LEVEL II HYDROGEOLOGIC CHARACTERIZATION REPORT: EAST CAPE GIRARDEAU WETLAND MITIGATION SITE

FAP 312 (IL 146)
BDE SEQ. NO. 633A
ALEXANDER COUNTY, ILLINOIS

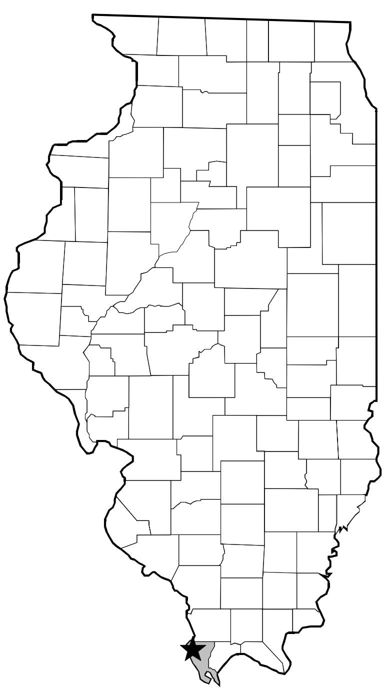
Eric T. Plankell

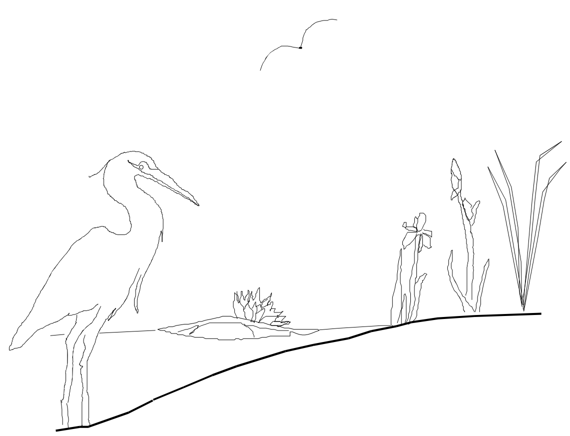
University of Illinois at Urbana-Champaign
Institute of Natural Resource Sustainability
Illinois State Geological Survey

Open-File Series 2010-3

Submitted Under Contract Number IDOT SW PESA WIP PART B FY10 JM to
Illinois Department of Transportation
Bureau of Design and Environment, Wetlands Unit
2300 South Dirksen Parkway
Springfield, IL 62764-0002

March 24, 2010





EXECUTIVE SUMMARY

In December 2008, the Illinois Department of Transportation (IDOT) tasked the Wetlands Geology Section of the Illinois State Geological Survey (ISGS) to conduct a hydrogeologic characterization of the East Cape Girardeau potential wetland mitigation site, located near the town of East Cape Girardeau, in Alexander County, Illinois. The goals of this characterization are to define the existing hydrogeological conditions at the site and to make recommendations regarding wetland mitigation strategies. Wetland mitigation activities are currently underway, based on previously made recommendations summarized herein.

Results of this investigation indicate that 5.2 ha (12.8 ac) of the entire site met jurisdictional wetland hydrology criteria in 2009, although only 0.4 ha (1.0 ac) of the site is classified by the Illinois Natural History Survey (INHS) as farmed wetland and 0.6 ha (1.5 ac) of the site is classified by the INHS as forested wetland. The existing wetland areas are located within and north of the forested area in the northeast portion of the site. Back-flooding from the East Cape Main Ditch (ECMD) is the primary hydrologic input to the site. Water levels on the Mississippi River have exceeded the outlet elevation for the ECMD gravity drain in 13 of the last 13 years during the growing season, which generally results in back-flooding adjacent to the ECMD when the gravity drain is closed. In 2009, elevated water levels on the ECMD resulted in flooding of the southern and northeastern portions of the site.

Approximately 5.5 ha (13.5 ac) of the site is not wetland according to the INHS, and therefore is available for wetland mitigation (not including the 0.8-ha [2.0-ac] parking lot and the 1.0 ha [2.5 ac] of existing farmed and forested wetlands). IDOT plans call for a total of 3.1 ha (7.6 ac) of mitigation, including 2.6 ha (6.4 ac) of forested wetland and 0.5 ha (1.2 ac) of emergent wetland. To date, IDOT has constructed a berm along the southern site boundary and excavated a shallow basin in the southwestern portion of the site. IDOT also plans to expand the wetlands in the northeast corner of the site through additional shallow excavation, and also to install two drainage control structures that will hold back water to an elevation of 100.5 m (329.7 ft). It is estimated that these modifications will allow the retention of surface water over approximately 2.5 ha (6.1 ac) of the portion of the site that is available for wetland mitigation. While the area of expected surface-water inundation is 0.6 ha (1.5 ac) less than the total mitigation area needed by IDOT, measurements of wetland hydrology made at the site by the ISGS in 2009 suggest that sufficient additional acreage will be saturated to allow IDOT to meet its mitigation goals.

TABLE OF CONTENTS

FIGURES

INTRODUCTION

This report was prepared by the Illinois State Geological Survey (ISGS) to provide the Illinois Department of Transportation (IDOT) with observations regarding the hydrogeologic conditions at a 7.3-ha (18.0-ac) wetland mitigation site along Illinois Route 146, approximately 3.2 km (2 mi) east of East Cape Girardeau in Alexander County, Illinois (SW 1/4, SW 1/4, Section 16, T14S, R3W). The property is bordered on the north by the raised roadbed of IL 146, on the east by commercial property and a man-made pond, on the south by undeveloped land, and on the west by a regional drainage ditch (Figure 1).

In addition to identifying the hydrogeologic conditions at the site, this report provides IDOT recommendations for constructing wetland mitigation on site. Therefore, a summary of findings and wetland mitigation recommendations are presented first, followed by a discussion of the methods and the supporting data. The supporting data include groundwater levels, surface-water levels, and precipitation data (December 2008 through November 2009), as well as observations made during a preliminary site evaluation in Summer 2008 (Plankell et al. 2008). Soils and vegetation information in this report are based on a Wetland Mitigation Site Assessment (Keene et al. 2008) prepared by the Illinois Natural History Survey (INHS). This information is presented for hydrogeologic purposes, and further consultation with qualified soil scientists and botanists from the INHS should be considered if a more detailed assessment of these specific parameters is required for this project.

Data collection at the site is ongoing, and will continue until no longer required by IDOT. The data currently being collected will be used to determine the impact of existing hydrologic alterations on the area, to compare the pre- and post-construction hydrology of the site, and to measure the duration and extent of wetland hydrology.

SUMMARY: EAST CAPE GIRARDEAU SITE

The following factors indicate that the potential for wetland mitigation at this site is **MODERATE TO HIGH**.

- Hydric soil (Karnak silty clay) was identified throughout the site by the INHS (Keene et al. 2008). The permeability of Karnak silty clay is described as very slow to slow, and flooding and ponding of this soil is described as frequent (Soil Survey Staff 2009). Surficial geologic materials observed at the site by the ISGS consisted of greater than 90 cm (35 in.) of dense silty clay. During the initial site evaluation, the ISGS observed hydrologic indicators such as standing water perched on top of unsaturated, clay-rich soil, water marks on tree trunks, drift lines, oxidized root channels, water-stained leaves, and active and abandoned crayfish chimneys across the site, all of which indicated recent, sustained inundation and suggested that the permeability of these surficial materials may be low enough to pond surface water periodically at the site (Plankell et al. 2008). These findings suggest that the site supported wetlands in the past, and may continue to do so today.

- A predominance of hydrophytic vegetation was mapped across the site in 2008 by the INHS (Keene et al. 2008).

- In 2008, the INHS mapped small areas of forested wetland and farmed wetland in the northeast corner of the site (Figure 2), while the National Wetlands Inventory (NWI) mapped no wetlands within the boundaries of the proposed site (Plankell et al. 2008).

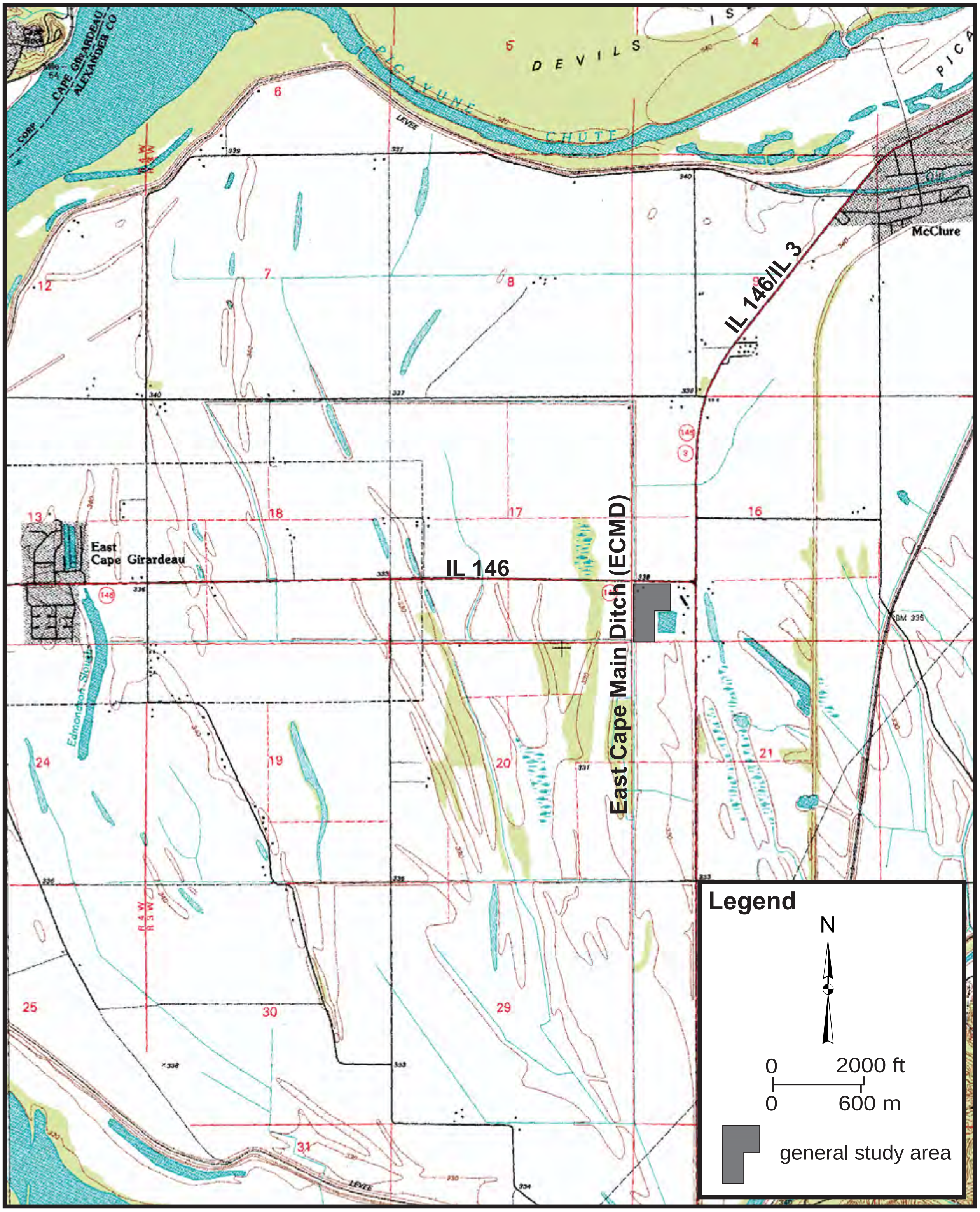


Figure 1 Location of the East Cape Girardeau wetland mitigation site along IL 146 (FAP 312) near the town of East Cape Girardeau, Alexander County, Illinois. Figure modified from the Mc Clure, IL-MO 7.5-minute U.S. Geological Survey (USGS) Quadrangle (USGS 1993): contour interval (CI) = 20 ft, supplemental CI = 10 ft, NGVD 1929.

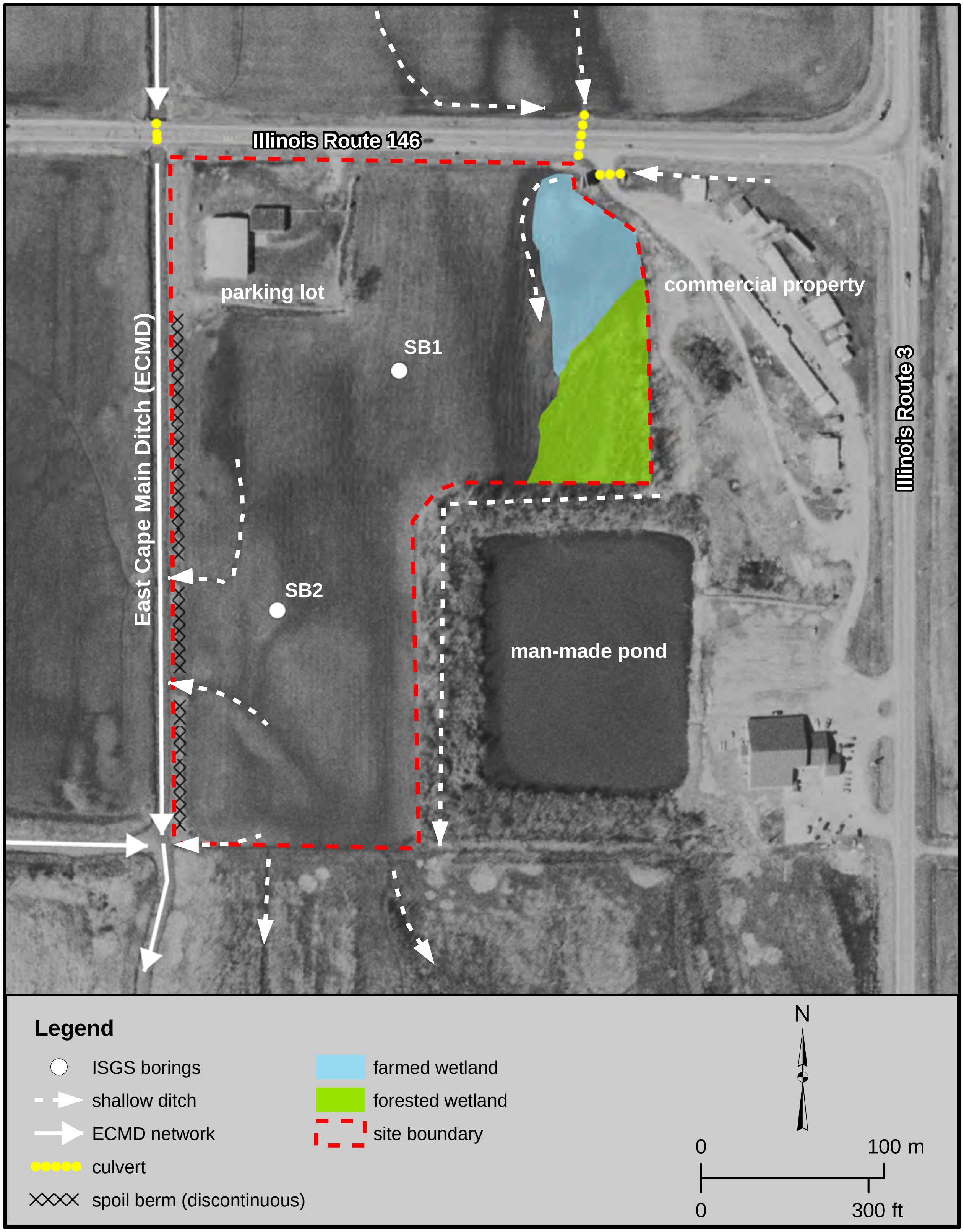


Figure 2 Drainage features and the locations of INHS-delineated pre-existing wetlands and ISGS hand-augered borings at the East Cape Girardeau wetland mitigation site. Figure modified from Plankell et al. (2008).

The INHS calculates the farmed and forested wetland areas to be approximately 0.4 ha (1 ac) and 0.6 ha (1.5 ac) in size, respectively (Keene et al. 2008).

- Several local and regional hydrologic alterations affect the hydrology at the site. Local alterations include several shallow ditches that drain excess water from the site either directly into the East Cape Main Ditch (ECMD) or onto the undeveloped land south of the site (Figure 2). Regional hydrologic alterations that affect the site include: 1) the leveeing-off of the Mississippi River from the floodplain, 2) the drainage of much of the floodplain west of IL 3 by the ECMD network, and 3) the construction of the elevated roadbeds of IL 3 and IL 146 and their associated ditches, resulting in water from the north and east being routed onto the northeast corner of the site through culverts under IL 146 and under the north entrance drive of the commercial property (Plankell et al. 2008; Figure 2).

- The primary source of water available to the site comes from back-flooding of the ECMD, a regional drainage ditch that borders the western edge of the site (Figure 3). During periods of elevated water levels on the Mississippi River, the gravity drain for the ECMD is closed and water cannot drain from the floodplain, resulting in back-flooding of the ECMD drainage network. Water levels on the Mississippi River have exceeded the outlet elevation for the gravity drain during the growing season in 13 of the last 13 years, suggesting that back-flooding on the ECMD might occur frequently depending on the amount of runoff generated by precipitation falling within the regional watershed when the gravity drain is closed. At times when water levels on the Mississippi River rise above the elevation of the floodplain, regional groundwater discharge may also contribute to rising surface-water levels. Additional water sources that provide hydrologic inputs to the site include direct precipitation, runoff from agricultural fields to the north and from the roadside ditches along IL 146 and IL 3, and overflow from the ECMD during intense local precipitation.

- Water-level data collected from December 2008 through November 2009 indicated that approximately 5.2 ha (12.8 ac), or 71% of the total site acreage, including the parking lot and the farmed and forested wetlands, satisfied jurisdictional wetland hydrology criteria (Environmental Laboratory 1987) for greater than 5% of the 2009 growing season, while the estimated area that satisfied jurisdictional wetland hydrology criteria for greater than 12.5% of the 2009 growing season was approximately 4.9 ha (12.0 ac), or 67% of the total site acreage (Fucciolo et al. 2009, Figure 4). Additionally, using new guidance proposed by the U.S. Army Corps of Engineers (2008), it was estimated that 5.2 ha (12.8 ac) also satisfied jurisdictional wetland hydrology criteria for 14 or more consecutive days during the 2009 growing season (Fucciolo et al. 2009; Figure 4). These estimates were calculated over a period of near-average precipitation as recorded by the Jackson, Missouri and Cape Girardeau Regional Airport weather stations.

- Approximately 5.5 ha (13.5 ac) of the site is available for wetland mitigation, of which 3.6 ha (8.3 ac) exhibited wetland hydrology in 2009 (not including the 0.8-ha [2.0-ac] parking lot and the 1.0 ha [2.5 ac] of existing farmed and forested wetlands). IDOT plans call for a total of 3.1 ha (7.6 ac) of mitigation, including 2.6 ha (6.4 ac) of forested wetland and 0.5 ha (1.2 ac) of emergent wetland. To date, IDOT has constructed a berm along the southern site boundary and excavated a shallow basin in the southwestern portion of the site. IDOT also plans to expand, by approximately 0.8 ha (2.0 ac), the wetlands in the northeast corner of the site through additional shallow excavation, and to install two drainage-control structures that will hold back water to an

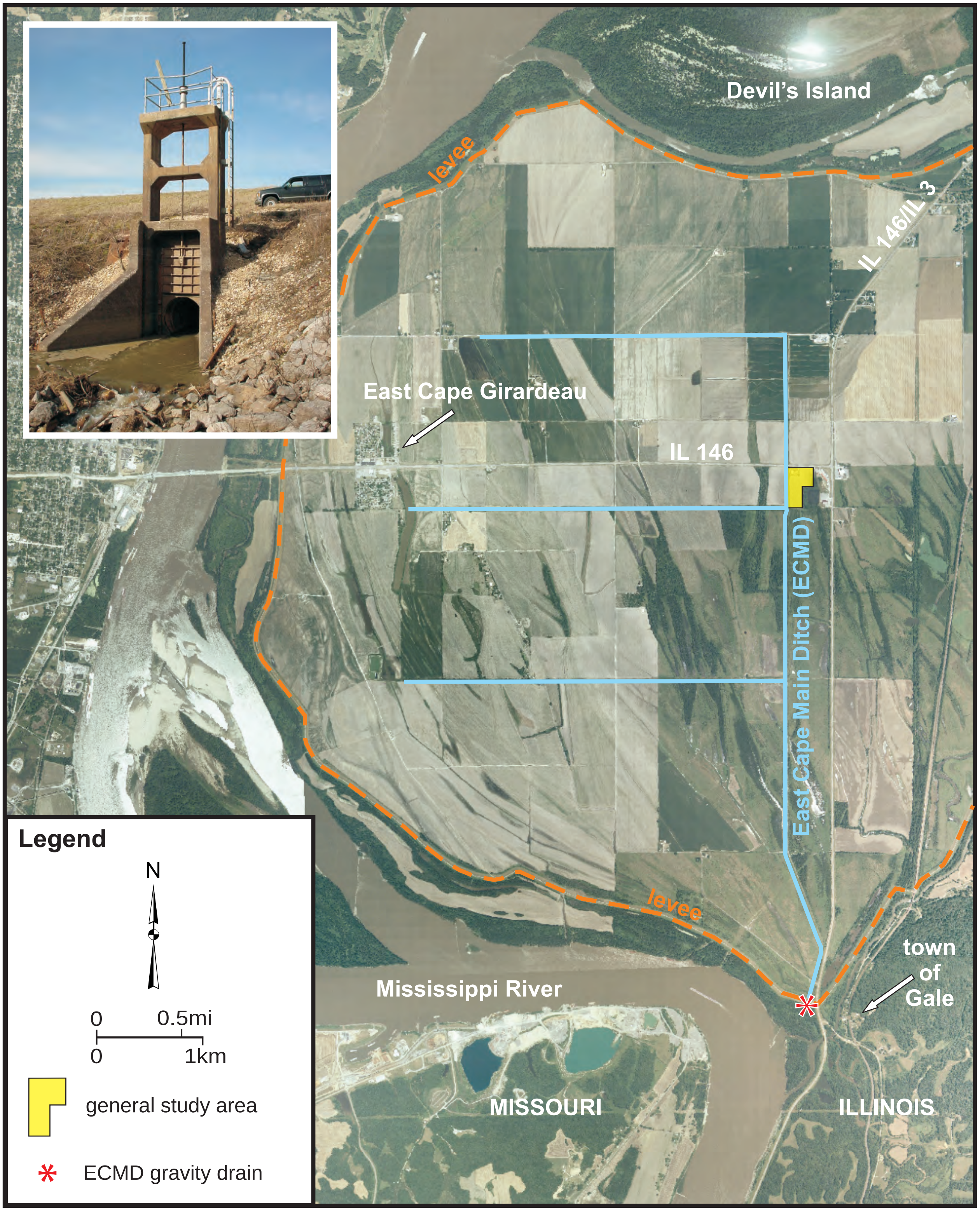


Figure 3 Location and photograph (inset) of the gravity drain at the end of the East Cape Main Ditch (ECMD) network. Figure drawn atop 2007 digital orthophotograph of Alexander County, Illinois (USDA 2007). Photograph of gravity drain taken by G. Pociask on March 5, 2005.

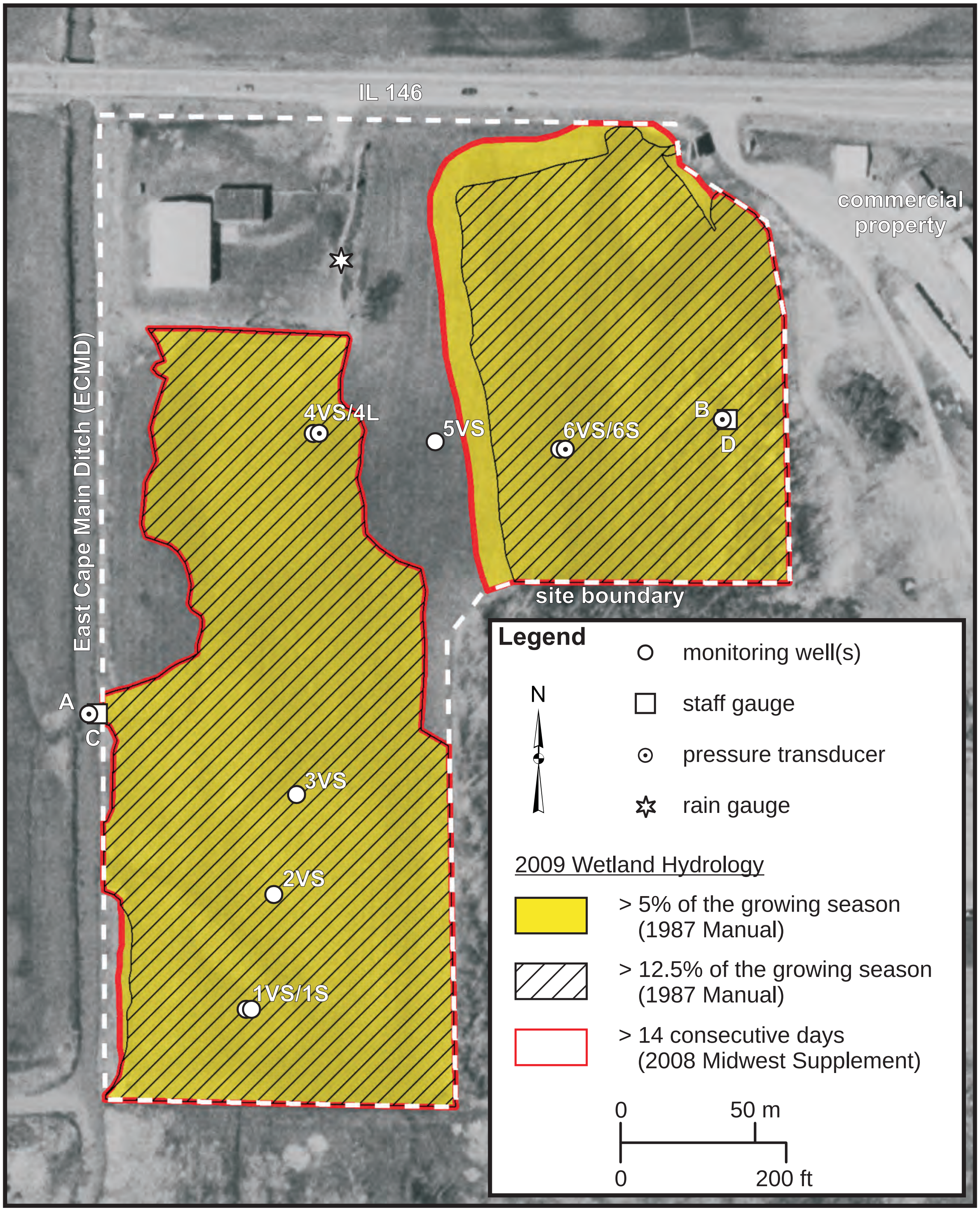


Figure 4 Estimated areal extent of wetland hydrology at the East Cape Girardeau wetland mitigation site for the 2009 growing season (figure based on Fucciolo et al. 2009).

elevation of 100.5 m (329.7 ft). It is estimated that these modifications will retain surface water over approximately 2.5 ha (6.1 ac) of the portion of the site that is available for wetland mitigation. Additional acreage outside the ponded area is likely to meet wetland hydrology criteria via saturation to land surface. The 3.0 ha (7.5 ac) of the site (not including the parking lot and the existing farmed and forested wetlands) that satisfied wetland hydrology criteria for greater than 12.5% of the 2009 growing season did so during a period of sustained surface-water levels of approximately 100.51 m (329.76 ft) (Fucciolo et el. 2009), which is the same elevation as the proposed drainage-control structures. It is therefore expected that the modifications under construction at the site will allow IDOT to meet its mitigation goals in years of near-average precipitation and back-flooding from the ECMD.

WETLAND MITIGATION RECOMMENDATIONS

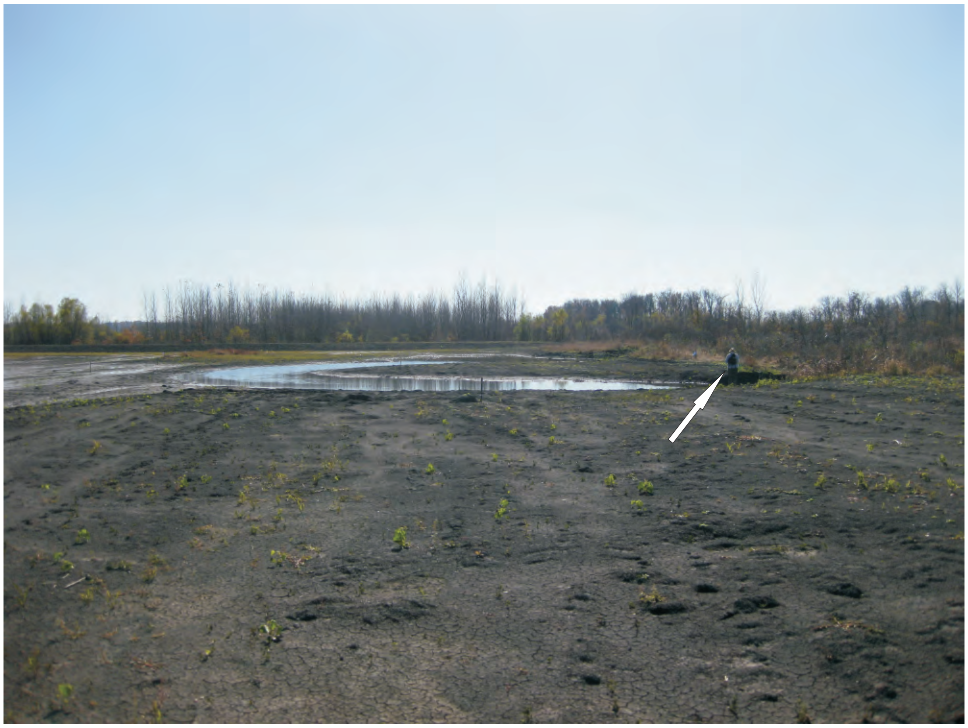
The total site area is 7.3 ha (18.0 ac). Based on the INHS Wetland Mitigation Site Assessment (Keene et al. 2008), 0.4 ha (1.0 ac) of farmed wetland and 0.6 ha (1.5 ac) of forested wetland are mapped by the INHS in the northeast portion of the site (Figure 2). Subtracting an additional 0.8 ha (2.0 ac) for the parking lot leaves approximately 5.5 ha (13.5 ac) of the site available for wetland mitigation, of which 3.6 ha (8.3 ac) exhibited wetland hydrology in 2009. IDOT's plan is to create 2.6 ha (6.4 ac) of forested wetland and 0.5 ha (1.2 ac) of emergent wetland in the western portion of the site, and to expand, by approximately 0.8 ha (2.0 ac), the existing wetlands in the northeastern portion of the site (Appendix A, Sheet 1) for a total of 3.9 ha (9.6 ac) of mitigation.

- Shallow excavation is planned both in the northeast and southwest portions of the site (Appendix A, Sheet 1). As of December 4, 2009, the two northernmost drainage ditches that empty into the ECMD (Figure 2) were connected via shallow excavation into a semicircular depression in the area proposed for created emergent wetland in the southwest portion of the site (Figure 5, Photograph 1 and Appendix A, Sheet 1). It did not appear that excavation in the northeast portion of the site, designed to enhance and expand existing wetlands, had begun.

- A berm, with a planned elevation of 101.5 m (333.0 ft), has been constructed along the southern site boundary to restrict drainage from the site to the undeveloped land to the south, as well as to block off the southernmost outlet into the ECMD (Figure 5, Photograph 2 and Appendix A, Sheet 1).

- Further restriction of drainage from the western half of the site is proposed to be accomplished by installation of two control structures located at each end of the semicircular depression mentioned above, where they connect to the ECMD (Appendix A, Sheet 1). IDOT plans call for the control structures to have slab elevations of 99.9 m (327.8 ft), with additional restriction to 100.5 m (329.7 ft) provided by pressure treated stop logs (Appendix A, Sheet 2). Drainage-control structures incorporating stop logs are currently in use at the Harrisburg Site 2 wetland mitigation site, and have been shown to be ineffective for holding water back on that site (Pociask, pers. comm.). On August 6, 2009 an email was sent to Julie Klamm, Environmental Studies Coordinator for IDOT District 9, with the following recommendations: 1) the flow of water onto and off of the site via the ECMD is expected to be relatively low in energy, and a single control structure would likely be sufficient to manage that flow; 2) stop logs have been shown to be ineffective at holding water back and should not be used; 3) the slabs for the control structure(s) should be poured to a spillover elevation of 100.5 m (329.7 ft). As of

Figure 5 Site Photographs



Photograph 1 Water standing in the shallow excavation completed in the proposed emergent wetland area in the southwest portion of the site, view to the south. Note person standing in the location of the northernmost proposed drainage control structure (arrow). Photograph taken by C. Knight on November 4, 2009.

Photograph 2 IDOT-constructed berm extending along the southern site boundary, as seen from the southwestern corner of the site. View is to the east, with the East Cape Girardeau wetland mitigation site on the left and undeveloped land on the right. Photograph taken by M. Campbell on December 4, 2009.

December 4, 2009, no work had been completed on the control structures. However, implementing these recommendations would likely reduce both construction costs and maintenance issues, while assuring that sufficient water is held on site to achieve the target wetland acreage.

- Any mitigation site design that interrupts the current drainage network must provide a continued means of drainage for adjacent agricultural and commercial areas immediately north and east of the site, as well as not have any adverse affects on the roadbeds of IL 146 and IL 3. As long as the slab for the drainage-control structure(s) is built to the proposed elevation of 100.5 m (329.7 ft), then excess water should be able to drain from the site before it can negatively impact surrounding properties or roadways (Appendix A, Sheet 1).

METHODS

Geology

Surface sediments were described from two hand-augered soil borings made at the site during the initial site evaluation. Both borings were completed to final depths of approximately 90 cm (35 in.). Materials retrieved from the borings are described under Site Characterization below.

Hydrology

Surface-water levels and shallow groundwater levels have been monitored on site by ISGS since December 2008. Inundation and/or saturation to land surface must occur for at least 5 percent of the growing season to satisfy wetland hydrology criteria as outlined in the 1987 U.S. Army Corps of Engineers Wetland Delineation Manual (Environmental Laboratory 1987). Water levels within 30 cm (1 ft) of land surface in shallow monitoring wells are interpreted to show saturation to land surface due to the presence of a capillary fringe, as suggested by informal Corps guidance. Interpolation and/or extrapolation were performed to determine the duration of saturation for wells where manual water-level measurements were collected.

A total of 9 monitoring wells were installed at six locations throughout the mitigation site to monitor near-surface groundwater levels (Figure 4). Water-level data from these wells were used to map the extent of wetland hydrology, to identify water sources, and to help design the wetland mitigation plans.

The deepest well on site (Well 4L) was installed near the center of the northern half of the site to a depth of 3.00 m (9.84 ft) below land surface. This well has a screen length of 30 cm (1.0 ft), and was installed to determine the vertical hydraulic gradient on site.

Very shallow wells (VS-wells) were installed at each of the six locations. These wells are designed to be 37.5 cm (1.23 ft) deep with screens 15 cm (0.49 ft) in length. Soil-zone wells (S-wells) were installed at two of the six locations. These wells are designed to be 75 cm (2.5 ft) deep with screens 0.30 m (1.0 ft) in length. Both S- and VS-wells are designed to monitor saturation in the near-surface sediments for the purpose of delineating areas of wetland hydrology. However, VS-wells are designed to better monitor near-surface saturation in fine-grained, low-permeability sediments, such as are found on the site.

All well screens have a slip-on bottom cap with a single drainage hole. Well screens were packed with quartz sand with a grain size of 0.9 mm (0.038 inch), typically #5 silica filter pack or equivalent. The annulus was then back-filled to land surface with medium bentonite chips. Well-construction details are provided in Appendix B.

Non-vented In-Situ Level Troll 500 data loggers were used to continuously record shallow groundwater levels and surface-water levels as Gauges A and B. Water-level readings recorded by the four data loggers were corrected with on-site barometric data measured with an In-Situ Baro Troll. Staff gauges (Gauges C and D) were installed adjacent to the loggers, and are used as quality control. Data from the loggers were compared to assess relationships among the various water sources.

Data loggers were installed in monitoring well 4L, in the ECMD (Gauge A), and in the existing forested wetland (Gauge B) on December 12, 2008, and were programmed to monitor water levels every hour. An additional data logger was installed in monitoring well 6S on February 19, 2009. This data logger was originally programmed to monitor water levels every 3 hours, but was reprogrammed to record water levels every hour beginning on April 14, 2009.

In 2009, the wells, data loggers, and staff gauges were monitored once in January, biweekly in February, weekly from March through May, biweekly in June, and monthly thereafter. The complete records of surface-water elevations from staff gauges and depths-to-water in monitoring wells are reported in graphical form in Appendix C and as tabular data in Appendix D.

All monitoring wells and associated data loggers were removed from the site in July 2009, in preparation for wetland construction activities. Gauges A, B, C, and D are located in areas that were not intended to be impacted by construction activities, and were not removed.

Climate

On-site precipitation was measured with a Davis Instruments tipping-bucket rain gauge equipped with an Onset data logger (Figure 4). On-site data supplemented regional precipitation data recorded at the Jackson, Missouri weather station (Station 234226) and the Cape Girardeau Regional Airport (Station 231289) (Figure 6; Appendix E) (Midwestern Regional Climatic Center 2009). The precipitation data were used to determine the effect of monthly, seasonal, and annual precipitation trends on surface-water levels and groundwater levels.

Air-temperature data recorded at the Cape Girardeau Regional Airport (Station 231289) were used to determine the length of the growing season for the region. The growing season is defined as the period between the last occurrence of -2.2°Celsius (C) [28°Fahrenheit (F)] air temperatures in the spring and the first occurrence of that temperature in the fall (Environmental Laboratory 1987). The median length (5 out of 10 years) of the growing season for the region is 228 days, starting on March 26 and ending on November 9 (Midwestern Regional Climate Center 2009).

On-site soil-temperature and soil-moisture data were measured every three hours with a Decagon Devices ECH_2O EC-TM temperature and moisture probe attached to a ECH_2O Em50 data logger. The temperature/moisture probe was installed at a depth of 30 cm (12 in.) in the side of a soil pit dug adjacent to wells 6S and 6VS, in a portion of the site that was expected to be near the transition from existing wetland to upland. Manual soil-temperature readings, used for quality control for the soil-temperature probe, were collected by field staff using bimetal thermometers inserted to a depth of 30 cm (12 in.) during site visits in the spring of 2009.

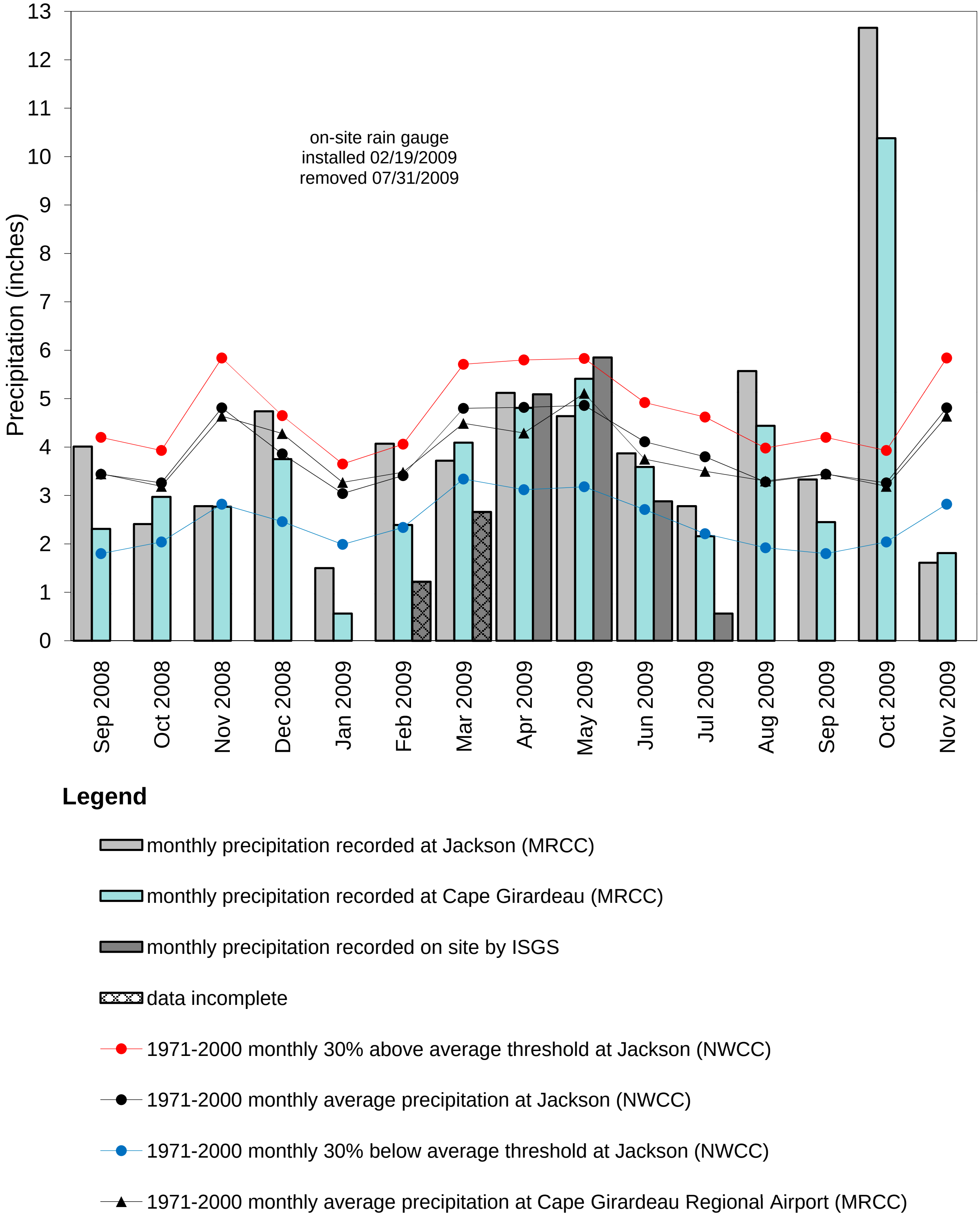


Figure 6 Total monthly precipitation recorded by the ISGS at the East Cape Girardeau wetland mitigation site versus climatic data and the monthly precipitation totals recorded by the weather stations at the Cape Girardeau Regional Airport (Station 231289) and at Jackson, Missouri (Station 234226) (Midwestern Regional Climatic Center 2009 and National Water and Climate Center 1995).

These soil-temperature data were used to determine the start of the growing season following guidance outlined in the Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region (U.S. Army Corps of Engineers 2008), hereafter referred to as the 2008 Midwest Supplement. Soil-moisture data were not evaluated for this report.

Elevations

The elevations of the monitoring wells, staff gauges, and data loggers were measured on February 9, 2009 using a Leica TC702 total station. Elevation control was obtained by tying into National Geodetic Survey monument #9503, located in the northwest quadrant of IL 3 and IL 146 (37°17'45.36660" N, 89°26'55.72911" W) and referenced to the North American Vertical Datum of 1988 (NAVD 1988). Instrument locations were surveyed on the same day using a Trimble ProXR GPS receiver. To increase positional accuracy, these locations were differentially corrected using Trimble Pathfinder software.

All elevations in this report are presented in reference to the North American Vertical Datum of 1988 (NAVD 88), unless otherwise noted. Conversions from the National Geodetic Vertical Datum of 1929 (NGVD 29) to NAVD 88 were processed using the National Geodetic Survey's VERTCON datum conversion tool (National Oceanic and Atmospheric Administration 2009).

SITE CHARACTERIZATION

Setting

The East Cape Girardeau wetland mitigation site is located in the Upper Mississippi-Cape Girardeau Watershed (HUC 07140105) and lies within the 100-year floodplain of the Mississippi River (Illinois State Water Survey 1996), approximately 3.2 km (2 mi) east of East Cape Girardeau in Alexander County, Illinois (Figure 1). Specifically, the site is located one parcel west of the southwest quadrant of the intersection of IL 146/IL 3 and IL 146. The 7.3-ha (18.0-ac) site is bordered on the north by the raised roadbed of IL 146, on the east by commercial property and a man-made pond, on the south by undeveloped land, and on the west by a regional drainage ditch, the ECMD.

The site is situated within a large ridge and swale complex that extends from the main channel of the Mississippi River to the eastern bluff of the river valley. This ridge and swale complex is interpreted to be large-scale point bars that were deposited as the main channel of the Mississippi River migrated from east to west across the region (McKay et al. 1979).

Topography

According to topographic data collected by the ISGS, the site ranges in elevation from approximately 100.3-101.3 m (329.0-332.5 ft), not including the former parking lot at the northwest corner (Figure 7). The site is essentially divided into two low areas separated by a subtle ridge running from the southeast corner of the parking lot to the northwest corner of the man-made pond. The northeastern portion of the site slopes gently to the east-southeast, toward the forested wetland, while the western half of the site slopes gently toward the south-southwest, toward the undeveloped land south of the site. A subtle swale extends southward from the parking lot approximately 145 m (476 ft) before turning west and emptying into the ECMD through a break in the berm along the ditch (Figure 2 and Figure 7). A second break in the berm is located approximately 57 m (187 ft) further south, and directs flow into the ECMD from a well-developed drainage ditch that extends across the southern portion of the site.

Figure 7 Pre-construction topography at the East Cape Girardeau wetland mitigation site (contour interval = 0.5 ft). Topographic data collected by the ISGS on October 21, 2008. Map based on Figure 5 from Plankell et al. (2008).

Regional and Local Drainage Patterns

Regionally, surface-water runoff south of Devil's Island and west of IL 3 is directed into the ECMD network, where it eventually drains into the mouth of Sexton Creek via a gravity drain located approximately 4.9 km (3.0 mi) south of the site, just west of the town of Gale, Illinois (Figure 3). Historical aerial photographs indicate that the ECMD network was in place by at least 1938. Locally, surface-water runoff from the agricultural field immediately north of IL 146 and from the roadside ditches surrounding the commercial property is directed toward the northeast corner of the site via culverts under IL 146 and under the northern entrance drive to the commercial property (Figure 2). This water, along with runoff from the northeastern portion of the site, collects in the forested wetland in the northeastern corner, though it occasionally overflows into a shallow ditch rimming the northern and western edges of the man-made pond, where it then drains to the undeveloped land to the south (Figure 2). Surface-water runoff from the western half of the site drains either into the ECMD or onto the undeveloped land south of the site via shallow ditches (Figure 2).

Geology

Bedrock Geology

The uppermost bedrock unit in the project area is mapped as the Maquoketa Formation/Group of the Ordovician System (Kolata et al. 2005). The Maquoketa Formation/Group includes limestone, sandstone and shale units (Kolata et al. 2005). The buried bedrock surface is mapped at an elevation of approximately 61 m (200 ft) above mean sea level (Herzog et al. 1994), or approximately 40 m (130 feet) below land surface at the site. No specific bedrock geologic structures are mapped at the site (Nelson 1995).

Unconsolidated Sediments

Surficial materials covering the site are as much as 40 m (130 ft) thick, and are mapped as more than 6 m (19.7 ft) of Cahokia Formation overlying more than 6 m (19.7 ft) of the Henry Formation (Berg and Kempton 1988). The Cahokia Formation represents modern alluvium consisting of poorly sorted sand, silt, or clay, with local deposits of sandy gravel (Lineback et al. 1979). The Henry Formation is interpreted as glacial outwash consisting primarily of stratified sand and gravel, with local lenses of silt, clay, and organic debris (Hansel and Johnson 1996).

Two shallow borings were completed during the initial ISGS site visit (Plankell et al. 2008). Boring SB1 was located along the crest of the subtle ridge at the north end of the site, and SB2 was located in a lower landscape position near the two shallow ditches in the southern part of the site (Figure 2). Sediments recovered from both borings consisted of dense silty clay, analogous to the fine-grained "swale-fill" deposits described at the surface of a wetland located approximately 1.8 km (1.1 mi) southwest of the site (McKay et al. 1979). Oxidized root channels, manganese nodules, and iron concentrations and depletions were observed in the cuttings from the borings, essentially from land surface downward. However, no free ground water was encountered in either borehole down to final depths of approximately 90 cm (35 in.).

Soils

Darwin silty clay and Cairo silty clay, both hydric soils, were mapped over the entire site by the NRCS (Soil Survey Staff 2009). However, on-site soil observations by INHS staff suggest that the entire site is actually covered by Karnak silty clay, a hydric soil that lacks the mollic epipedon seen in Darwin silty clay (Keene et al. 2008). According to the soil survey (Soil Survey Staff 2009), the Karnak silty clay soil is very poorly drained, with 0 to 2 percent slopes and moderately-low to moderately-high permeability ranging from 0.15-0.51 cm/hr (0.06-0.20 in./hr). Depth to water ranges from 0-30 cm (0-12 in.), and flooding and ponding are listed as frequent. The INHS should be consulted if a more detailed inventory of the soils at the site is required.

Vegetation

The INHS identified three vegetation cover types at the site, each with dominant hydrophytic vegetation (Keene et al. 2008). The three cover types identified, and the dominant species encountered within are as follows: wet floodplain forest - *Salix nigra*, *Forestiera acuminata*, *Campsis radicans*; farmed wetland - *Ammannia coccinea*, *Echinochloa muricata*, *Ipomoea lacunosa*; and agricultural land - *Amaranthus tuberculatus*, *Ipomoea lacunosa*. The INHS has not yet been tasked to further evaluate the vegetation at the site (A. Plocher, pers. comm.). The INHS should be consulted if a detailed inventory of the vegetation at the site is required.

Wetlands

Due to prolonged flooding of the site in 2008, the INHS followed USDA NRCS guidance and reviewed 10 years of crop slides to determine the average extent of wetland signatures (P. Marcum, pers. comm.) according to Corps-recommended procedures for determining wetland hydrology under difficult situations (U.S. Army Corps of Engineers 2008). Using crop slides from 1992 to 2002 (2002 was the most recent year that crop slides were available from the Alexander County NRCS office, according to P. Marcum), and excluding 1993 (due to major flooding of the Mississippi River), the INHS identified small areas of farmed wetland and forested wetland near the northeastern corner of the site (Keene et al. 2008, Figure 2). The INHS calculated the farmed and forested wetland areas to be approximately 0.4 ha (1 ac) and 0.6 ha (1.5 ac) in size, respectively. The forested wetland lies at the same elevation and over similar geologic materials as other wetlands mapped in the region (Plankell et al. 2008). The presence of scratch ditches cutting across the site on historical aerial photographs dating back to 1950 indicates that wet conditions have existed historically at the site since at least that time. No evidence for drainage tile has been observed at the site.

Hydrology

Precipitation

Average annual precipitation at the Jackson, Missouri weather station is 120.6 cm (47.49 in.) (National Water and Climate Center 1995), while average annual precipitation at the Cape Girardeau Regional Airport is 118.7 cm (46.75 in.) (Midwestern Regional Climate Center 2009) (Appendix E, Table E1). Precipitation at these stations is typically greatest between March and May, and again in November.

From September 2008 through November 2009, precipitation measured at the Jackson, Missouri weather station was at or above average for the months of September and December 2008, and February, April, May, June, August, September, and October 2009. For the same period, precipitation measured at the Cape Girardeau Regional Airport was at or above average for the months of October 2008, and April, May, June, August, and October 2009. Precipitation recorded at these two stations was below average for the remaining months in the period from September 2008 through November 2009. Total precipitation recorded from September 2008 through November 2009 was 159.5 cm (62.81 in.) and 136.9 cm (53.89 in.) at the Jackson, Missouri and Cape Girardeau Regional Airport weather stations, respectively. These totals were 106% and 93% of the averages for the same 15-month period for the Jackson, Missouri and Cape Girardeau Regional Airport weather stations, respectively. The above totals include precipitation amounts in October 2009 that were 419% and 325% above average, at those respective stations, for that month.

The ISGS collected on-site precipitation data between February 19 and July 31, 2009, obtaining complete records for the entire months of April, May, June, and July 2009. These data were compared to data collected from nearby weather stations located in Jackson, Missouri (Station 234226) and at the Cape Girardeau Regional Airport (Station 231289), in Cape Girardeau, Missouri (Appendix E; Figure 6) to determine variances from long-term averages. On-site precipitation was within the normal range for the months of April and June, was slightly above average during the month of May, and was below average for the month of July. On-site data varied the most from the weather station data during the month of July, when totals were 4.06 cm (1.60 in.) and 4.64 (2.22 in.) less than the totals recorded at the Jackson and Cape Girardeau weather stations, respectively.

Figure 8 depicts stage levels measured on the Mississippi River at Thebes, Illinois, surface-water levels and groundwater levels measured by data loggers at the mitigation site, and daily precipitation totals measured at the Cape Girardeau Regional Airport, the weather station nearest to the site. While intense local rainfall events do sometimes result in short-term elevated water levels on the ECMD, the site typically does not flood as a result of intense local precipitation when the gravity drain is open. Only on August 4, 2009, when 8.9 cm (3.5 in.) of rain was recorded at the Cape Girardeau Regional Airport weather station, did water levels rise on the ECMD to an elevation high enough to inundate portions of the site during a time when the ECMD gravity drain was open. An analysis of Mississippi River stage measured at Thebes, Illinois indicates that river stage has risen above the ECMD outlet elevation in each of the last 13 years, during the growing season, for sustained periods ranging from 24 to 184 days (Appendix F). Based on water-level data collected at the site thus far, sustained high water levels in the ECMD are more likely to occur when the gravity drain is closed during elevated stage levels on the Mississippi River.

Precipitation and runoff may also help support limited areas of wetland hydrology at the site. ISGS field observations indicate that heavy rainfall events and associated runoff directed onto the site through culverts at the northeast corner of the site (Figure 2) result in surface water collecting in and around the forested wetland at the northeast corner of the site, in shallow depressions bordering the eastern and southern sides of the parking lot, and in the shallow swale immediately south of the parking lot. However, before larger areas of the site can become inundated, excess water is directed off the site through the shallow drainage ditches shown in Figure 2, unless drainage into the ECMD is impeded by back-flooding along the ditch.

Surface-Water Hydrology

To date, water-level data collected at this site suggest that back-flooding from the ECMD is the primary water source on site. In 2009, data recorded at Gauge A indicated that water levels in the ECMD reached an elevation sufficient to begin flooding the site in mid-April, as a response to the closure of the ECMD gravity drain due to springtime flooding on the Mississippi River (Figure 8). Water levels on the Mississippi River receded slightly at the end of April, but then rose again and were sustained through the entire month of May. During this time, water backed up along the ECMD and resulted in standing water across much of the northeastern and southern portions of the site. Surface-water levels on the ECMD and at the site started to drop

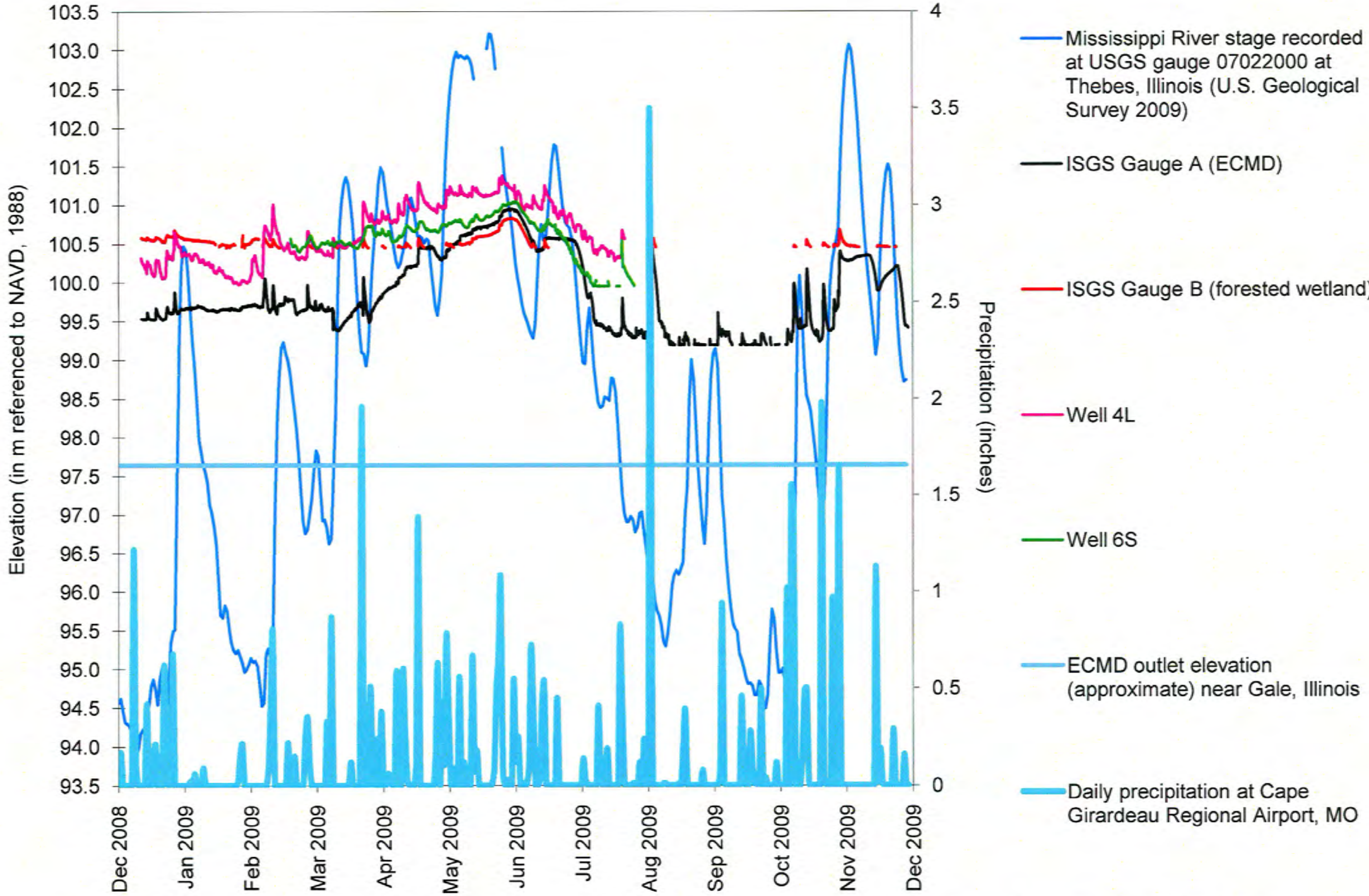


Figure 8 Water levels recorded on the Mississippi River at Thebes, Illinois (U.S. Geological Survey 2009) and at the East Cape Girardeau wetland mitigation site compared to daily precipitation recorded at the Cape Girardeau Regional Airport (Midwestern Regional Climate Center 2009).

by the beginning of July, corresponding to falling water levels on the Mississippi River (Appendices C and D; Figure 8).

Results from a flood-history analysis of the Mississippi River at Thebes, Illinois indicate that there is a high likelihood of back-flooding on the ECMD during the growing season (Appendix F). The outlet elevation for the ECMD gravity drain is mapped at approximately 97.64 m (320.35 ft), and when river stage exceeds the outlet elevation, the gate is closed and no drainage through the ECMD occurs. The analysis shows that river stage has exceeded the ECMD outlet elevation during the growing season in 13 of the last 13 years. Additionally, the analysis indicates that river stage can exceed the outlet elevation multiple times during the growing season, as well as prior to the beginning of the growing season in some years. Whether or not water in the ECMD will back up to levels sufficient to flood the East Cape Girardeau site depends primarily on the amount of runoff generated by precipitation falling within the regional watershed when the gate is closed, which in turn is controlled by the precipitation total and rate, the antecedent soil moisture conditions, the percent of vegetative cover, the timing of the precipitation events relative to seasonal evaporation and transpiration rates, and other factors. Additionally, as water levels on the Mississippi River rise above the elevation of the floodplain, regional groundwater discharge may occur in the lower reaches of the floodplain, and thus contribute to rising surface-water levels across the region. It is unknown how often back-flooding in the ECMD spills over onto the site, but flooding did occur at the site during the growing season in 2009, over a period of slightly higher than average precipitation in April and May.

In years with no back-floods on the ECMD, surface water derived solely from precipitation and runoff is likely to pond at the surface due to the clay-rich nature of the surficial sediments, provided that drainage is restricted. Evidence for this is apparent in the near-continuous record of water-level measurements recorded at Gauge D in the shallow basin within the forested wetland in the northeast corner of the site. However, the extent of wetland area that could be supported in this manner is unknown.

Groundwater Hydrology

Shallow groundwater levels measured in this study are presented in both graphical and tabular form in Appendix C and D, respectively. Water levels measured in monitoring wells from January through July 2009 show water levels peaking in spring, and dropping to lower levels in summer. Measurable water levels were most persistent in Wells 1VS, 1S, 2VS, 6VS, and 6S, reflecting their positions near the forested wetland at the northeast corner of the site, and apparent wetlands in the undeveloped land south of the site. Water levels in wells 3VS and 5VS tended to fall off much more rapidly, likely reflecting their locations on gently sloping ground where surface water tends to run off before it can infiltrate. Well 4VS, located in a relatively high position at the site, showed greater persistence in water levels than wells 3VS and 5VS, possibly reflecting its position in a relatively flatter portion of the site, where surface water does not run off as quickly.

Water levels measured in Well 4L have at times been greater than those recorded in Well 4VS and nearby Well 5VS (Appendices C and D), suggesting upward groundwater flow. No evidence for groundwater discharge has been observed at the site, perhaps due to the low-permeability sediments covering the site. However, this upward pressure gradient may help sustain near-surface saturation.

Wetland Hydrology

In 2009, water-level data collected by the ISGS showed that approximately 5.2 ha (12.8 ac), or 71% of the total site acreage, satisfied jurisdictional wetland hydrology criteria (Environmental Laboratory 1987) for greater than 5% of the growing season, while the estimated area that satisfied jurisdictional wetland hydrology criteria for greater than 12.5% of the growing season was approximately 4.9 ha (12.0 ac), or 67% of the total site acreage (Fucciolo et al. 2009, Figure 4). Additionally, using new guidance proposed by the U.S. Army Corps of Engineers (2008), it was estimated that 5.2 ha (12.8 ac) of the total site acreage also satisfied jurisdictional wetland hydrology criteria for 14 or more consecutive days during the growing season (Fucciolo et al. 2009, Figure 4). These estimates were calculated over a period of near-average precipitation as recorded by the Jackson, Missouri and the Cape Girardeau Regional Airport weather stations, and during a time when the ECMD outlet was closed due to flooding on the Mississippi River.

As a result of near-record rainfall during the month of October 2009 (Figure 6; Appendix E, Table E1) a significant late-season flood event occurred on the Mississippi River, which peaked in early November (Figure 8). While the November flood peak was of similar magnitude to the April-May flood, water levels on the river subsided much more rapidly, and water levels measured at Gauges A and B, along with ISGS field observations, suggest that the area meeting wetland hydrology criteria for the 2009 growing season was not greater than the estimates presented above.

While restoring the regional hydrology is impractical, IDOT is currently modifying the site to capture runoff and back-floods from the ECMD in order to prolong inundation and saturation. Assuming that the proposed drainage-control structure(s) are able to hold back water to the design-elevation of 100.5 m (329.7 ft), and based on proposed land-surface contours from IDOT's mitigation plan (Appendix A, Sheet 1), surface water can potentially be retained over approximately 2.5 ha (6.1 ac) of the site, excluding the 1.0 ha (2.5 ac) already occupied by the farmed and forested wetlands in the northeastern portion of the site. This acreage is less than planned by IDOT. However, additional acreage outside of the inundated portion will likely be saturated. Based on ISGS water-level measurement collected in 2009, prior to the start of construction, the 4.9 ha (12.0 ac) that satisfied wetland hydrology criteria for greater than 12.5% of the 2009 growing season did so during a period of average precipitation when inundation was sustained at approximately 100.63 m (330.15 ft) and 100.51 m (329.76 ft) at Gauges A and B, respectively, due to back-flooding on the ECMD (Fucciolo et al. 2009; Figure 4). These results suggest that IDOT will likely meet its mitigation goals at the site in years with average precipitation, as long as sufficient water is available from back-flooding on the ECMD or runoff from the agricultural field to the north and the roadside ditches. While back-flooding on the ECMD resulted in flooding at the site in 2009, there is no historical data available that suggest how often or for what average duration this is likely to happen.

CONCLUSIONS AND RECOMMENDATIONS

Hydric soil was mapped over the entire site by the NRCS (Soil Survey Staff 2009), and later confirmed by the INHS (Keene et al. 2008). This suggests that wetlands once were present across the site.

A predominance of hydrophytic vegetation was mapped across the entire site by the INHS in 2008 (Keene et al. 2008). Additionally, in 2009, the ISGS collected water-level data that, during a year of near-average precipitation, indicated approximately 5.2 ha (12.8 ac), or 71% of the total site acreage, satisfied jurisdictional wetland hydrology criteria for greater than 5% of the growing season, while the estimated area that satisfied jurisdictional wetland hydrology criteria for greater than 12.5% of the growing season was approximately 4.9 ha (12.0 ac), or 67% of the total site acreage (Fucciolo et al. 2009; Figure 4). Also, using new guidance proposed by the U.S. Army Corps of Engineers (2008), the ISGS estimated that 5.2 ha (12.8 ac) of the total site acreage also satisfied jurisdictional wetland hydrology criteria for 14 or more consecutive days during the growing season (Fucciolo et al. 2009; Figure 4). The ISGS findings are in contrast to those of the INHS, which, in 2008, mapped 0.6 ha (1.5 ac) of forested wetland and 0.4 ha (1 ac) of farmed wetland in the northeast corner of the site (Keene et al. 2008; Figure 2). The discrepancy between the findings by the INHS and ISGS is attributed to the two different methods used to measure wetland hydrology at the site. Due to prolonged flooding on the Mississippi River in 2008, the INHS had to rely on the NRCS method of determining wetland signatures from 10 years worth of crop slides, while in 2009, the ISGS collected actual on-site surface-water and groundwater measurements during a year of near-average precipitation. Both of these methods are Corps-approved, and while the NRCS method provides a historical context that the ISGS data lack, the conclusions in this report are based upon the actual on-site measurements collected by the ISGS.

Back-flooding from the ECMD is the primary hydrologic input contributing to wetland hydrology at the site in its pre-construction configuration. In 2009, high water levels on the ECMD resulted in flooding across the southern and northeastern portions of the site. Water levels on the ECMD are primarily affected by flooding on the Mississippi River, and the subsequent closing of the outlet structure near Gale, Illinois which results in water backing up along the ECMD. Analysis of Mississippi River stage at Thebes, Illinois indicates that in 13 of the last 13 years the outlet was closed during the growing season, thus creating the potential for back-flooding from the ECMD at the wetland mitigation site. In years where water levels on the ECMD do not rise to an elevation sufficient to flood the site, the tight surficial materials at the site will likely allow an undetermined acreage of wetland areas to be maintained through ponding of surface water derived from precipitation and runoff, provided that drainage from the site is restricted. Groundwater discharge is not believed to occur at the site, though water levels measured in well 4L do indicate that an upward pressure gradient does exist at times. This pressure gradient may help support limited wetland hydrology in areas of the site by slowing the rate of infiltration into the subsurface, or by upward groundwater flow.

Following recommendations made in Plankell et al. (2008), IDOT constructed a berm along the southern edge of the site and excavated an area between the two northernmost drainage points into the ECMD. The berm will limit drainage of water from the site, while the excavation is intended to increase wetland acreage at the site. IDOT plans also call for the installation of two drainage-control structures in the aforementioned drainage points, shallow excavation in the northeastern portion of the site, and the planting of wetland-appropriate vegetation at the site.

Based on the observed failure of stop-log drainage-control structures at another IDOT wetland site (Pociask, pers. comm.), the ISGS sent IDOT an email on August 6, 2009 that suggested eliminating one of the control structures and pouring the slab for the remaining control structure to an elevation of 100.5 m (329.7 ft), the original design elevation of the stop-logs. As of December 4, 2009, no work had been completed on the control structures. However, implementing these recommendations would likely reduce both construction costs and maintenance issues, while assuring that sufficient water is held on site to achieve the target wetland acreage.

Regardless of the final design of the drainage-control structures, if they are able to hold back water to the design elevation of 100.5 m (329.7 ft), then approximately 2.5 ha (6.1 ac) of the site, excluding the 1.0 ha (2.5 ac) already occupied by the farmed and forested wetlands in the northeastern portion of the site, could potentially be inundated through the capture and retention of surface water from back-flooding from the ECMD, runoff from the road-side ditches and the agricultural field to the north, and direct precipitation. Additional areas will likely be saturated, if not inundated, as previously discussed. ISGS wetland hydrology calculations at the site for the 2009 growing season, along with the presence of low-permeability soils across the site, suggest that the hydrologic alterations underway at the site will be sufficient for IDOT to meet its mitigation goals in years of average precipitation and back-flooding from the ECMD.

Any mitigation site design that interrupts the current drainage network must provide continued drainage for adjacent areas. The drainage control structures that IDOT has planned to install are designed to specifications that, while retaining more water on the East Cape Girardeau wetland mitigation site, should not adversely affect drainage from the agricultural field north of IL 146, or from the roadside ditches.

ACKNOWLEDGMENTS

This material is based upon work supported by the Illinois Department of Transportation under award number IDOT SW PESA WIP PART B FY10 JM. I would also like to thank Paul Marcum and Dennis Keene of the Illinois Natural History Survey for providing their assessments of the wetlands, vegetation, and soils present at the site, and Kathleen Bryant, Melinda Campbell, Keith Carr, Christine Fucciolo, Charles Knight, James Miner, and Geoffrey Pociask of the ISGS who have each contributed to this study. Release of this report is authorized by the Director, Illinois State Geological Survey.

REFERENCES

Berg, R.C. and J.P. Kempton, 1988, Stack-Unit Mapping of Geologic Materials in Illinois to a Depth of 15 Meters: Illinois State Geological Survey Circular 542, Champaign, Illinois, 23 p.

Environmental Laboratory, 1987, Corps of Engineers Wetlands Delineation Manual, Techincal Report Y-87-1: U.S. Army Engineer Waterways Experimentation Station, Vickburg, Mississippi, 92p.

Fucciolo, C.S., S.E. Benton, K.E. Bryant, M.C. Campbell, K.W. Carr, A.K.M. Knight, C.W. Knight, J.J. Miner, E.T. Plankell, and G.E. Pociask, 2009, Annual Report for Active IDOT Wetland Compensation and Hydrologic Monitoring Sites, September 1, 2008 through August 31, 2009: University of Illinois at Urbana-Champaign, Institute of Natural Resource Sustainability, Illinois State Geological Survey Open-File Series 2009-5, Champaign, Illinois, 240 p.

Hansel, A.K and W.H. Johnson, 1996, Wedron and Mason Groups: Lithostratigraphic Reclassification of Deposits of the Wisconsin Episode, Lake Michigan Lobe Area: Illinois State Geological Survey, Bulletin 104, Champaign, Illinois, 116 p.

Herzog, B., B. Stiff, C. Chenoweth, K. Warner, J. Sieverling, and C. Avery, 1994, Buried Bedrock Surface of Illinois: Illinois State Geological Survey, Illinois Map 5, Champaign, Illinois, map scale 1:500,000, 1 sheet.

Illinois State Water Survey, 1996, One-Hundred and Five-Hundred Year Floodzones for Unincorporated Areas in Illinois: Illinois Natural Resources Geospatial Data Clearinghouse, Champaign, Illinois, available at http://www.isgs.uiuc.edu/nsdihome/webdocs/st-hydro.html.

Keene, D., P. Marcum, V. Sivicek, and B. Zercher, 2008, Wetland Mitigation Site Assessment for FAP 312 (IL 146), Alexander County, Illinois. Unpublished contract report to the Illinois Department of Transportation, Illinois Natural History Survey, Champaign, Illinois, 13 p.

Kolata, D. (compiler), 2005, Bedrock Geology of Illinois: Illinois State Geological Survey, Illinois Map 14, Champaign, Illinois, map scale 1:500,000, 2 sheets.

Lineback, J.A. (compiler), 1979, Quaternary Deposits of Illinois: Illinois State Geological Survey, Champaign, Illinois, map scale 1:500,000, 1 sheet.

McKay, E.D., A. Elzeftawy, and K. Cartwright, 1979, Ground-Water Geology of Selected Wetlands in Union and Alexander Counties, Illinois: Illinois State Geological Survey, Environmental Geology Notes, No. 85, Urbana, Illinois, 41 p.

Midwestern Regional Climate Center, 2009, Midwestern Climate Information System: Illinois State Water Survey, Champaign, Illinois, available at http://mcc.sws.uiuc.edu/.

National Oceanic and Atmospheric Administration, 2009, VERTCON datum conversion tool, National Geodetic Survey, http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html.

National Water and Climate Center, Natural Resources Conservation Service, 1995, WETS Table Documentation, available at http://www.wcc.nrcs.usda.gov/climate/wets_doc.html.

Nelson, W.J., 1995, Structural Features in Illinois: Illinois State Geological Survey, Bulletin 100, Champaign, Illinois, 144 p.

Plankell, E.T., K.W. Carr, and G.E. Pociask, 2008, Initial Site Evaluation: Cape T Proposed Wetland Compensation Site, Alexander County, Illinois. Unpublished contract report to the Illinois Department of Transportation, Illinois State Geological Survey, Champaign, Illinois, 28 p.

Soil Survey Staff, 2009, Web Soil Survey: Natural Resources Conservation Service, United States Department of Agriculture, available at http://websoilsurvey.nrcs.usda.gov/.

U.S. Army Corps of Engineers, 2008, Interim Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Midwest Region: U.S. Army Corps of Engineers, U.S. Army Engineer Research and Development Center, Environmental Laboratory, Vicksburg, Mississippi, 152 p.

U.S. Department of Agriculture, 2007, Digital orthophotograph of Alexander County, IL: National Agriculture Imagery Program, U.S. Department of Agriculture Farm Service Agency Aerial Photography Field Office, Salt Lake City, Utah.

U.S. Geological Survey, 1993, Mc Clure, IL-MO, 7.5-Minute Series (Topographic) Quadrangle: U.S. Department of the Interior, Geological Survey, Reston, Virginia, map scale 1:24,000, 1 sheet.

U.S. Geological Survey, 2009, USGS Surface-Water Data for USA: available at http://waterdata.usgs.gov/nwis/sw.

AERIAL PHOTOGRAPHY (Alexander County, IL)

(available for viewing at the Map and Geography Library, University of Illinois at Urbana-Champaign)

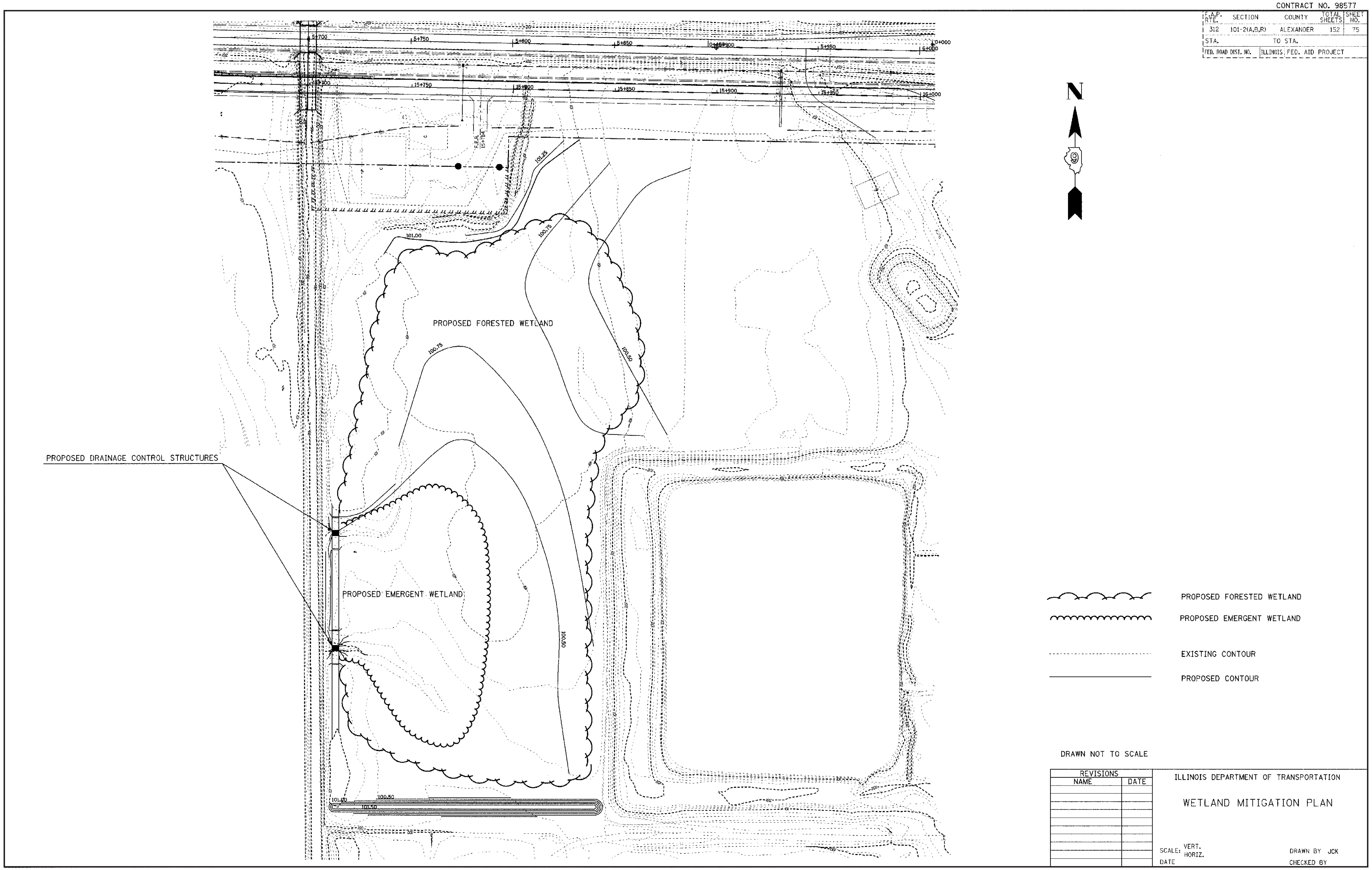
Markhurd Corporation

Year	Flight Line/Photo Number	Photo Date
1998	ST 34 427	04/06/1998
1993	ST 34 427	03/11/1993
1988	3789-34-IL427	03/22/1988

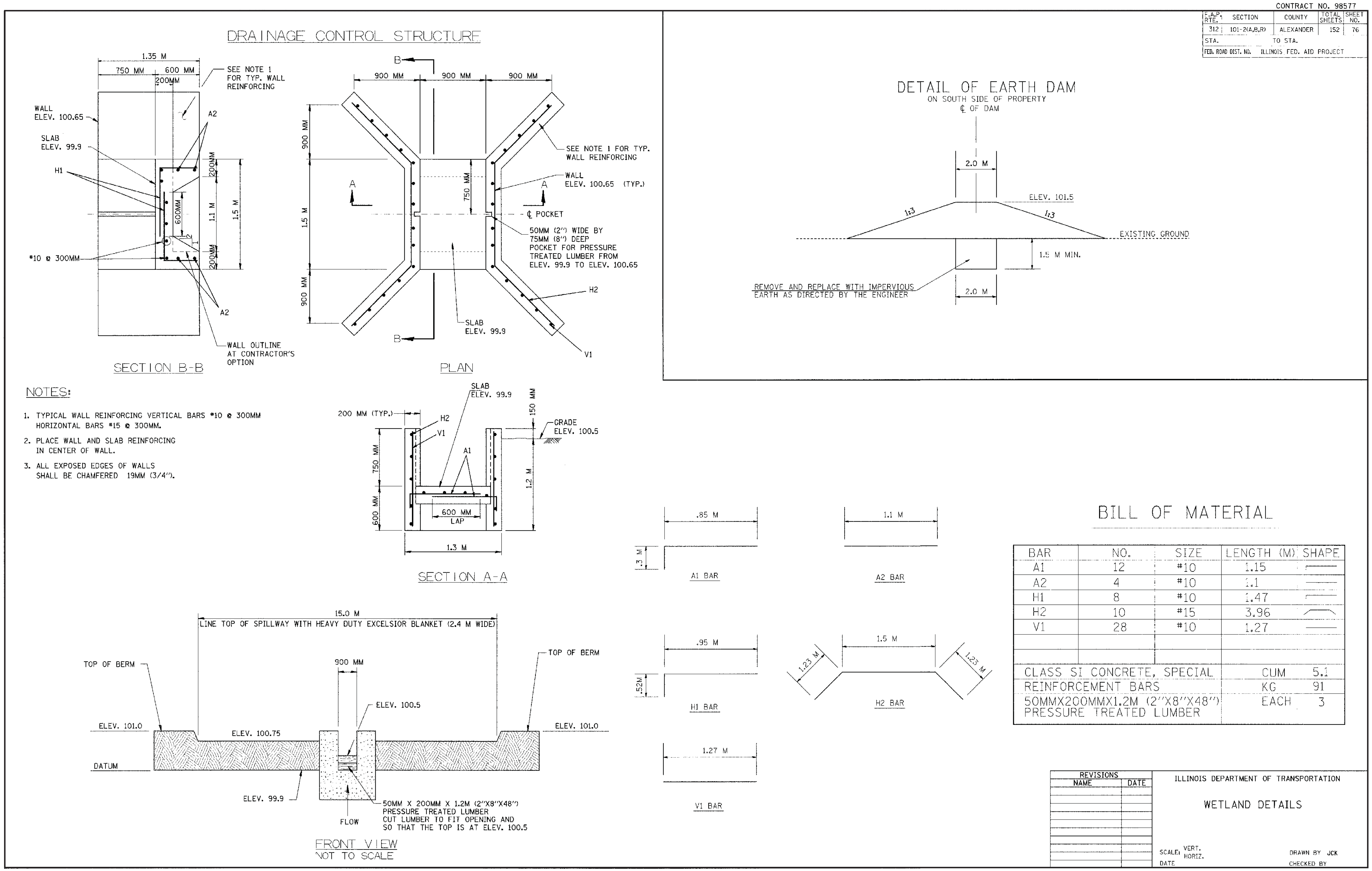
U.S. Department of Agriculture

Year	Flight Line/Photo Number	Photo Date
1980	17003-180-138	08/22/1980
1971	BFZ-1MM-248	10/28/1971
1965	BFZ-3FF-54	10/18/1965
1959	BFZ-4W-96	10/20/1959
1956	BFZ-2R-167	09/24/1956
1950	BFZ-2F-172	06/30/1950
1938	BFZ-1-36	07/05/1938

APPENDIX A, Sheet 1 IDOT Mitigation Plan for the East Cape Girardeau Wetland Mitigation Site, FAP 312 (IL 146)



APPENDIX A, Sheet 2 IDOT-Proposed Water-Control Structures for the East Cape Girardeau Wetland Mitigation Site, FAP 312 (IL 146)



BILL OF MATERIAL

BAR	NO.	SIZE	LENGTH (M)	SHAPE
A1	12	#10	1.15	
A2	4	#10	1.1	
H1	8	#10	1.47	
H2	10	#15	3.96	
V1	28	#10	1.27	
CLASS SI CONCRETE, SPECIAL			CUM	5.1
REINFORCEMENT BARS			KG	91
50MMX200MMX1.2M (2"X8"X48") PRESSURE TREATED LUMBER			EACH	3

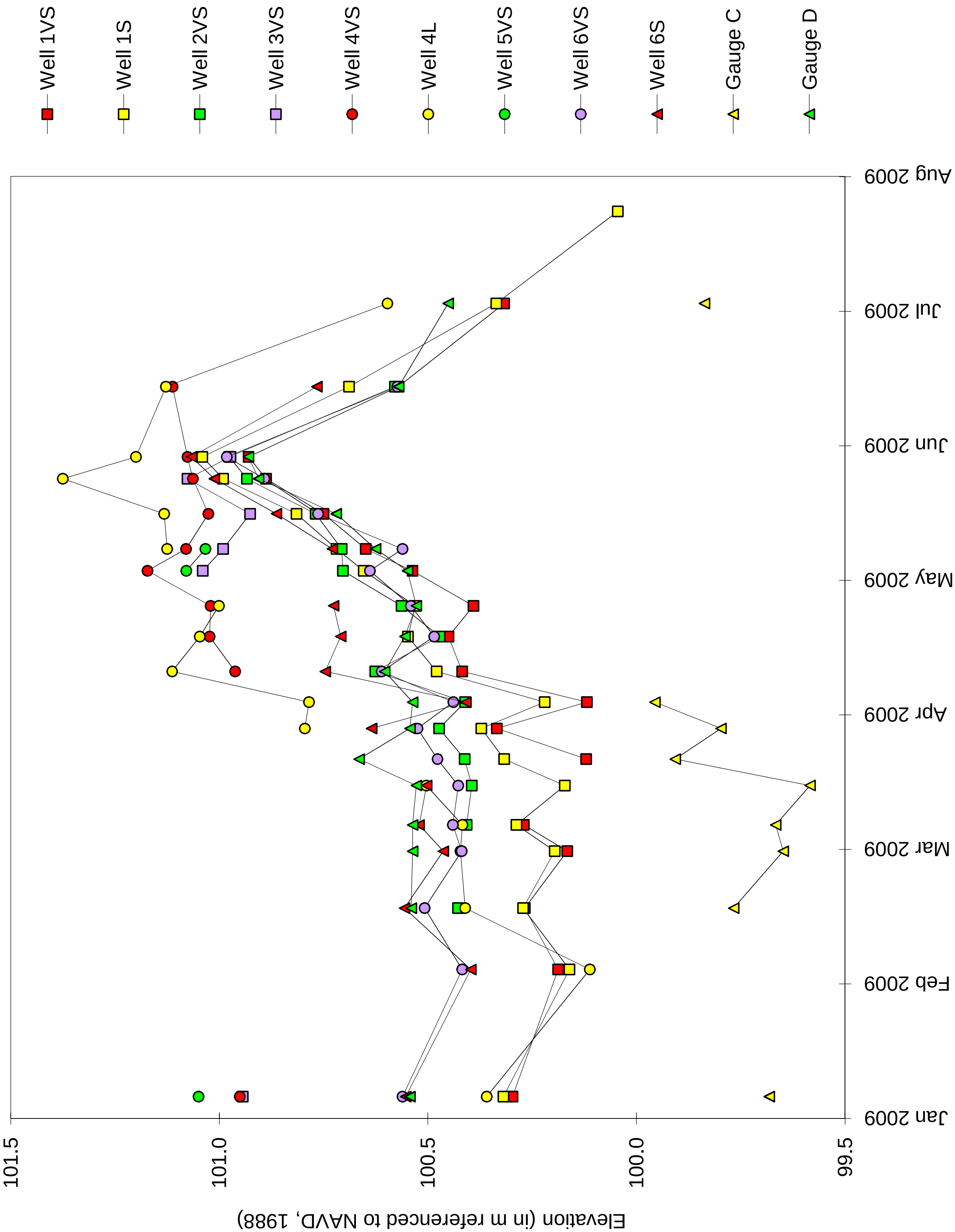
APPENDIX B Well-Construction Information

Table B1 Construction Information for Monitoring Wells

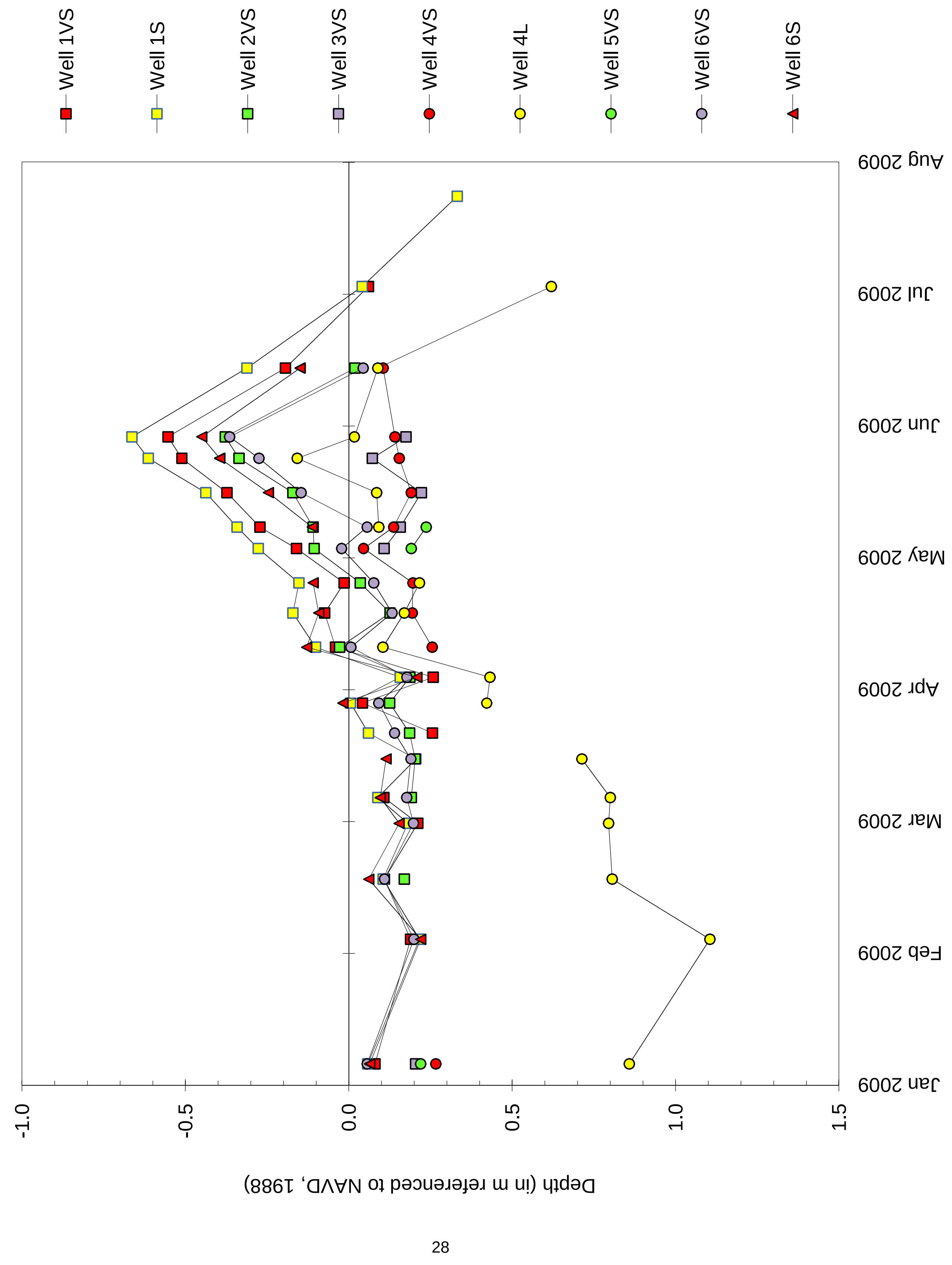
Well-Construction Information	1VS	1S	2VS	3VS	4VS	4L	5VS	6VS	6S
Total length of well (m)	1.26	1.93	1.25	1.26	1.01	3.47	1.01	1.01	1.93
Screen length (m)	0.15	0.30	0.15	0.15	0.18	0.30	0.17	0.17	0.30
Depth of borehole (m) *	0.39	0.77	0.39	0.37	0.40	3.00	0.39	0.39	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.13	0.34	0.15	0.15	0.15	2.50	0.15	0.15	0.30
Sand pack - bottom (m) *	0.35	0.72	0.37	0.35	0.40	3.00	0.36	0.39	0.73
Depth to top of screen (m) *	0.16	0.39	0.19	0.15	0.19	2.67	0.16	0.19	0.40
Depth to bottom of screen (m) *	0.35	0.72	0.37	0.35	0.40	3.00	0.36	0.39	0.73

* referenced to land surface

APPENDIX C Water-Level Elevations in Monitoring Wells and on Staff Gauges at the East Cape Girardeau Wetland Mitigation Site for the Period of January 2009 through July 2009 (All Monitoring Wells Removed by July 31, 2009).



APPENDIX C (Continued) Depth-to-Water in Monitoring Wells at the East Cape Girardeau Wetland Mitigation Site for the Period of January 2009 through July 2009 (All Monitoring Wells Removed by July 31, 2009).



APPENDIX D Water-Level Elevations and Depth-to-Water Tables

Table D1 Water-Level Elevations

	Water-Level Elevations (in m referenced to NAVD, 1988)							
Date	1/7/2009	2/5/2009	2/19/2009	3/4/2009	3/10/2009	3/19/2009	3/25/2009	4/1/2009
Well 1VS	100.297	100.188	100.268	100.166	100.270	dry	100.121	100.335
Well 1S	100.319	100.161	100.272	100.196	100.288	100.172	100.317	100.372
Well 2VS	dry	dry	100.428	dry	100.407	100.395	100.412	100.473
Well 3VS	100.944	dry	dry	dry	dry	dry	dry	dry
Well 4VS	100.951	dry	dry	dry	dry	dry	dry	dry
Well 4L	100.359	100.112	100.411	100.422	100.417	100.504	*	100.795
Well 5VS	101.050	dry	dry	dry	dry	dry	dry	dry
Well 6VS	100.561	100.418	100.508	100.419	100.440	100.427	100.477	100.525
Well 6S	100.553	100.397	100.556	100.463	100.521	100.503	*	100.635
Gauge C	99.682	**	99.767	99.648	99.666	99.584	99.907	99.797
Gauge D	100.543	**	100.540	100.537	100.537	100.528	100.665	100.543

Table D1 Water-Level Elevations *(continued)*

	Water-Level Elevations (in m referenced to NAVD, 1988)							
Date	4/7/2009	4/14/2009	4/22/2009	4/29/2009	5/7/2009	5/12/2009	5/20/2009	5/28/2009
Well 1VS	100.119	100.418	100.451	100.391	100.537	100.649	100.750	100.888
Well 1S	100.220	100.479	100.548	100.530	100.654	100.719	100.815	100.991
Well 2VS	100.411	100.626	100.472	100.563	100.704	100.707	100.769	100.934
Well 3VS	dry	dry	dry	dry	101.040	100.991	100.926	101.076
Well 4VS	dry	100.962	101.023	101.021	101.172	101.080	101.026	101.063
Well 4L	100.785	101.113	101.047	101.001	*	101.125	101.132	101.375
Well 5VS	dry	dry	dry	dry	101.079	101.033	dry	dry
Well 6VS	100.439	100.611	100.485	100.541	100.639	100.561	100.763	100.892
Well 6S	100.409	100.746	100.709	100.726	*	100.729	100.863	101.012
Gauge C	99.956	***	***	***	***	***	***	***
Gauge D	100.537	100.604	100.555	100.528	100.549	100.625	100.720	100.906

* no measurement
** frozen
*** flooded

S indicates soil-zone monitoring well
L indicates lower monitoring well
VS indicates very shallow monitoring well

APPENDIX D Water-Level Elevations and Depth-to-Water Tables

Table D1 Water-Level Elevations *(continued)*

	Water-Level Elevations (in m referenced to NAVD, 1988)						
Date	6/2/2009	6/18/2009	7/7/2009	7/28/2009	9/4/2009	10/1/2009	11/4/2009
Well 1VS	100.930	100.571	100.317	dry	removed	removed	removed
Well 1S	101.041	100.689	100.336	100.045	removed	removed	removed
Well 2VS	100.976	100.579	dry	dry	removed	removed	removed
Well 3VS	100.973	dry	dry	dry	removed	removed	removed
Well 4VS	101.076	101.112	dry	destroyed	destroyed	destroyed	destroyed
Well 4L	101.200	101.128	100.597	destroyed	destroyed	destroyed	destroyed
Well 5VS	dry	dry	dry	destroyed	destroyed	destroyed	destroyed
Well 6VS	100.982	100.573	dry	dry	removed	removed	removed
Well 6S	101.067	100.766	dry	dry	removed	removed	removed
Gauge C	***	***	99.837	dry	99.520	***	***
Gauge D	100.930	100.571	100.452	dry	dry	*	100.574

* no measurement
** frozen
*** flooded

S indicates soil-zone monitoring well
L indicates lower monitoring well
VS indicates very shallow monitoring well

APPENDIX D Water-Level Elevations and Depth-to-Water Tables

Table D2 Depth-to-Water

	Depth-to-Water (in m referenced to land surface)							
Date	1/7/2009	2/5/2009	2/19/2009	3/4/2009	3/10/2009	3/19/2009	3/25/2009	4/1/2009
Well 1VS	**0.080**	**0.189**	**0.109**	**0.211**	**0.107**	dry	**0.256**	**0.042**
Well 1S	**0.058**	**0.216**	**0.105**	**0.181**	**0.089**	**0.205**	**0.060**	**0.005**
Well 2VS	dry	dry	**0.170**	dry	**0.191**	**0.203**	**0.186**	**0.125**
Well 3VS	**0.204**	dry	dry	dry	dry	dry	dry	dry
Well 4VS	**0.266**	dry	dry	dry	dry	dry	dry	dry
Well 4L	0.858	1.105	0.806	0.795	0.800	0.713	*	0.422
Well 5VS	**0.220**	dry	dry	dry	dry	dry	dry	dry
Well 6VS	**0.056**	**0.199**	**0.109**	**0.198**	**0.177**	**0.190**	**0.140**	**0.092**
Well 6S	**0.064**	**0.220**	**0.061**	**0.154**	**0.096**	**0.114**	*	**-0.018**

Table D2 Depth-to-Water *(continued)*

	Depth-to-Water (in m referenced to land surface)							
Date	4/7/2009	4/14/2009	4/22/2009	4/29/2009	5/7/2009	5/12/2009	5/20/2009	5/28/2009
Well 1VS	**0.258**	**-0.041**	**-0.074**	**-0.014**	**-0.160**	**-0.272**	**-0.373**	**-0.511**
Well 1S	**0.157**	**-0.102**	**-0.171**	**-0.153**	**-0.277**	**-0.342**	**-0.438**	**-0.614**
Well 2VS	**0.187**	**-0.028**	**0.126**	**0.035**	**-0.106**	**-0.109**	**-0.171**	**-0.336**
Well 3VS	dry	dry	dry	dry	**0.108**	**0.157**	**0.222**	**0.072**
Well 4VS	dry	**0.255**	**0.194**	**0.196**	**0.045**	**0.137**	**0.191**	**0.154**
Well 4L	0.432	**0.104**	**0.170**	**0.216**	*	**0.092**	**0.085**	**-0.158**
Well 5VS	dry	dry	dry	dry	**0.191**	**0.237**	dry	dry
Well 6VS	**0.178**	**0.006**	**0.132**	**0.076**	**-0.022**	**0.056**	**-0.146**	**-0.275**
Well 6S	**0.208**	**-0.129**	**-0.092**	**-0.109**	*	**-0.112**	**-0.246**	**-0.395**

* no measurement
** frozen
*** flooded

– indicates water above land surface
S indicates soil-zone monitoring well
L indicates lower monitoring well
VS indicates very shallow monitoring
bold values less than or equal to 0.304 m

APPENDIX D Water-Level Elevations and Depth-to-Water Tables

Table D2 Depth-to-Water *(continued)*

	Depth-to-Water (in m referenced to land surface)						
Date	6/2/2009	6/18/2009	7/7/2009	7/28/2009	9/4/2009	10/1/2009	11/4/2009
Well 1VS	**-0.553**	**-0.194**	**0.060**	dry	removed	removed	removed
Well 1S	**-0.664**	**-0.312**	**0.041**	0.332	removed	removed	removed
Well 2VS	**-0.378**	**0.019**	dry	dry	removed	removed	removed
Well 3VS	**0.175**	dry	dry	dry	removed	removed	removed
Well 4VS	**0.141**	**0.105**	dry	destroyed	destroyed	destroyed	destroyed
Well 4L	**0.017**	**0.089**	0.620	destroyed	destroyed	destroyed	destroyed
Well 5VS	dry	dry	dry	destroyed	destroyed	destroyed	destroyed
Well 6VS	**-0.365**	**0.044**	dry	dry	removed	removed	removed
Well 6S	**-0.450**	**-0.149**	dry	dry	removed	removed	removed

* no measurement
** frozen
*** flooded

– indicates water above land surface
S indicates soil-zone monitoring well
L indicates lower monitoring well
VS indicates very shallow monitoring
bold values less than or equal to 0.304 m

APPENDIX E Precipitation Data

Table E1 Monthly and annual average precipitation totals recorded at the Jackson, Missouri weather station (Station 234226) and at the Cape Girardeau Regional Airport (CGRA) (Station 231289). Average and above- and below-average thresholds are calculated from data collected during the 30-year period between 1971 and 2000.

	Precipitation Totals (in inches)			
Month	**1971–2000 30% below average threshold Jackson, MO (NWCC 2009)**	**1971–2000 average Jackson, MO (NWCC 2009)**	**1971–2000 30% above average threshold Jackson, MO (NWCC 2009)**	**1971–2000 average CGRA (MRCC 2009)**
January	1.99	3.04	3.65	3.27
February	2.34	3.41	4.06	3.48
March	3.34	4.80	5.71	4.49
April	3.12	4.82	5.80	4.29
May	3.18	4.86	5.83	5.11
June	2.71	4.11	4.92	3.75
July	2.21	3.80	4.62	3.50
August	1.92	3.28	3.98	3.30
September	1.80	3.44	4.20	3.45
October	2.04	3.26	3.93	3.19
November	2.82	4.81	5.84	4.64
December	2.46	3.86	4.65	4.28
Annual Total	43.02	47.49	51.10	46.75

APPENDIX E Precipitation Data

Table E2 Monthly and annual precipitation totals recorded at the Jackson, Missouri weather station (Station 234226), the Cape Girardeau Regional Airport (CGRA) (Station 231289), and on site by ISGS.

	Precipitation Totals (in inches)					
	2008			**2009**		
Month	**Jackson, MO weather station (MRCC 2009)**	**CGRA (MRCC 2009)**	**on site**	**Jackson, MO weather station (MRCC 2009)**	**CGRA (MRCC 2009)**	**on site**
January	1.71	2.71	*	1.50	0.56	*
February	7.29	6.30	*	4.07	2.39	***1.22***
March	15.57	17.84	*	3.72	4.09	***2.66***
April	7.35	6.61	*	5.12	4.81	5.09
May	7.53	6.21	*	4.64	5.41	5.85
June	1.49	2.20	*	3.87	3.59	2.88
July	5.46	2.97	*	2.78	2.16	0.56
August	3.13	3.58	*	5.57	4.44	*
September	4.01	2.31	*	3.33	2.45	*
October	2.41	2.97	*	12.66	10.38	*
November	2.78	2.77	*	1.61	1.81	*
December	4.74	3.75	*	*	*	*
Total	63.47	60.22	*	48.83	42.09	***18.26***
Δ from average	+15.98	+13.47		+5.24	-0.38	

* no data ***bold italic*** data incomplete

APPENDIX F Flood-History Analysis of the Mississippi River at Thebes, Illinois