HARRISBURG POTENTIAL WETLAND COMPENSATION SITE: LEVEL II HYDROGEOLOGIC CHARACTERIZATION REPORT

Harrisburg, Saline County, Illinois
(Federal Aid Project 332)

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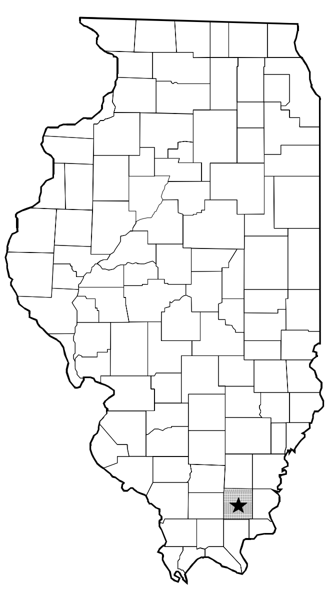

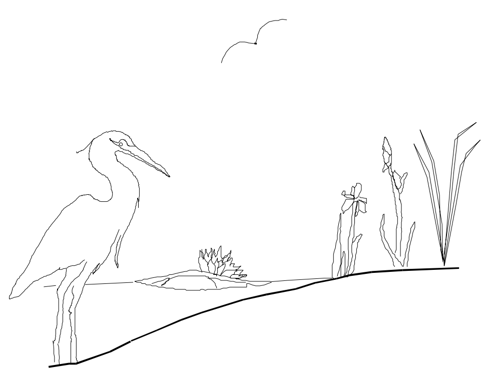

Executive Summary

In December 2001, the Illinois Department of Transportation tasked the Wetlands Geology Section of the Illinois State Geological Survey to conduct a hydrogeologic characterization of a potential wetland compensation site near Harrisburg in Saline County, Illinois. Data collection at this site began in March 2002 with the installation of a network of monitoring wells, staff gauges, and data loggers. The purpose of this report is to identify the hydrogeologic conditions of the site and to determine if wetland hydrology can be restored or created.

The data indicate that 42% of the site in 2002 and 58% of the site in 2003 conclusively satisfied jurisdictional wetland hydrology criteria. The area of wetland hydrology was 3.3 ha (8.3 ac) in 2002 and 4.6 ha (11.5 ac) in 2003. The remainder of the site has moderate potential for wetland creation. Wetland hydrology at the site is attributed to combined hydrologic inputs from flooding and ground-water discharge in the spring. Generally, precipitation events result in frequent short-duration (three days or less) floods at this site. The period of inundation of observed floods was not long enough to satisfy jurisdictional wetland hydrology criteria over a significant area. However, soil saturation persists after floods recede and thus contributes to wetland hydrology. Ground-water discharge observed along the south margin of the site was the main factor contributing to wetland hydrology in higher areas. Areas of the compensation site that do not conclusively satisfy jurisdictional wetland hydrology criteria are slightly higher in elevation and do not exhibit ground-water discharge.

Potential wetland compensation activities are limited to wetland creation. Lack of restorable wetlands and reversible hydrologic alterations preclude wetland restoration at this site. We recommend that areas intended for wetland mitigation be excavated to 111.38 m (365.42 ft) or lower based on the elevation of areas already meeting wetland hydrology criteria and heights of regular flooding events. Excavation to this level will not only increase the likelihood of ground-water contribution to wetland creation but also allow excavated areas to be inundated by surface water more frequently.

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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 observations regarding the hydrogeologic conditions in an 8.1-hectare (20-acre) potential wetland compensation site (SW 1/4 Section 17, T9S R6E, Saline County) located in Harrisburg, Illinois (Figure 1).

The purpose of this report is to provide IDOT with recommendations regarding the suitability of the site for wetland compensation. Therefore, wetland compensation recommendations and summary are presented first, followed by a discussion of the methods and supporting data. The supporting data include surface-water, ground-water and precipitation data collected from March 2002 to September 2003, and geologic data collected from soil borings.

Data collection at the site will continue until no longer required by IDOT. Further data collection will be used to compare the pre- and post-construction hydrology and determine the impact of hydrologic alterations at the site.

SUMMARY

The following factors indicate that the potential for wetland restoration and creation at this compensation site is moderate.

- The site is an excavated basin adjacent to the right-of-way of Illinois Route 13 (IL RT 13). Surface topography has been altered across the entire site and three drainage ditches have been routed or re-routed through the site. The current grade promotes runoff generally from the southwest to the northeast. Recent excavation and grading activities during the realignment of IL RT 13 (prior this study) have made conditions conducive to satisfying jurisdictional wetland hydrology criteria over a significant portion of the site.

- The geologic deposits at the site are silty clay and clayey silt associated with the Equality Formation. Due to relatively low permeability, these materials are conducive to ponding surface water. However, pumping tests showed that this shallow geologic unit provides a significant amount of ground water to wells at the site despite low hydraulic conductivity (Table 3).

- Hydric soils (Bonnie silt loam and Belknap silt loam) are mapped over 45% of the site, and all soils mapped on site have relatively low permeability (Figure 3 and Table 1). The mapped soils were disrupted during the excavation and grading of the site during construction of IL RT 13. However, examination of soil borings at wells 1S, 4M, and 5M showed hydric-soil indicators.

- Potential water sources include surface-water flooding from drainage ditches, runoff from residential areas south of the site and adjacent roadways, ground-water discharge along the southern margin of the site, and direct precipitation. Surface water frequently inundates large areas of the site. However, the duration of individual floods is too short to supply wetland hydrology in higher areas of the site. Ground-water level measurements indicate that ground water was at or near land surface in the vicinity of well nests 4, 5 and 6 during the early portion of the growing season in 2002 and 2003.

- Water-level data collected during 2002 and 2003 indicated that 42% and 58% of the site, respectively, satisfied jurisdictional wetland hydrology criteria (Figure 2). The area of wetland hydrology was

3.3 ha (8.3 ac) in 2002 and 4.6 ha (11.5 ac) for 2003. Wetland hydrology resulted from frequent floods replenishing soil saturation in lower areas in the east portion of the site. Higher areas along the south margin of the site satisfied wetland hydrology criteria due to ground-water discharge.

- Wetland compensation activities are limited to wetland creation. Lack of restorable wetlands and reversible hydrologic alterations preclude wetland restoration at this site. Potential impacts to surrounding areas limit wetland creation options to excavation.

WETLAND COMPENSATION RECOMMENDATIONS

The following recommendations for creating wetlands on the site are based on the geologic and hydrologic data collected at the site.

- The minimum area of wetland hydrology calculated during this study was 3.3 ha (8.3 ac) in 2002 (Figure 2). If additional acres are needed for wetland mitigation, we recommend excavating areas in the west portion of the site to increase the frequency and duration of flooding and promote ground-water discharge. We recommend that additional areas intended for wetland creation (Figures 2 and 4) be excavated to at least 111.38 m (365.42 ft). We suggest that excavated areas slope gradually toward the west to prevent runoff, capture flood peaks, and further promote groundwater discharge in western portions of the site. Required excavation depths are shown in Figure 4. Excavation volume estimates and corresponding potential wetland creation areas are given in Appendix D.

- Excavation of areas that already satisfy wetland hydrology criteria may be necessary. Any earthwork, including construction of a berm (recommended below), will impact the hydrology of the site, especially in those areas surrounding well nests 5 and 6. Because earthwork activities may have undetermined impacts on the hydrology of the site, we recommend that all areas intended for wetland mitigation credit be excavated to 111.38 m (365.42 ft) or lower.

- Construct a berm along the southern margin of the site to divert effluent away from the wetland mitigation area. We recommend the berm be constructed to minimize adverse impacts to water quality in the compensation area while not obstructing septic system drainage from residences to the south.

- Due to potential damage to a control structure and possible adverse off-site impacts, impounding surface water on the site is not recommended. Impounding water may cause flooding on adjacent properties. Also, a control structure may be susceptible to erosion or other damage by frequent high flows. Impounding water would be feasible if the control structure is designed to tolerate high flows and if measures are taken to avoid off-site impacts.

METHODS

Sediments were described from hand auger borings made during the Initial Site Evaluation (Ketterling et al. 2000) and well installation to characterize the geology of the compensation site and corroborate existing local geologic data. Each boring was described in the field noting soil properties such as Munsell color, texture, structures, and hydric-soil indicators (Appendix A).

A total of nine monitoring wells were installed at six locations (Figure 2) to evaluate vertical and horizontal hydraulic gradients, identify water sources that might be suitable for wetland creation, and map the extent of wetland hydrology. Shallow wells (S-wells) were installed to detect saturated conditions within

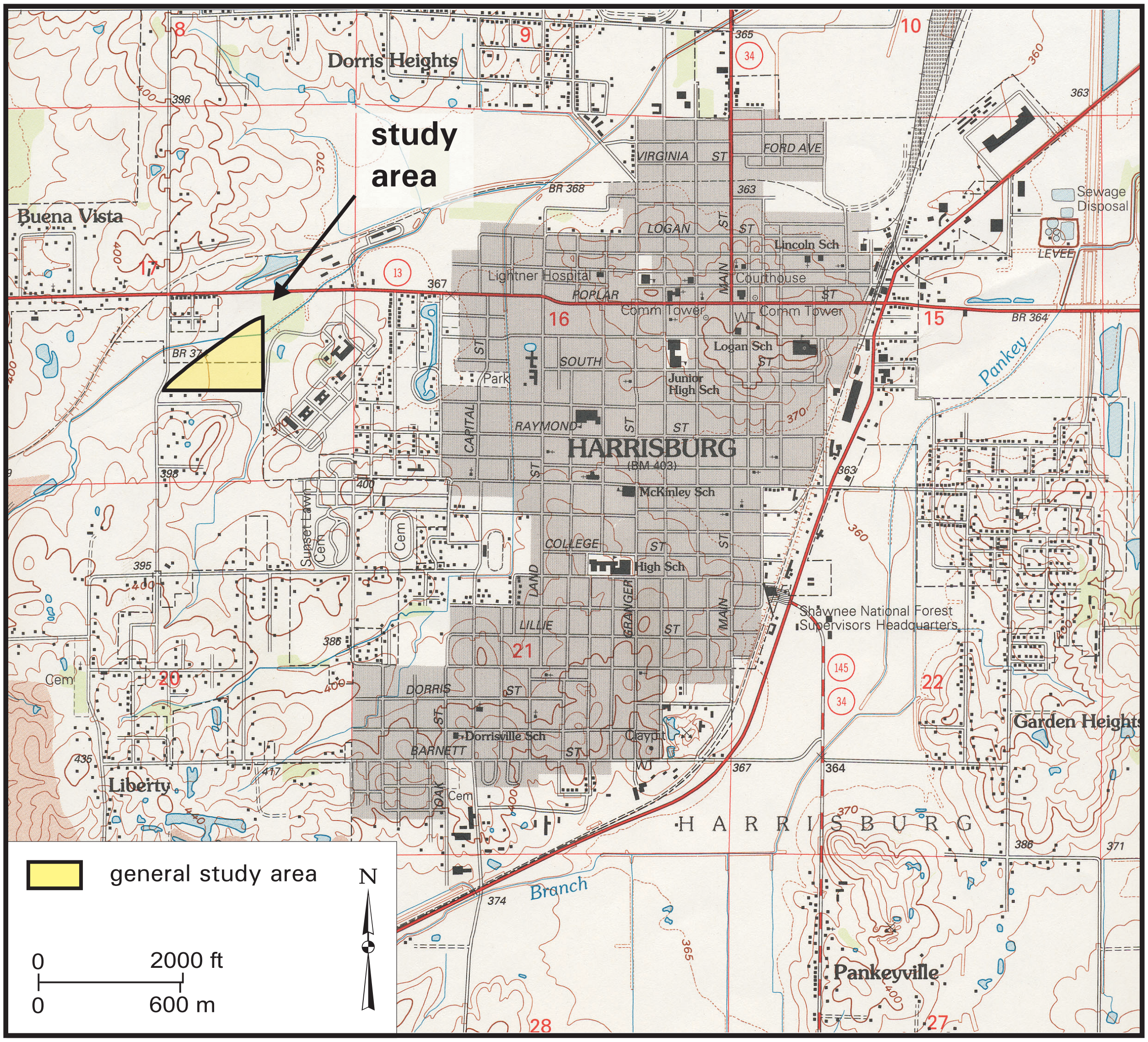

Figure 1. Location of the wetland compensation site on the Harrisburg, IL 7.5-minute quadrangle map (USGS 1996). Contour interval is 10 ft (3 m).

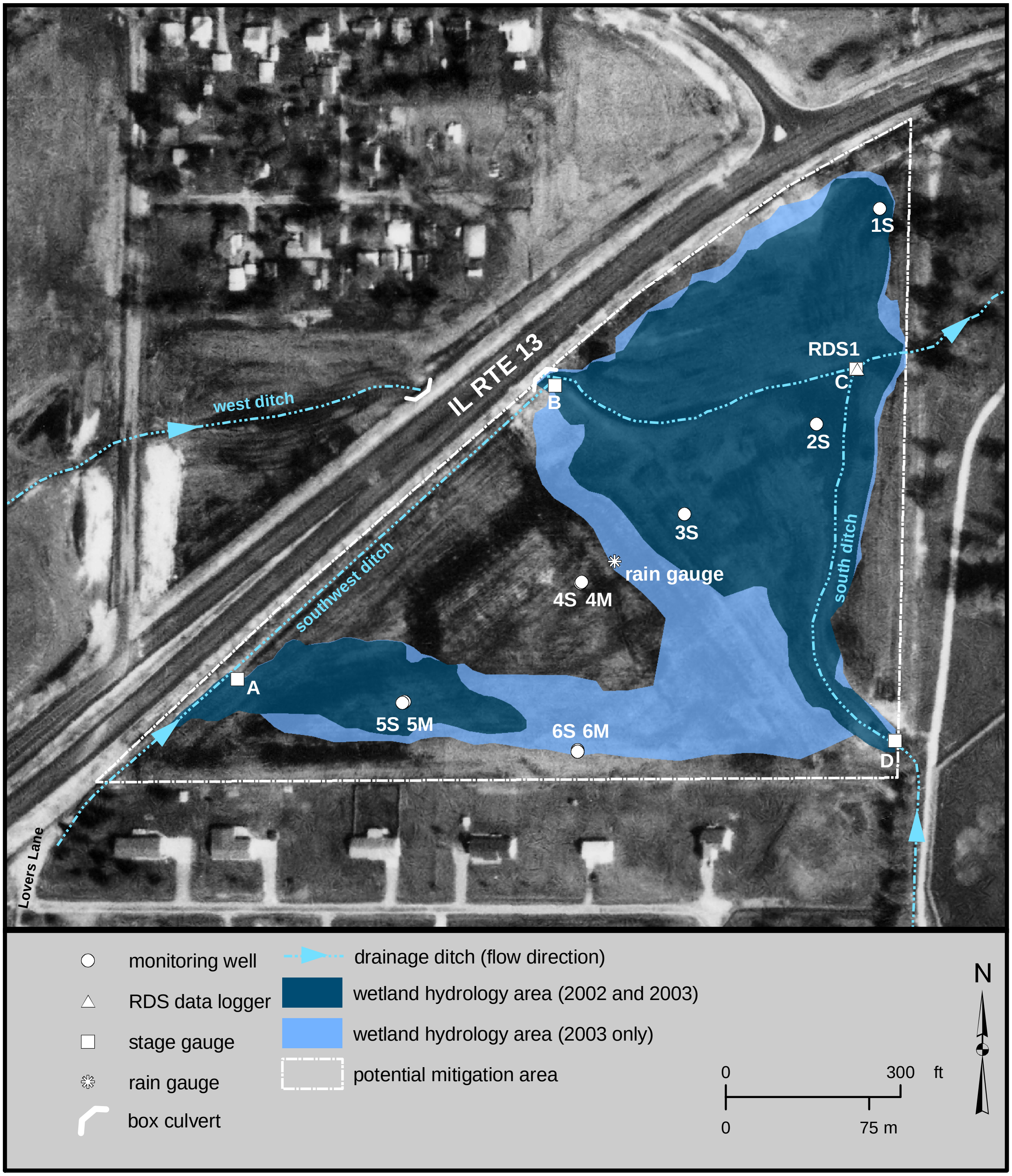

Figure 2. Areas satisfying jurisdictional wetland hydrology criteria in 2002 and 2003. Dark blue shading shows area that qualified both years. Light blue shading shows area that qualified in 2003 only (ISGS 2003).

Figure 3. Soils mapped within the potential wetland compensation site (adapted from USDA 1978).

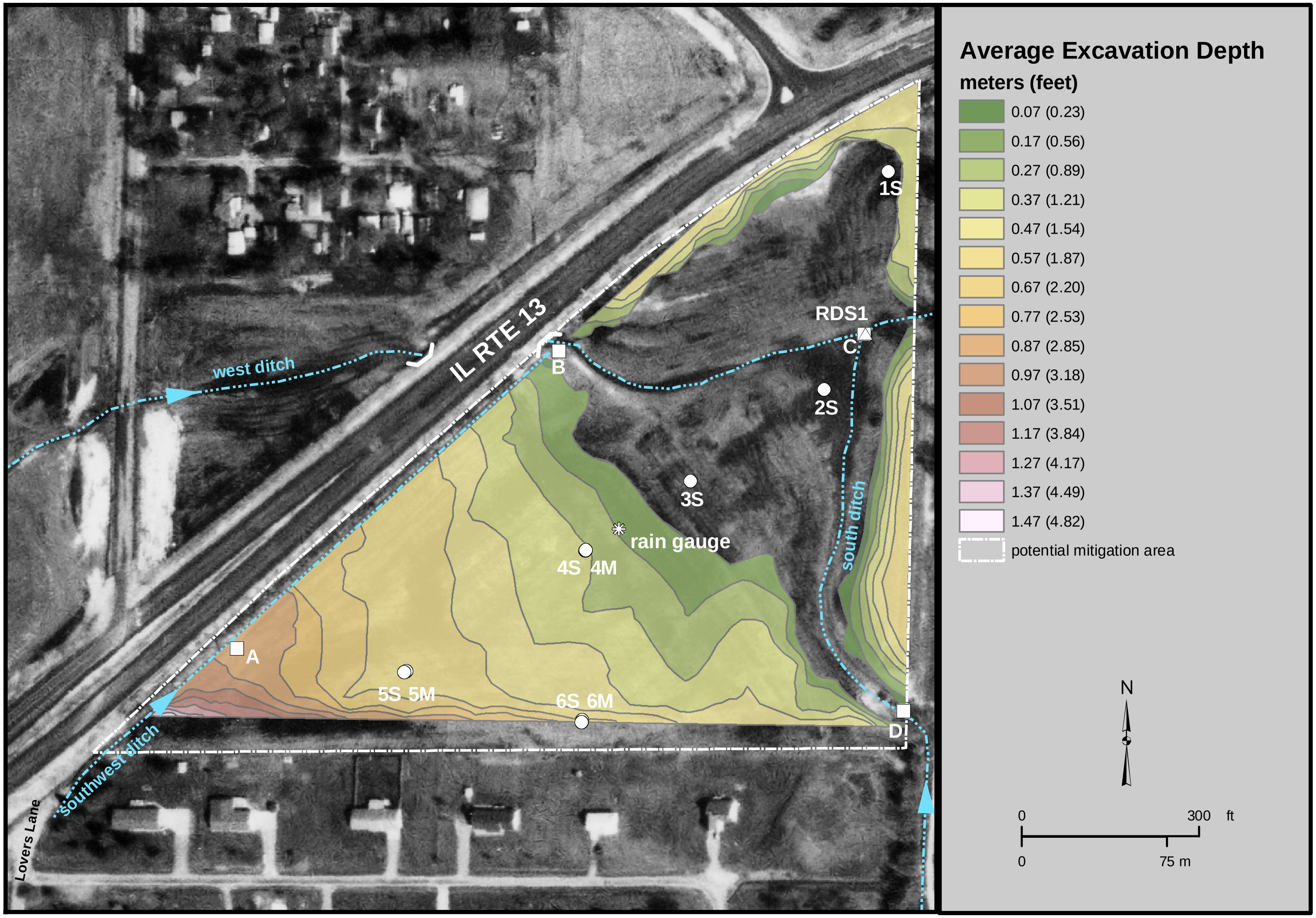

Figure 4. Excavation recommended for wetland creation (see Appendix D). Excavation depths associated with color shading are indicated in the legend (ISGS 2003).

0.30 m (1.0 ft) of land surface. Deeper wells (M-wells) were also installed to detect vertical hydraulic gradients in the surrounding geologic materials. All monitoring wells were installed within 2.9 m (9.4 ft) of land surface in deposits that ranged in texture from clayey silt to silty clay. Most wells were constructed with a 2.5-cm (1-in.) diameter PVC casing and slotted screen, however wells 5M and 6M were constructed using 5.1-cm (2-in.) diameter casing. Each well boring was 7.6 cm (3 in.) in diameter and was made using a hand auger. After each well was inserted, sand pack was placed around the screen. Bentonite was used to seal the annulus from the top of the sand pack to land surface. Specific dimensions and depths of each monitoring well are given in Appendix B. Water levels in monitoring wells were measured manually using a Solinst water-level meter. Wells were monitored biweekly during the early portion of the growing season (April through June) and read monthly through the remainder of the study (Appendix C).

One falling-head and one rising-head slug test were performed for wells 5M and 6M in September 2003 to measure the hydraulic conductivity of the shallow geologic materials and assess the potential for ground-water contribution to created wetlands. The falling-head test was conducted by introducing a 750-mL sealed PVC slug into each well. The water level was recorded at 3-second intervals until it stabilized to near-static conditions. The duration for each falling head test was approximately 17 hours. After the falling-head test was stopped, a rising-head test was initiated by removing the slug from each well. The water level was logged until it again recovered to near-static conditions. The duration for each rising-head test was approximately 9 hours. The slug-test data were analyzed using the Aqtesolv™ software package. The Bouwer and Rice (1976) model for slug tests in unconfined partially-penetrating wells was applied to obtain estimates of hydraulic conductivity. Visual best-fit procedures were used to fit the model to the water-level data. In addition, rudimentary pumping tests were conducted to verify that water levels read from the M-wells accurately reflect saturation in the adjacent formation. Each well was pumped dry using an electronic peristaltic pump. The extracted volume of water was measured and recorded and water level was allowed to recover for approximately 15 hours. Each well was again pumped dry and the extracted water volume was recorded. For each well, the extracted volume was compared to the combined volume of the well and pore space in the surrounding sand pack. The extracted water volume in excess of the volume of the well and pore space in the sand pack was assumed to be extracted from the surrounding geologic formation.

Surface-water data were collected to evaluate the elevation and duration of inundation across the site. Surface-water levels were recorded automatically using a electronic data logger (RDS1) and manually at four staff gauges (A, B, C, D) installed in drainage ditches at the site (Figure 2). RDS1 was installed at the confluence of the south and west ditches. At this station, surface-water depth was recorded at 3-hour intervals. Water depth was converted to elevation by subtracting the water depth from the surveyed elevation of the measuring point for the data logger. The data logger was downloaded monthly to biweekly. Staff gauge C was deployed at station RDS1 to compare data for quality control purposes. Three additional staff gauges were deployed: Gauge A in the southwest ditch, Gauge B at the confluence of the west and southwest ditches near the box culvert under IL RT 13, and Gauge D in the south ditch at the southeast corner of the site. For each staff gauge, water-levels were read biweekly during the early portion of the growing season (April through June) and monthly through the remainder of the study.

Precipitation data were used to observe the effects of annual, seasonal, monthly, and daily trends on surface- and ground-water levels. On-site precipitation data were collected during non-winter months using a tipping-bucket rain gauge and data logger. The on-site data were used in conjunction with the local Midwestern Regional Climate Center (MCC) weather station at Harrisburg (station # 113879). Additional precipitation data were obtained from the National Water and Climate Center (2003). Normal or average precipitation values are calculated by the NWCC and are based on the 30-year period 1961 through 1990.

Growing season information was obtained from the MCC weather station at Harrisburg, IL. The growing season is the period between the last occurrence of -2.2 °C (28 °F) temperatures in the spring and the first occurrence in fall (United States Army Corps of Engineers 1987). The median length of the growing season (in 5 out of 10 years) for the region was 211 days, with the median starting date on April 1 and the median ending date on October 29 (Midwestern Regional Climate Center 2003).

Elevation surveys were conducted to produce detailed site topography and obtain the elevation of the measuring point and land surface at each instrument. Site topography was surveyed in June 2002, and elevations of measuring points and corresponding land surface were surveyed each spring. Elevation surveys were based on the NAVD 1988 datum plane. Elevation measurements were made using either an optical auto level or total station. Additionally, the locations of the water-level monitoring instruments were determined in July 2003 using a GPS.

SITE CHARACTERIZATION

Regional Geology and Geomorpology

Harrisburg lies in the unglaciated region of southern Illinois near the southern margin of Illinoian glacial deposits. The mapped units at land surface in Saline County are Glasford Formation, Equality Formation, Pennsylvanian rocks, and surface mines. Glasford Formation (Illinois Episode) till is mapped in northern and western parts of Saline County (Lineback 1979). Equality Formation (Wisconsin Episode) sediments fill ancient river valleys across large portions of Saline County (Hansel and Johnson 1996). The deposits of the Equality Formation flank higher unglaciated areas composed of Pennsylvanian sandstones and shales of the Carbondale Formation mantled by thin loess deposits (Berg and Kempton 1988, Willman et al. 1967). As mapped, unconsolidated materials in the area are typically thin or discontinuous (Piskin and Bergstrom 1975, Herzog et al. 1994).

Site Geology and Geomorphology

Surface sediments on site are mapped Equality Formation (Lineback 1979, Berg and Kempton 1988, Hansel and Johnson 1996). Soil borings with depths ranging between 2.00 m (6.56 ft) and 2.85 m (9.35 ft) revealed brown (10YR 5/3) to weak red (2.5 YR 5/2) clayey silt to silty clay with no distinct bedding structures. The material observed in the soil borings was consistent with the lithologic description of the Equality Formation (Hansel and Johnson 1996). The sediments from each boring varied slightly in texture vertically, ranging from silty clay to clayey silt.

The wetland compensation site lies at the confluence of two small tributary valleys of the Saline River. The larger tributary valley, which trends southwest to northeast between Dorris Heights and Harrisburg, contains the west and southwest ditches, West Harrisburg Ditch and the re-alignment of IL RT 13 (Figures 1 and 2). The smaller tributary valley contains the south ditch and a portion of the village of Liberty. The new IL RT 13 road bed lies along the northwest boundary of the site and the natural grade of the site has been altered as a result of road construction activities. The land surface slopes gradually from southwest to northeast. The maximum elevation is 112.8 m (370.1 ft) at the southwest corner of the site and minimum elevation is 110.9 m (363.8 ft) at the ditch outlet at the east side of the site. The current grade of the site allows runoff from southwest to northeast. A pronounced interfluve rises to the south and is likely a local ground-water recharge area.

Soils

Three soils are mapped on site (Figure 3): Bonnie, Belknap, and Banlic silt loams (U.S. Department of Agriculture 1978). Each of these soils is somewhat poorly to poorly drained with moderately slow to very slow permeability (Table 1). Banlic silt loam is mapped over 4.3 ha (10.6 ac) or 53% of the site, occurring in the center portion and along the northern boundary of the site (Figure 3). Banlic silt loam is not listed on either the state (U.S. Department of Agriculture 1991) or county (U.S. Department of Agriculture 1995) hydric soils lists. It is known, however, to have inclusions of the hydric Bonnie silt loam. Bonnie silt loam, a state- and county- listed hydric soil, is mapped over 3.0 ha (7.5 ac), or 38% of the site along the south and east margins. Belknap silt loam is a state-listed hydric soil mapped in the southwest corner, over 0.55 ha (1.4 ac) or 7% of the site.

Grading activities related to the realignment of IL RT 13 have altered the soil profile at the compensation site and the most recent data from the Soil Survey (1978) predate grading of the site. Soil borings logged during the installation of wells 1S, 4M and 5M (Figure 2 and Appendix A) show hydric indicators within 30 cm (1 ft) of land surface. The soils at these locations likely qualify as hydric soils under the *F3* (Depleted Matrix) hydric-soil indicator (U.S. Department of Agriculture 1998). The soil features observed from borings suggest that excavation during the construction of IL RT 13 may have altered the hydrology of the site thereby creating conditions conducive to hydric soil development in areas not previously mapped as hydric soil.

Table 1: Hydrologic properties of the on-site soils (USDA 1978).

Soil Name (code)	Soil Order	State Hydric	County Hydric	Permeability depth: (in/hr)	Flooding	Seasonal High Water Table (depth in ft)
Banlic silt loam (787)	inceptisol	no	no	0-25 in: 0.6-2.0 25-62 in: <0.06 62-67 in: 0.2-0.6	somewhat poorly drained; rarely or occasionally flooded	1 to 3
Belknap silt loam (382)	entisol	yes	no	0-13 in: 0.6-2.0 13-47 in: 0.2-0.6 47-74 in: 0.2-0.6	somewhat poorly drained; subject to flooding and overflow	0 to 0.5
Bonnie silt loam (108)	entisol	yes	yes	0-8 in: 0.6-2.0 8-62 in: 0.06-0.2	somewhat poorly drained; subject to flooding and overflow	1 to 3

Hydrology

In general, surface-water responds to daily or weekly precipitation patterns and seasonal evapotranspiration patterns (Figure 5). The trends in ground-water levels follow seasonal precipitation and evapotranspiration patterns (Figure 6). During this study, monthly observations showed that frequent flooding and elevated ground-water levels corresponded to wetter precipitation patterns and low evapotranspiration. When precipitation totals were less than potential evapotranspiration, as was typical during summer months, little runoff occurred and ground-water levels receded. During fall and early winter, precipitation generally exceeded evapotranspiration and resulted in more flooding and recovery of ground-water levels. Some

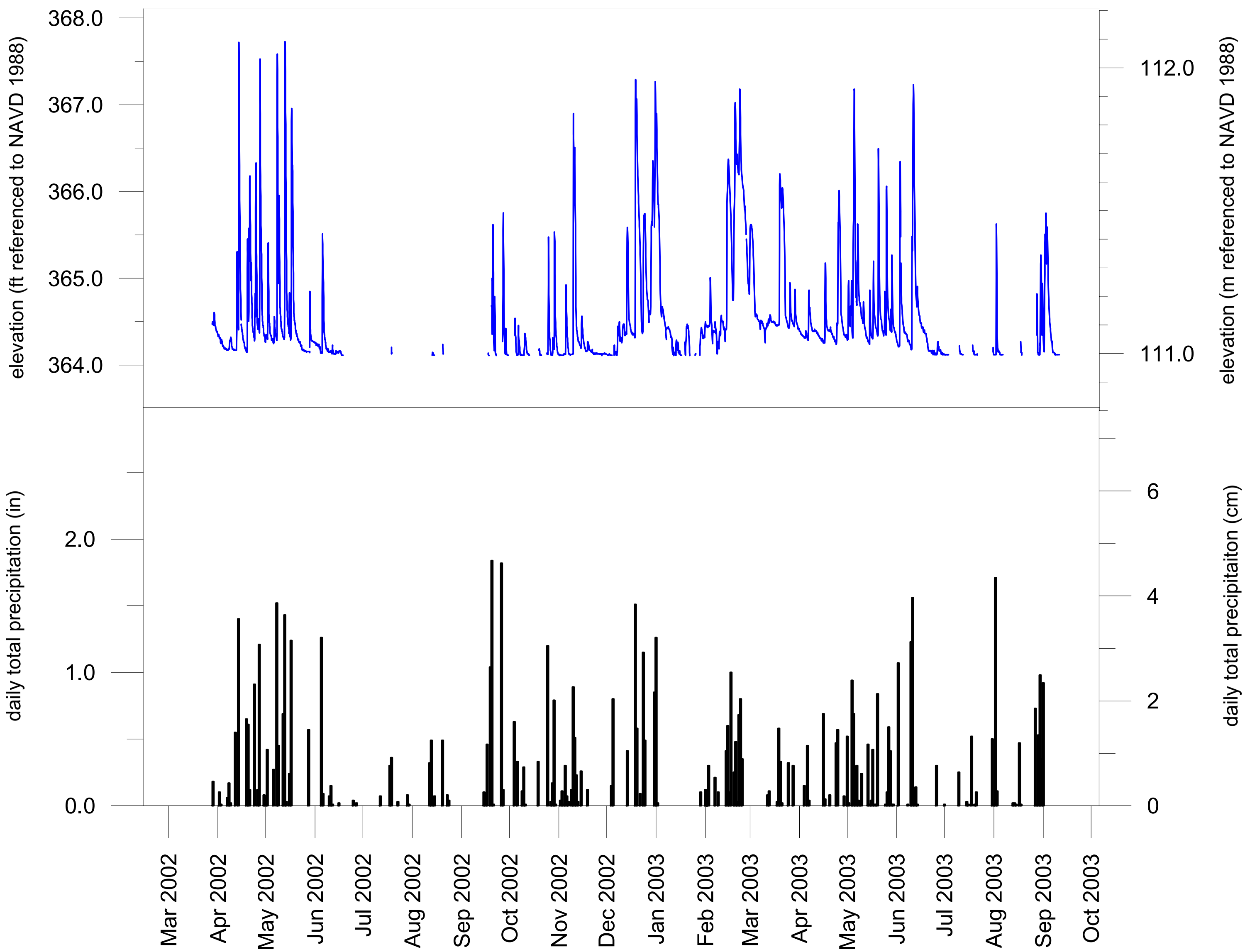

Figure 5. Surface-water elevation at RDS1 and daily total precipitation at the Harrisburg wetland compensation site: March 2002-September 2003.

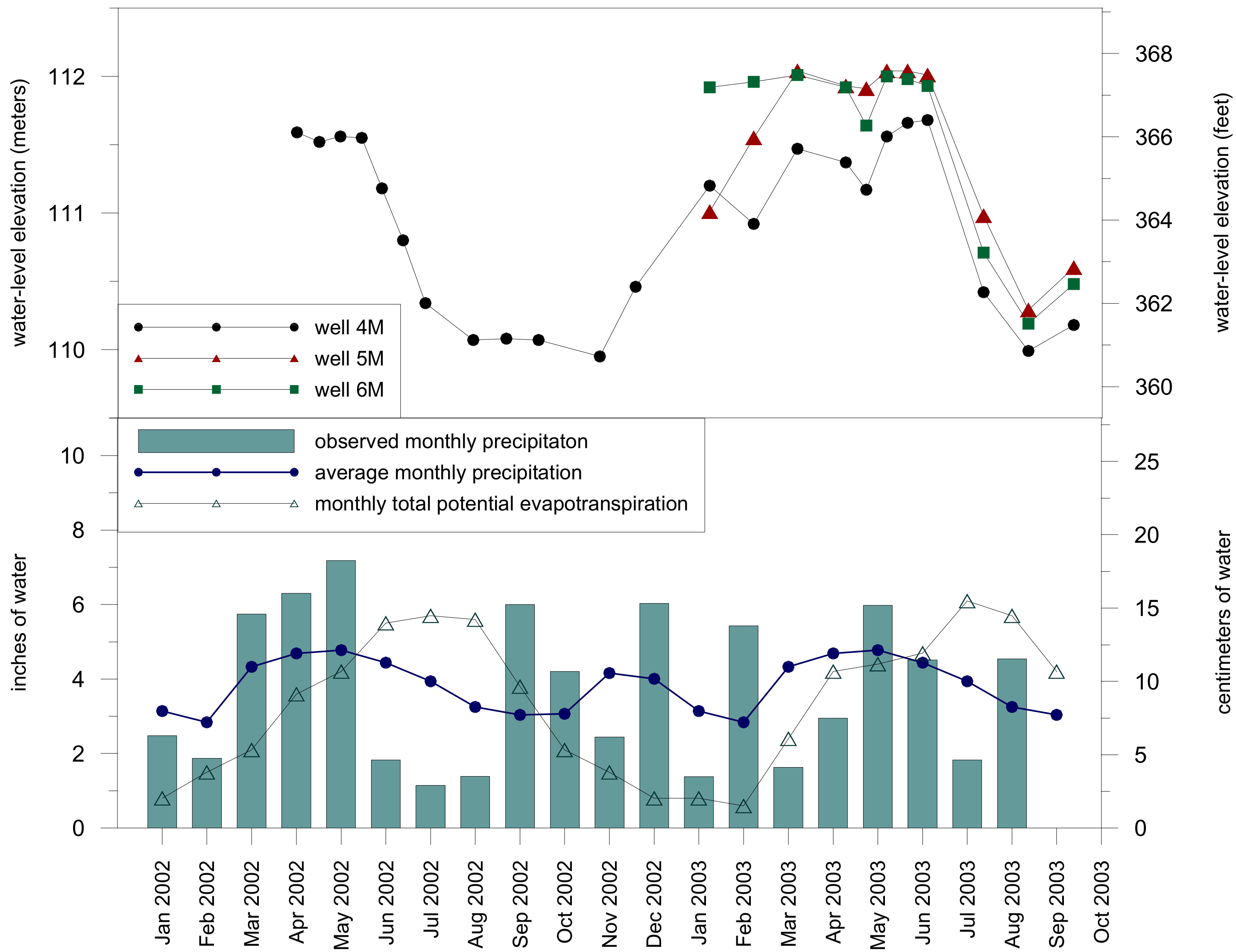

Figure 6. Ground-water elevatons and average and observed monthly precipitation at the Harrisburg potential wetland compensation site: January 2002-September 2003. Monthly total potential evapotranspiration data were taken from the Paducah, KY airport (Midwestern Regional Climate Center 2003).

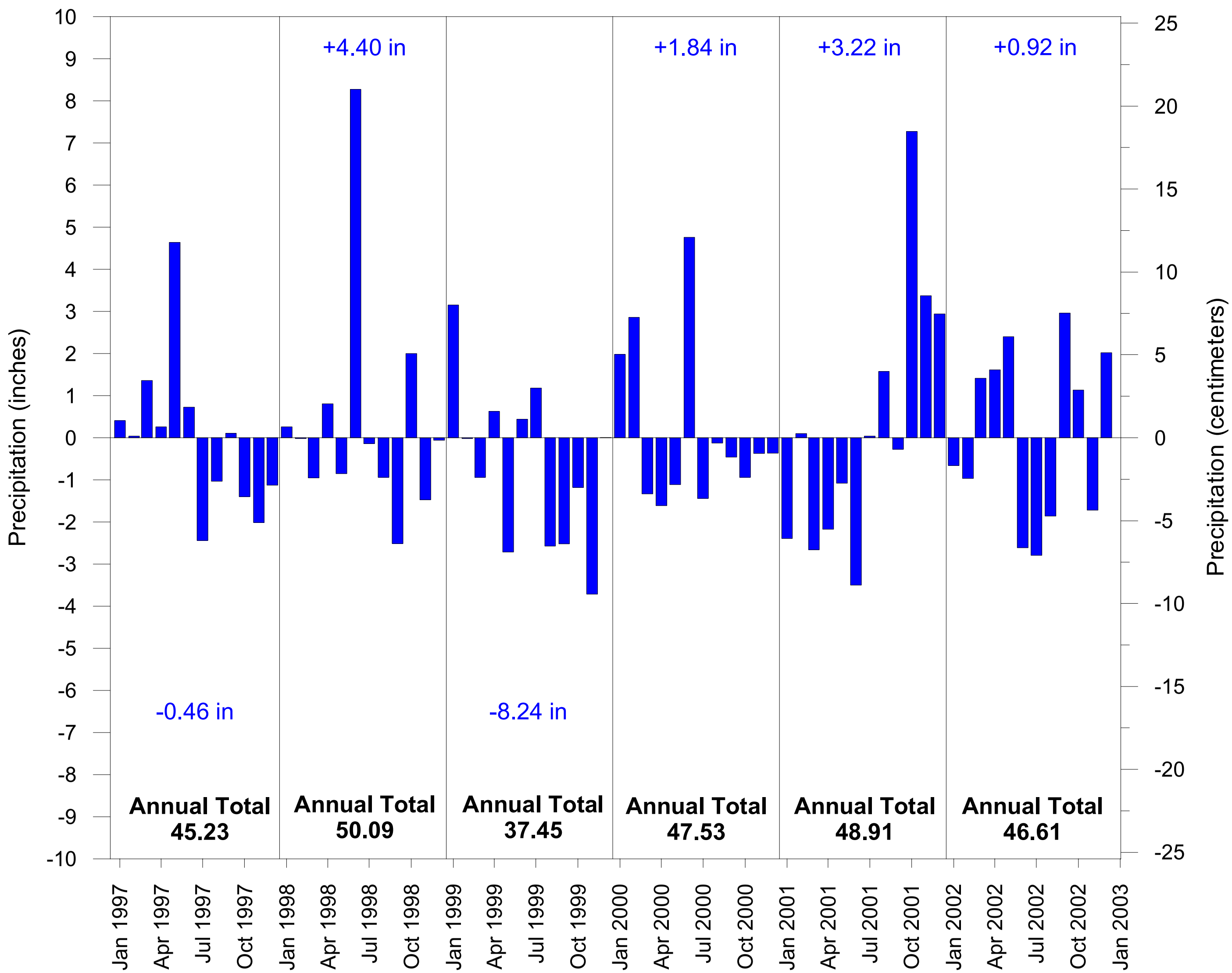

Figure 7. Histogram showing deviation of observed precipitation from monthly average for the period 1997 through 2002 (Midwestern Regional Climate Center 2003). Annual total precipitation is shown in bold type. Deviation of annual total precipitation from the 30-year average is shown in blue type.

ground-water recharge during winter and early spring months (Figure 5) is attributable to gradual releases of water from melting snow and ice (Hensel 1992).

Precipitation

Monthly average precipitation shows a seasonal wet-dry pattern (Figure 6). On average, January and February have lesser amounts of precipitation followed by a wet period from March through June. Another drier period is typical from July through October followed by wetter conditions in November and December. Figure 7 shows the deviation of observed monthly precipitation from the 30-year average at Harrisburg. During this study, 10 months were above and 10 months were below the 30-year average (45.69 in). The annual total for 2002 was 104% of average. For 2003, the annual total-to-date through September was 95% of the 30-year average. Despite the near-average annual precipitation totals for 2002 and 2003 data showed considerable variability in monthly precipitation totals and seasonal precipitation patterns.

Surface water

High-amplitude, short-duration floods in response to intense rainfall events characterize the surface-water hydrology at the site (Figure 5). For example, data from RDS1 recorded during April 14-16, 2002 indicate the water level rose over 1.0 m (3.3 ft) to a maximum elevation of 112.09 m (367.74 ft) within 5 hours of the start of a 1.4-in (3.6-cm) rainfall over the same duration. While this flood event inundated approximately 84% of the site, the water level receded to base-flow conditions over the next 48 hours. Flood events exceeding 112.00 m (367.45 ft) occurred on 3 other occasions, including the highest flood stage 112.09 m (367.75 ft) recorded on May 13, 2002. While each of these events inundated up to 85% of the site, none lasted more than three days from onset of the precipitation event to return to base flow. Surface water is the dominant source of water supporting wetland hydrology in the east portion of the site (Figure 2), because flooding in lower areas (i.e. in the vicinity of wells 1S, 2S, and 3S) frequently replenishes shallow ground water contributing to wetland hydrology. While the period of inundation of observed floods was not long enough to satisfy jurisdictional wetland hydrology criteria over a significant area (Figure 2), the frequency of floods sustained soil saturation for duration sufficient to satisfy wetland hydrology criteria as indicated by water levels in shallow monitoring wells (Appendix C).

Table 2 shows the probability that given stages will be equaled or exceeded during the growing season and the corresponding area inundated at each stage. These values were calculated from a partial duration series. The partial duration series was calculated from stage data collected at RDS1 during the 2002 and 2003 growing seasons. These data further illustrate that floods often inundate large portions of the site but do not last long enough to satisfy wetland hydrology criteria for significant portions of the site. The floods do replenish soil saturation frequently enough to satisfy wetland hydrology criteria in eastern portions of the site but not in higher areas. Very few if any topographically isolated areas exist onsite, therefore we assume that all areas below a given stage are inundated.

The amount of precipitation during individual events is an important factor in determining the magnitude of floods. However, surface-water and precipitation data show that seasonal patterns and timing of individual precipitation events relative to one another also influence the magnitude of surface-water response. For example, the highest daily rainfall total of 1.84 in (4.67 cm) occurred on September 20, 2002. This intense precipitation event resulted in a moderate magnitude peak stage of 111.45 m (365.65 ft) recorded at RDS1 on the same day (Figure 5). In contrast, the two highest stages were recorded on April 14 and May 13, 2002. Each event reached 112.09 m (367.74 ft), but the corresponding precipitation events preceding these peak stages were 1.40 in (3.94 cm) and 1.44 in (3.66 cm), respectively. More pronounced surface-water response during the spring was likely a result of more frequent rainfall events and more antecedent soil moisture.

Ground water

The ground-water hydrology at the site is characterized by seasonal trends that generally follow precipitation and evapotranspiration patterns (Figure 6). Ground-water level response subsequent to precipitation events is slower than surface-water response and corresponds more closely to monthly precipitation averages. The water level in wells generally peaked during spring (May 2002 and May 2003) and reached lows in late summer or fall (October 2002 and August 2003). In 2002, water levels in the wells peaked during April and May and receded during June and into July when all S-wells went dry (Figure 8 and Appendix C). The water level the deeper well, 4M, remained low through October, began to recover in November and continued an upward trend into Spring 2003. In 2003, water level followed a trend similar to 2002, however the higher water levels in wells during the early part of the growing season were sustained slightly longer into late spring due in part to above average precipitation in May 2003. Along the south margin of the site, ground water is likely the dominant source for wetland hydrology. This area exhibits wetland hydrology despite higher elevation and less frequent flooding than lower areas in the east portion of the site. Data indicate weak upward hydraulic gradient along the south margin during late winter and spring. The upward gradient suggests that ground-water may discharge at land surface during the early growing season.

Table 2. Flood-frequency analysis, duration and corresponding percentage and area of the site inundated at Harrisburg. Only data from the 2002 and 2003 growing seasons were analyzed.

Stage exceeded meters (feet)	**Number of events**	**Recurrance interval** years	**Probability of exceedance** %	**Maximum duration** days	**% of site inundated**	**Area inundated** hectares (acres)
112.05 (367.61)	2	0.56	1.8	0.1	83.4	6.57 (16.23)
111.95 (367.29)	4	0.34	3.0	0.2	80.4	6.33 (15.64)
111.85 (366.96)	7	0.23	4.3	0.4	71.3	5.61 (13.87)
111.75 (366.63)	7	0.21	4.8	0.5	61.8	4.86 (12.02)
111.65 (366.30)	11	0.15	7.0	0.9	49.9	3.93 (9.71)
111.55 (365.97)	15	0.10	9.9	1.1	40.8	3.21 (7.93)
111.45 (365.64)	18	0.08	12.0	1.5	32.9	2.59 (6.41)
111.35 (365.32)	26	0.07	17.6	2.0	22.4	1.76 (4.36)
111.25 (364.99)	33	0.05	21.7	2.3	12.7	1.00 (2.46)
111.15 (364.66)	49	0.03	32.8	5.0	7.5	0.59 (1.46)
111.05 (364.33)	64	0.03	40.4	16.9	3.7	0.29 (0.72)

Vertical hydraulic gradients also follow seasonal trends. At monitoring stations 4, 5, and 6, elevations of water levels measured in nested intermediate depth wells (M-wells) and S-wells indicated upward hydraulic gradients during late winter and spring (Figure 8). Water-level measurements at well nests 5 and 6 show water level at or near land surface during spring months. Upward gradients at these locations, though weak, suggests that ground water discharge occurs in late winter and early spring and currently supports wetland

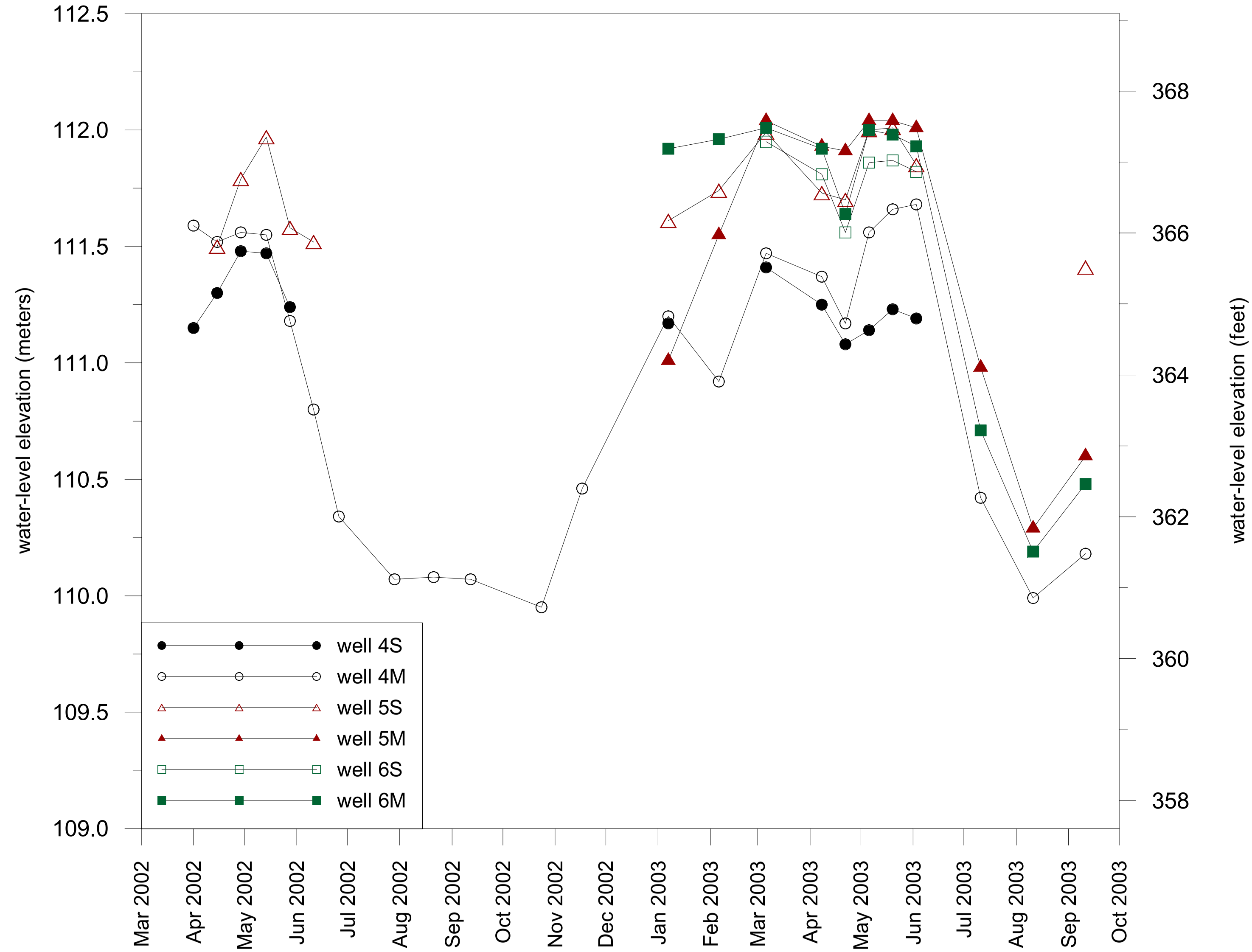

Figure 8. Water-level elevations from monitoring well nests 4, 5 and 6 at Harrisburg.

hydrology. In 2002, wells 4S and 4M showed an upward gradient from April through May (Figure 8). Additional M-wells were installed at stations 5 and 6 in November 2002 to corroborate the hydraulic gradients observed at well nest 4. During Spring 2003, well nests 4, 5 and 6 all showed upward gradients from March into June (Figure 8 and Appendix C). The water levels in wells 4M, 5M and 6M indicate that the horizontal hydraulic gradient is generally from southwest to northeast.

To test the hydraulic properties of the geologic formation, slug tests were conducted in September 2003. The results of the slug tests (Table 3) show that the Equality Formation at this location responds readily to introduction and extraction of water from the water column in the well. The falling- and rising-head tests showed that water level in the wells responded within a relatively short period of time. The falling-head test showed a return to near-static water level within 10 hours and 4 hours after the slug was introduced for well 5M and well 6M, respectively. The rising-head tests showed a return to near-static conditions within 9 hours and 8 hours after the slug was removed for 5M and 6M, respectively. The hydraulic conductivity values calculated here (Table 3) are consistent with the range of values expected the material encountered in the borings (Fetter 1994 and Appendix A). The pumping trials showed that the volume of water extracted from each well was in excess of the volume of the well and the pore space in the sand pack. After pump trial 2, water levels recovered nearly completely within approximately 4 hours from the end of pumping at each well. The water-level recovery after the end of the pump tests indicates discharge from the surrounding geologic formation. The water-level recovery subsequent to pumping coupled with the total volume of water extracted from each well demonstrated that water levels in these monitoring wells reflect saturated conditions in the surrounding formation.

Table 3: Hydraulic conductivity of the geologic formation and volumes extracted from wells at the Harrisburg wetland compensation site.

Well	**Hydraulic conductivity** cm/sec		**Volume** Liters (time at end of test)			
	falling head	rising head	pump trial 1 (9/17/03)	pump trial 2 (9/18/03)	total water extracted (trial 1 plus trial 2)	Well and sand pack*
5M	1.608×10^{-5}	1.729×10^{-5}	4.1 (17:05 CST)	3.9 L (08:20 CST)	8.0 L	5.5 L
6M	4.375×10^{-5}	2.236×10^{-5}	3.8 (17:29 CST)	3.4 L (12:26 CST)	7.2 L	5.9 L

* total volume of sand pack pore space and well volume below the top of sand pack

Hydrologic Alterations

The natural hydrologic regime of the wetland compensation site has been altered by the construction of West Harrisburg Ditch and its tributaries, the recent realignment of IL RT 13, and urban development.

West Harrisburg Ditch drains a catchment which contains the wetland compensation site, northwest portions of the city of Harrisburg and northern portions of village of Liberty. The west ditch (a tributary to West Harrisburg Ditch), southwest ditch, and south ditch coalesce within the proposed wetland compensation site (Figure 2) and exit the site at a single outlet. This ditch system expedites the drainage of storm water from the site and surrounding residential areas. No drainage tile was encountered at this site.

During construction of the new IL RT 13 alignment, the site was excavated and the configuration of the surface-water drainage was altered. The new road grade diverts runoff from areas to the northwest from reaching the site. Water from these areas is concentrated in the west ditch which enters the site through a box culvert under IL RT 13 (Figure 2). The southwest ditch enters the site through a culvert under Lovers Lane. This ditch now runs along the south side of the new road grade and connects with the west ditch near the box culvert under IL RT 13.

The total catchment area for the site is approximately 372 ha (920 ac). The catchment area consists predominantly of urban land use and reclaimed coal mines. Hydrologic alterations to the catchment such as impervious surfaces in urban areas and sparsely vegetated reclaimed mined areas, combined with relatively steep valley gradients in the catchment, hasten runoff and promote rapid surface-water response to precipitation events (Figure 5). Rapid surface-water response causes frequent short-term flooding at the compensation site.

CONCLUSIONS AND RECOMMENDATIONS

The conclusions of this study are as follows:

- The site is an excavated basin adjacent to the right-of-way of Illinois Route 13 (IL RT 13). Land-surface topography has been altered across the entire site, and three drainage ditches have been routed or re-routed through the site. The current grade promotes runoff generally from the southwest to the northeast. Recent excavation and grading activities during the realignment of IL RT 13 (prior this study) have made conditions conducive to satisfying jurisdictional wetland hydrology criteria over a significant portion of the site.

- The geologic deposits at the site are silty clay and clayey silt associated with the Equality Formation. Due to relatively low permeability, these materials are conducive to ponding surface water. However, pumping tests showed that this shallow geologic unit provides a significant amount of ground water to wells at the site despite low hydraulic conductivity (Table 3).

- Water-level data collected during 2002 and 2003 indicated that 42% and 58% of the site, respectively, satisfied jurisdictional wetland hydrology criteria. The area of wetland hydrology was 3.3 ha (8.3 ac) in 2002 and 4.6 ha (11.5 ac) for 2003. Wetland hydrology resulted from frequent floods replenishing soil saturation in lower areas in the east portion of the site. Higher areas along the south margin of the site satisfied wetland hydrology criteria due to ground-water discharge at or near land surface. Storm flow conveyed by the drainage ditches frequently inundated large areas of the site for short durations, contributing to wetland hydrology by replenishing soil saturation in east portion of the site. However, these floods receded too quickly to satisfy jurisdictional wetland hydrology criteria in higher areas. Flooding of the on-site drainage ditches inundates only those areas lower than 111.02 m (364.23 ft) for durations sufficient to satisfy wetland hydrology criteria.

- Potential water sources include flooding from drainage ditches, runoff from residential areas south of the site, road runoff, ground-water discharge along the southern margin of the site, and direct precipitation. Surface water frequently inundates large areas of the site, however the duration of inundation is too short to satisfy wetland hydrology criteria over a significant area. Ground-water elevations and gradients suggest ground-water discharge to land surface at well nests 4, 5 and 6 during the early portion of the growing season.

- The minimum area of wetland hydrology calculated during this study was 3.3 ha (8.3 ac) in 2002 (Figure 2). If additional acres are needed for wetland mitigation, we recommend excavating areas in the west portion of the site to increase the chance and duration of flooding and promote ground-water discharge. We recommend that any additional areas intended for wetland creation (Figures 2 and 4) be excavated to at least 111.38 m (365.42 ft). We suggest that excavated areas slope gradually toward the west to prevent runoff, capture flood peaks, and further promote groundwater discharge in western portions of the site. Recommended excavation depths are shown in Figure 4. Excavation volume estimates and corresponding potential wetland creation areas are given in Appendix D.

- If additional wetland acreage is needed, excavation of areas that already satisfy wetland hydrology criteria may be necessary. The hydrology of areas at higher elevations that already meet wetland hydrology criteria (areas surrounding well nests 5 and 6) may be impacted by wetland creation activities. Earthwork activities would have undetermined impacts on the hydrology of the site. Therefore, we recommend that all areas intended for wetland mitigation credit be excavated to 111.38 m (365.42 ft) or lower. In addition, construction of a berm (recommended below) would exclude portions of the area that already satisfies wetland hydrology criteria from wetland mitigation.

- Construction of a berm along the southern margin of the site to divert effluent away from the wetland mitigation area is recommended. We suggest the berm be constructed to minimize adverse impacts to water quality in the compensation area while not obstructing septic system drainage from residences to the south. Though the berm would prevent runoff from areas to the south from reaching the mitigation area, it is not likely that it will significantly reduce the potential for satisfying jurisdictional wetland hydrology criteria in wetland creation areas assuming excavation to elevation specified above.

- Due to potential damage to a control structure and possible adverse off-site impacts, impounding surface water on the site is not recommended. Impounding water may cause flooding on adjacent properties. Also, a control structure may be susceptible to erosion or other damage by frequent high flows. Impounding water would be feasible if the control structure is designed to tolerate high flows and if measures are taken to avoid off-site impacts. For instance, if the base-level elevation of the control structure does not exceed 111.2 m (364.82 ft) and created wetland areas are excavated to some depth below 111.2 m (364.83 ft) but not lower than 110.6 m (362.86 ft) to allow appropriate water depths for wetland vegetation (Morris et al. 1997), wetland acres may be created with minimal impacts to nearby residences. If a control structure is planned, we recommend elevations for the inlets and outlets of the ditches and adjacent properties be verified prior to installation.

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Appendix A: Geologic/Soil Logs

Boring #:	**4M**
Site:	Harrisburg
Location:	NE1/4, SE1/4 Sec.17 T9S R6E Harrisburg, IL
Date:	3/28/02
Field Crew:	Geoff Pociask, Steve Benton

Depth	Description
0-50 cm	Dark grayish brown (10YR 4/2) silty clay; many, distinct Fe masses, dark yellowish brown (10 YR 4/4)
50-140 cm	Brown (10YR 5/3) silty clay; common, prominent Fe masses, yellowish brown (10YR 5/6)
140-200 cm	Light brownish gray 10YR 6/2 silty clay; many, prominent Fe concentrations, yellowish brown (10YR 5/6); diffuse boundaries between depletions and masses; Mn and Fe concentrations present

Appendix A: Geologic/Soil Logs

Boring #:	**5M**
Site:	Harrisburg
Location:	NE1/4, SE1/4 Sec.17 T9S R6E Harrisburg, IL
Date:	3/28/02
Field Crew:	Geoff Pociask, Marshall Lake

Depth	Description
0-50 cm	Dark grayish brown (10YR 4/2) clayey silt; common, distinct, dark yellowish brown (10 YR 4/6) Fe concentrations and light brownish gray (10YR 6/2) depletions
50-120 cm	Brown (10YR 5/3) clayey silt; common, prominent, yellowish brown (10YR 5/8) Fe masses and light grey (10YR 7/2) depletions
120-282 cm	Alternating, grading silt and clay layers; mottled; many, prominent, yellowish brown (10YR 5/6) Fe masses and grayish brown (10YR 5/2) depletions; Mn concretions present

Appendix A: Geologic/Soil Logs

Boring #:	**Boring B1** (description from Ketterling et al. 2000)
Site:	Harrisburg
Location:	NE1/4, SE1/4 Sec.17 T9S R6E Harrisburg, IL
Date:	2/9/00
Field Crew:	Keith Carr, Brad Ketterling, Jim Miner, Blaine Watson

Depth	Description
0-50 cm	Brown (10YR 4/2) clayey silt with few mottles and nodules each less than 1 mm in diameter
50-90 cm	Grayish brown (10YR 5/2) clayey silt with occasional mottles and nodules each less than 1 mm in diameter
90-160 cm	Weak red (2.5 YR 5/2) clayey silt, commonly occurring dark yellowish brown mottles (10YR 4/6) between 2 and 3 mm in diameter (10-15% of whole)
120-282 cm	Weak red (2.5YR 5/2 clayey silt with many black (10YR 2/1) nodules and dark yellowish brown (10YR 4/6) mottles of diameter greater than 5 mm (40-50% of whole).

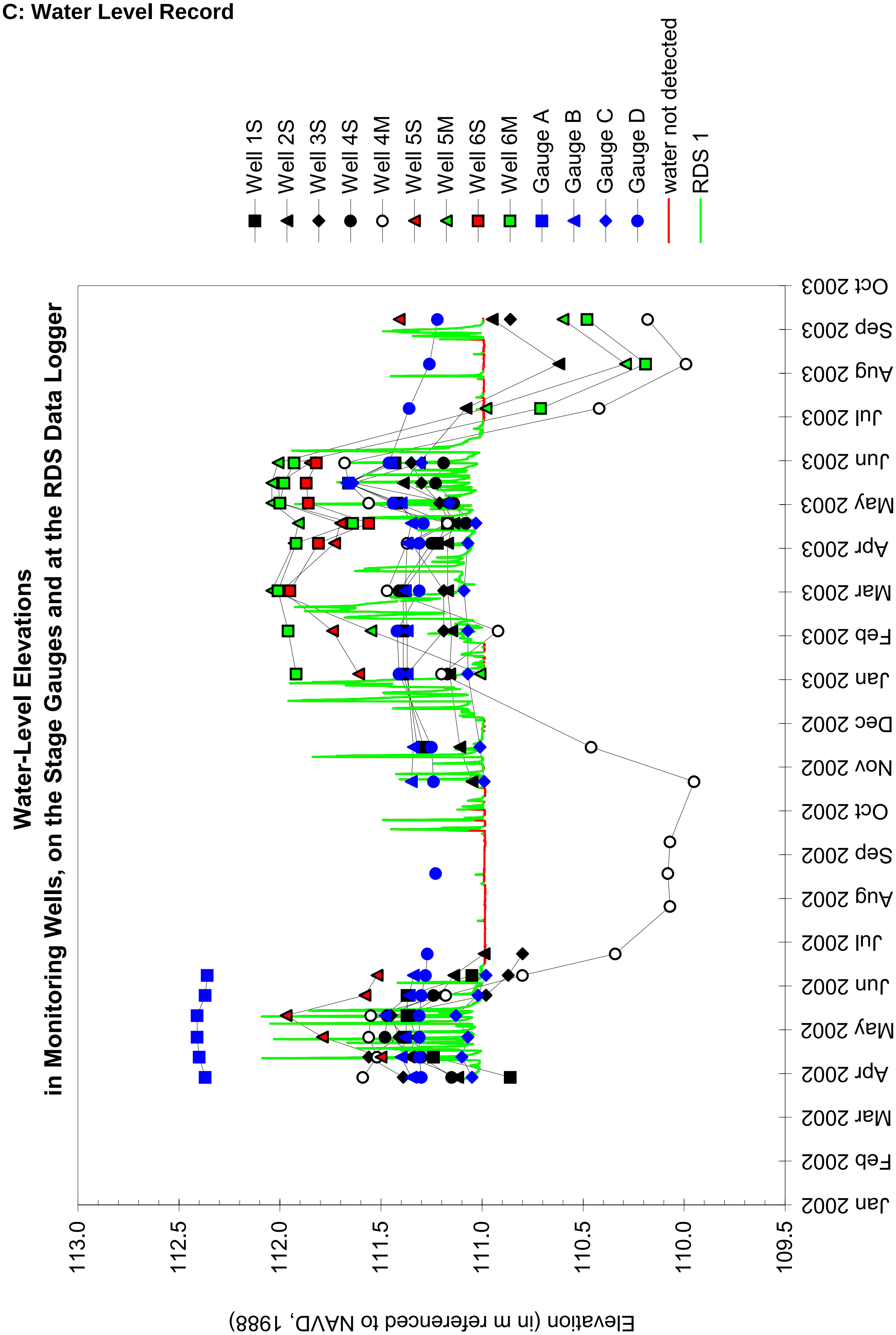
Appendix B: Well Construction Specifications

Well Number	Elevation of well top (m) *	Land surface elevation 2002 (m) *	Land surface elevation 2003 (m) *	Bottom of well **	Well seal - top**	Well seal - bottom **	Sand pack - top **	Sand pack - bottom **	Top of screen **	Bottom of screen **
1S	112.63	111.44	111.44	0.71	0.00	0.24	0.24	0.71	0.38	0.68
2S	112.25	111.07	111.10	0.71	0.00	0.28	0.28	0.71	0.38	0.68
3S	112.60	111.46	111.47	0.74	0.00	0.30	0.30	0.74	0.41	0.71
4S	112.89	111.71	111.71	0.74	0.00	0.30	0.30	0.74	0.39	0.71
4M	113.10	111.71	111.71	1.90	0.00	0.93	0.93	1.90	1.59	1.86
5S	113.18	111.97	112.00	0.71	0.00	0.30	0.30	0.71	0.41	0.68
5M	113.03	111.95	112.00	2.76	0.00	2.01	2.01	2.76	2.03	2.70
6S	113.15	n/a	111.99	0.76	0.00	0.30	0.30	0.76	0.46	0.71
6M	113.01	112.03	111.99	2.86	0.00	2.02	2.02	2.86	2.14	2.80

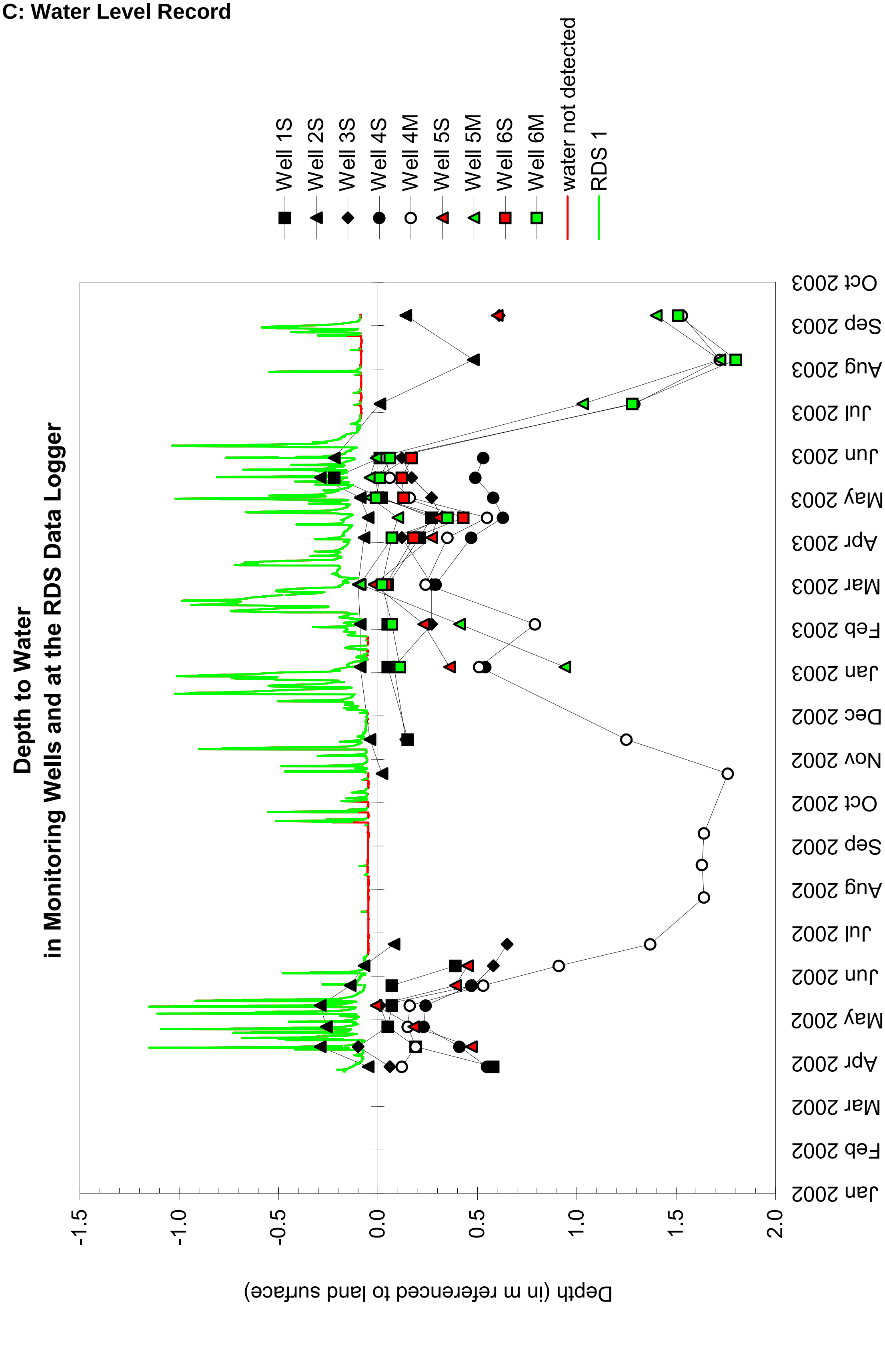
* NAVD 1988

** reported in meters below ground surface

Appendix C: Water Level Record



Appendix C: Water Level Record



Appendix C: Water Level Record

Harrisburg Potential Wetland Compensation Site
2002 to 2003

	Water-Level Elevations (in m referenced to NAVD, 1988)											
Date	04/01/02	04/15/02	04/29/02	05/14/02	05/28/02	06/11/02	06/26/02	07/29/02	08/21/02	09/12/02	10/24/02	11/17/02
Well 1S	110.86	111.24	111.38	111.37	111.37	111.05	dry	dry	dry	dry	dry	111.29
Well 2S	111.12	111.36	111.33	111.36	111.21	111.14	110.99	dry	dry	dry	111.05	111.11
Well 3S	111.39	111.56	111.41	111.45	110.98	110.87	110.80	dry	dry	dry	dry	111.32
Well 4S	111.15	111.30	111.48	111.47	111.24	dry	dry	dry	dry	dry	dry	dry
Well 4M	111.59	111.52	111.56	111.55	111.18	110.80	110.34	110.07	110.08	110.07	109.95	110.46
Well 5S	dry	111.50	111.79	111.97	111.58	111.52	dry	dry	dry	dry	dry	dry
Well 5M	**	**	**	**	**	**	**	**	**	**	**	**
Well 6S	**	**	**	**	**	**	**	**	**	**	**	**
Well 6M	**	**	**	**	**	**	**	**	**	**	**	**
Gauge A	112.37	112.40	112.41	112.41	112.37	112.36	dry	dry	dry	dry	dry	dry
Gauge B	111.35	111.40	111.38	111.48	111.36	111.34	dry	dry	dry	dry	111.35	111.34
Gauge C	111.05	111.10	111.07	111.13	111.02	110.98	dry	dry	dry	dry	110.99	111.01
Gauge D	111.30	111.31	111.31	111.31	111.30	111.28	111.27	dry	111.23	dry	111.24	111.25

	Depth to Water (in m referenced to land surface)											
Date	04/01/02	04/15/02	04/29/02	05/14/02	05/28/02	06/11/02	06/26/02	07/29/02	08/21/02	09/12/02	10/24/02	11/17/02
Well 1S	0.58	**0.19**	**0.05**	**0.07**	**0.07**	0.39	dry	dry	dry	dry	dry	**0.15**
Well 2S	**-0.05**	**-0.29**	**-0.26**	**-0.29**	**-0.14**	**-0.07**	**0.08**	dry	dry	dry	**0.02**	**-0.04**
Well 3S	**0.06**	**-0.10**	**0.05**	**0.01**	0.48	0.58	0.65	dry	dry	dry	dry	**0.14**
Well 4S	0.55	0.41	**0.23**	**0.24**	0.47	dry	dry	dry	dry	dry	dry	dry
Well 4M	**0.12**	**0.19**	**0.15**	**0.16**	0.53	0.91	1.37	1.64	1.63	1.64	1.76	1.25
Well 5S	dry	0.47	**0.18**	**-0.01**	0.39	0.45	dry	dry	dry	dry	dry	dry
Well 5M	**	**	**	**	**	**	**	**	**	**	**	**
Well 6S	**	**	**	**	**	**	**	**	**	**	**	**
Well 6M	**	**	**	**	**	**	**	**	**	**	**	**

- indicates water above land surface
** not yet installed
bold depth values less than or equal to 0.304 m
S indicates soil-zone monitoring well
M indicates middle monitoring well

Appendix C: Water Level Record

Harrisburg Potential Wetland Compensation Site
2002 to 2003

	Water-Level Elevations (in m referenced to NAVD, 1988)										
Date	01/07/03	02/06/03	03/06/03	04/08/03	04/22/03	05/06/03	05/20/03	06/03/03	07/11/03	08/11/03	09/11/03
Well 1S	111.39	111.39	111.39	111.22	111.17	111.42	111.66	111.43	dry	dry	dry
Well 2S	111.16	111.15	111.17	111.17	111.14	111.19	111.39	111.31	111.08	110.62	110.95
Well 3S	111.37	111.19	111.19	111.35	111.16	111.21	111.30	111.35	dry	dry	110.86
Well 4S	111.17	dry	111.41	111.25	111.08	111.14	111.23	111.19	dry	dry	dry
Well 4M	111.20	110.92	111.47	111.37	111.17	111.56	111.66	111.68	110.42	109.99	110.18
Well 5S	111.61	111.74	111.99	111.73	111.70	112.00	112.01	111.85	dry	dry	111.41
Well 5M	111.01	111.55	112.04	111.93	111.91	112.04	112.04	112.01	110.98	110.29	110.60
Well 6S	**	**	111.95	111.81	111.56	111.86	111.87	111.82	dry	dry	dry
Well 6M	111.92	111.96	112.01	111.92	111.64	112.00	111.98	111.93	110.71	110.19	110.48
Gauge A	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged	damaged
Gauge B	111.37	111.37	111.38	111.37	111.35	111.40	111.67	111.45	dry	dry	dry
Gauge C	111.07	111.07	111.09	111.07	111.03	111.16	111.64	111.30	dry	dry	dry
Gauge D	111.41	111.42	111.31	111.31	111.29	111.44	111.66	111.46	111.36	111.26	111.22

	Depth to Water (in m referenced to land surface)										
Date	01/07/03	02/06/03	03/06/03	04/08/03	04/22/03	05/06/03	05/20/03	06/03/03	07/11/03	08/11/03	09/11/03
Well 1S	**0.05**	**0.05**	**0.05**	**0.21**	**0.27**	**0.02**	**-0.22**	**0.01**	dry	dry	dry
Well 2S	**-0.09**	**-0.09**	**-0.10**	**-0.07**	**-0.05**	**-0.09**	**-0.29**	**-0.22**	**0.01**	0.48	**0.14**
Well 3S	**0.08**	**0.27**	**0.27**	**0.12**	0.32	**0.27**	**0.17**	**0.12**	dry	dry	0.61
Well 4S	0.54	dry	**0.29**	0.47	0.63	0.58	0.49	0.53	dry	dry	dry
Well 4M	0.51	0.79	**0.24**	0.35	0.55	**0.16**	**0.06**	**0.04**	1.29	1.72	1.53
Well 5S	0.36	**0.23**	**-0.02**	**0.27**	**0.30**	**0.00**	**-0.01**	**0.15**	dry	dry	0.60
Well 5M	0.94	0.41	**-0.09**	**0.07**	**0.10**	**-0.04**	**-0.04**	**-0.01**	1.03	1.72	1.40
Well 6S	**	**	**0.04**	**0.18**	0.43	**0.13**	**0.12**	**0.17**	dry	dry	dry
Well 6M	**0.11**	**0.07**	**0.02**	**0.07**	0.35	**-0.01**	**0.01**	**0.06**	1.28	1.80	1.51

- indicates water above land surface
** not yet installed
bold depth values less than or equal to 0.304 m
S indicates soil-zone monitoring well
M indicates middle monitoring well

Appendix D: Excavation-Area Table

Elevation meters (feet)	**Volume of excavation needed to yield corresponding area*** hectare-meters (acre-feet)	**Corresponding area**** hectares (acres)
111.5 (365.81)	0.004 (0.03)	0.07 (0.2)
111.6 (366.14)	0.091 (0.74)	0.6 (1.4)
111.7 (366.47)	0.267 (2.16)	1.2 (3.0)
111.8 (366.79)	0.611 (4.95)	2.2 (5.3)
111.9 (367.12)	0.963 (7.81)	2.9 (7.2)
112.0 (367.45)	1.372 (11.12)	3.6 (9.0)
112.1 (367.78)	1.530 (12.40)	3.9 (9.5)
112.2 (368.11)	1.622 (13.15)	4.0 (9.8)
112.3 (368.43)	1.757 (14.24)	4.1 (10.2)
112.4 (368.76)	1.813 (14.70)	4.2 (10.4)
112.5 (369.09)	1.850 (15.00)	4.2 (10.4)

*Volumes calculated based on excavation to 111.38 m (365.42 ft).

**Area includes all site area below the specified elevation.