LEVEL II HYDROGEOLOGIC CHARACTERIZATION REPORT: SUGAR CAMP CREEK POTENTIAL WETLAND COMPENSATION SITE

Franklin County, Illinois
(Federal Aid Project 312, Sequence Number 9282)

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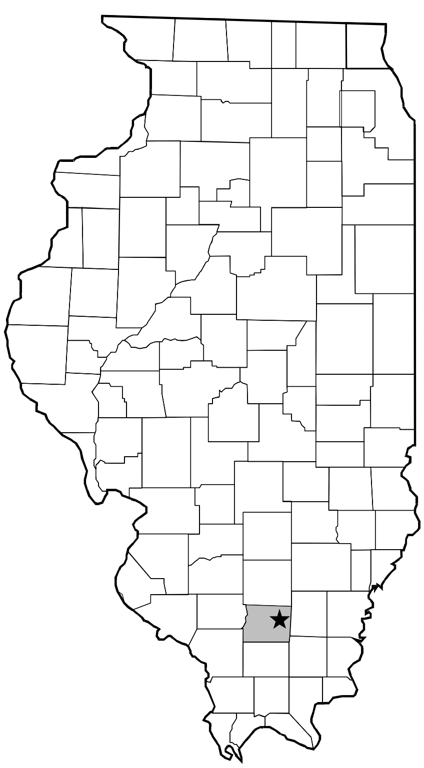

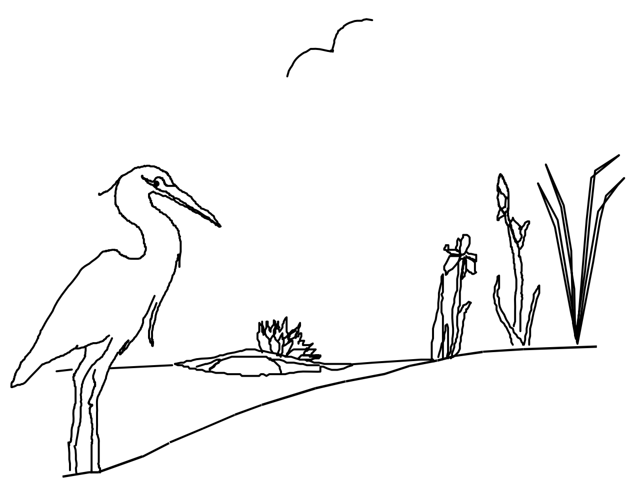

EXECUTIVE SUMMARY

In March 2005, the Illinois Department of Transportation (IDOT) tasked the Wetlands Geology Section of the Illinois State Geological Survey (ISGS) to conduct a hydrogeologic characterization of a 50.9-ha (125.7-ac) parcel along Sugar Camp Creek in Franklin County, Illinois. The IDOT has developed 8.3 ha (20.5 ac) of the parcel as a wetland compensation site for Federal Aid Project 312 (FAP 312, Illinois Route 3, Alexander and Union Counties), and proposes to develop the remainder of the site as a wetland mitigation bank. The purpose of this report is to identify the hydrogeologic conditions of the entire site and to recommend wetland compensation strategies. The data presented in this report include descriptions of geologic materials, and measurements of surface-water levels, ground-water levels, and precipitation collected by the ISGS from March 2005 through July 2006.

Factors that indicate favorable conditions for wetland restoration at this site include: susceptibility of most of the site to frequent flooding, the presence and wide extent of slowly permeable geologic materials, and hydric soils mapped over 80% of the site. Also, the entire site is classed as prior-converted (drained) wetlands by the U.S. Department of Agriculture, and several of the hydrologic alterations used to drain the site can feasibly be reversed.

Although there are multiple water inputs at the site, the most significant potential source for restoring wetlands is flooding from Sugar Camp Creek. Data collected at the site show that most of the parcel is subject to frequent flooding. However, the period of inundation due to flooding from the creek is usually very brief and not sufficient to satisfy jurisdictional wetland hydrology criteria. The areal estimates of jurisdictional wetland hydrology (4.4 ha [10.9 ac] in 2005 and 28.8 ha [71.2 ac] in 2006) show that the site effectively drains in its current condition and that closely-spaced flood events (less than 1 week return interval) are required to support wetland hydrology over most of the site. Therefore, reversal or modification of existing hydrologic alterations is needed to prolong the period of inundation and saturation after flood peaks and promote wetland conditions at the site.

Previous wetland restoration activities at the FAP 312 wetland compensation site, including blocking a ditch, have demonstrated that the slowly permeable geologic materials can effectively perch water, resulting in persistent ponding and soil saturation. This demonstration supports the strategy of blocking and filling ditches and surface drainage in other portions of the site to expand and prolong inundation and saturation in areas that do not currently flood or do not flood long enough to satisfy wetland hydrology criteria. Further recommendations for restoring wetlands include lowering and regrading levees, building low berms, removing field tiles and culverts, and redirecting perimeter ditches.

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INTRODUCTION

This report was prepared by the Illinois State Geological Survey (ISGS) to provide the Illinois Department of Transportation (IDOT) with conclusions regarding the hydrogeologic conditions of a 50.9-hectare (ha) (125.7-acre [ac]) potential wetland compensation site in Northern Township (SE1/4 of NE1/4, and E1/2 of SE1/4, Sec. 32, T5S, R4E), Franklin County, Illinois (Figure 1). The site is bounded by raised road embankments for Santor Road/Hen Lane on the north, by agricultural fields on the west and south, and by agricultural fields and forested areas to the east. IDOT has proposed to use approximately 8.3 ha (20.5 ac) in the southeast portion of the site for wetland compensation required for Federal Aid Project 312 (FAP 312), Illinois Route 3 in Alexander and Union Counties. IDOT has temporarily leased the remainder of the site for agricultural use and proposes to develop this area into a wetland mitigation bank.

The purpose of this report is to provide IDOT with data and interpretations regarding the hydrogeologic conditions of the entire parcel including both the FAP 312 wetland compensation area and the proposed wetland mitigation bank, and to make recommendations regarding restoration and/or creation of wetlands on the property. Therefore, this report presents conclusions and design recommendations first, followed by a discussion of the methods and supporting data. Supporting data include ground-water, surface-water, and precipitation data collected from March 2005 through July 2006, geologic data collected during monitoring well installation, and relevant file information. Soils information included in this report is from published reports and maps, and is presented for hydrogeologic purposes.

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 compare the pre- and post-construction hydrology of the sites, and to determine the influence of wetland compensation activities on the extent of jurisdictional wetland hydrology.

SUMMARY

The potential for wetland compensation at the Sugar Camp Creek site is **MODERATE TO HIGH** based on the following factors:

- The extent of hydric soil suggests that much of the site was wetland prior to forest clearing and modification of hydrology for agricultural activity. The U.S. Department of Agriculture (USDA) mapped hydric soils over approximately 36.4 ha (90.0 ac) or 80% of the site (Preloger 2003). The mapped hydric soils cover most of the east half of the site and low areas in the west portion of the site. Partial field verification of soil map units by the Illinois Natural History Survey (INHS) suggests that the area of hydric soil may be somewhat less extensive (Figure 2), but the site has not been fully mapped.

- The hydrologic conditions that supported former wetlands have been altered. Within the last 40 years, forested areas at the site were cleared, Sugar Camp Creek was channelized and the former creek channel was filled, ditches and levees were built, and culverts were installed (Figures 3 and 4). It is presently undetermined whether a drainage tile system exists at the site. Ditches and culverts currently promote drainage, and levees and raised road beds prevent minor to moderate floods from reaching portions of the site. Reversal or modification of these alterations may allow wetlands to be restored. However, the natural hydrologic conditions that existed prior to modification cannot be completely replicated due to channelization and incision of Sugar Camp Creek, and land-use changes and drainage modifications in the watershed.

- Geologic materials at the site are slowly permeable and generally promote ponding and soil saturation. Examination of borings showed that the geologic profile (Figure 5) typically consists of clayey silt over slightly denser deposits of silty clay, although some sandier deposits and fill materials were encountered in locations corresponding with areas where the former creek channel was backfilled and graded for farming. Hydrogeologic analysis showed somewhat higher ground-water flow rates near the creek, suggesting that fill and/or coarse-textured materials may expedite subsurface drainage locally.

- There are multiple potential water sources for wetland restoration at the site. The primary water source is frequent, brief flooding from Sugar Camp Creek. Water levels recorded in Sugar Camp Creek suggest that most of the site is typically inundated by flooding at least once a year during the growing season. Floods replenish surface water in closed depressions and recharge shallow ground water, but the duration of flood peaks is generally too short to satisfy jurisdictional wetland hydrology criteria. Precipitation, runoff, and stormflow in ditches constitute relatively minor contributions to the east portion of the site compared to flooding from the creek. Runoff and overland flow from the west may provide significant, although small, contributions to the northwest and west-central portions of the site. Ground-water contribution at the site is limited, although localized ground-water discharge appears to occur along sloped areas in the northwest and west-central portions of the site, causing seasonal saturation at land surface.

- Wetland conditions occur at the site over limited areas, and wetlands occur nearby at similar landscape positions. The National Wetlands Inventory (NWI) mapped numerous wetland areas within the broad lowland that contains Sugar Camp Creek and the Middle Fork Big Muddy River (Figure 6). On-site wetland determinations by the INHS indicated three separate areas with low or very low natural quality that satisfied the three-parameter definition of wetlands (Environmental Laboratory 1987). The INHS also examined forested areas at similar elevations adjacent to the east and found that portions of these areas are jurisdictional wetlands with good natural quality. Further, historical aerial photography shows that, prior to 1965, an area of forest concentrated in the eastern portion of the parcel covered up to 32 ha (78 ac) of the site.

- Based on topography, susceptibility to flooding, and hydrogeologic properties at this site, we estimate that between 20 and 32 ha (50 and 80 ac) of wetlands could be restored if the existing hydrologic alterations are reversed or appropriately modified.

WETLAND COMPENSATION RECOMMENDATIONS

We recommend the following wetland compensation activities based on our hydrogeologic observations and with guidance from the Illinois Wetland Restoration and Creation Guide (Admiraal et al. 1997). The approximate locations of the recommended wetland restoration activities described below are depicted in Figure 7.

1. Fill all on-site ditches and block outlets. Ditches 4 and 5 and numerous smaller "scratched" ditches are located entirely within the site (Figure 4). These ditches drain surface water from low areas, expedite drainage of shallow groundwater locally, and route water to Sugar Camp Creek through openings in the levees. We recommend blocking and filling the remaining segments of Ditch 5 within the FAP 312 wetland

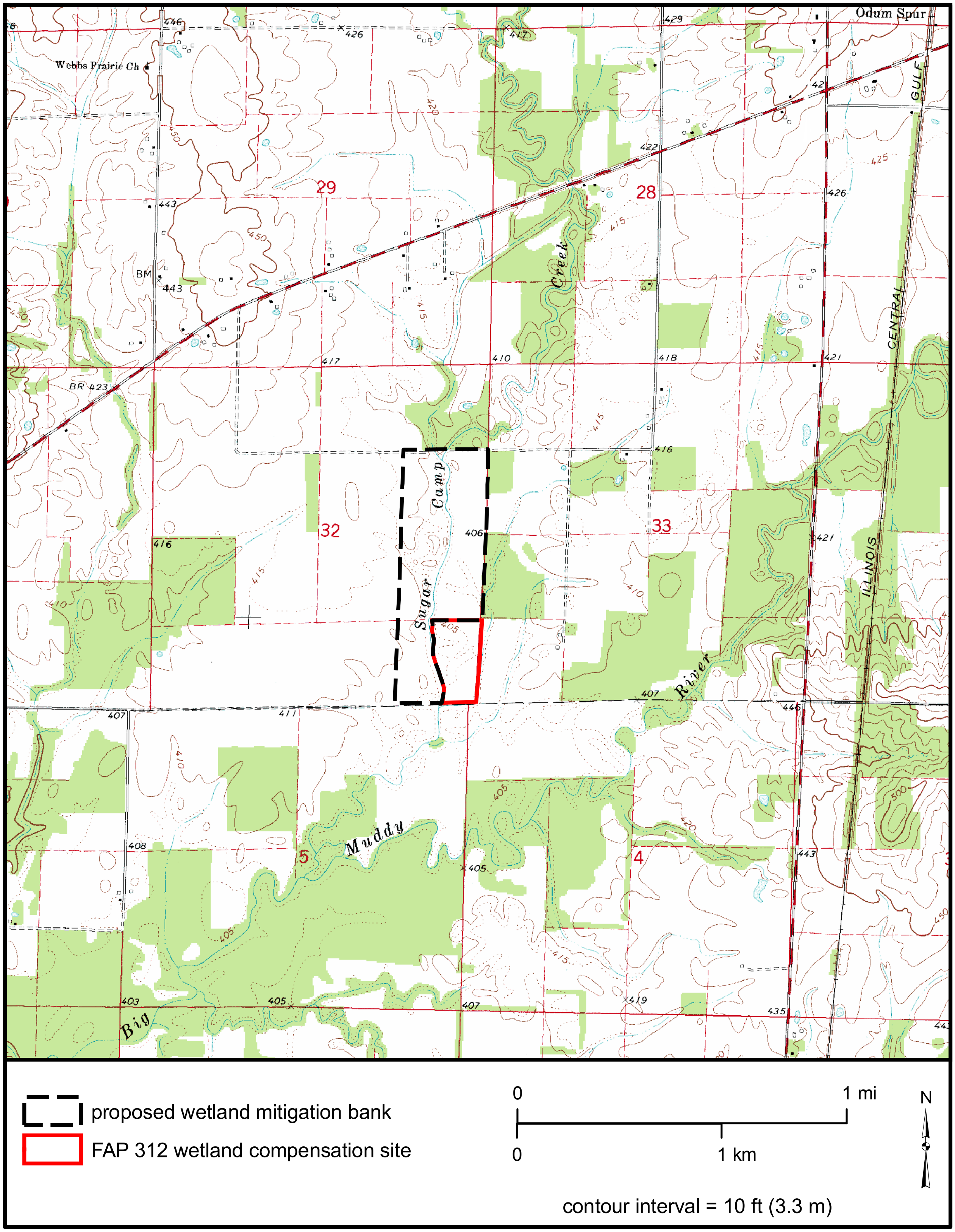

Figure 1 Proposed wetland mitigation bank, existing compensation site and vicinity. Map based on USGS Topographic Series, Ewing, IL 7.5-Minute Quadrangle (U.S. Geological Survey 1974).

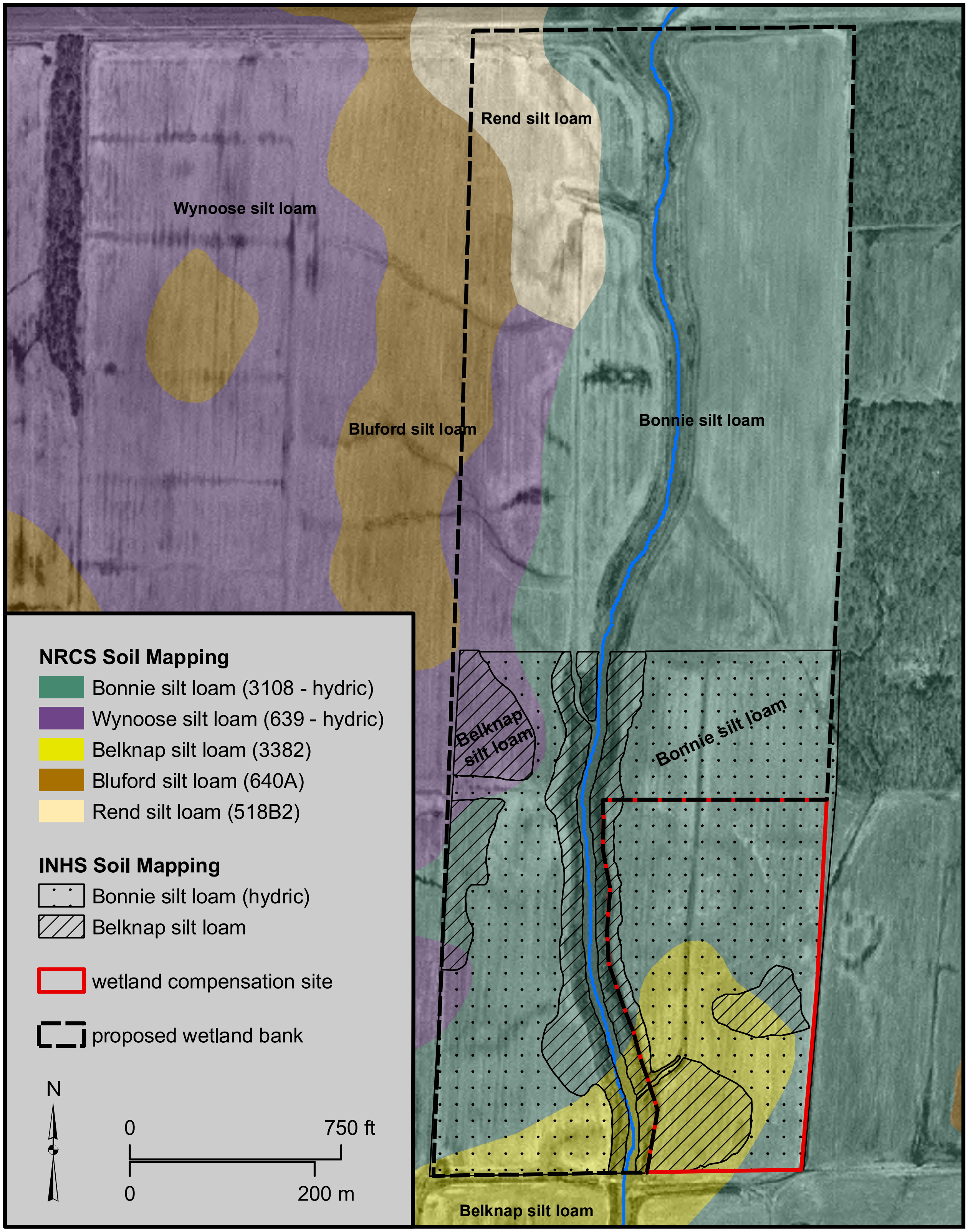

Figure 2 Soil map of the proposed wetland mitigation bank, compensations site and vicinity, showing Soil Survey (Preloger 2003) and INHS soil map units (Plocher and Wiesbrook 2004). Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

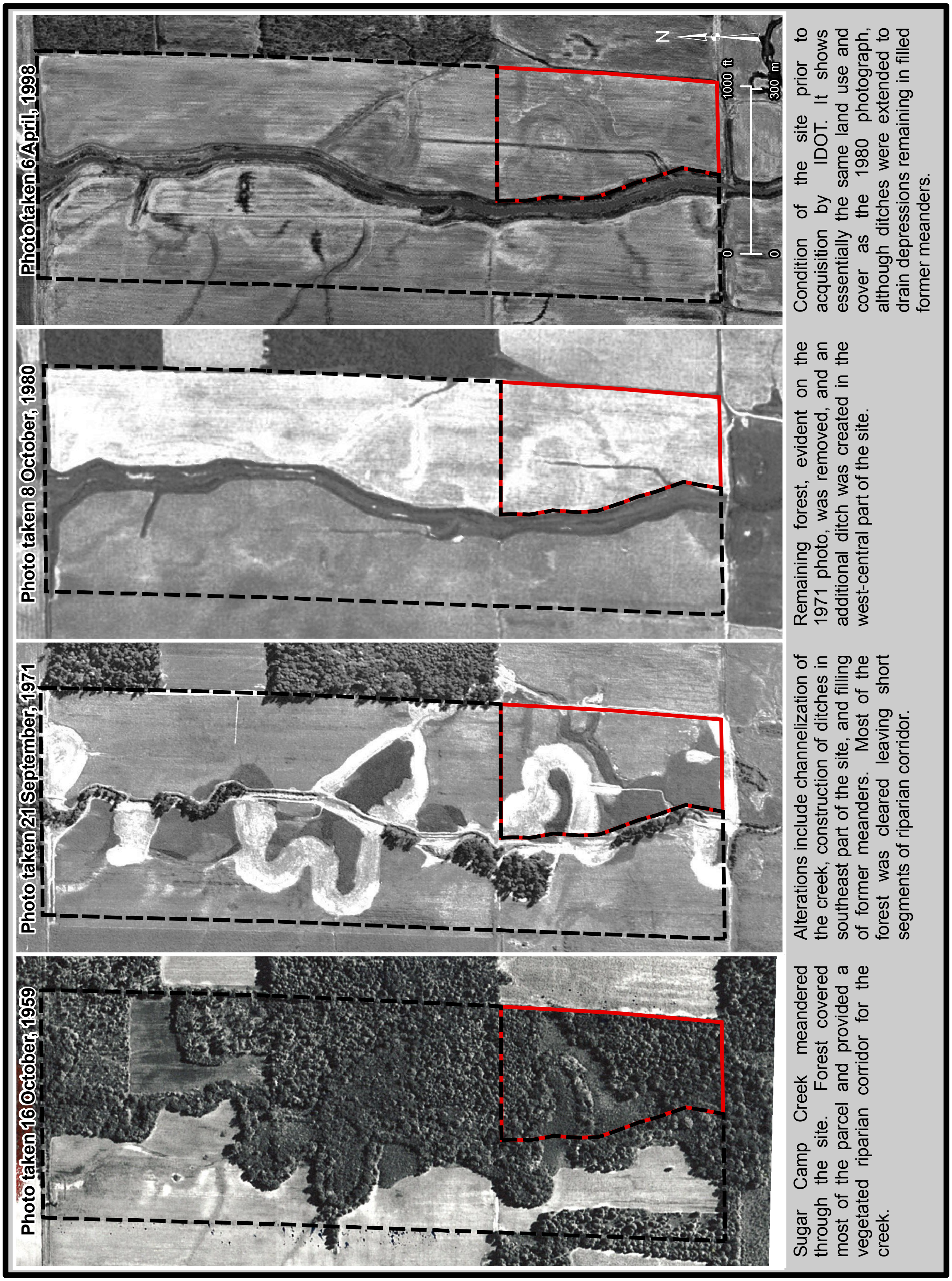

Figure 3 Historical aerial photography showing land-use changes and hydrologic alterations at the Sugar Camp Creek site (U.S. Department of Agriculture, 1959, 1971, 1980; Illinois State Geological Survey 2001).

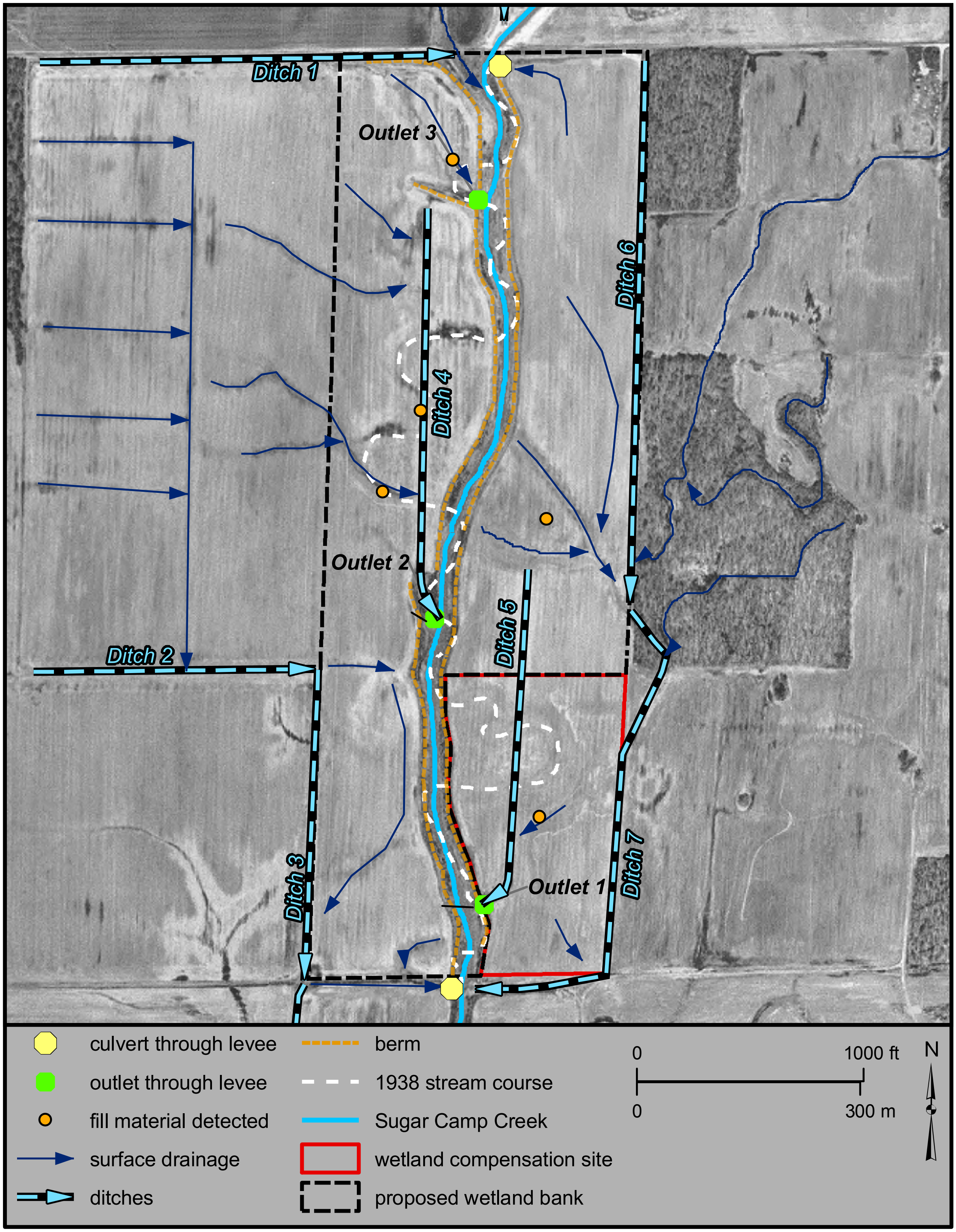

Figure 4 Hydrologic alterations and surface-water features. The 1938 stream course was digitized from 1938 historical aerial photography (U.S. Department of Agriculture 1938). Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

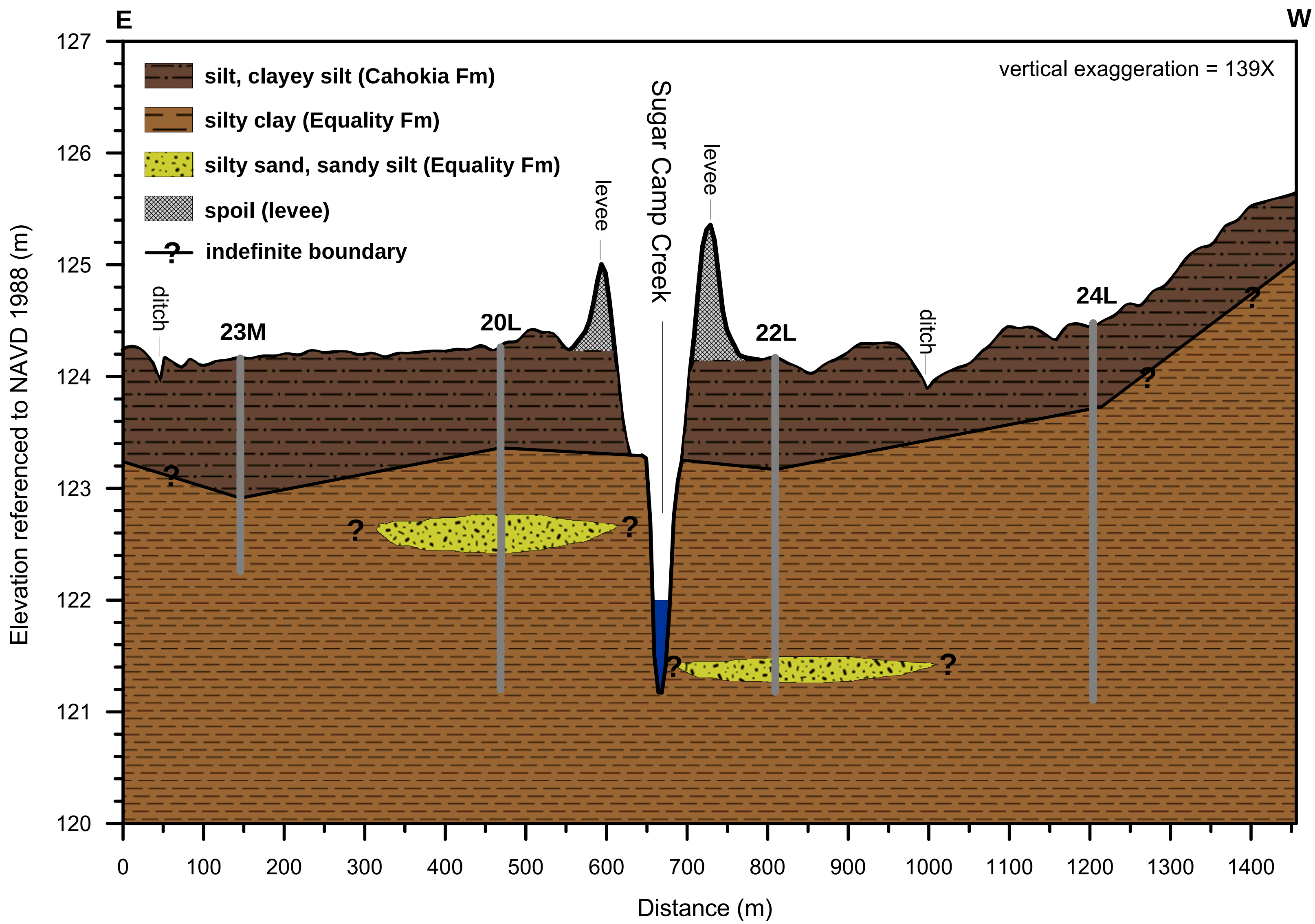

Figure 5 Cross section of geologic materials at the Sugar Camp Creek proposed wetland mitigation bank and compensation site. Geologic boring locations and depths are represented by the gray vertical lines; labels correspond to the well placed in the boring. The location of the cross-section line is indicated in Figure 8.

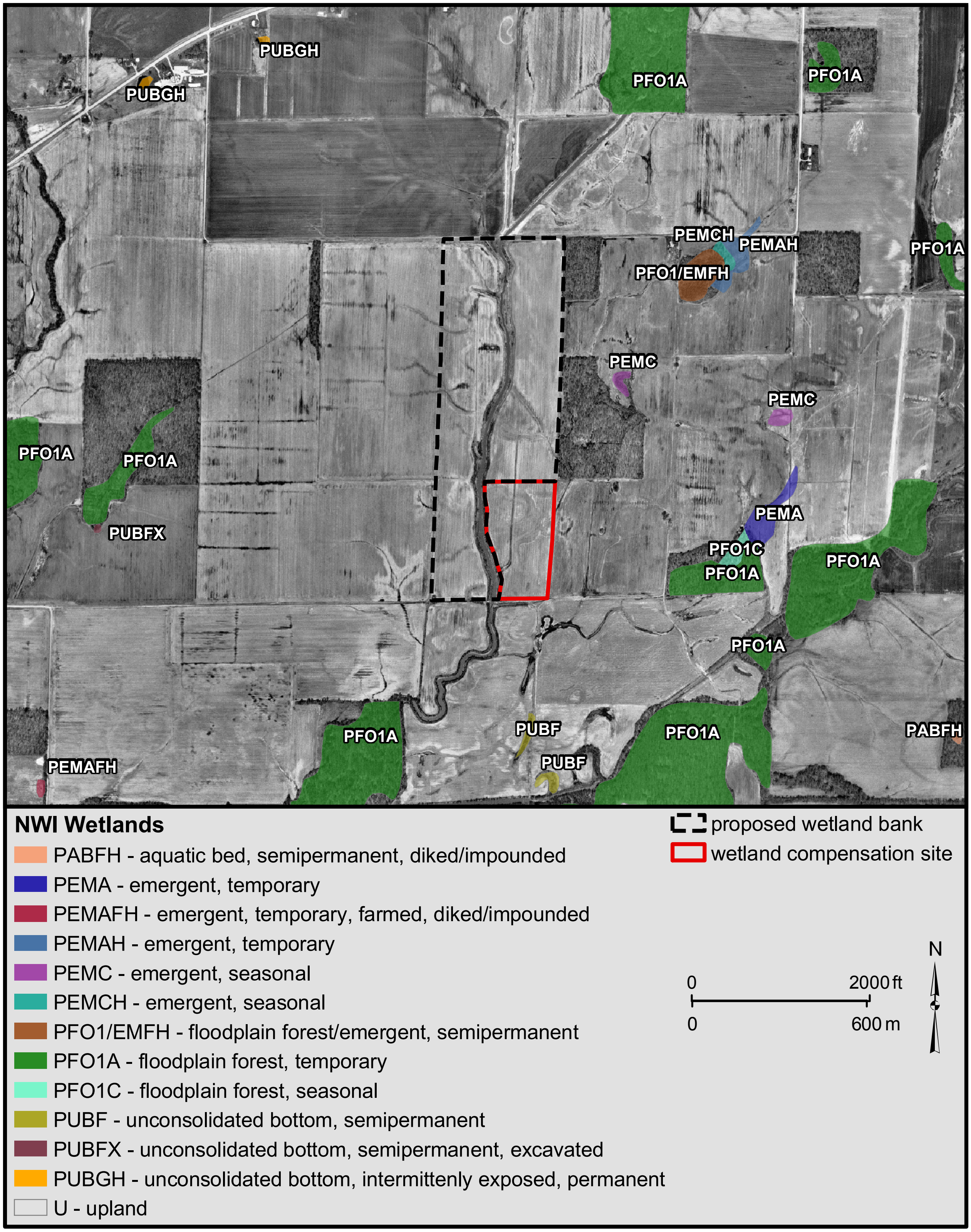

Figure 6 Wetland areas mapped by the National Wetlands Inventory in the vicinity of study area (U.S. Fish and Wildlife Service 1987). Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

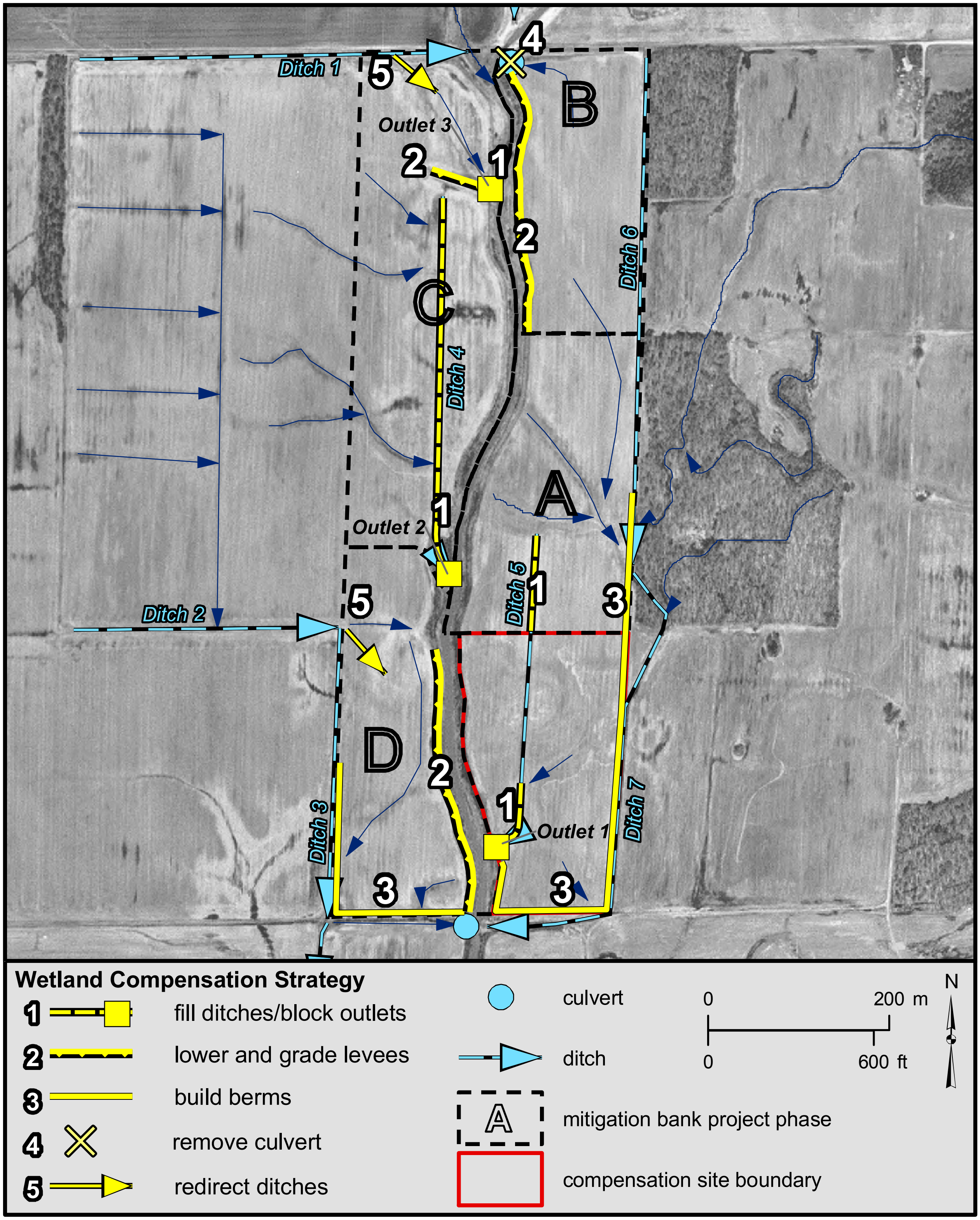

Figure 7 Wetland compensation recommendations for the Sugar Camp Creek site. The numbers refer to the recommendations listed in this report and the letter index refers to the project phases outlined in the Wetland Banking Instrument (Illinois Department of Transportation, in preparation). Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

compensation site and Phase A, Ditch 4 within Phase C, and all scratched ditches (Figure 7). We suggest blocking each of these ditches at their respective outlets, building thresholds to specified elevations at each outlet (see Table 1), and backfilling the length of each ditch to surrounding grade. Filling ditches completely and reinforcing the thresholds with erosion-control plantings and/or structures will reduce the likelihood of degradation of the thresholds after construction.

2. Lower the existing levees along Sugar Camp Creek. Levees between Sugar Camp Creek and the floodplain in Phases B and D prevent more frequent, lower-elevation floods from reaching these areas (Figure 7). Also, a short segment of the levee partitions the northwest portion of the site from the remainder of the floodplain west of Sugar Camp Creek. We recommend lowering these levee segments to elevations specified in Table 1. Seeding and planting for erosion control is strongly recommended immediately after levee grading is complete, and erosion-control structures (e.g., spillways/weirs) may be necessary in back-filled areas at the existing outlets or areas otherwise susceptible to erosion and degradation after construction.

3. Build low, broad berms along the east and south perimeter of the FAP 312 wetland compensation site, the east perimeter of Phase A, and the west and south perimeter of Phase D to prevent flood water and runoff from draining off the site or to perimeter ditches (Figure 7). Recommended construction elevations for these berms are given in Table 1. Construction of the berms should not block Ditches 3 and 7 or hinder drainage to the off-site culvert from the property adjacent to Phase D. Blocking these features can be avoided by ensuring that the footprint of each berm lies entirely within the property boundary.

4. Remove the culvert and gravity valve located in the east levee at the north end of the site in Phase B (Figures 4 and 7). In its current configuration, this culvert and gravity valve drains the site after storms and larger floods, and prevents more frequent smaller floods from reaching the northeast portion of the site. We recommend removing this culvert and backfilling to an elevation lower than the top of the current levee (see Table 1) to allow more frequent flooding and retention of flood and storm water, thus locally prolonging inundation and saturation.

5. Redirect ditches onto the site where feasible. Ditches 1 and 2 could contribute water to wetland restoration areas in Phases C and D (Figure 7). We recommend redirecting these ditches by reconfiguring the levee at the north perimeter of Phase C, and excavation of a broad, shallow swale leading from the corner of Ditches 2 and 3 at the west property boundary into the central portion of Phase D. We do not recommend modifying Ditches 6 and 7 at this time because these ditches are substantially lower than the adjacent potential wetland restoration areas, and would not contribute significantly to hydrology without significant earthwork. Further, modifying these ditches could drain potential restoration areas and/or hinder drainage of adjacent properties.

6. Search for drainage tile and disable where found. Although suspected drainage tiles were previously reported, further inspection revealed buried logs but no drainage tiles. Nevertheless, the presence or absence of drainage tiles should be confirmed. If drainage tiles are found they should be removed in accordance with procedures outlined in IDOT’s wetland banking instrument for the Sugar Camp Creek site.

7. Continue hydrogeologic evaluation of fill materials. Unconsolidated debris used to fill the former creek channel may expedite drainage locally. The connectivity of the filled areas to Sugar Camp Creek should be further evaluated as they may provide conduits that drain potential wetland restoration areas.

Table 1 Target threshold elevations for selected recommended hydrologic modifications at the Sugar Camp Creek site (see also Figure 7).

Phase/Project Area	**Modification(s)**	**Threshold Elevation** meters (m) (feet [ft])
FAP 312	block Outlet 1	123.8 m (406.2 ft)
FAP 312, Phase A, Phase D	build perimeter berm, lower the levee along the creek	123.8 m (406.2 ft)
Phase C (south)	block Outlet 2	124.0 m (406.8 ft)
Phase C (north)	block Outlet 3, lower the levee bisecting the floodplain	124.2 m (407.1 ft)
Phase B	remove culvert/backfill, lower the levee along the creek	124.4 m (407.5 ft)

METHODS

Geology

A total of 39 geologic borings were examined and described during the installation of monitoring wells, and 4 additional sections were described from supplemental borings (Appendix A). All boreholes were made using a bucket-type hand auger. Most borings were made to depths of 0.75 m (2.46 ft). However, boring depths ranged up to 3.37 m (11.05 ft). Geologic materials were observed and described during excavation of each boring. Texture, Munsell color, presence and type of redoximorphic features, soil and sedimentary structures, moisture content, and other features were recorded for most of the borings. The geologic profiles observed in the deeper borings provided the basis for the interpretations of the geology at the site.

Hydrogeologic Monitoring and Analysis

A total of 39 wells were installed in 33 locations at the site (Figure 8). Shallow (S-) wells were designed to monitor saturation in the soil zone and were used to determine the extent of wetland hydrology at the site. Deeper wells (M- and L-wells) were designed to monitor hydraulic potential at specific depths in deeper geologic units. Nested S-, M-, and L-wells were installed at 4 locations to detect vertical ground-water gradients and test subsurface flow rates.

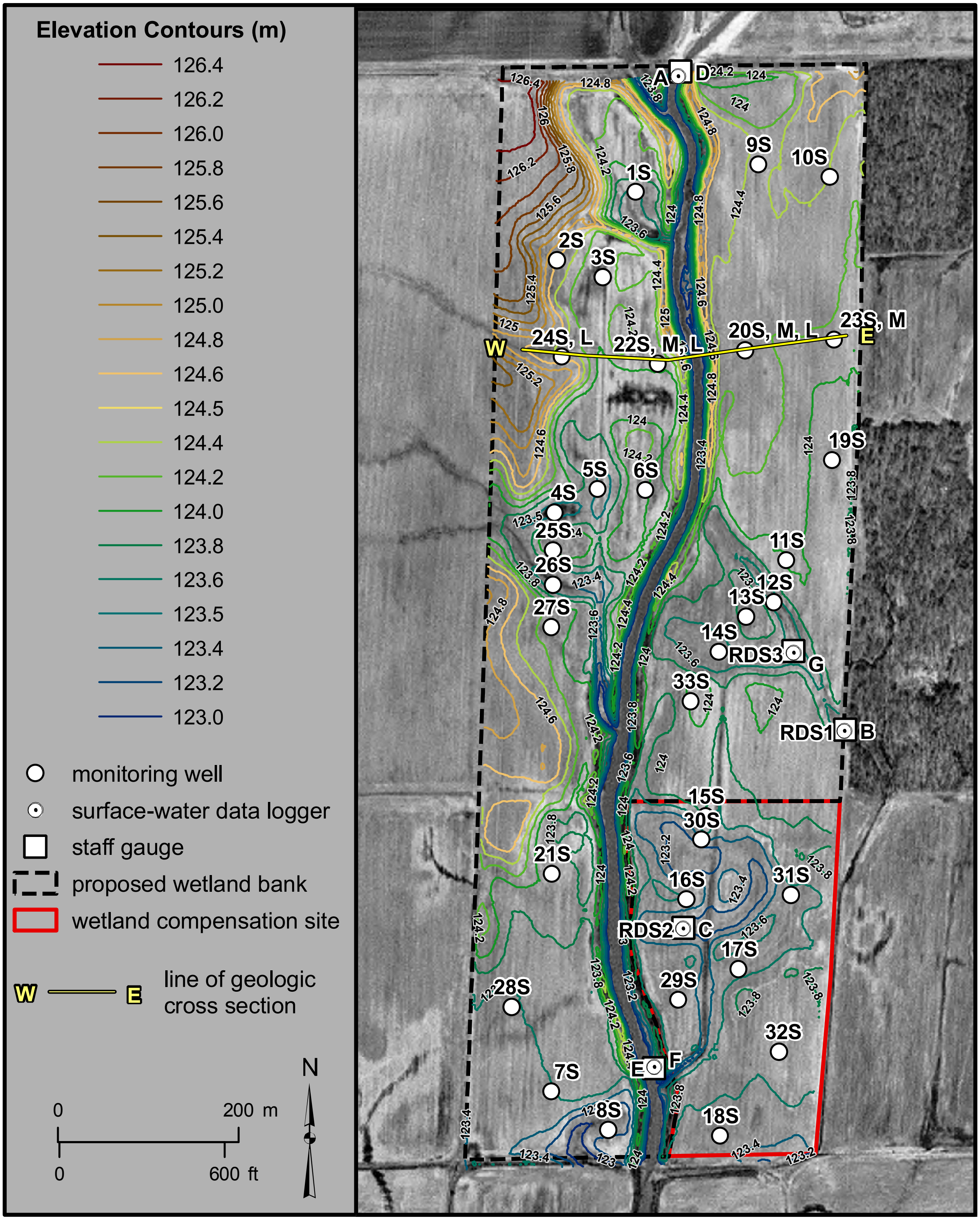

Figure 8 Hydrologic monitoring network and topography at the Sugar Camp Creek site. The cross-section line for the geologic profile (Figure 5) is also indicated. Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

Most of the S-wells were constructed with 2.5-centimeter (cm) (1.0-inch [in]) diameter PVC casing and manufactured slotted screen. Two of the S-wells, and all of M- and L-wells, were constructed using 5.1-cm (2.0-in) diameter PVC casing and slotted screen. Screen slots for all wells are 0.025-cm (0.01-in) wide. The screened interval for each S-well was approximately 45 to 75 cm (17-30 in). Screen lengths for M- and L-wells ranged from approximately 13 to 38 cm (5-15 in). The depth of the screened interval for these wells was determined based on the geologic materials encountered in each boring. Sand was placed in each borehole so that the sand pack encompassed the entire screened interval. The boreholes were then sealed from the top of the sand pack to land surface using bentonite chips. Further details of well construction can be found in Appendix B. The deeper M- and L-wells were developed using a battery-powered peristaltic pump. After installation, each well was pumped dry, then allowed to recharge. This was repeated until the water pumped from each well was visibly clear.

The depth to water in the wells was read manually with an electronic water-level meter on a weekly or biweekly basis in April, May and June, and on a monthly basis during the remainder of the year (Appendix C). These measurements were made relative to the top of the wells. To calculate the depth-to-water below land surface at each well location, the measured height of the well casing above land surface was subtracted from the measured depth to water from the top of the well. Ground-water elevations (Appendix D) were calculated by subtracting the depth to water in the well from the elevation of the top of the well. Selected wells were instrumented with data loggers that recorded water levels at 1- or 3-hour intervals.

Falling-head tests were conducted to measure hydrogeologic properties of the subsurface materials. Tests were conducted by placing a 750-milliliter (mL) slug into the well and recording the fall of water level continuously using an In-Situ Inc. miniTroll™ data logger set at a 1-second sampling interval or manually at 5-second intervals. Falling-head tests were conducted in this manner for 4 separate monitoring wells. Hydraulic conductivity (K) values were obtained for each well by visually fitting the Bouwer and Rice (1976) model to the water-level data using AQTESOLV® for Windows Pro v.3.5 software. The methods and analyses for slug tests are fully described in Appendix E.

Surface-water data were collected at various locations using data loggers and staff gauges (Figure 8). Data loggers with either capacitance or pressure transducer sensors were used. Steel staff gauges were installed at or near the logger locations to provide quality control and to provide water-level measurements in the event of logger failure. The staff gauges were read on the same schedule as the monitoring wells.

The elevations of the monitoring wells and stage gauges were surveyed each spring with a Sokkia B1 Automatic Level or a Leica TS702 total station. Instrument locations were surveyed using a Trimble Pathfinder ProXR GPS unit. Site elevations were surveyed relative to survey benchmarks set at the site by the ISGS. These benchmarks consist of 2.0-m (6.6-ft) long steel rods set in concrete. The ISGS benchmark elevations relative to the North American Vertical Datum of 1988 (NAVD 1988) were determined by leveling from a nearby benchmark placed and surveyed by IDOT.

Climate

Precipitation data recorded at Du Quoin (Station 112483) were used to identify precipitation trends and to determine the deviation from average climate conditions (Midwestern Regional Climate Center 2006). The Du Quoin weather station is located approximately 40 kilometers (km) (21 miles [mi]) west of the site. On-site precipitation data were also collected by the ISGS using a tipping-bucket rain gauge equipped with a data logger. The on-site data were used both as a check against weather station data, and to analyze the correspondence of individual precipitation events with fluctuations in surface- and ground-water levels.

For the purpose of wetland determination, the growing season is the period of time between the last occurrence of 28°Fahrenheit (-2.2°Celsius) temperature in the spring and the first occurrence in the fall (Environmental Laboratory 1987). The growing season at the site was determined using temperature data recorded at the Du Quoin weather station. According to these data, the median length of the growing season for the region is 207 days, with the median starting date on April 5th and the median ending date on October 26th (Midwestern Regional Climate Center 2006).

SITE CHARACTERIZATION

Geographic Setting

The potential wetland compensation site is located in the upper portion of the Big Muddy River watershed (HUC 07140106), along Sugar Camp Creek. Sugar Camp Creek flows through the site from north to south and drains into the Middle Fork of the Big Muddy River approximately 1.7 km (1.0 mi) downstream. The site is situated in a broad alluvial valley within the Mount Vernon Hill Country of the Till Plains Section of Illinois' physiographic provinces (Leighton et al. 1948). The topographic relief of the valley is roughly 30 m (100 ft).

The surface topography on the parcel (Figure 8) is flat to moderately sloping, with total relief, excluding the creek channel, of approximately 3.6 m (11.8 ft); elevations range from 122.9 to 126.5 m (403.2-415.0 ft). The highest elevations are located on the terrace in the northwest portion; the lowest elevations are located on the floodplain along the perimeter in the southwest portion of the site. The landscape east of the creek is low relief (0.2 m [0.7 ft]), although both natural drainage features and ditches in the southeast portion of the site create slightly greater relief (0.8 m [2.6 ft]). The western half of the site has more pronounced relief (up to 3.0 m [9.8 ft]) and steeper slopes (up to 5%) due to the terrace located along the west perimeter. Relief, slope, and elevation between the base of the terrace and the creek are similar to areas east of the creek. The channel bed of Sugar Camp Creek ranges from approximately 2.5 to 4.0 m (8.2-13.1 ft) below the surrounding floodplain.

Geology

The site overlies the north flank of the Big Muddy bedrock valley (Herzog et al. 1994). Bedrock in the area is mapped as Pennsylvanian Bond Formation (Kolata 2005) and is reported to be between 6.0 to 15.0 m (19.7-49.2 ft) below land surface in the vicinity (Berg and Kempton 1988). The Bond Formation consists principally of limestone, and calcareous clays and shales (Willman et al. 1975). Surficial geologic deposits in the area include the Glasford, Equality, and Cahokia Formations. Glasford Formation deposits consisting of sandy and loamy glacial diamicton form the uplands in the region. Equality Formation deposits consisting primarily of clay-rich lake sediment are located in the broad valley containing the Middle Fork of the Big Muddy River and Sugar Camp Creek. Silty Cahokia Formation alluvial deposits, though not mapped at the site, are generally located along smaller tributary streams in the region (Berg and Kempton 1988, Lineback 1979).

Most borings made at the site revealed clayey silt (with traces of sand in a few instances) over slightly denser silty clay (Figure 5 , Appendix A). The siltier materials near the surface reflect recent floodplain deposition and are consistent with descriptions of the Cahokia Formation (Willman et al. 1975, Lineback 1979). The silty surface deposit is generally uniform and ranges from 0.4 to 1.3 m (1.3-4.3 ft) thick. The underlying deposits are more dense and clay-rich, characteristics associated with the mapped deposits of the Equality Formation (Willman et al. 1975, Lineback 1979). The deeper borings made at the site each terminated in this lower deposit and the deepest boring (24L) indicated a minimum thickness of 2.6 m (8.6 ft) in this location.

Channel fill (debris) materials were encountered in borings at several locations (1S, 5S, 13S, 17S, 26S). Bright mottling, wood fragments and charcoal were observed within silty material at boring locations corresponding with areas where the former meandering creek channel was backfilled and graded for farming (Figure 4). The depth to undisturbed materials in these locations also suggests that the present channel bed is approximately 1.0 m (3.3 ft) lower than it was prior to 1971.

Soils

The U.S. Department of Agriculture (Preloger 2003) mapped five soil units at the site: Rend silt loam, Wynoose silt loam, Bluford silt loam, Bonnie silt loam, and Belknap silt loam (Figure 2). The Wynoose and Bonnie map units are both listed as county and state hydric soils (U.S. Department of Agriculture 1991, 1995) and together represent approximately 80% of the total site area. The Soil Survey reports that the Bonnie silt loam is very poorly drained, is subject to frequent, brief flooding, and exhibits an apparent high water table from 0 to 0.3 m (0-1 ft) below land surface from January through June; the Wynoose silt loam is poorly drained, is not subject to flooding, and exhibits a perched high water table from 0 to 0.3 m (0-1 ft) below land surface from March through June.

INHS personnel verified the soil map unit boundaries by conducting traverses over approximately 23 ha (56 ac) in the southern portion of the parcel. Following inspection, the INHS confirmed the presence of the Bonnie and Belknap soils in the southern half of the site and adjusted the map unit boundaries accordingly. They also determined the soils in the west-central part of the site are more similar to Belknap silt loam than Wynoose silt loam. Within the area examined, the INHS delineated 16.0 ha (39.5 ac) of hydric Bonnie silt loam, and 6.5 ha (16 ac) of non-hydric Belknap silt loam as compared to 16.4 ha (40.5 ac) of Bonnie silt loam, 4.7 ha (11.5 ac) of Belknap silt loam, and 1.6 ha (4 ac) of Wynoose silt loam mapped by the USDA (Plocher and Wiesbrook 2004, Preloger 2003).

Wetlands

The National Wetlands Inventory (NWI) mapped numerous wetland areas nearby, many in geomorphic settings similar to the Sugar Camp Creek site (Figure 6, U.S. Fish and Wildlife Service 1987). The majority of the mapped wetlands in both number and area are classed as floodplain forest (palustrine, forested, broad-leaved deciduous, temporary [PFO1A]), although emergent, scrub-shrub, unconsolidated bottom, and aquatic bed wetland types are also located in the vicinity. Most mapped wetlands in the area are located within a broad lowland that contains Sugar Camp Creek, the Middle Fork of the Big Muddy River, and several other smaller streams and, with few exceptions, are adjacent to these streams.

The INHS conducted routine wetland determinations at four sites (Appendix F): three sites (Sites 1, 2, and 3) were located on the parcel and one site (Site 4) consisted of three separate forested areas located adjacent to the parcel (Plocher and Wiesbrook 2004). Although Sites 1, 2, and 3 met the 3-parameter definition for wetlands (Environmental Laboratory 1987), these areas showed low or very low natural quality. Further, the jurisdictional wetland status for each of these sites was reported as “undetermined” because they were used as cropland in the growing season prior to the wetland determination and were determined to be "prior-converted" by the NRCS. The INHS also found that the forested areas adjacent to the parcel (Site 4), although not mapped by the NRCS or the NWI, contained jurisdictional wetland areas and had good natural quality (Plocher and Wiesbrook 2004).

Hydrology

Precipitation

Average annual precipitation at the Du Quoin station is 44.1 in (112.0 cm) (Midwest Regional Climate Center 2006). The 30-year monthly averages show that most of the annual precipitation falls during the period March through June, with seasonal peaks occurring in May and November (Appendix G). Drier periods typically occur during late summer into fall (August through October) and mid-winter (January and February).

Precipitation amounts recorded at the site during the early growing season were below normal in both years of this study (Table 2). For 2005, annual precipitation totaled 43.21 in (109.75 cm) or 0.85 in (2.16 cm) less than normal. Exceedingly dry conditions prevailed from February through July 2005, with 59% of normal precipitation during this period. For 2006, the year-to-date precipitation through September totaled 39.76 in (101.0 cm) or 6.86 in (17.4 cm) more than normal for that period (Table 2). Rainfall in March 2006 was much above average causing high soil-moisture conditions, although drier conditions prevailed during the early growing season. Precipitation was below normal in April and May and near-normal in June.

Table 2 Annual and April through June precipitation totals compared to 30-year averages at the Du Quoin weather station. Annual totals were recorded at the Du Quoin weather station and April through June totals were recorded by ISGS at the Sugar Camp Creek site.

	30-Year Average	2005	2006
April - June	13.29 in. (33.76 cm)	6.66 in. (16.92 cm)	7.91 in. (20.1 cm)
Annual	44.06 in. (111.91 cm)	43.21 in. (109.75 cm)	39.76 in. (101.0 cm)**
Deviation From Annual Average		-0.85 in. (-2.2 cm)	+6.86 in. (+17.4 cm)**

** year to date value through September

Surface Water

Most of the site is subject to flooding from Sugar Camp Creek, although the period of inundation for individual flood events is usually brief. During this study, 15 months of stage data recorded at the site showed frequent flooding despite relatively dry climatic conditions during the critical spring period. The creek flooded some portion of the site (flood elevation = 123.0 m [403.5 ft] or greater) on 20 occasions (Table 3). The median elevation for these floods was 123.8 m (406.2 ft), which corresponds to the inundation of at least 24.2 ha (59.8 ac) of the site (see Appendix H). However, floods exceeded or reached the overall median level only twice during the 2005 growing season and three times during the 2006 growing season. Further, these flood events were very brief, with inundation of the site lasting 2 days or less. During a typical flood event, the stage rises from baseflow to peak flow within 24 hours after a storm event, and recedes to base flow within a week.

West of Sugar Camp Creek, several swales collect water within a small catchment in the farm field to the west and convey it onto the site. Although no surface-water levels were collected in these locations, field observations of erosion patterns and flood debris near wells 2S and 4S indicate that flow in these swales approaches 30 cm (1 ft) deep after intense rainfall events. This suggests that runoff and overland flow from the west may contribute small but significant amounts of water to the site, particularly in the west-central portion.

Table 3 Flooding statistics at the Sugar Camp Creek site. The column 'All Floods' represents all events exceeding 123.0 m (403.5 ft) during the period-of-record March 22, 2005 through July 31, 2006. Corresponding area of inundation estimates can be found in Appendix H.

	All Floods (Period-of-Record)	**2005 Growing Season**	**2006 Growing Season***
Maximum Peak	125.2 m (410.8 ft)	124.5 m (408.5 ft)	124.9 (409.8 ft)
Median Peak	123.8 m (406.2 ft)	123.5 m (405.2 ft)	123.9 (406.5 ft)
Number of Events	20	4	7

* data represents 57% of the growing season (April 5-July 31).

East of Sugar Camp Creek, water-level data shows that, in the absence of flooding from Sugar Camp Creek, runoff from areas adjacent to the east of the site appears to remain confined within Ditches 6 and 7 and does not contribute significant water to the site (Figure 9). Because the bed elevation of these ditches is generally lower than the potential wetland compensation areas, rerouting these ditches onto the site is not possible without draining portions of planned wetland areas. Further, we do not recommend filling the perimeter ditches at this time because it would interrupt drainage of the adjacent properties.

Hydrologic modifications made during this study also help show the potential of retaining surface water within planned wetland compensation areas. During May 2005, IDOT constructed a low-elevation (30 to 60-cm [1-2-ft]) earthen dam in Ditch 5, just south of the depression in the center of the FAP 312 wetland compensation site. After this ditch was blocked, a flood event during late August 2005 exceeded the threshold level of the dam (123.41 m [404.90 ft]) and inundated most of the compensation site. Since this flood event, water levels have fluctuated between the threshold elevation and 123.20 m (404.19 ft), and approximately 0.5 ha (1.3 ac) of the wetland compensation site has remained persistently inundated. Prior to that time, precipitation and runoff events occurred, but no widespread or persistent inundation or saturation occurred within the depression. These data illustrate that blocking ditches elsewhere at the site can be an effective strategy for retaining flood water and increasing the extent and duration of inundation in localized depressions where surface materials are sufficiently impermeable.

Ground Water

Ground-water contribution is generally limited due to the fine-grained sediments underlying the site, although localized discharge to land surface was observed. The water levels in nested wells (20, 22, 23, 24) suggest that the vertical ground-water gradient is generally downward or neutral (Appendix C). However, water levels in well nests 23 and 24 indicate that an upward

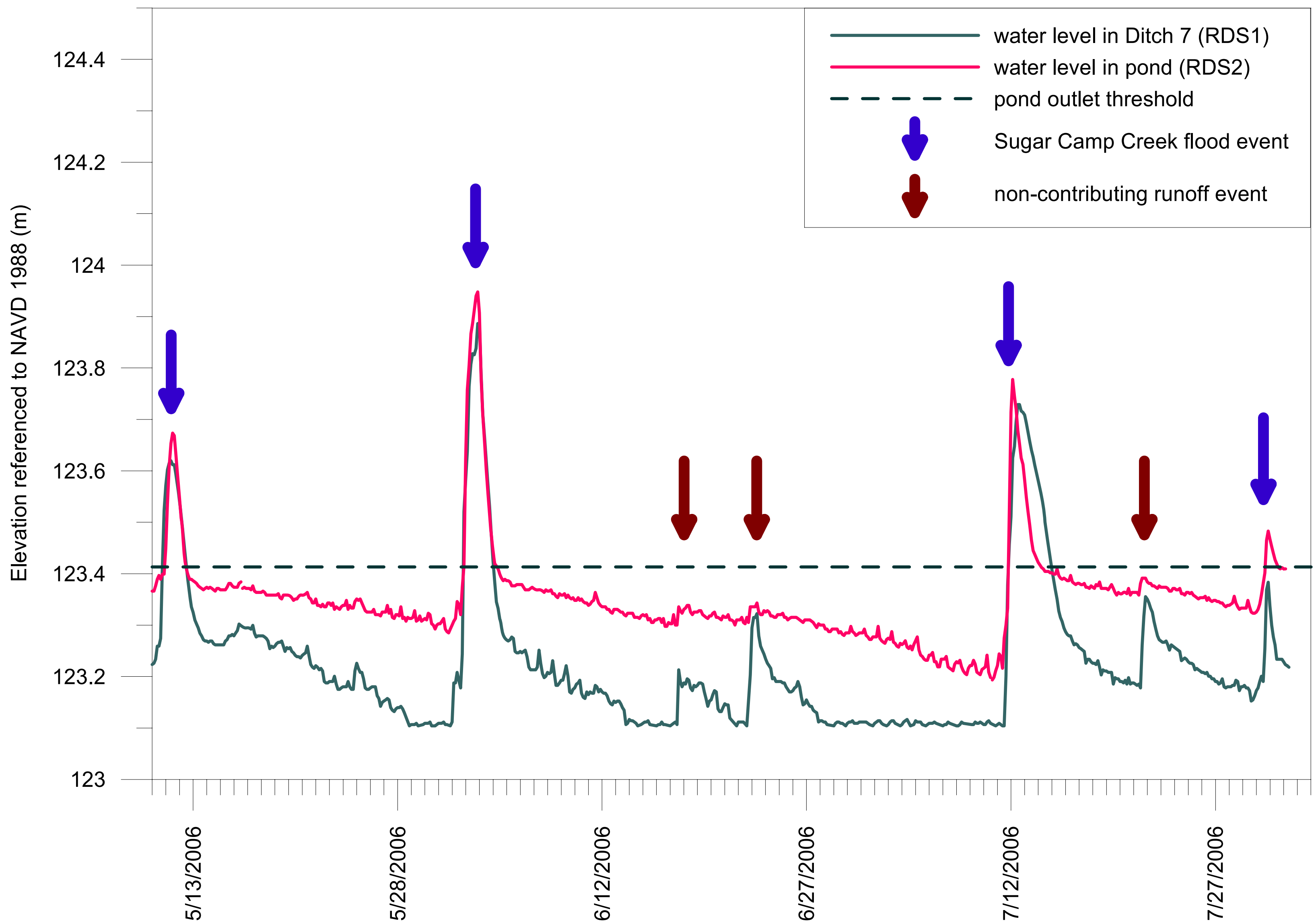

Figure 9 Response of surface-water levels east of Sugar Camp Creek to flooding and runoff. Flood events are indicated by the blue arrows. The dark red arrows indicate when runoff was intercepted by Ditch 7 and did not contribute to the site.

gradient occurs intermittently in these locations, particularly during winter and early spring months. Along the slope west of Sugar Camp Creek, field observations of surface saturation support the interpretation of discharge to land surface based on water-level observations in wells 24S and 24L. Further, salt crusts were also observed at land surface along slopes in the vicinity. These salt crusts, called “slick spots”, are commonly observed in the region and form as salts are precipitated from ground water as it discharges at land surface (Follmer, personal communication 2005).

Ground-water flow through geologic materials at the site is generally slow. Slug tests were conducted in wells 20L, 22M, 22L, 23M, and 24L during January and February 2006. Hydraulic conductivity estimates from these tests are given in Table 4 and analyses are presented in Appendix E. The estimates ranged from 1.4 x10^{-3} cm/s at well 22M to 1.5 x 10^{-5} cm/s at well 20L and are consistent with the range of values expected for the materials encountered in the geologic borings (Fetter 1994, page 98). The relatively low hydraulic conductivity measured at wells 20L, 23M, and 24L indicates that flow through geologic materials at least within the upper 3.3 m (10.8 ft) is generally very slow. Somewhat higher hydraulic conductivity values were estimated for wells 22M and 22L, and are attributable to slightly coarser-textured geologic materials at depth that may provide a localized conduit for flow to the creek. Nevertheless, hydrogeologic conditions at the site are generally conducive to surface ponding and perching of ground water in the shallow subsurface.

Table 4 Hydraulic conductivity values estimated by slug tests in selected wells at the Sugar Camp Creek wetland compensation site. Data and analyses for the slug tests are given in Appendix E.

Well	Date	Hydraulic Conductivity (K) (cm/s)
20L	1/11/2006	1.5 X 10^{-5}
22M	2/6/2006	1.4 X 10^{-3}
22L	2/7/2006	1.3 X 10^{-4}
23M	2/7/2006	7.5 X 10^{-5}
24L	1/11/2006	4.2 X 10^{-5}

Data collected on May 16, 2006 and May 25, 2006 were used to produce water-table contour maps of the unconfined upper sediments on each date (Figures 10 and 11). Respectively, these data sets represent relatively high and relatively low water levels, and were selected to illustrate typical ground-water flow conditions during the early growing season. Comparison of the maps showed that Sugar Camp Creek has substantial influence on subsurface drainage during both wet and dry periods, although the influence of local topography on drainage of the shallow subsurface becomes stronger as water levels recede. During drier conditions, more flow was directed toward ditches, closed depressions, and areas that had been filled, showing the increased influence of local topography and subsurface conditions, particularly east of the creek. These data also show that the slope of the water table steepened in the north portion of the site and flattened in the south portion of the site, reflecting the influence of topography as conditions became drier.

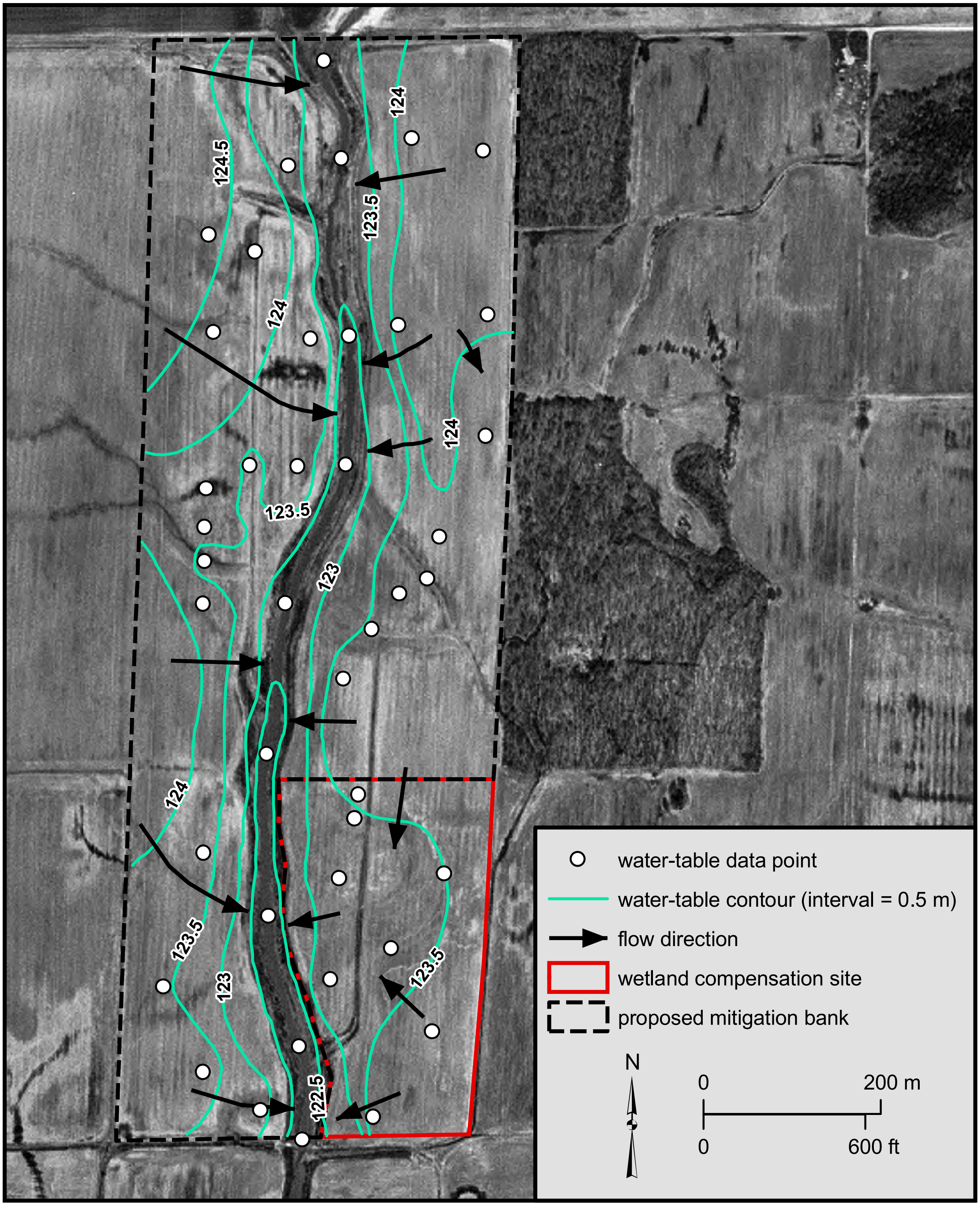

Figure 10 Water-table contours in the unconfined upper sediments during relatively wet conditions at the Sugar Camp Creek site. Water-level data used to draw the contours were measured in shallow wells and surface-water gauges in Sugar Camp Creek on May 16, 2006 and are referenced to NAVD 1988. Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

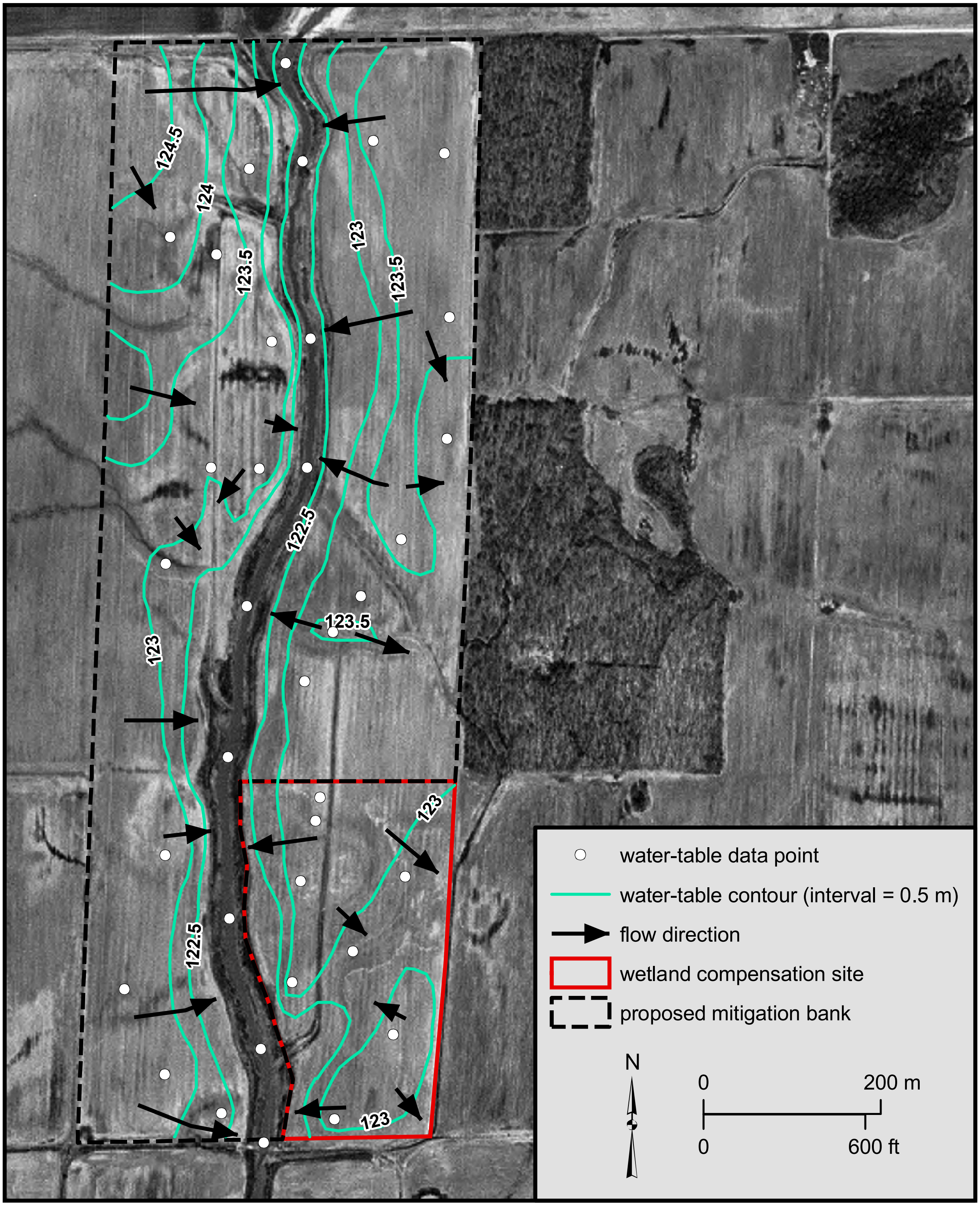

Figure 11 Water-table contours in the unconfined upper sediments during relatively dry conditions at the Sugar Camp Creek site. Water-level data used to draw the contours were measured in shallow wells and surface-water gauges in Sugar Camp Creek on May 25, 2006 and are referenced to NAVD 1988. Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

Hydrologic Alterations

Surface-water hydrology of the site has been significantly altered by agricultural use within the last 40 years. Examination of historical aerial photography shows that, in 1959, as much as 32 ha (78 ac) of the site was forested, no ditches were evident, and Sugar Camp Creek meandered through the site (Figure 3). Sometime between 1965 and 1971, forested areas were cleared, Sugar Camp Creek was channelized, and the former meandering channel was filled. Modifications subsequent to 1971 include excavation and maintenance of ditches, construction of discontinuous levees along both banks of Sugar Camp Creek, installation of a culvert with a gravity valve at the north end of the site, and removal of remaining forested areas (Figures 3 and 4). It is presently undetermined whether a drainage tile system exists at the site.

The channelization of Sugar Camp Creek reduced the length of the stream through the site by approximately 0.84 km (0.52 mi). Further, borings made in the former meandering channel show that, prior to channelization, the bed of Sugar Camp Creek was as much as 1.2 m (3.9 ft) higher than the current bed level (Appendix A). These data suggest that the creek bed has incised, although it is not clear how much incision is due to the original channelization, subsequent channel maintenance, or post-channelization erosion. Regardless, the lower channel bed (and baseflow) relative to the floodplain elevation requires larger discharges to flood the site and has likely contributed to reducing the extent of saturation and inundation from the pre-channelization condition. Also, channelization and incision have likely expedited drainage where the channel intersects coarse-grained and/or fill materials, creating conduits for subsurface flow to the creek, as suggested by flow rates estimated for well nest 22.

Levees along Sugar Camp Creek partially inhibit flooding, particularly in the northeast and southwest portions of the site. Although notches in the levee make most of the site open to flooding, the northeast and southwest portions of the site do not receive water directly from the creek during floods below approximately 124.5 m (408.5 ft). Also, a short segment of the levee partitions the northwest portion of the site and hinders connectivity with the remainder of the floodplain west of Sugar Camp Creek (Figure 4).

Several ditches drained the site prior to initial wetland restoration activities, and many of these ditches continue to drain most of the site effectively (Figure 4). IDOT initiated wetland compensation activities at the site by blocking Ditch 5 during May 2005, resulting in a small, persistently inundated area within the FAP 312 compensation site. The remaining unfilled segments of Ditch 5 continue to provide localized drainage. Ditches 3, 4, 6, and 7 remain active, and smaller "scratched" ditches have recently been excavated by the tenant farmer. These ditches also continue to drain the site effectively after storm and flood events. Shallow wells near these ditches show relatively fast drawdown rates, suggesting that the ditches may have a local influence on shallow subsurface water levels. Ditches 1 and 2 approach the site boundary at elevations above the potential wetland restoration areas and could be redirected to provide water to the site.

The possibility that a drainage tile system exists at the site was previously reported in the Initial Site Evaluation (Pociask et al. 2004). However, subsequent examination revealed that what appeared to be drainage tiles may be buried logs that were used as fill material in the former meanders of Sugar Camp Creek. Further, it is unlikely that an extensive drainage tile system would have been installed at the site given the slow flow rates through subsurface materials. Nevertheless, the site should be further examined to determine whether drainage tiles are present.

Wetland Hydrology

Areas that satisfied wetland hydrology criteria were identified at the site for the 2005 and 2006 growing seasons. Wetland hydrology criteria are defined as inundation or saturation to land surface for 10 consecutive days (5%) during the growing season where soils and vegetation criteria are met (Environmental Laboratory 1987). Additionally, areas that are inundated or saturated to land surface for 26 days (12.5%) during the growing season are considered to conclusively satisfy jurisdictional wetland hydrology, and can be used to identify wetland conditions where soils and vegetation data are lacking or inconclusive. Saturation to land surface was determined by measuring water levels in S-wells. Locations where water level was measured within 0.30 m (1.0 ft) of land surface are considered saturated to land surface according to informal guidance from the U.S. Army Corps of Engineers. Inundation was determined by measuring water-level elevation above land surface using electronic data loggers, staff gauges, and field observations. Locations where standing surface water was either measured or observed in the field are considered inundated. For wells and staff gauges where manual water-level measurements were collected, the duration of saturation or inundation was determined by linear interpolation and/or extrapolation. Visual field observations and topographic data were also used to document the extent and duration of saturation or inundation.

For 2005, 4.4 ha (10.9 ac) of the total site area of 50.9 ha (125.7 ac), satisfied wetland hydrology criteria for greater than 5% of the growing season, whereas 1.3 ha (3.1 ac) satisfied wetland hydrology criteria for greater than 12.5% of the growing season (Figure 12). For 2006, 28.8 ha (71.2 ac) satisfied wetland hydrology criteria for greater than 5% of the growing season, whereas 3.9 ha (9.6 ac) satisfied wetland hydrology criteria for greater than 12.5% of the growing season (Figure 13).

The areal extent of wetland hydrology was markedly larger in 2006 compared to 2005. Although IDOT had initiated wetland compensation activities at the site prior to the 2006 growing season, most of the increase in wetland hydrology acreage between 2005 and 2006 was due to frequent, closely-spaced floods that occurred in early May 2006. Precipitation during the early growing season (April-June) in each year was well below the 30-year average. However, a wet period during late April and early May 2006 led to three separate flood events on May 1st, 3rd, and 11th that inundated approximately 21.8, 8.7, and 26.4 ha (53.8, 21.5, and 65.2 ac) of the site, respectively. These floods and preceding storms replenished soil moisture and shallow ground water over large areas of the site, whereas the initial wetland compensation activities influenced hydrology over smaller areas and account for a maximum of 2.4 ha (6.0 ac) of increased wetland hydrology acreage between 2005 and 2006. The similar precipitation totals during the early portion of the growing seasons in 2005 and 2006 coupled with the disparate estimates of wetland hydrology underscore the importance of frequent, closely-spaced flood events for supplying sufficient water to support wetland hydrology. Given the effective drainage in the current condition of the site, widespread wetland hydrology will not occur with sufficient regularity without hydrologic modifications.

CONCLUSIONS

Historical aerial photography and the extent of hydric soils indicate that wetlands covered much of the site until the 1960s. Forest covered as much as 32 ha (78 ac) of the site in 1959, approximating the extent of wetlands on the site at that time. During the 1960s and 1970s, the hydrology of the site was drastically altered. Forested areas were cleared, Sugar Camp Creek was channelized, the former channel was filled, and ditches and levees were constructed. As a result, nearly all former wetlands at the site have been drained. The channelization and incision

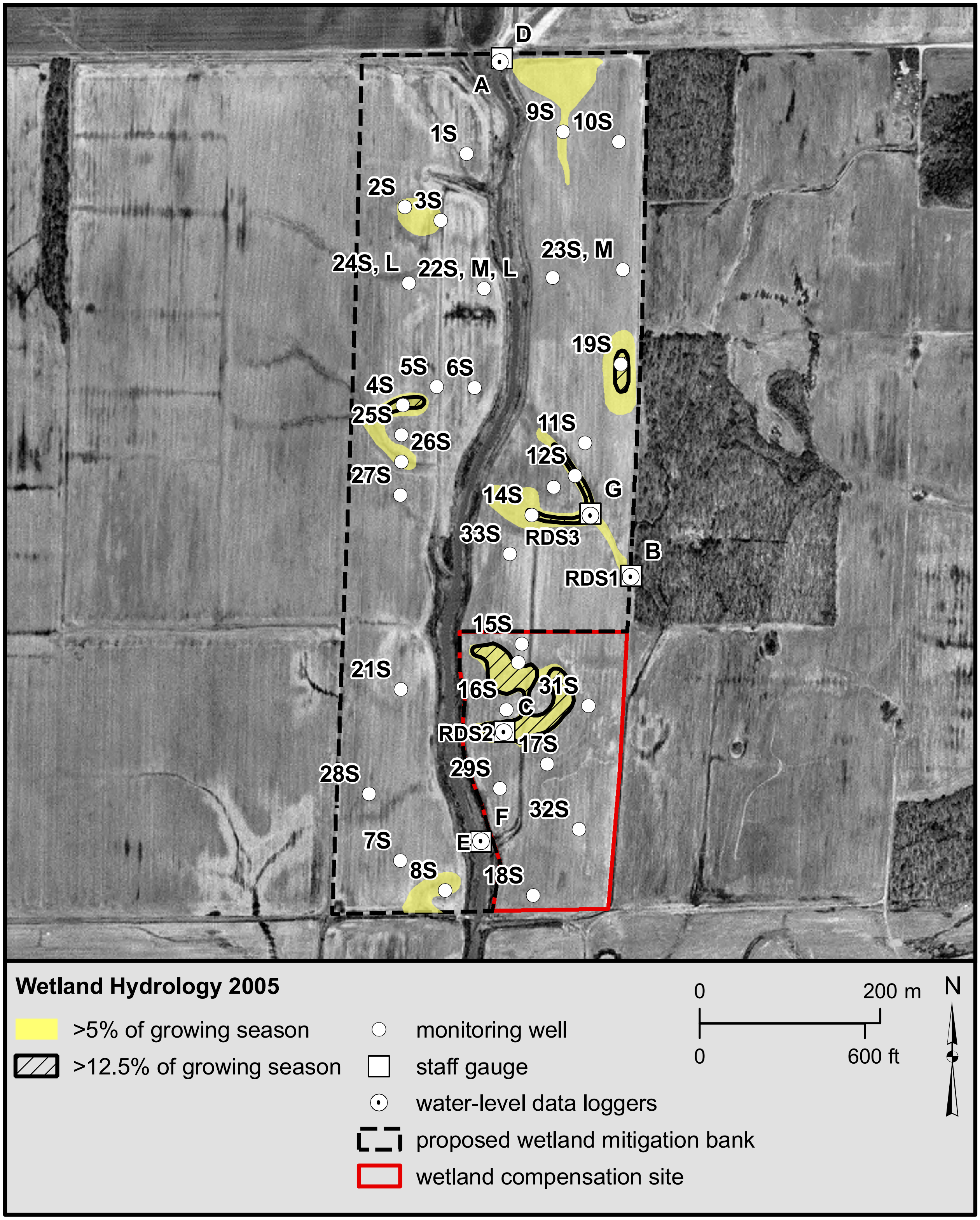

Figure 12 Estimated areal extent of 2005 wetland hydrology at the Sugar Camp Creek proposed wetland mitigation bank and potential compensation site (Fucciolo et al. 2005). The wetland hydrology polygons were drawn based on data collected between March 30 and September 20, 2005. Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

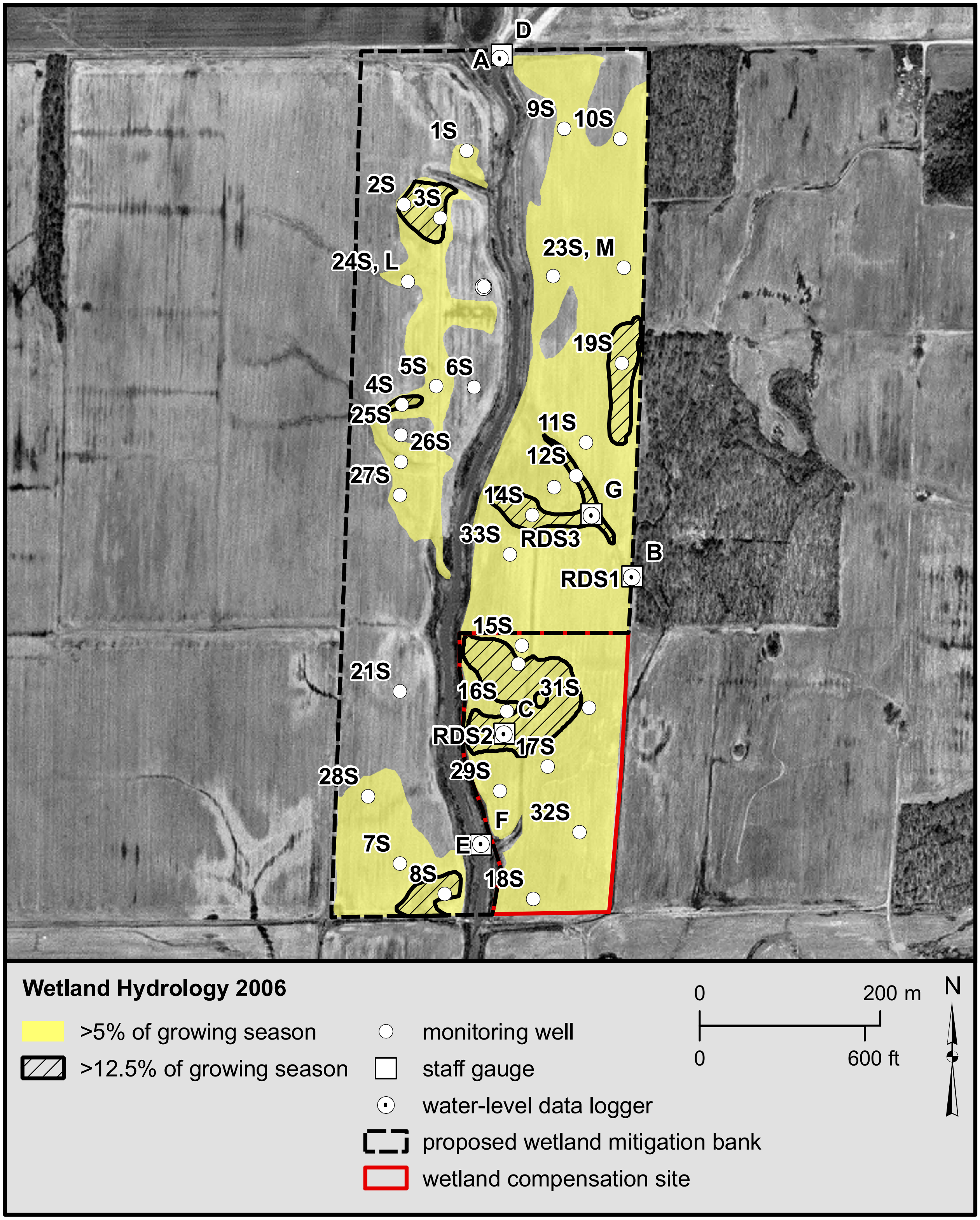

Figure 13 Estimated areal extent of 2006 wetland hydrology at the Sugar Camp Creek proposed wetland mitigation bank and potential compensation site (Fucciolo et al. 2006). The wetland hydrology polygons were drawn based on data collected between September 1, 2005 and June 30, 2006. Map based on USGS digital orthophotography, Ewing SE quarter-quadrangle produced from 4/6/1998 aerial photography (Illinois State Geological Survey 2001).

of Sugar Camp Creek at the site and widespread changes in land use within the watershed preclude complete restoration of the hydrologic conditions that supported past wetlands. However, the presence of slowly permeable geologic materials coupled with frequent flooding over most of the site suggests that hydrogeologic conditions are generally favorable for some restoration of wetland hydrology if various hydrologic alterations are reversed or modified.

Although there are multiple potential water sources, the primary source is frequent, brief flooding from Sugar Camp Creek. Currently, floods replenish surface water in closed depressions and recharge shallow ground water, but the durations of flood peaks are generally too short to satisfy jurisdictional wetland hydrology criteria over much of the site. Contributions from precipitation, runoff, and stormflow in ditches are comparatively minor, although runoff and overland flow from areas west of the site may provide small yet significant contributions. Ground-water contributions at the site are limited, although localized ground-water discharge appears to occur, causing seasonal saturation at land surface along sloped areas in the northwest and west-central portions of the site.

In the current condition of the site, surface water drains quickly after floods and storm events for two primary reasons: the flashy hydrology of Sugar Camp Creek, and the presence of ditches that effectively drain larger depressions. Therefore we recommend that the overall strategy for wetland compensation focus on capturing and retaining water from peak floods and eliminating drainage from all surface depressions. Filling all on-site ditches, modifying levees and building berms and outlets to appropriate threshold elevations will be critical to implementing this strategy.

We estimate that implementation of the wetland compensation recommendations provided in this report could yield between 20 and 32 ha (50 and 80 ac) of restored wetlands, although there is increasing uncertainty toward the upper end of this range because it is difficult to predict how reversal of hydrologic alterations will translate into higher areas of the site. Nevertheless, we suggest reserving the option of creating wetlands by excavating higher parts of the site until after the effects of reversing and modifying existing hydrologic alterations are determined.

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REFERENCES

Admiraal, A.N., M.J. Morris, T.C. Brooks, J.W. Olson, and M.V. Miller, 1997, Illinois Wetland Restoration and Creation Guide: Illinois Natural History Survey Special Publication 19, Champaign, IL, viii + 188 p.

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, IL, 23 p.

Bouwer H. and R. C. Rice, 1976, A Slug Test for Determining Hydraulic Conductivity of Unconfined Aquifers with Completely or Partially Penetrating Wells: Water Resources Research, 12, pages 423-428.

Environmental Laboratory, 1987, Corps of Engineers Wetlands Delineation Manual: Technical Report Y 87-1, U.S. Army Engineer Waterways Experimentation Station, Vicksburg, MS, 100 p., www.saj.usace.army.mil/permit/documents/87manual.pdf.

Fetter, C.W., 1994, Applied Hydrogeology: Macmillan College Publishing, New York, NY, 691 p.

Follmer, L., 2005, Personal communication, Geologist, Illinois State Geological Survey Champaign, IL.

Fucciolo, C.S., S.E. Benton, K.W. Carr, M.V. Miller, J.J. Miner, E.T. Plankell, G.E. Pociask, B.J. Robinson, G.A. Shofner, K.D. Weaver, 2005, Annual Report for Active Wetland Compensation and Hydrologic Monitoring Sites, September 1, 2004 to September 1, 2005: Illinois State Geological Survey Open-File Series 2005-14, Champaign, IL, 228 p.

Fucciolo, Christine S., S. E. Benton, K. W. Carr, C. W. Knight, J. J. Miner, E. T. Plankell, G. E. Pociask, and B. J. R. Sperling, 2006, Annual Report for Active Wetland Compensation and Hydrologic Monitoring Sites, September 1, 2005 to September 1, 2006: Illinois State Geological Survey Open-File Series 2006–04, Champaign, IL, 206 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, IL, map scale 1:500,000, 1 sheet.

Illinois Department of Transportation, in preparation, Wetland Banking Instrument: Sugar Camp Creek Site: Regulatory document submitted to the US Army Corps of Engineers in accordance with Federal Register 1995, 60(228): 58605-58614 (approval pending).

Illinois State Geological Survey, 2001, Illinois Digital Orthophoto Quadrangles: Illinois Geospatial Data Clearinghouse, Champaign, IL, www.isgs.uiuc.edu/nsdihome/webdocs/doqs/.

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

Leighton, M. M., G. E. Ekblaw, and L. Horberg, 1948, Physiographic Divisions of Illinois: Illinois State Geological Survey Report of Investigations 129, Champaign, IL, 19 p.

Lineback, Jerry A., 1979, Quaternary Deposits of Illinois: Illinois State Geological Survey Map Series, Map Scale 1:500,000, Champaign, IL, 1 sheet.

Midwestern Regional Climate Center, 2006, Midwest Climate Information System: Illinois State Water Survey, Champaign, IL, http://mrcc.sws.uiuc.edu/.

Plocher, A. and S. Wiesbrook, 2004, Mitigation Site Assessment for the Willis Property, Franklin County, Illinois: Illinois Natural History Survey, Technical report submitted to the Illinois Department of Transportation, Champaign, IL, 20 p.

Pociask, G. E., B. J. Robinson, G. A. Shofner, and S. E. Benton, 2004, Initial Site Evaluation Willis Property Proposed Wetland Compensation Site: Illinois State Geological Survey, contract report submitted to the Illinois Department of Transportation, Champaign, IL, 24 p.

Preloger, D.E., 2003, Soil Survey of Franklin and Jefferson Counties, Illinois: U. S. Department of Agriculture-Natural Resources Conservation Service in cooperation with Illinois Agricultural Experimentation Station, Champaign, IL, 283 p. + maps.

U.S. Department of Agriculture, 1938, Aerial Photography of Franklin County, Illinois, July 6, 1938, Photo# BGM-1-61, 1:20,000 scale: Agricultural Adjustment Administration, Washington, D.C.

U.S. Department of Agriculture, 1959, Aerial Photography of Franklin County, Illinois, October 16, 1959, Photo# BGM-2W-46,1:20,000 scale: Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT.

U.S. Department of Agriculture, 1971, Aerial Photography of Franklin County, Illinois, September 21, 1971 Photo# BGM-1MM-69,1:20,000 scale: Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT.

U.S. Department of Agriculture, 1980, Aerial Photography of Franklin County, Illinois, October 8, 1980 Photo# 17055 180-50-46, 1:20,000 scale: Farm Service Agency Aerial Photography Field Office, Salt Lake City, UT.

U.S. Department of Agriculture, 1991, Hydric Soils of Illinois (revised December 15, 1995): Natural Resource Conservation Service, unpublished database, Champaign, IL.

U.S. Department of Agriculture, 1995, Hydric Soils by Illinois County: Natural Resource Conservation Service, unpublished database, Champaign, IL.

U.S. Fish and Wildlife Service, 1987, National Wetlands Inventory Map, Ewing Quadrangle, Illinois, Arlington, VA, map scale 1:24,000, 1 sheet.

U.S. Geological Survey, 1974, Ewing Quadrangle, Illinois, 7.5-Minute Series (Topographic): U.S. Department of the Interior, Geological Survey, Reston, VA, map scale 1:24,000. 1 sheet.

Willman, H., E. Atherton, T.C. Buschbach, C. Collinson, J. C. Frye, M.E. Hopkins, J.A. Lineback, and J. Simon, 1975, Handbook of Illinois Stratigraphy: Illinois State Geological Survey Bulletin 95, Champaign, IL, 261 p.

APPENDIX A Geologic Boring Descriptions

Note: Munsell colors were determined only for a few representative borings because the geologic materials in the upper 75 cm were generally uniform. Matrix color of the near-surface materials were generally 10YR or 7.5YR with a few instances of redder hues.

Well Boring (date made)	Depth (cm)	Description
1S - B1 (3/21/05)	0-30	Clayey silt; brown.
	30-72	Clayey silt; light to medium gray; many large (>5cm), decayed wood fragments present; buried log intersected (refusal) at 72 cm.

1S - B2 (3/21/05)	0-30	Clayey silt; brown.
	30-75	Clayey silt; light gray to dark gray; matrix color changes from light to dark at 50 cm; many iron (Fe) concentrations and wood fragments beginning at 60 cm; materials wet at 60 cm, saturated at 65 cm, and standing water was measured at 68 cm depth after completion of the borehole.

2S (3/21/05)	0-76	Clayey silt; brown; moist at 40 cm and saturated near the base of the boring.

3S (3/21/05)	0-75	Clayey silt; brown; Fe concentrations and redox depletions are common; wet at 39 cm and saturated at 65 cm.

4S (3/21/05)	0-40	Clayey silt; brown; redox depletions are common to many.
	40-75	Silty clay to clayey silt; grayish brown; decreasing abundance of redox depletions with depth.

5S (3/21/05)	0-60	Clayey silt; brown; charcoal at 35 cm.
	60-78	Clayey silt; brown; redox depletions observed throughout; few wood fragments.

5SR (11/8/05)	0-65	Clayey silt; 10YR 4/3 (brown); very fine blocky structure; few manganese (Mn) nodules.
	65-75	Clayey silt; bright, abundant mottling; wood fragments at 35 cm; moist between 0 and 50 cm, saturated 50 to 75 cm.

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
6S (3/21/05)	0-77	Clayey silt; brown; few redox depletions and Fe concentrations within 30 cm of surface; varying from dry to slightly moist.

Well Boring (date made)	Depth (cm)	Description
7S (3/21/05)	0-55	Clayey silt; light brown; grades to silty clay between 40 and 55 cm; few to common redox depletions and Fe concentrations.
	55-75	Silty clay; grayish brown to gray; abundance of redox depletions and Fe concentrations greater than above; moisture increases with depth but material is not saturated.

Well Boring (date made)	Depth (cm)	Description
8S (3/21/05)	0-35	Clayey silt; brown.
	35-76	Clayey silt; light brown; redox depletions are common; moisture greater than above but material is not saturated.

Well Boring (date made)	Depth (cm)	Description
9S (3/21/05)	0-15	Silty clay; brown.
	15-75	Clayey silt; light brown to yellowish colors (value>=5, chroma>=3); few Fe/Mn concentrations and a few nodules; moist.

Well Boring (date made)	Depth (cm)	Description
10S (3/21/05)	0-20	Silty clay; brown.
	20-76	Clayey silt; mottled; few 1 to 2 mm Mn nodules; very moist near the base of the boring but no free water in the hole.

Well Boring (date made)	Depth (cm)	Description
11S (3/21/05)	0-77	Silty clay; light brown to yellowish colors (value>=5, chroma>=3); dry.

Well Boring (date made)	Depth (cm)	Description
12S (3/21/05)	0-45	Silty clay; light brown.
	45-50	Sandy silt; brown.
	50-80	Clayey silt with sand and organics; medium gray matrix color, darker (lower value) than above; common mottling with reddish concentrations surrounding organics and on peds; strong, blocky structure; many very fine roots; (hydrogen sulfide) H_2S odor present; saturated at 78cm.

Well Boring (date made)	Depth (cm)	Description
13S (3/21/05)	0-20	Clayey silt; brown
	20-79	Clayey silt; brown; few to common 1- to 2-cm mottles as redox depletions and Fe concentrations; small fragments of decayed wood; saturated below 40 cm.

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
14S (3/21/05)	0-10	Silty clay; brown.
	10-76	Clayey silt to sandy silt and sand; interbedded below 40 cm and 1-mm laminations near base; few, fine to very fine roots with common depletion haloes; dry.
15S (3/21/05)	0-77	Clayey silt; brown to brownish yellow (value>=5, chroma>=3); few Fe/Mn concentrations and a few nodules; slightly moist.
16S (3/21/05)	0-20	Clayey silt; brown.
	20-50	Clayey silt; brown; common, distinct redox concentrations and depletions.
	50-60	Clayey silt with sand; moisture content greater than above.
	60-76	Clayey silt; light brown matrix; few concentrations and depletions; near saturated.
17S (3/21/05)	0-10	Clayey silt; brown.
	10-74	Clayey silt; brown; few to common redox depletions and concentrations; wood fragments and charcoal present; moist.
18S (3/21/05)	0-76	Clayey silt; brown; common concentrations and depletions; near saturated at base of boring.
19S (3/21/05)	0-75	Clayey silt; brown; mottles, Fe concentrations, and Mn nodules are common.
20S (3/21/05)	0-79	Clayey silt; light brown to yellowish colors (value >= 5, chroma >= 3); few Fe/Mn concentrations and a few nodules; saturated at 45 cm.
21S (3/21/05)	0-75	Clayey silt; red; dry.
22S (4/7/05)	0-76	Clayey silt; 10YR 5/4 (yellowish brown); few depletions and concentrations; moist to saturated at base of boring.
23S (4/7/05)	0 – 76	Clayey silt; redox depletions and concentrations within the upper 17 cm; saturated at 70 cm.

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
24S (11/8/05)	0-77	No log recorded - see description for 24 L
25S (11/8/05)	0-75	Clayey silt; 10YR 4/4 (dark yellowish brown); no redox features evident.
26S (11/8/05)	0-15	Clayey silt; 10YR 4/3 (brown); few Fe concentrations.
	15-60	Clayey silt; 10YR 6/3 (pale brown); common Fe concentrations up to 5 mm diameter.
	60-75	bright, abundant mottling; disturbed soil, similar to the boring for well 5SR.
27S (11/8/05)	0-20	Clayey silt; 10YR 4/3 (brown); few, 1-mm Fe concentrations.
	20-35	Clayey silt; 10YR 4/3 (brown); common 10YR 6/2 (light brownish grey); redox depletions and Fe concentrations common.
	35-77	Clayey silt; 10YR 4/3 (brown); distinct mottling; many redox depletions and Fe concentrations; very moist to wet.
28S (11/8/05)	0-15	Clayey silt; 10YR 4/3 (brown); few Fe concentrations.
	15-45	Clayey silt; 10YR 4/3 (brown); common 10YR 6/2 (light brownish gray) depletions and few Mn nodules (up to 1cm).
	45-75	Clayey silt, 10YR 6/2 (light brownish gray); common Fe concentration occuring as soft masses.
29S (11/9/05)	0-78	Clayey silt grading to silty clay below 40 cm; 10YR 4/3 to 10YR 4/4 (brown to dark yellowish brown); common to many redox depletions and concentrations each increasing in size with depth; moist near surface to near saturation at base of borehole.
30S (11/9/05)	0-74	Clayey silt; gray matrix with abundant reddish redox concentrations; slightly moist in upper few cm, dry to ~40 cm, then increasing moisture with depth but not saturated.
31S (11/9/05)	0-76	Clayey silt; 10YR4/4 (dark yellowish brown); few redox depletions; moist above 55 cm, near saturated below 55 cm.
32S (11/29/05)	0-78	Clayey silt; common redox features within the upper 15 cm; saturated at 78 cm and water level rose to 60 cm depth within 2-minute period after completion of the boring.

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
33S (11/29/05)	0-75	Clayey silt; brown; common redox concentrations; saturated at 70 cm; borehole filled with water to 40 cm within 2 minute period after completion of the boring.

20M (11/29/05)	0-141	No log recorded; see 20L.

20L (11/29/05)	0-15	Clayey silt; dark grayish brown; few to common depletions and concentrations; moist to nearly saturated.
	15-50	Clayey silt; light to medium gray matrix; common to many orangish redox concentrations that are more distinct than above.
	50-80	Silty clay; colors similar to above with many distinct redox features (depletions and concentrations); blocky structure.
	80-90*	Silty clay; matrix colors are a 50/50 mix of brownish gray and medium gray; few concentrations; very moist to saturated.
	90-100	Silty clay; common to many Mn nodules and concentrations; clay content slightly greater than above; fine to medium blocky structure; very moist to saturated.
	100-120	Silty clay; common Fe concentrations; sandy appearance due to abundance of Mn nodules and concretions; very moist to saturated.
	120-140	Silty clay; brownish gray; common to many depletions; few Fe concentrations; very moist to saturated.
	140-150	Clayey silt with sand; brownish gray; common dark grey depletions; sand is composed of coarse Mn nodules and medium, subangular quartz grains; very moist to saturated.
	150-185	Clayey silt with sand; brownish gray; common to many Fe concentrations and depletions; medium to coarse Mn concentrations; materials drier below 170 cm, moist but not saturated.
	185-235	Clayey silt; brownish gray; blocky structure; many, coarse Fe concentrations and depletions zonally distributed.
	235-280	Clayey silt, grading to clay; dark gray; common depletions and Fe concentrations.
	280-306	Silty clay to clay, dark gray; few to common Mn concentrations;
	*Note: At time the boring was made, there was ponded water at the surface and materials in upper ~1.7 m were very moist to saturated. Surface water and seepages from the soil zone entered the borehole. Textures below 80 cm were difficult to determine using ribbon test, especially where wet, but materials were generally very sticky to stiff (like modeling clay).	

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
22M (4/7/05)	0-178	No log recorded, but similar to the same interval in 22L
22L (4/7/2005)	0-180	Clayey silt; 10YR 5/4 (brown); greater clay content below 100 cm; saturated below 80 cm, seepage encountered at 120 cm and water level rose from 120 cm to 100 cm depth within 1 minute after pausing excavation at 120 cm.
	180-260	Clayey silt; light to medium gray; common to many distinct Fe concentrations.
	260-280	clayey silt with sand to sandy silt; sand consists of fine to very fine quartz grains; mottled with many, coarse Fe and Mn concretions.
	280-299	Silty clay;10YR 5/8 (yellowish brown); light gray; many, coarse concentrations; moisture content is less than above.
23M (4/7/2005)	0-25	Clayey silt; dark brown.
	25-100	Clayey silt; gray; distinct 10YR5/6 (yellowish brown) concentrations; Mn nodules observed between below 60 cm; saturated at 95 cm.
	100-190	Clayey silt to silty clay; mottled brown, yellowish brown, and gray; common Mn nodules and Fe concretions increasing in abundance with depth; strong soil structure near the base of the boring.
24L (11/8/2005)	0-25	Clayey silt; 10YR4/4 (dark yellowish brown); common 1-mm Mn nodules; very fine blocky structure; moist
	25-75	Clayey silt grading to silty clay; 2.5Y 5/4 (light olive brown); common, 2.5Y 6/2 (light brownish gray) depletions; 1-mm Mn nodules and Fe concentrations; medium granular structure; moist
	75-337	Clayey silt; 2.5Y5/4 (light olive brown); common gray (2.5Y6/1) depletions and many Fe masses; increased moisture content with depth (not saturated).

APPENDIX A Geologic Boring Descriptions

Well Boring (date made)	Depth (cm)	Description
S1 (2/7/2006)	0-20	Clayey silt; 10YR 4/4 (dark yellowish brown).
	20-75	Clayey silt; 10YR 7/2 (light gray); common to many, distinct yellowish brown (10YR5/6) stains along peds and root channels; increasing moisture with depth.
	75-115	Silty clay; 10YR 7/2 (light gray) and 10YR 5/6 (yellowish brown); distinct textural boundary with overlying materials at 75 cm; many, coarse (>3 cm) mottles; saturated at 85 cm.
	115-180	Clayey silt to silty clay; 10YR 6/1 (gray); many, distinct yellowish brown (10YR 5/6) mottles; texture varies roughly every 10 to 20 cm from sandy silt to silty clay; reddish colors below 165 cm; moist but not saturated.

S2 (2/7/2006)	0-20	Clayey silt; 10YR 4/4 (dark yellowish brown).
	20-135	Clayey silt; 10YR 5/6 (yellowish brown); few, prominent mottles between 20 to 70 cm, becoming common below 70 cm, occuring as pale brown (10YR 6/3) depletions and yellowish brown (10YR 5/8) Fe masses along peds; higher clay content below 110 cm.
	135-200	Clayey silt with sand grading to sand, silt, and clay; distinct mottling with abundant Mn masses; organics (plant stems) between 195 and 200 cm; saturation and seepage into borehole at 140 cm.
	200-220	Sandy silt; 7.5YR 7/1 (light gray); many, prominent strong brown (7.5YR 5/8) mottles occuring as Mn masses 1 to 1.5 cm in diameter; wet, not saturated.
	220-267	Sand, silt, and clay; coarse strong brown mottles, coarse Mn masses, and fine Fe concretions; saturated below 260 cm.

APPENDIX B Well-Construction Information

Well Construction Information	1S	2S	3S	4S	5S	5SR	6S	7S	8S
Date installed	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05	11/08/05	03/21/05	03/21/05	03/21/05
Total length of well (m)	1.91	1.95	1.93	1.91	1.87	1.92	1.88	1.92	1.88
Screen length (m)	0.31	0.30	0.30	0.30	0.29	0.32	0.30	0.31	0.29
Depth of borehole (m) *	0.75	0.76	0.75	0.75	0.76	0.75	0.77	0.75	0.76
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) *	0.30	0.30	0.30	0.30	0.31	0.30	0.30	0.31	0.31
Sand pack - bottom (m) *	0.75	0.76	0.75	0.75	0.76	0.75	0.77	0.75	0.76
Depth to top of screen (m) *	0.40	0.41	0.43	0.40	0.45	0.42	0.43	0.40	0.44
Depth to bottom of screen (m) *	0.71	0.71	0.73	0.70	0.74	0.74	0.72	0.71	0.73

* referenced to land surface

Well Construction Information	9S	10S	11S	12S	13S	14S	15S	16S	17S
Date installed	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05	03/21/05
Total length of well (m)	1.95	1.91	1.91	1.91	1.91	1.87	1.88	1.93	1.89
Screen length (m)	0.31	0.30	0.30	0.31	0.30	0.28	0.29	0.31	0.29
Depth of borehole (m) *	0.75	0.76	0.77	0.77	0.79	0.76	0.77	0.76	0.74
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) *	0.30	0.30	0.31	0.30	0.32	0.31	0.30	0.31	0.30
Sand pack - bottom (m) *	0.75	0.76	0.77	0.77	0.79	0.76	0.77	0.76	0.74
Depth to top of screen (m) *	0.40	0.45	0.43	0.45	0.47	0.44	0.44	0.42	0.42
Depth to bottom of screen (m) *	0.71	0.75	0.74	0.76	0.76	0.72	0.73	0.72	0.71

* referenced to land surface

Well Construction Information	18S	19S	20S	20M	20L	21S	22S	22M	22L
Date installed	03/21/05	03/21/05	03/21/05	11/29/05	11/29/05	03/21/05	04/07/05	04/07/05	04/07/05
Total length of well (m)	1.91	1.91	1.91	1.86	3.40	1.93	1.95	2.76	4.29
Screen length (m)	0.30	0.31	0.30	0.25	0.23	0.33	0.37	0.07	0.32
Depth of borehole (m) *	0.76	0.75	0.76	1.41	3.06	0.76	0.76	1.78	2.99
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) *	0.31	0.31	0.30	1.00	2.60	0.29	0.30	1.50	2.51
Sand pack - bottom (m) *	0.76	0.75	0.76	1.41	3.06	0.76	0.76	1.78	2.99
Depth to top of screen (m) *	0.40	0.40	0.42	1.12	2.79	0.37	0.27	1.66	2.56
Depth to bottom of screen (m) *	0.70	0.71	0.72	1.36	3.02	0.70	0.64	1.73	2.88

* referenced to land surface

APPENDIX B Well-Construction Information

Well Construction Information	23S	23M	24S	24L	25S	26S	27S
Date installed	04/07/05	04/07/05	11/08/05	11/08/05	11/08/05	11/08/05	11/08/05
Total length of well (m)	1.48	2.09	1.95	3.69	1.90	1.95	1.94
Screen length (m)	0.25	0.30	0.29	0.46	0.30	0.34	0.27
Depth of borehole (m) *	0.76	1.19	0.77	3.32	0.76	0.76	0.77
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.31	0.83	0.31	2.52	0.31	0.30	0.31
Sand pack - bottom (m) *	0.76	1.19	0.77	3.32	0.76	0.76	0.77
Depth to top of screen (m) *	0.43	0.82	0.46	2.82	0.42	0.40	0.47
Depth to bottom of screen (m) *	0.68	1.13	0.75	3.27	0.72	0.74	0.74

* referenced to land surface

Well Construction Information	28S	29S	30S	31S	32S	33S
Date installed	11/08/05	11/09/05	11/09/05	11/09/05	11/29/05	11/29/05
Total length of well (m)	1.94	1.95	1.96	1.95	1.88	1.93
Screen length (m)	0.32	0.33	0.32	0.33	0.30	0.33
Depth of borehole (m) *	0.75	0.78	0.74	0.76	0.78	0.75
Bentonite seal - top (m) *	0.00	0.00	0.00	0.00	0.00	0.00
Sand pack - top (m) *	0.31	0.30	0.29	0.30	0.31	0.29
Sand pack - bottom (m) *	0.75	0.78	0.74	0.76	0.78	0.75
Depth to top of screen (m) *	0.40	0.42	0.38	0.42	0.48	0.39
Depth to bottom of screen (m) *	0.72	0.75	0.70	0.75	0.78	0.72

* referenced to land surface

APPENDIX C Depths To Water
(in meters referenced to land surface)

Date	03/30/05	04/06/05	04/12/05	04/18/05	04/27/05	05/02/05	05/16/05	06/01/05
Well 1S	**-0.08**	**0.28**	0.31	0.47	0.46	0.39	0.53	dry
Well 2S	**-0.06**	**0.14**	**0.06**	0.44	0.34	0.31	0.38	dry
Well 3S	**-0.06**	**0.21**	**0.25**	0.54	0.31	**0.24**	0.31	dry
Well 4S	**-0.15**	**-0.09**	**-0.06**	0.45	**0.30**	**-0.06**	**-0.03**	dry
Well 5S	**0.17**	0.33	0.35	0.54	0.44	0.39	0.56	dry
Well 5SR	**	**	**	**	**	**	**	**
Well 6S	**0.15**	0.52	0.61	dry	dry	dry	dry	dry
Well 7S	**0.03**	0.40	0.43	0.58	0.46	0.38	0.65	dry
Well 8S	**-0.09**	**0.24**	**0.19**	0.33	**0.23**	**0.27**	0.39	dry
Well 9S	**-0.06**	**-0.02**	**0.01**	0.48	0.38	0.33	dry	dry
Well 10S	**0.09**	0.44	0.47	dry	dry	0.48	0.70	dry
Well 11S	**0.00**	**0.30**	0.34	0.60	0.56	0.40	0.61	dry
Well 12S	**-0.03**	**0.01**	**0.01**	0.39	**0.23**	**0.14**	**0.27**	0.69
Well 13S	**0.06**	0.35	0.42	0.65	0.67	0.45	0.68	dry
Well 14S	**-0.13**	**-0.06**	**-0.04**	0.33	**0.08**	**-0.01**	**0.24**	dry
Well 15S	**0.13**	0.49	0.64	dry	dry	dry	dry	dry
Well 16S	**0.12**	0.56	0.65	dry	dry	0.62	dry	dry
Well 17S	**-0.02**	**0.29**	**0.28**	0.47	0.36	0.33	0.46	dry
Well 18S	**-0.03**	0.36	0.40	0.55	0.52	0.44	0.55	dry
Well 19S	**-0.08**	**0.04**	**-0.04**	0.36	**0.24**	**0.00**	**0.23**	dry
Well 20S	**-0.03**	0.34	0.42	0.69	0.69	0.54	dry	dry
Well 20M	**	**	**	**	**	**	**	**
Well 20L	**	**	**	**	**	**	**	**
Well 21S	**0.13**	0.47	0.57	dry	dry	0.51	dry	dry
Well 22S	**	**	RDS	RDS	RDS	dry	RDS	RDS
Well 22M	**	**	0.70	0.90	0.98	0.88	1.11	1.46
Well 22L	**	**	0.70	*	0.98	0.88	1.11	1.43
Well 23S	**	**	0.39	0.64	0.57	0.36	0.45	dry
Well 23M	**	**	0.36	0.60	0.49	0.33	0.43	0.99
Well 24S	**	**	**	**	**	**	**	**
Well 24L	**	**	**	**	**	**	**	**
Well 25S	**	**	**	**	**	**	**	**
Well 26S	**	**	**	**	**	**	**	**
Well 27S	**	**	**	**	**	**	**	**
Well 28S	**	**	**	**	**	**	**	**
Well 29S	**	**	**	**	**	**	**	**
Well 30S	**	**	**	**	**	**	**	**
Well 31S	**	**	**	**	**	**	**	**
Well 32S	**	**	**	**	**	**	**	**
Well 33S	**	**	**	**	**	**	**	**

S soil-zone well
M middle well
L lower well
R replacement well

* no measurement
** not yet installed
\- water above land surface
bold depth values less than or equal to 0.30 m

APPENDIX C Depths To Water
(in meters referenced to land surface)

Date	07/06/05	08/01/05	09/06/05	10/06/05	11/09/05	12/06/05	01/13/06	02/06/06
Well 1S	dry	dry	0.58	0.39	dry	**0.12**	**-0.10**	**-0.07**
Well 2S	dry	dry	dry	dry	dry	0.44	**-0.04**	**0.02**
Well 3S	dry	dry	dry	0.40	dry	**0.08**	**-0.08**	**-0.04**
Well 4S	dry	dry	0.41	**0.02**	dry	**-0.08**	**-0.13**	**-0.11**
Well 5S	dry	damaged	damaged	damaged	damaged	damaged	damaged	damaged
Well 5SR	**	**	**	**	**	0.33	**0.01**	**0.16**
Well 6S	dry	dry	dry	dry	dry	0.60	0.51	0.34
Well 7S	dry	dry	dry	dry	dry	0.59	**0.00**	**0.19**
Well 8S	dry	dry	dry	0.56	dry	**0.29**	**-0.05**	**0.03**
Well 9S	dry	dry	0.52	0.46	dry	frozen	**-0.07**	**-0.04**
Well 10S	dry	dry	dry	dry	dry	dry	**-0.01**	**0.29**
Well 11S	dry	dry	dry	dry	dry	0.32	**-0.01**	**0.10**
Well 12S	dry	dry	dry	**0.19**	0.59	**0.09**	**-0.04**	**-0.02**
Well 13S	dry	dry	dry	dry	dry	0.49	**0.12**	**0.26**
Well 14S	dry	dry	**0.23**	**-0.05**	0.57	**-0.07**	**-0.12**	**-0.10**
Well 15S	dry	dry	dry	dry	dry	0.44	**0.00**	**0.26**
Well 16S	dry	dry	dry	0.54	0.63	0.43	**0.03**	**0.23**
Well 17S	dry	dry	0.55	**0.19**	0.60	**0.08**	**-0.05**	**-0.03**
Well 18S	dry	dry	0.50	**0.13**	0.61	**0.02**	**-0.05**	**-0.04**
Well 19S	dry	dry	dry	0.56	dry	frozen	**-0.09**	**-0.07**
Well 20S	dry	dry	dry	dry	dry	0.44	**-0.03**	**0.02**
Well 20M	**	**	**	**	**	0.49	**0.00**	**0.11**
Well 20L	**	**	**	**	**	0.85	*	0.51
Well 21S	dry	dry	dry	dry	dry	0.47	**0.06**	0.33
Well 22S	RDS	RDS	dry	dry	dry	dry	**0.19**	0.37
Well 22M	dry	dry	dry	1.68	dry	0.78	**0.23**	0.37
Well 22L	1.88	2.26	2.12	1.76	1.81	0.82	**0.26**	0.38
Well 23S	dry	dry	dry	dry	dry	0.45	**0.01**	0.44
Well 23M	dry	dry	dry	dry	dry	0.42	**0.01**	**0.23**
Well 24S	**	**	**	**	**	0.49	**-0.02**	**0.23**
Well 24L	**	**	**	**	**	**0.27**	*	**0.19**
Well 25S	**	**	**	**	**	dry	**0.19**	0.53
Well 26S	**	**	**	**	**	0.39	**-0.01**	**0.27**
Well 27S	**	**	**	**	**	0.55	**0.01**	**0.27**
Well 28S	**	**	**	**	**	0.49	**-0.01**	**0.13**
Well 29S	**	**	**	**	**	0.31	**-0.02**	**0.02**
Well 30S	**	**	**	**	**	**0.11**	**-0.03**	**0.01**
Well 31S	**	**	**	**	**	**0.24**	**0.01**	**0.04**
Well 32S	**	**	**	**	**	**0.21**	**-0.03**	**-0.01**
Well 33S	**	**	**	**	**	0.53	**0.05**	0.34

S soil-zone well
M middle well
L lower well
R replacement well

* no measurement
** not yet installed
\- water above land surface
bold depth values less than or equal to 0.30 m

APPENDIX C Depths To Water

(in meters referenced to land surface)

Date	03/06/06	04/03/06	04/10/06	04/18/06	05/04/06
Well 1S	**0.25**	**-0.09**	**-0.07**	0.43	**-0.05**
Well 2S	**0.12**	**0.02**	**0.15**	0.49	**0.01**
Well 3S	**0.19**	**-0.03**	**-0.02**	0.56	**-0.08**
Well 4S	**-0.09**	**-0.10**	**-0.12**	0.31	**-0.14**
Well 5S	damaged	damaged	damaged	damaged	damaged
Well 5SR	0.36	**0.12**	**0.26**	0.66	**0.03**
Well 6S	0.64	0.36	0.45	dry	0.67
Well 7S	0.41	**0.10**	0.33	0.63	**0.22**
Well 8S	**0.23**	**0.07**	**0.02**	0.44	**-0.10**
Well 9S	**0.00**	**-0.04**	**-0.06**	0.36	**-0.07**
Well 10S	0.46	**0.14**	**0.29**	dry	**0.05**
Well 11S	0.37	**0.07**	**0.22**	0.58	**0.00**
Well 12S	**0.09**	**-0.06**	**-0.03**	0.41	**-0.18**
Well 13S	0.54	**0.11**	**0.25**	dry	**0.03**
Well 14S	**-0.03**	**-0.09**	**-0.10**	0.36	**-0.18**
Well 15S	0.47	**0.21**	0.36	0.65	**0.15**
Well 16S	0.37	**0.24**	0.35	0.61	**0.16**
Well 17S	**0.09**	**-0.04**	**-0.02**	0.42	**-0.04**
Well 18S	**0.05**	**-0.07**	**-0.05**	0.47	**-0.06**
Well 19S	**-0.04**	**-0.07**	**-0.06**	**0.30**	**-0.09**
Well 20S	0.46	**0.03**	**0.19**	0.64	**-0.01**
Well 20M	0.53	**0.07**	**0.21**	0.65	**0.01**
Well 20L	0.81	0.46	0.48	0.87	0.38
Well 21S	0.52	**0.24**	0.40	0.65	0.62
Well 22S	dry	0.42	0.50	dry	0.51
Well 22M	0.69	0.44	0.53	0.86	0.52
Well 22L	0.71	0.45	*	0.85	*
Well 23S	0.40	**0.13**	**0.28**	0.64	**0.06**
Well 23M	0.41	**0.09**	**0.24**	0.64	**0.04**
Well 24S	0.42	**0.10**	0.31	dry	**-0.02**
Well 24L	0.44	**0.09**	**0.03**	0.69	**0.28**
Well 25S	dry	0.49	0.56	dry	0.51
Well 26S	0.37	**0.07**	**0.28**	0.65	**-0.04**
Well 27S	0.58	**0.12**	0.39	dry	**0.06**
Well 28S	0.42	**0.05**	**0.21**	0.60	**0.06**
Well 29S	**0.24**	**0.03**	**0.16**	0.45	**-0.02**
Well 30S	**0.04**	**0.01**	**0.00**	**0.19**	**-0.08**
Well 31S	**0.18**	**0.02**	**0.14**	0.52	**0.03**
Well 32S	**0.19**	**0.00**	**0.11**	0.53	**0.00**
Well 33S	0.58	0.34	0.44	dry	**0.23**

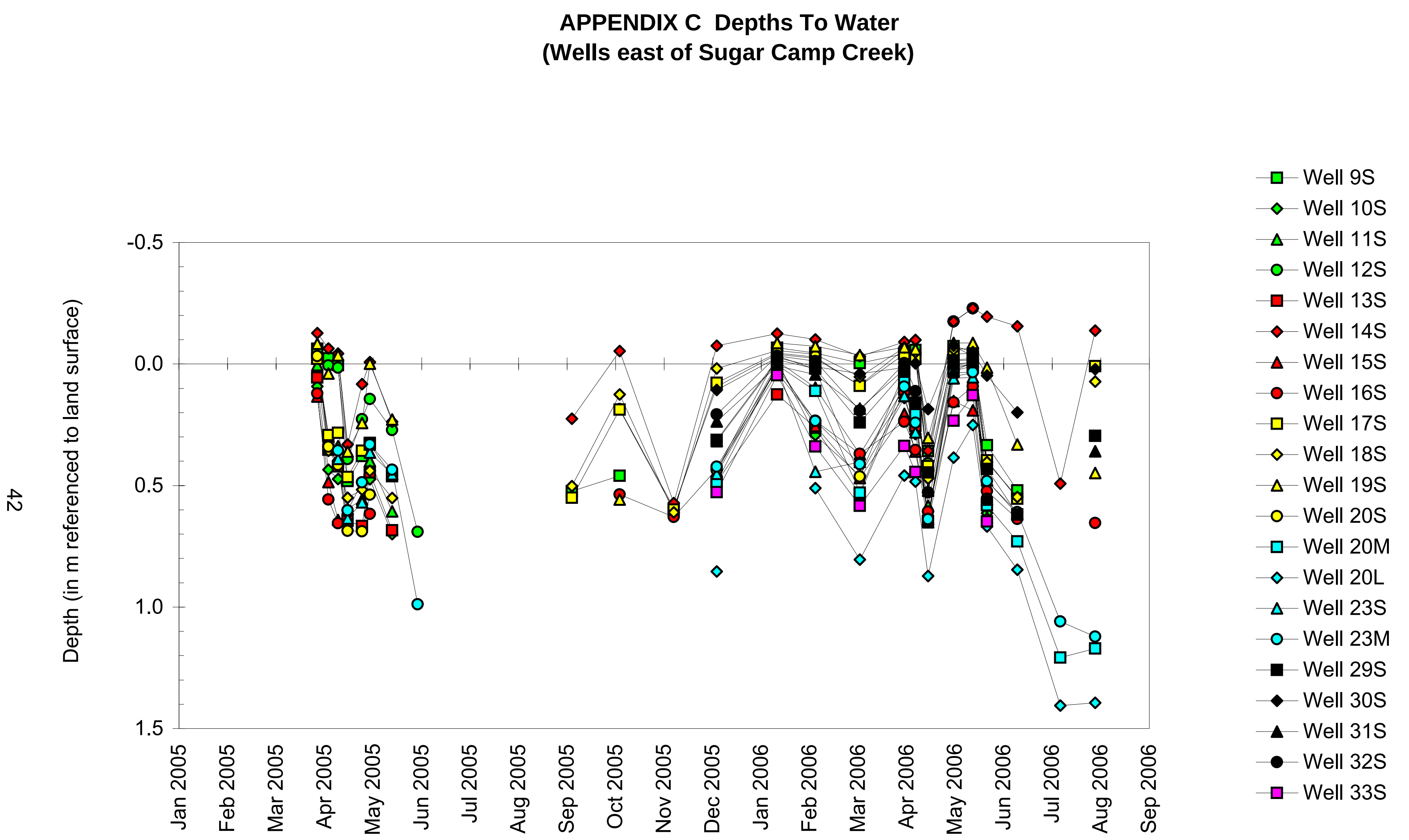
S soil-zone well
M middle well
L lower well
R replacement well

* no measurement
** not yet installed
− water above land surface
bold depth values less than or equal to 0.30 m

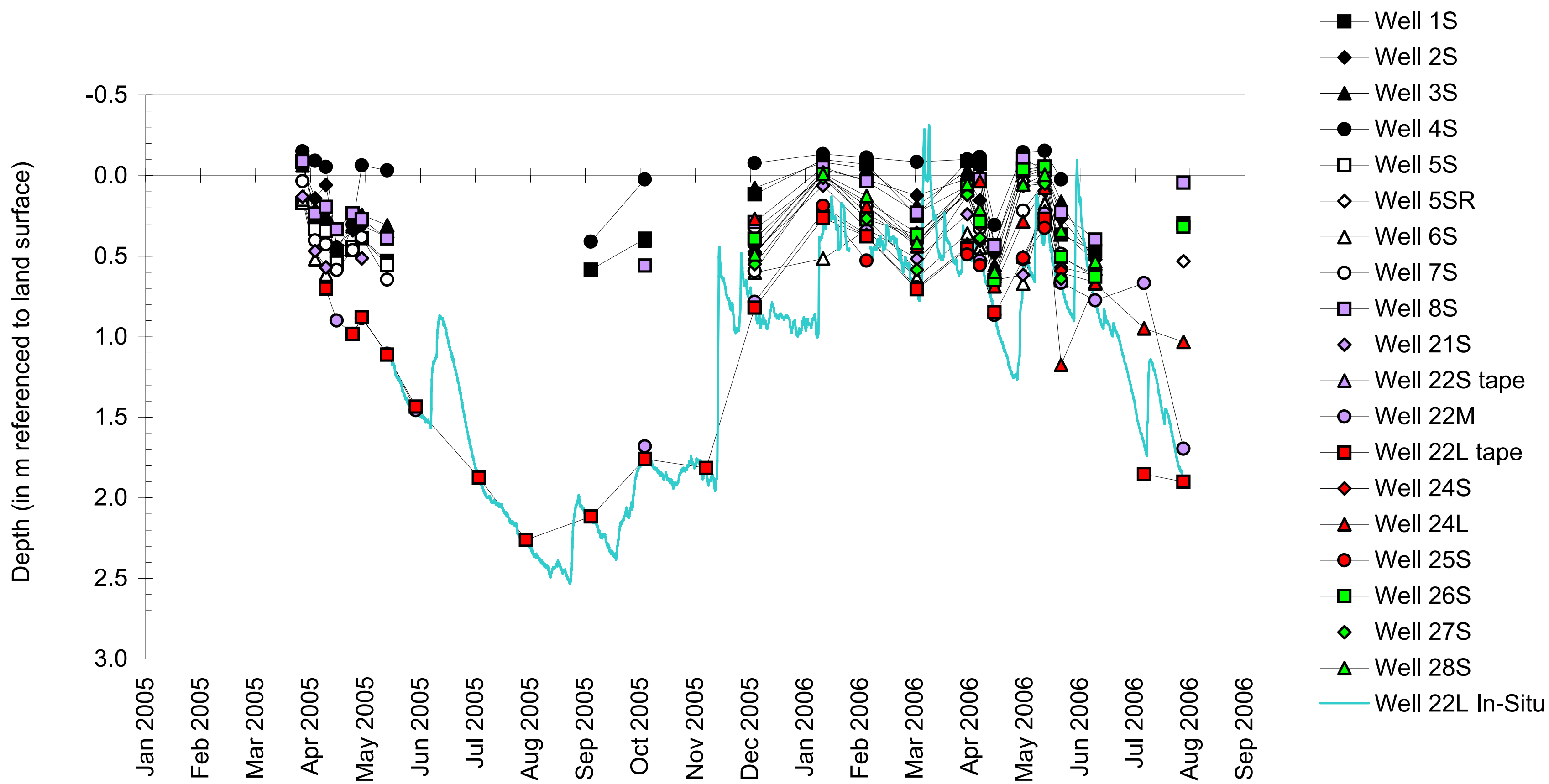
APPENDIX C Depths To Water
(in meters referenced to land surface)

Date	05/16/06	05/25/06	06/13/06	07/10/06
Well 1S	**-0.04**	0.37	0.47	dry
Well 2S	**-0.04**	**0.27**	0.52	dry
Well 3S	**-0.07**	**0.16**	0.54	dry
Well 4S	**-0.15**	**0.02**	damaged	damaged
Well 5S	damaged	damaged	damaged	damaged
Well 5SR	**0.04**	0.51	0.61	dry
Well 6S	**0.17**	0.60	0.66	dry
Well 7S	**0.04**	0.49	dry	dry
Well 8S	**-0.03**	**0.23**	0.40	dry
Well 9S	**-0.03**	0.33	0.52	dry
Well 10S	**0.04**	0.61	dry	dry
Well 11S	**0.01**	0.41	dry	dry
Well 12S	**-0.23**	damaged	damaged	damaged
Well 13S	**0.01**	0.42	dry	dry
Well 14S	**-0.23**	**-0.20**	**-0.16**	0.49
Well 15S	**0.19**	0.63	dry	dry
Well 16S	**0.09**	0.52	0.64	dry
Well 17S	**-0.04**	0.40	0.55	dry
Well 18S	**-0.06**	0.40	0.55	dry
Well 19S	**-0.09**	**0.01**	0.33	dry
Well 20S	**-0.02**	0.58	dry	dry
Well 20M	**0.00**	0.58	0.73	1.21
Well 20L	**0.25**	0.67	0.85	1.40
Well 21S	**0.09**	0.57	0.62	dry
Well 22S	**0.22**	0.65	dry	dry
Well 22M	**0.24**	0.67	0.77	0.67
Well 22L	**0.27**	*	*	1.85
Well 23S	**0.06**	0.48	0.62	dry
Well 23M	**0.03**	0.48	0.61	1.06
Well 24S	**-0.04**	0.59	dry	dry
Well 24L	**0.08**	1.17	0.67	0.95
Well 25S	0.33	dry	dry	dry
Well 26S	**-0.06**	0.51	0.63	dry
Well 27S	**0.05**	0.64	dry	dry
Well 28S	**-0.01**	0.34	0.53	dry
Well 29S	**-0.02**	0.43	0.62	dry
Well 30S	**-0.05**	**0.05**	**0.20**	dry
Well 31S	**-0.01**	0.56	dry	dry
Well 32S	**-0.01**	0.56	dry	dry
Well 33S	**0.13**	0.65	*	dry

S	soil-zone well	*	no measurement
M	middle well	**	not yet installed
L	lower well	-	water above land surface
R	replacement well	**bold**	depth values less than or equal to 0.30 m


APPENDIX C Depths To Water
(Wells east of Sugar Camp Creek)
Depth (in m referenced to land surface)
-0.5
0.0
0.5
1.0
1.5
Jan 2005
Feb 2005
Mar 2005
Apr 2005
May 2005
Jun 2005
Jul 2005
Aug 2005
Sep 2005
Oct 2005
Nov 2005
Dec 2005
Jan 2006
Feb 2006
Mar 2006
Apr 2006
May 2006
Jun 2006
Jul 2006
Aug 2006
Sep 2006
Well 9S
Well 10S
Well 11S
Well 12S
Well 13S
Well 14S
Well 15S
Well 16S
Well 17S
Well 18S
Well 19S
Well 20S
Well 20M
Well 20L
Well 23S
Well 23M
Well 29S
Well 30S
Well 31S
Well 32S
Well 33S

APPENDIX C Depths To Water
(Wells west of Sugar Camp Creek)



APPENDIX D Water-Level Elevations
(in meters referenced to North American Vertical Datum, 1988)

Date	03/30/05	04/06/05	04/12/05	04/18/05	04/27/05	05/02/05	05/16/05	06/01/05
Well 1S	123.66	123.30	123.27	123.11	123.12	123.19	123.05	dry
Well 2S	124.73	124.52	124.60	124.22	124.32	124.35	124.28	dry
Well 3S	124.12	123.85	123.80	123.51	123.74	123.81	123.74	dry
Well 4S	123.64	123.58	123.55	123.04	123.19	123.55	123.52	dry
Well 5S	123.39	123.23	123.22	123.02	123.12	123.17	123.01	dry
Well 5SR	**	**	**	**	**	**	**	**
Well 6S	123.82	123.45	123.36	dry	dry	dry	dry	dry
Well 7S	123.57	123.20	123.18	123.02	123.15	123.22	122.96	dry
Well 8S	123.12	122.79	122.83	122.69	122.79	122.75	122.64	dry
Well 9S	124.29	124.25	124.22	123.75	123.85	123.90	dry	dry
Well 10S	124.31	123.97	123.93	dry	dry	123.93	123.71	dry
Well 11S	123.96	123.67	123.63	123.37	123.41	123.56	123.36	dry
Well 12S	123.44	123.40	123.40	123.02	123.18	123.27	123.14	122.72
Well 13S	123.72	123.42	123.35	123.13	123.11	123.33	123.09	dry
Well 14S	123.49	123.43	123.41	123.03	123.28	123.37	123.13	dry
Well 15S	123.67	123.31	123.16	dry	dry	dry	dry	dry
Well 16S	123.48	123.05	122.95	dry	dry	122.99	dry	dry
Well 17S	123.42	123.10	123.11	122.93	123.04	123.07	122.94	dry
Well 18S	123.50	123.11	123.07	122.92	122.95	123.03	122.92	dry
Well 19S	123.85	123.72	123.80	123.40	123.52	123.76	123.53	dry
Well 20S	124.24	123.87	123.79	123.52	123.52	123.67	dry	dry
Well 20M	**	**	**	**	**	**	**	**
Well 20L	**	**	**	**	**	**	**	**
Well 21S	123.75	123.41	123.31	dry	dry	123.36	dry	dry
Well 22S	**	**	RDS	RDS	RDS	dry	RDS	RDS
Well 22M	**	**	123.36	123.17	123.08	123.18	122.96	122.61
Well 22L	**	**	123.36	*	123.08	123.19	122.95	122.63
Well 23S	**	**	123.74	123.50	123.56	123.77	123.68	dry
Well 23M	**	**	123.78	123.53	123.64	123.80	123.70	123.14
Well 24S	**	**	**	**	**	**	**	**
Well 24L	**	**	**	**	**	**	**	**
Well 25S	**	**	**	**	**	**	**	**
Well 26S	**	**	**	**	**	**	**	**
Well 27S	**	**	**	**	**	**	**	**
Well 28S	**	**	**	**	**	**	**	**
Well 29S	**	**	**	**	**	**	**	**
Well 30S	**	**	**	**	**	**	**	**
Well 31S	**	**	**	**	**	**	**	**
Well 32S	**	**	**	**	**	**	**	**
Well 33S	**	**	**	**	**	**	**	**
Gauge B	**	**	**	**	**	**	dry	dry
Gauge C	**	**	**	**	**	**	dry	dry
Gauge D	**	**	**	**	**	**	121.99	121.95
Gauge F	**	**	**	**	**	**	**	**
Gauge G	**	**	**	**	**	**	**	**

S soil-zone well M middle well * no measurement
R replacement well L lower well ** not yet installed

APPENDIX D Water-Level Elevations
(in meters referenced to North American Vertical Datum, 1988)

Date	07/06/05	08/01/05	09/06/05	10/06/05	11/09/05	12/06/05	01/13/06	02/06/06
Well 1S	dry	dry	123.00	123.19	dry	123.46	123.68	123.65
Well 2S	dry	dry	dry	dry	dry	124.22	124.70	124.64
Well 3S	dry	dry	dry	123.65	dry	123.98	124.14	124.10
Well 4S	dry	dry	123.08	123.47	dry	123.57	123.62	123.60
Well 5S	dry	damaged	damaged	damaged	damaged	damaged	damaged	damaged
Well 5SR	**	**	**	**	**	123.21	123.54	123.38
Well 6S	dry	dry	dry	dry	dry	123.37	123.45	123.63
Well 7S	dry	dry	dry	dry	dry	123.01	123.61	123.42
Well 8S	dry	dry	dry	122.47	dry	122.74	123.08	122.99
Well 9S	dry	dry	123.71	123.77	dry	frozen	124.30	124.27
Well 10S	dry	dry	dry	dry	dry	dry	124.42	124.11
Well 11S	dry	dry	dry	dry	dry	123.65	123.98	123.87
Well 12S	dry	dry	dry	123.22	122.82	123.32	123.45	123.43
Well 13S	dry	dry	dry	dry	dry	123.29	123.65	123.51
Well 14S	dry	dry	123.14	123.42	122.79	123.44	123.49	123.46
Well 15S	dry	dry	dry	dry	dry	123.36	123.80	123.54
Well 16S	dry	dry	dry	123.07	122.97	123.17	123.57	123.37
Well 17S	dry	dry	122.85	123.21	122.80	123.32	123.44	123.43
Well 18S	dry	dry	122.97	123.35	122.86	123.45	123.53	123.51
Well 19S	dry	dry	dry	123.20	dry	frozen	123.85	123.84
Well 20S	dry	dry	dry	dry	dry	123.77	124.24	124.19
Well 20M	**	**	**	**	**	123.72	124.20	124.10
Well 20L	**	**	**	**	**	123.35	*	123.70
Well 21S	dry	dry	dry	dry	dry	123.40	123.82	123.55
Well 22S	RDS	RDS	dry	dry	dry	dry	123.88	123.70
Well 22M	dry	dry	dry	122.39	dry	123.28	123.84	123.69
Well 22L	122.19	121.81	121.95	122.31	122.25	123.25	123.80	123.69
Well 23S	dry	dry	dry	dry	dry	123.68	124.12	123.69
Well 23M	dry	dry	dry	dry	dry	123.71	124.12	123.90
Well 24S	**	**	**	**	**	123.91	124.42	124.16
Well 24L	**	**	**	**	**	124.13	*	124.21
Well 25S	**	**	**	**	**	dry	123.88	123.54
Well 26S	**	**	**	**	**	123.06	123.46	123.18
Well 27S	**	**	**	**	**	123.52	124.05	123.80
Well 28S	**	**	**	**	**	123.01	123.51	123.38
Well 29S	**	**	**	**	**	123.14	123.47	123.44
Well 30S	**	**	**	**	**	123.23	123.36	123.33
Well 31S	**	**	**	**	**	123.28	123.51	123.47
Well 32S	**	**	**	**	**	123.41	123.65	123.63
Well 33S	**	**	**	**	**	123.49	123.97	123.68
Gauge B	dry	dry	dry	dry	dry	frozen	123.37	123.29
Gauge C	dry	dry	123.25	123.27	123.22	frozen	123.32	123.31
Gauge D	121.90	121.90	121.95	121.95	121.97	122.03	122.26	122.09
Gauge F	**	**	**	**	**	frozen	122.16	121.97
Gauge G	**	**	**	**	**	**	**	**

S soil-zone well　　M middle well　　* no measurement
R replacement well　　L lower well　　** not yet installed

APPENDIX D Water-Level Elevations

(in meters referenced to North American Vertical Datum, 1988)

Date	03/06/06	04/03/06	04/10/06	04/18/06	05/04/06
Well 1S	123.33	123.67	123.66	123.15	123.63
Well 2S	124.54	124.64	124.51	124.18	124.65
Well 3S	123.86	124.10	124.09	123.51	124.15
Well 4S	123.58	123.56	123.58	123.15	123.60
Well 5S	damaged	damaged	damaged	damaged	damaged
Well 5SR	123.19	123.41	123.27	122.87	123.50
Well 6S	123.33	123.61	123.52	dry	123.30
Well 7S	123.19	123.51	123.28	122.98	123.39
Well 8S	122.80	122.98	123.02	122.60	123.15
Well 9S	124.23	124.25	124.27	123.85	124.29
Well 10S	123.95	124.27	124.12	dry	124.36
Well 11S	123.59	123.87	123.73	123.36	123.94
Well 12S	123.32	123.44	123.41	122.96	123.55
Well 13S	123.24	123.66	123.51	dry	123.73
Well 14S	123.39	123.42	123.43	122.98	123.51
Well 15S	123.33	123.63	123.47	123.18	123.68
Well 16S	123.23	123.39	123.27	123.02	123.47
Well 17S	123.31	123.42	123.40	122.96	123.42
Well 18S	123.42	123.52	123.50	122.98	123.51
Well 19S	123.80	123.80	123.79	123.43	123.82
Well 20S	123.75	124.17	124.01	123.57	124.22
Well 20M	123.68	124.13	124.00	123.56	124.19
Well 20L	123.40	123.75	123.72	123.33	123.82
Well 21S	123.36	123.65	123.49	123.24	123.28
Well 22S	dry	123.64	123.57	dry	123.56
Well 22M	123.37	123.63	123.54	123.20	123.55
Well 22L	123.36	123.62	*	123.22	*
Well 23S	123.73	124.00	123.85	123.50	124.08
Well 23M	123.72	124.04	123.89	123.50	124.10
Well 24S	123.98	124.29	124.07	dry	124.40
Well 24L	123.96	124.29	124.35	123.70	124.10
Well 25S	dry	123.56	123.49	dry	123.53
Well 26S	123.08	123.36	123.15	122.78	123.47
Well 27S	123.48	123.92	123.65	dry	123.97
Well 28S	123.09	123.45	123.30	122.91	123.45
Well 29S	123.21	123.42	123.29	123.00	123.46
Well 30S	123.30	123.30	123.32	123.13	123.39
Well 31S	123.33	123.47	123.35	122.97	123.46
Well 32S	123.42	123.62	123.50	123.09	123.62
Well 33S	123.43	123.69	123.58	dry	123.79
Gauge B	123.22	123.34	123.30	123.24	123.46
Gauge C	123.29	123.30	123.35	123.28	123.37
Gauge D	122.02	122.79	122.28	121.99	121.99
Gauge F	122.02	flooded	122.31	121.85	122.69
Gauge G	**	**	**	**	**

S soil-zone well　　M middle well　　* no measurement

R replacement well　　L lower well　　** not yet installed

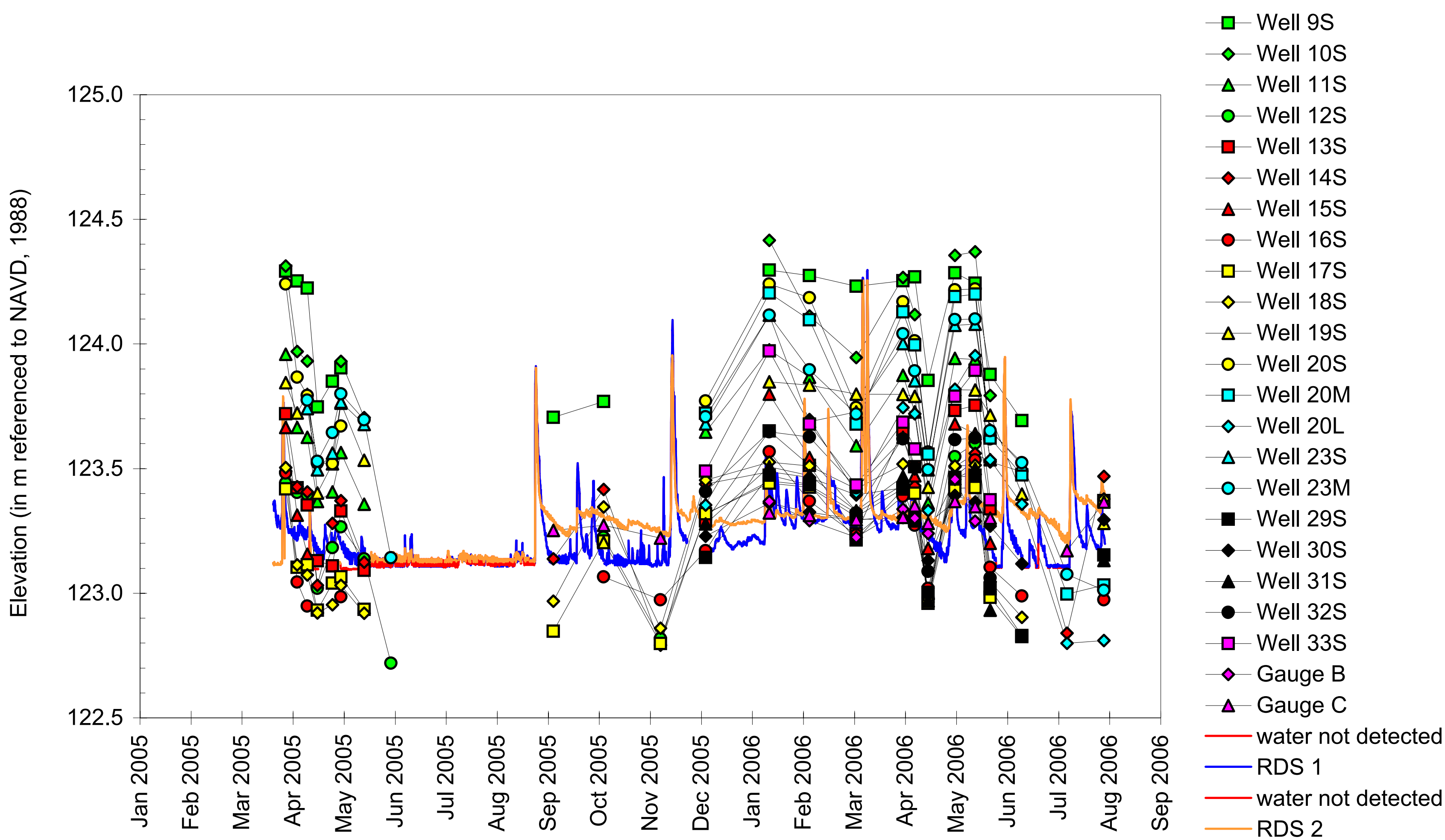
APPENDIX D Water-Level Elevations

(in meters referenced to North American Vertical Datum, 1988)

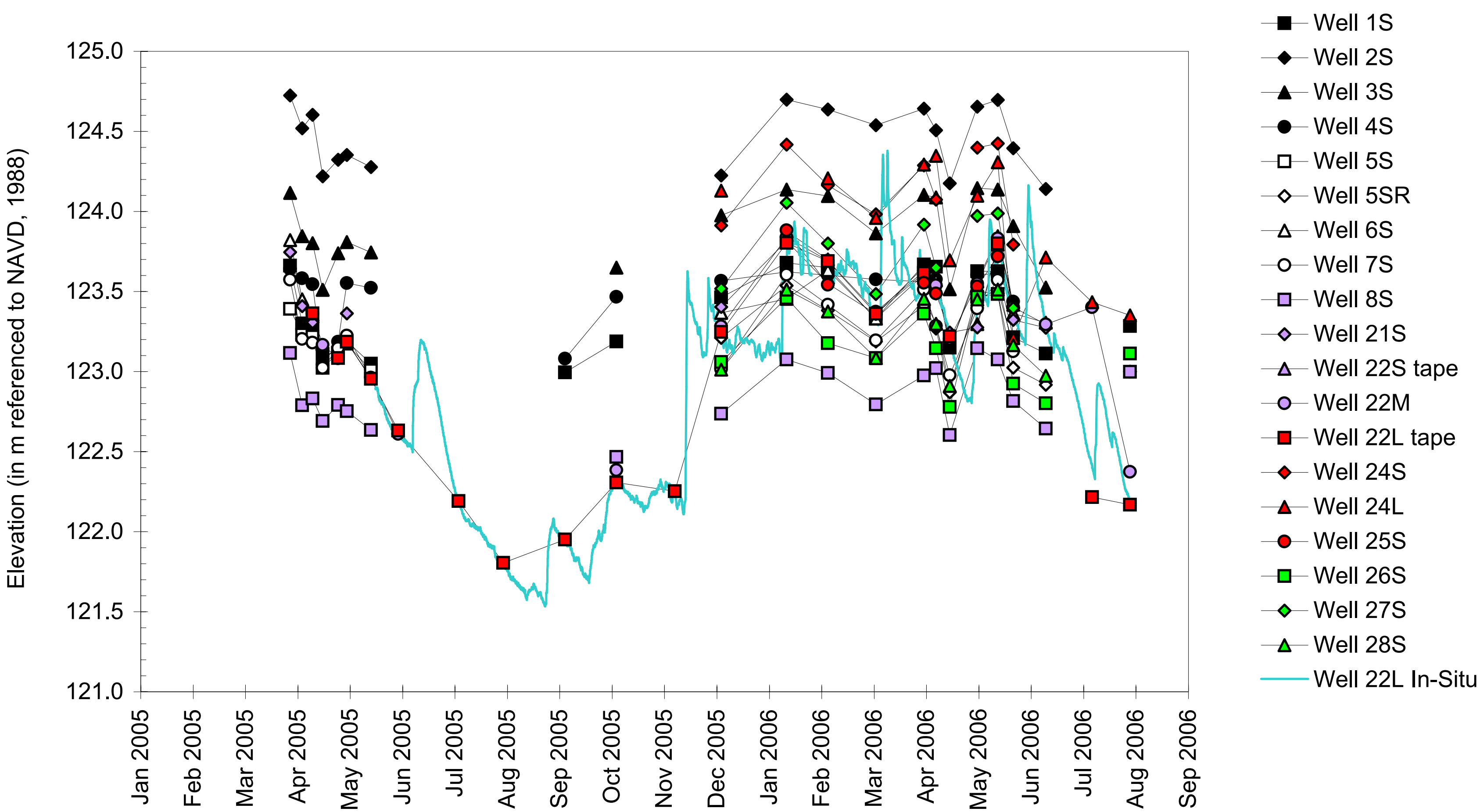
Date	05/16/06	05/25/06	06/13/06	07/10/06
Well 1S	123.63	123.21	123.11	dry
Well 2S	124.70	124.40	124.14	dry
Well 3S	124.14	123.91	123.53	dry
Well 4S	123.61	123.44	damaged	damaged
Well 5S	damaged	damaged	damaged	damaged
Well 5SR	123.49	123.02	122.92	dry
Well 6S	123.79	123.36	123.31	dry
Well 7S	123.57	123.13	dry	dry
Well 8S	123.08	122.82	122.64	dry
Well 9S	124.24	123.88	123.69	dry
Well 10S	124.37	123.79	dry	dry
Well 11S	123.94	123.54	dry	dry
Well 12S	123.60	damaged	damaged	damaged
Well 13S	123.75	123.34	dry	dry
Well 14S	123.56	123.53	123.49	122.84
Well 15S	123.64	123.20	dry	dry
Well 16S	123.54	123.10	122.99	dry
Well 17S	123.42	122.98	122.83	dry
Well 18S	123.51	123.05	122.90	dry
Well 19S	123.82	123.71	123.40	dry
Well 20S	124.22	123.62	dry	dry
Well 20M	124.20	123.62	123.47	123.00
Well 20L	123.95	123.54	123.36	122.80
Well 21S	123.80	123.32	123.27	dry
Well 22S	123.85	123.42	dry	dry
Well 22M	123.83	123.40	123.29	123.40
Well 22L	123.80	*	*	122.22
Well 23S	124.08	123.66	123.52	dry
Well 23M	124.10	123.65	123.52	123.08
Well 24S	124.43	123.79	dry	dry
Well 24L	124.31	123.21	123.71	123.43
Well 25S	123.72	dry	dry	dry
Well 26S	123.49	122.92	122.80	dry
Well 27S	123.99	123.40	dry	dry
Well 28S	123.51	123.17	122.97	dry
Well 29S	123.47	123.02	122.83	dry
Well 30S	123.37	123.27	123.12	dry
Well 31S	123.50	122.93	dry	dry
Well 32S	123.62	123.06	dry	dry
Well 33S	123.89	123.38	*	dry
Gauge B	123.29	dry	dry	dry
Gauge C	123.35	123.30	*	123.17
Gauge D	122.17	122.15	121.99	121.93
Gauge F	122.13	122.17	122.01	121.92
Gauge G	**	**	**	*

S soil-zone well M middle well * no measurement
R replacement well L lower well ** not yet installed

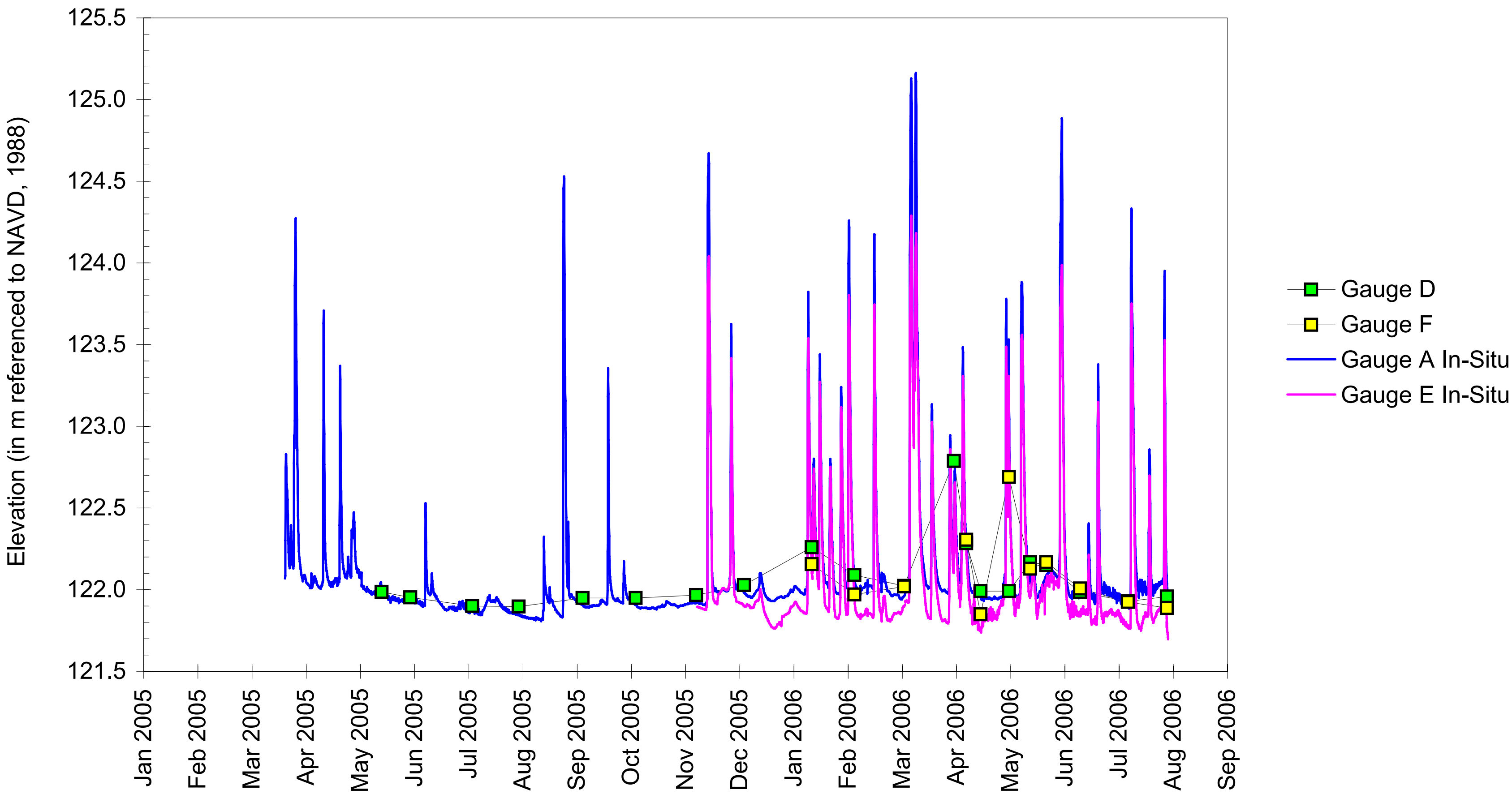
APPENDIX D Water-Level Elevations
(Instruments east of Sugar Camp Creek)



APPENDIX D Water-Level Elevations
(Instruments west of Sugar Camp Creek)



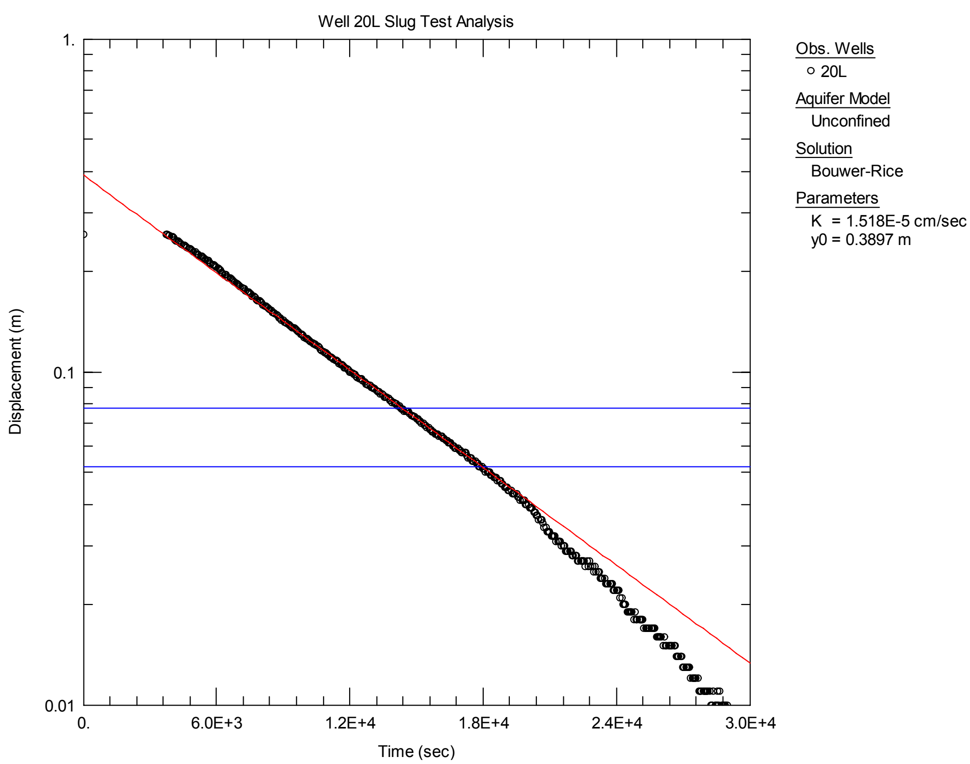
APPENDIX D Water-Level Elevations
(At gauges in Sugar Camp Creek)



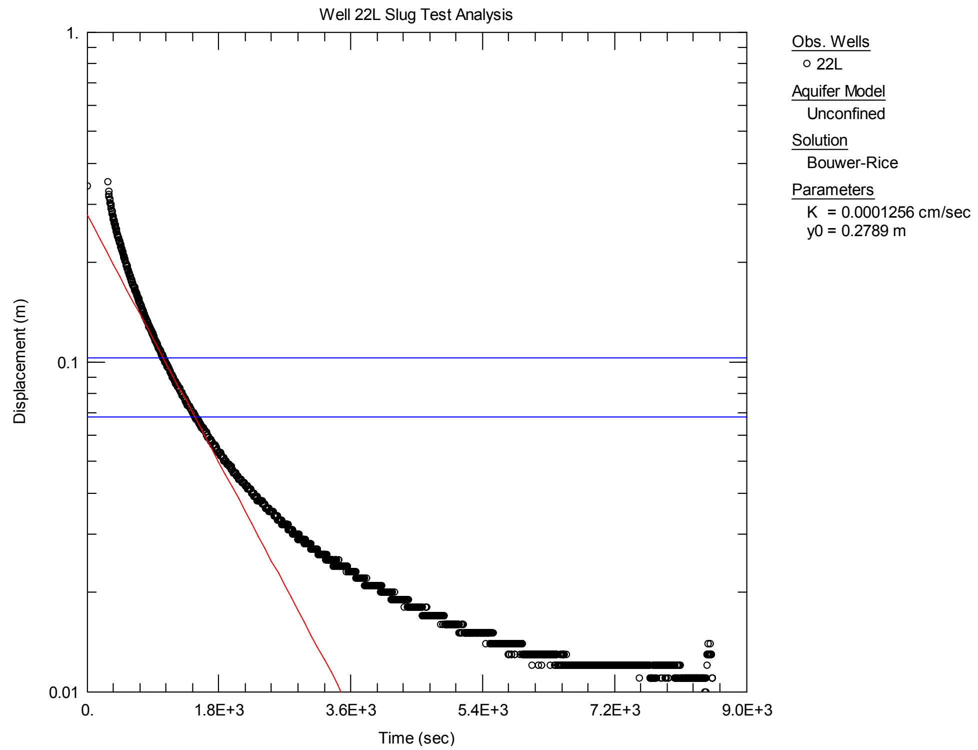
APPENDIX E Slug-Test Methods and Analysis

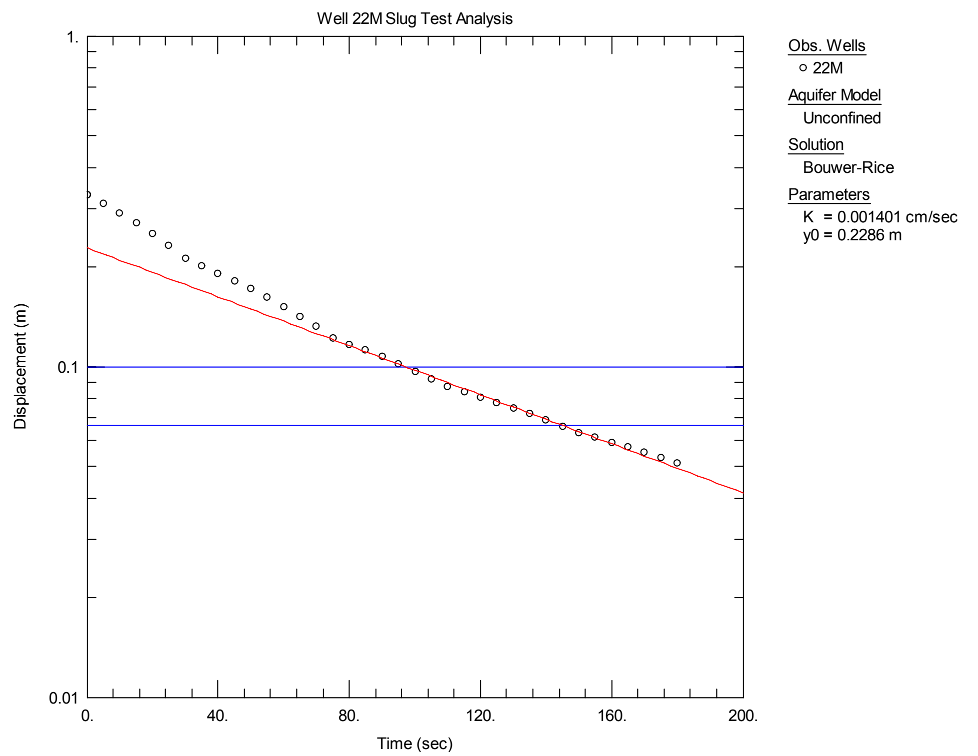
Falling-head slug tests were performed in selected wells in winter 2006 to measure the hydraulic conductivity of the shallow geologic materials and assess the potential for ground-water contribution to restored wetlands. Falling-head tests were conducted in wells 20L, 22M, 22L, 23M, and 24L by introducing a 750-mL sealed PVC slug into each well. Water level in each well (recorded at 1-, 5-, or 60-second intervals) was logged until it stabilized to near-static conditions. Automated dataloggers were used to record water levels in each well except 22M which was read manually. The durations for each test ranged from 3 minutes for well 22M to 8 hours for well 20L. For wells 20L and 24L, a rising-head test was initiated by removing the slug from each well after the falling-head tests were complete. The water level was logged until it again recovered to near-static conditions. The duration for each rising-head test was approximately 4.5 hours.

The slug test data were analyzed using the AQTESOLV® for Windows Pro v.3.5 software package. The Bouwer and Rice (1976) model for slug tests in unconfined partially-penetrating wells was applied to obtain estimates of hydraulic conductivity. The various well-dimension and aquifer parameters required to obtain solutions for these models are presented Table E1 below. Because each well tested was constructed using 2-in (5.2-cm) diameter PVC casing, well radii parameters used for all analyses were r(c) = 0.026 m, r(w) = 0.038 m, where r(c) is the radius of the well casing and r(w) is the effective well radius (radius of sand pack). Visual best-fit procedures were used to fit the model to the software-recommended range of water-level data. Graphs of the analysis are given below; circles indicate water-level data points, red lines indicate the visual best-fit line, blue lines indicate the recommended data range for the analysis.

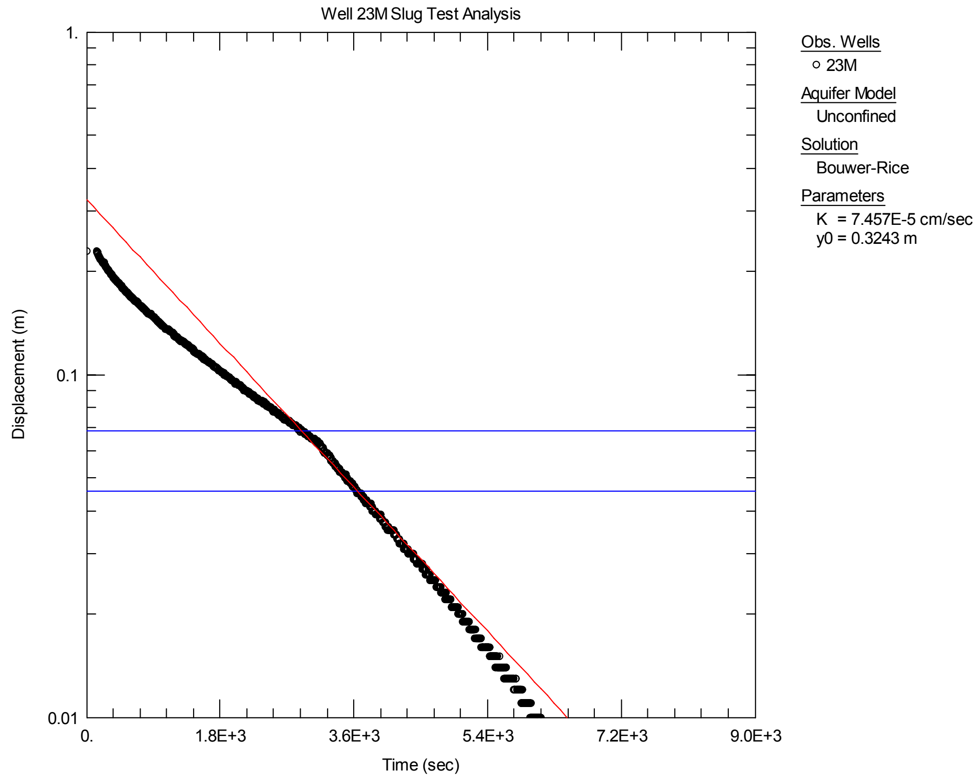


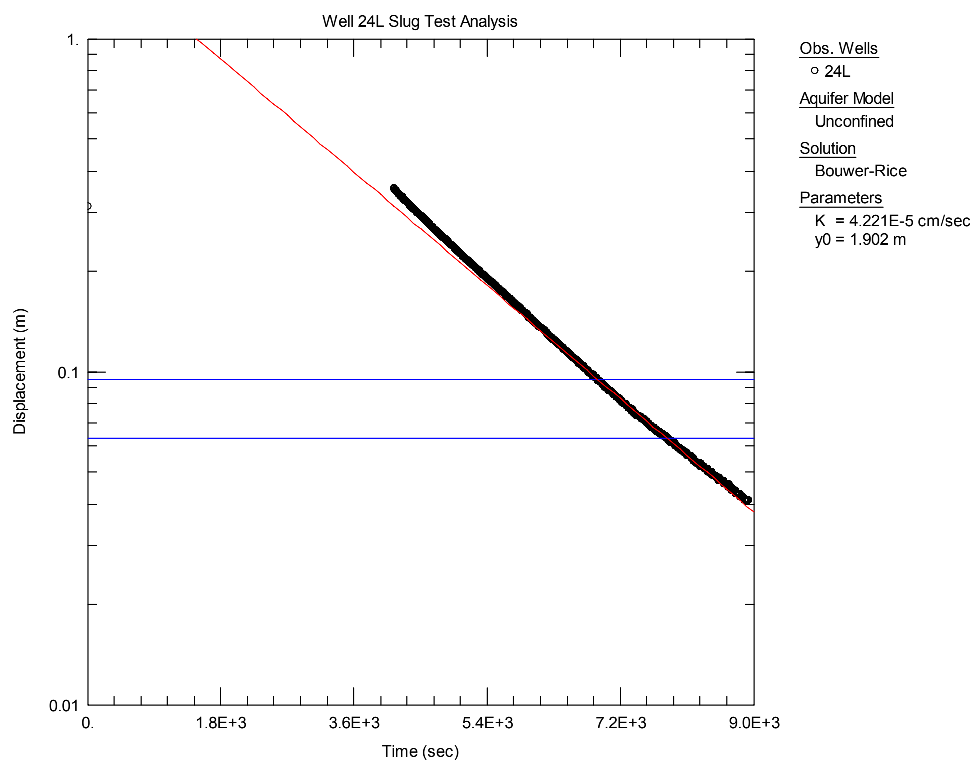
APPENDIX E Slug-Test Methods and Analysis





APPENDIX E Slug-Test Methods and Analysis





APPENDIX E Slug-Test Methods and Analysis

Table E1. Well construction and aquifer parameters required for the Bouwer and Rice (1976) method.

Well	Date	s(0)	H	D	L	n
20L	1/11/2006	0.399 m	2.555 m	10 m	0.460 m	0.4
22L	2/7/2006	0.352 m	2.463 m	10 m	0.480 m	0.4
22M	2/6/2006	0.332 m	1.403 m	10 m	0.280 m	0.4
23M	2/7/2006	0.336 m	0.936 m	3 m	0.390 m	0.4
24L	1/11/2006	0.356 m	3.251 m	10 m	0.800 m	0.4

s(0) - initial water-level displacement

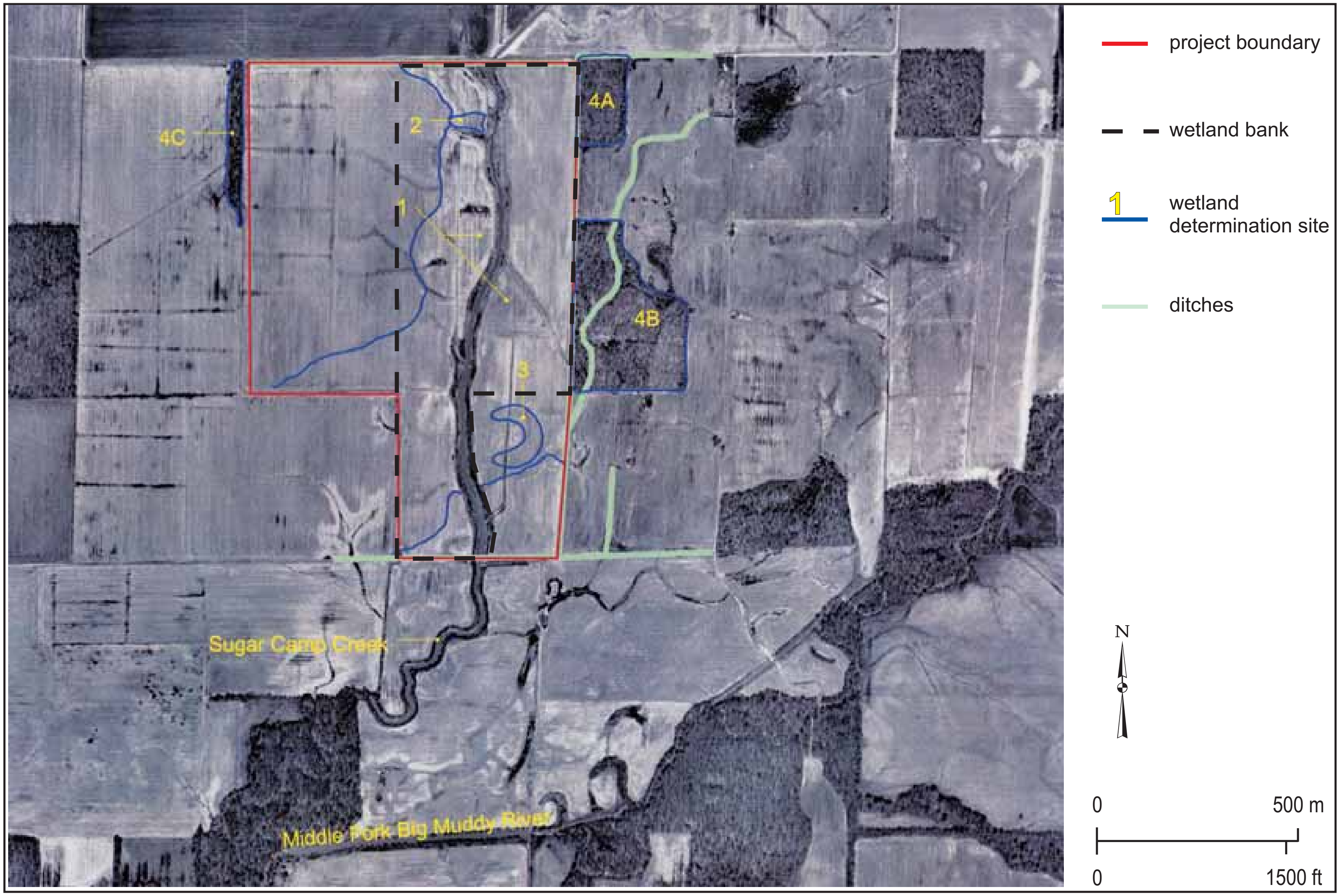
H - static water column height

D - saturated thickness of the water-bearing unit

L - length of the screened interval of the well

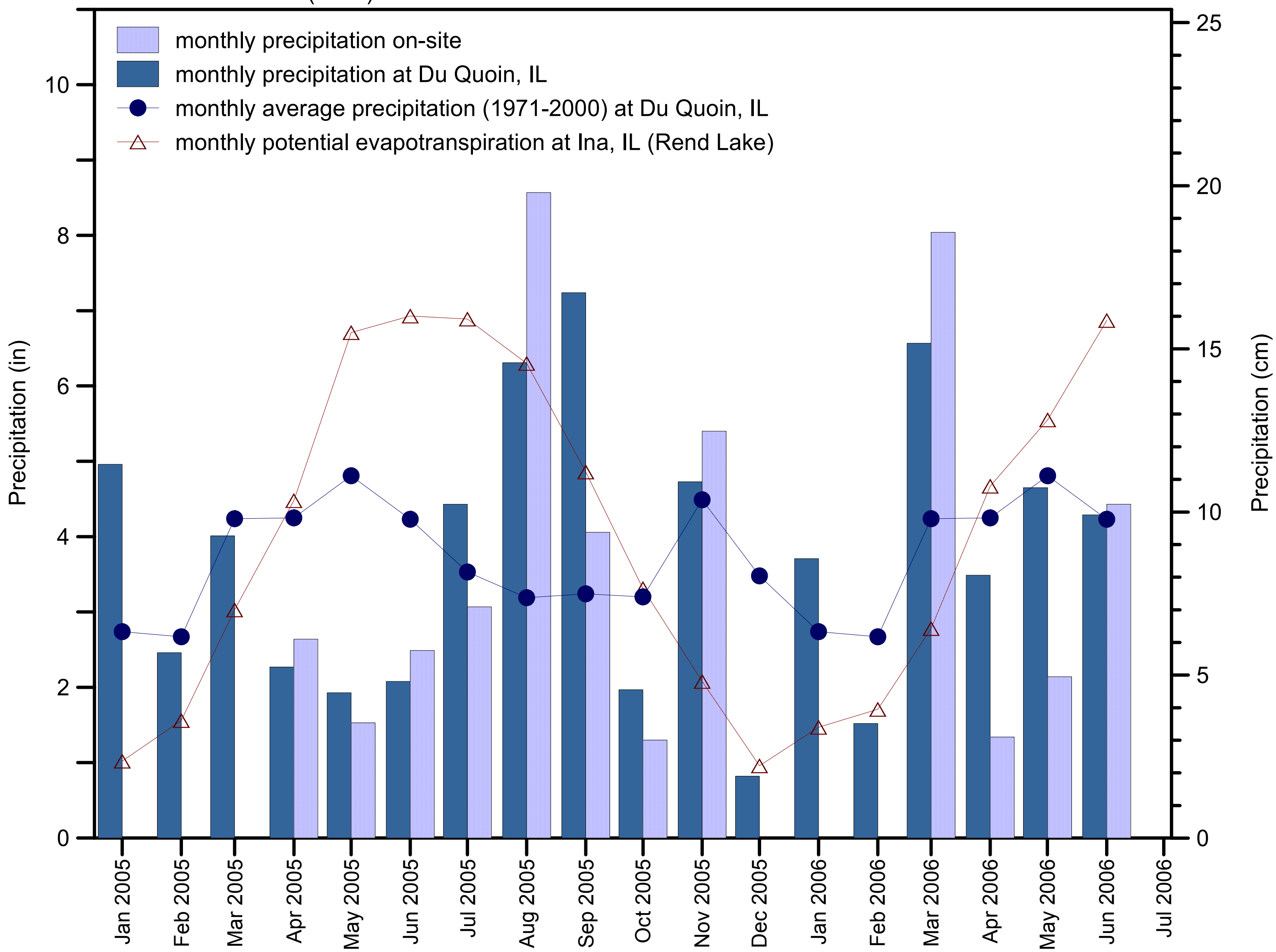
n - effective porosity of the well filter pack

APPENDIX F Locations of INHS Wetland Determinations at the Sugar Camp Creek Site
(Adapted from the Illinois Natural History Survey Mitigation Site Assessment report, Plocher and Weisbrook 2004).



APPENDIX G Precipitation and Potential Evapotranspiration Trends

On-site precipitation data was collected by ISGS. Weather station data from Du Quoin and Ina, IL were gathered by the Midwestern Regional Climate Center (2006).



APPENDIX H Elevation-Area Table

Elevation		Area	
m	ft	ha	ac
123.0	403.5	2.2	5.6
123.1	403.9	3.0	7.3
123.2	404.2	3.8	9.5
123.3	404.5	5.3	13.0
123.4	404.9	6.7	16.6
123.5	405.2	11.1	27.5
123.6	405.5	15.3	37.9
123.7	405.8	19.6	48.5
123.8	406.2	24.2	59.8
123.9	406.5	28.8	71.2
124.0	406.8	32.4	80.2
124.1	407.1	35.7	88.2
124.2	407.5	39.1	96.7
124.3	407.8	41.9	103.6
124.4	408.1	43.7	107.9
124.5	408.5	45.1	111.4
124.6	408.8	46.1	114.0
124.7	409.1	47.3	116.8
124.8	409.4	47.9	118.4
124.9	409.8	48.3	119.3
125.0	410.1	48.5	119.9
125.2	410.8	49.0	121.0
126.0	413.4	50.2	124.1
126.5	415.0	50.9	125.7

median flood level during this study (highlighted row: 123.8 m)

maximum flood level during this study (highlighted row: 125.2 m)