%	81.2%	**67.2%**	32	**42**	66.4%	**74.3%**	1.0%	**0.5%**	0.1%	0.1%	NA	NA
BAPW4	3.03	86%	73%	76%	14	17	0.5	0.8	4.4%	1.3%	16.3%	**61.8%**	36	**23**	76.1%	**74.6%**	0.9%	0.9%	0.1%	0.1%	0	0
BAPW7	NA	NA	68%	73%	32	26	0.4	0.4	3.3%	1.8%	52.4%	**55.5%**	50	50	72.9%	**67.3%**	1.6%	1.6%	0.1%	**0.2%**	0	**13**
BAPW9	7.32	76%	67%	71%	28	18	0.7	0.9	4.8%	3.0%	41.8%	**70.2%**	59	**29**	80.1%	**85.7%**	1.5%	1.5%	0.2%	**0.4%**	NA	NA
FPAW2	2.01	84%	67%	73%	32	27	0.6	0.4	0.0%	**40.0%**	63.4%	96.1%	25	**40**	56.6%	**75.0%**	5.7%	6.0%	0.3%	**0.2%**	0	**13**
FPAW4	1.43	76%	78%	81%	19	16	0.4	0.3	9.4%	**26.0%**	53.2%	**42.0%**	50	**18**	69.5%	**60.0%**	2.9%	**4.5%**	0.1%	0.1%	NA	NA
FPAW5	1.20	85%	71%	73%	15	23	0.6	0.4	25.0%	11.5%	46.9%	**56.0%**	51	54	77.6%	**55.3%**	3.6%	**3.3%**	0.1%	**0.2%**	NA	NA
FPAW7	1.39	48%	77%	78%	22	20	0.4	0.9	0.0%	1.0%	55.3%	**29.1%**	34	**13**	65.1%	**79.6%**	5.3%	5.7%	0.3%	**0.2%**	0	0
FPAW9	0.53	68%	30%	76%	53	**30**	0.6	0.3	0.0%	2.8%	23.6%	**58.3%**	50	56	73.2%	**85.9%**	1.7%	**4.3%**	0.1%	0.1%	0	**10**
PREW6	2.78	75%	75%	80%	13	7	0.3	0.5	0.4%	**17.3%**	55.9%	**46.2%**	43	**25**	70.3%	**74.9%**	0.5%	**0.4%**	0.1%	0.1%	13	13
NPPW4	0.71	73%	65%	70%	28	18	0.3	0.7	0.0%	5.3%	42.0%	**72.1%**	51	58	62.0%	**78.0%**	2.7%	**0.8%**	0.2%	**0.1%**	16	**33**
NPPW5	0.18	98%	67%	67%	28	24	0.5	0.6	0.3%	3.8%	32.2%	79.6%	51	61	68.6%	**71.2%**	0.8%	**0.6%**	0.1%	0.1%	24	**0**
WM1W1	0.94	68%	34%	**52%**	49	**41**	0.7	0.7	0.0%	1.3%	62.9%	**47.2%**	40	**39**	67.0%	**78.2%**	2.5%	**1.7%**	0.2%	**0.1%**	0	**3**
WM1W2	1.13	91%	67%	68%	36	**32**	0.5	0.4	0.1%	2.1%	65.9%	**60.6%**	71	61	69.1%	**77.8%**	1.0%	**1.1%**	0.1%	**0.3%**	NA	NA
WM1M3	0.76	80%	63%	63%	41	**38**	0.5	0.7	0.0%	3.8%	95.6%	75.6%	61	**46**	71.8%	**83.8%**	1.3%	1.3%	0.1%	**0.2%**	NA	NA
WM1W4	0.78	88%	77%	77%	24	22	0.4	0.4	1.1%	8.0%	67.9%	**60.2%**	61	54	72.8%	**76.3%**	1.8%	**0.6%**	0.0%	0.1%	13	**3**
WM1W5	0.23	71%	53%	61%	38	29	1.2	1.3	0.0%	0.0%	71.7%	**71.0%**	26	**32**	73.4%	**79.5%**	2.3%	**1.5%**	0.1%	0.1%	NA	NA
WM1W6	1.45	83%	66%	50%	30	**52**	0.4	0.6	0.0%	1.3%	35.2%	**43.3%**	67	48	67.5%	**85.5%**	1.1%	1.1%	0.1%	0.1%	NA	NA
WM1W7	0.53	76%	61%	58%	37	25	0.8	0.6	0.1%	2.9%	79.4%	**64.0%**	54	**42**	69.2%	**84.3%**	3.8%	**1.9%**	0.3%	**0.1%**	0	0
WM2W1	1.17	55%	97%	96%	15	4	0.5	0.9	12.5%	1.0%	78.7%	**63.8%**	50	53	70.7%	**73.9%**	3.4%	**0.5%**	0.1%	**0.0%**	3	**6**
WM2W2	0.55	89%	73%	71%	18	20	0.5	0.7	4.5%	**13.8%**	89.4%	81.0%	43	49	77.9%	**85.0%**	1.1%	**0.1%**	0.1%	0.1%	3	**6**
WM2W3	0.46	53%	66%	76%	31	0	0.5	0.6	13.3%	**20.5%**	82.7%	**55.6%**	57	51	80.1%	**78.6%**	1.5%	**0.3%**	0.0%	0.0%	16	**12**
All Basins	**31.33**		64%	71%	30	23	0.5	0.6	3%	7%	60%	63%	48	43	71%	77%	2.1%	1.8%	0.1%	0.1%	5.87	7.47

NA = not applicable

Legend:

Performance Standard Met

Performance Standard Not Met

Conditions Improving

Conditions Not Improving

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