CENTREVILLE POTENTIAL WETLAND COMPENSATION SITE: LEVEL II HYDROGEOLOGIC CHARACTERIZATION REPORT

Centreville, St. Clair County, Illinois
NW 1/4, Section 4, T1N, R9W
(Federal Aid Project 999)

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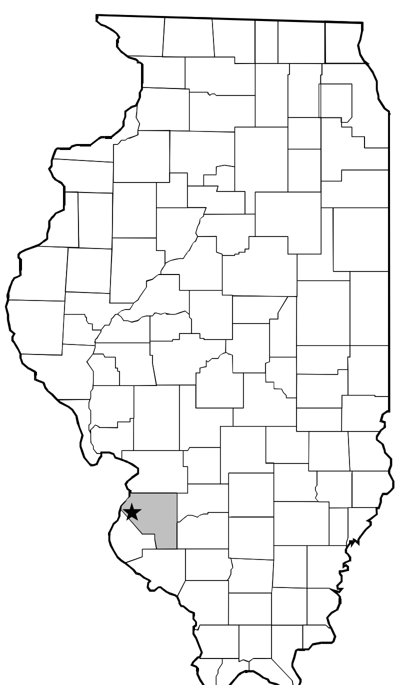
Submitted Under Contract No. IDOT SW WIP FY04 to
Illinois Department of Transportation
Bureau of Design and Environment, Wetlands Unit
2300 South Dirksen Parkway
Springfield, IL 62764

February 24, 2004

Illinois State Geological Survey
Open File Series 2004-6



Executive Summary

In April 2002, the Illinois Department of Transportation tasked the Wetlands Geology Section of the Illinois State Geological Survey to conduct a hydrogeologic characterization of the Centreville potential wetland compensation site in St. Clair Co., Illinois. Field work at this site began in July 2002 with the installation of a network of monitoring wells, staff gauges, and data loggers. The purpose of the hydrogeologic characterization was to determine the geology and hydrology of the site and to identify methods of restoring or creating wetland.

The results of this investigation indicate that wetland can be created at this site by trapping precipitation and runoff. Currently, precipitation and runoff are channeled down a swale via a drainage ditch that is bordered by berms. Removing the berms, filling the ditch, and building a control structure across the downstream end of the swale will produce wetland hydrology. Potentially, up to 8.1 ha (20.0 ac) of wetland could be created. However, the risk of off-site impacts means that the surface-water elevation in the wetland must be limited to no more than 123.4 m (404.9 ft), which would result in the creation of only about 2.4 ha (6.0 ac) of wetland. Attaining the full potential area of wetland (8.1 ha) would, along with the other alterations, require excavating the site. The drawback is that this may require the removal of large volumes of sediment.

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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 in a potential wetland compensation site (NE 1/4, Section 4, T1N, R9W, St. Clair County) located in Centreville, Illinois (Figure 1). The site covers about 21 hectares (53 acres) and includes farm fields (~ 11 hectares) and forest (~ 10 hectares).

The purpose of this report is to provide IDOT with data regarding the hydrogeologic conditions of the study site and to make recommendations regarding restoration and/or creation of wetlands. Therefore, for IDOT's convenience, the report presents conclusions and design recommendations first, followed by a discussion of the methods and supporting data. The supporting data include ground- and surface-water level data and precipitation data collected from July 2002 to August 2003, and geologic data collected during the installation of monitoring wells.

Data collection at the site is ongoing and will continue until terminated by IDOT. The data currently being collected will be used to compare the pre- and post-construction hydrology of the site and to determine the impact of hydrologic alterations on the area and the duration of wetland hydrology.

Summary

- Approximately 50% of the site is mapped as wetland (NWI 1988). This includes the forested area southwest of Westerheide Drive, along the primary drainage ditch, and in the farm field north of the primary ditch (figure 2). Surface- and ground-water data reveal that, in 2003, about 18% of the site had jurisdictional wetland hydrology (Environmental Laboratory 1987) including the forested area southwest of Westerheide Drive, in the farm field north of the primary ditch, and in the farm field west of the primary ditch (figure 2). Surface-water data reveal that these areas generally correspond to areas of the site that were inundated.

- Most of the site (figure 3) is mapped as Darwin silty clay, which is on both the state (USDA 1991) and county (USDA 1995, USDA 2000) hydric soils lists. The remainder of the site is mapped as Shaffton clay loam and Landes very fine sandy loam which are both non-hydric. The areas of the site that satisfied the criteria for jurisdictional wetland hydrology, and the areas mapped as wetland, were generally in the portion of the site underlain by Darwin silty clay.

- Hydrologic alterations on the site include drainage ditches, culverts, and berms. The primary drainage ditch (figure 2) is confined between two berms. This ditch receives runoff from IL-163 and from the farm fields on the site and discharges into Harding Ditch (figure 1). A secondary ditch along the west side of IL-163 (figure 2) captures runoff from the road and the adjacent properties and channels it into the primary ditch via a culvert under IL-163. Secondary ditches in the farm fields (figure 2) channel runoff into the primary ditch via a culvert located where the berms bend around to the south (figure 2). The primary ditch may also receive overland flow from the east side of IL-163.

- The NWI-mapped wetland southwest of Westerhiede Drive is drained by a secondary ditch which runs along the southeast side of the wetland (figure 2). This ditch discharges into a ditch which runs along the northeast side of the farm field between the NWI-mapped wetland and the primary ditch. These ditches have no outlet, though on-site observations suggest that there may be overland flow across the farm field which eventually into the primary ditch.

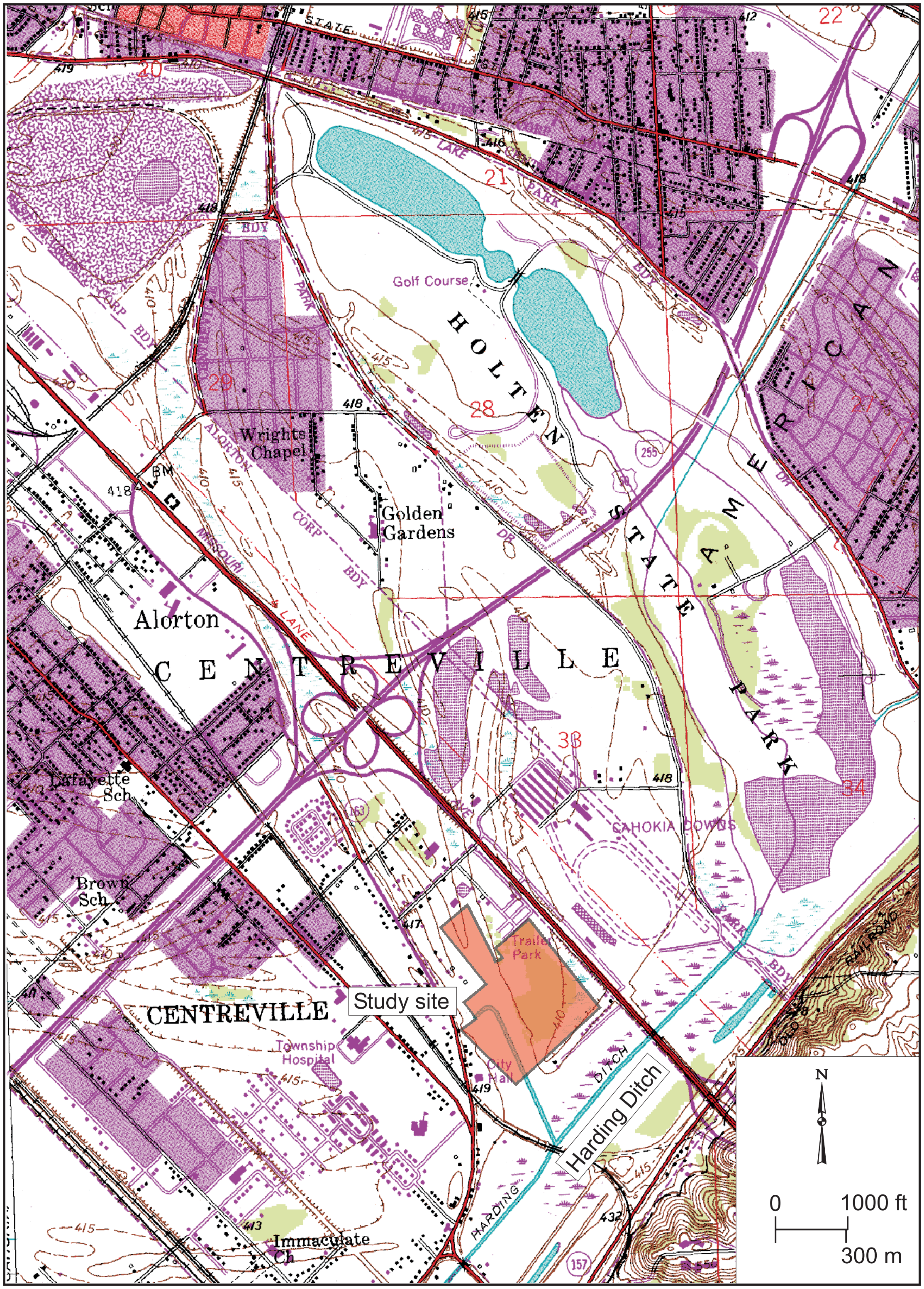

Figure 1: Site location map (Source: French Village Quadrangle, USGS 1993)

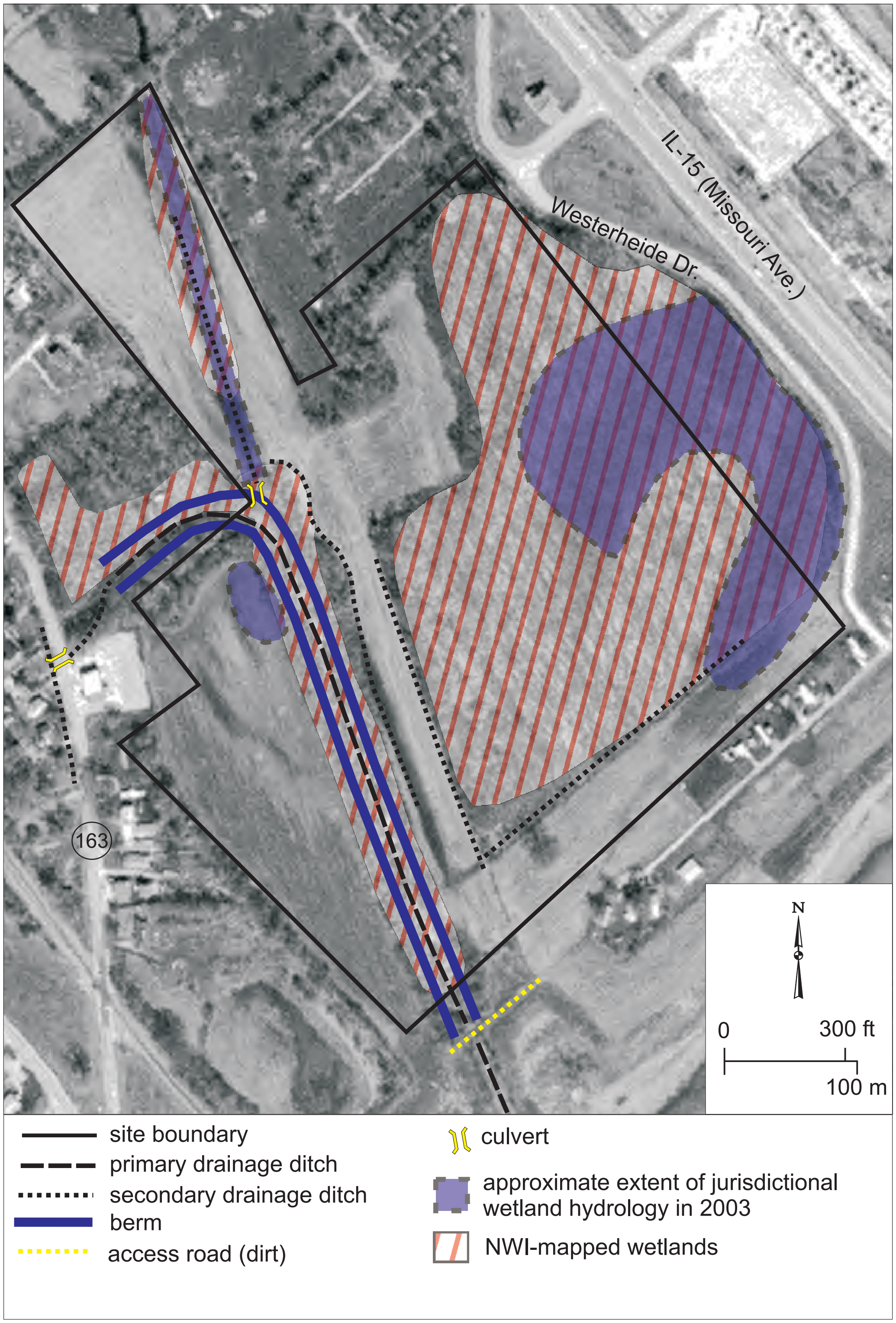

Figure 2: Hydrologic alterations, NWI-mapped wetlands, and areas of jurisdictional wetland hydrology

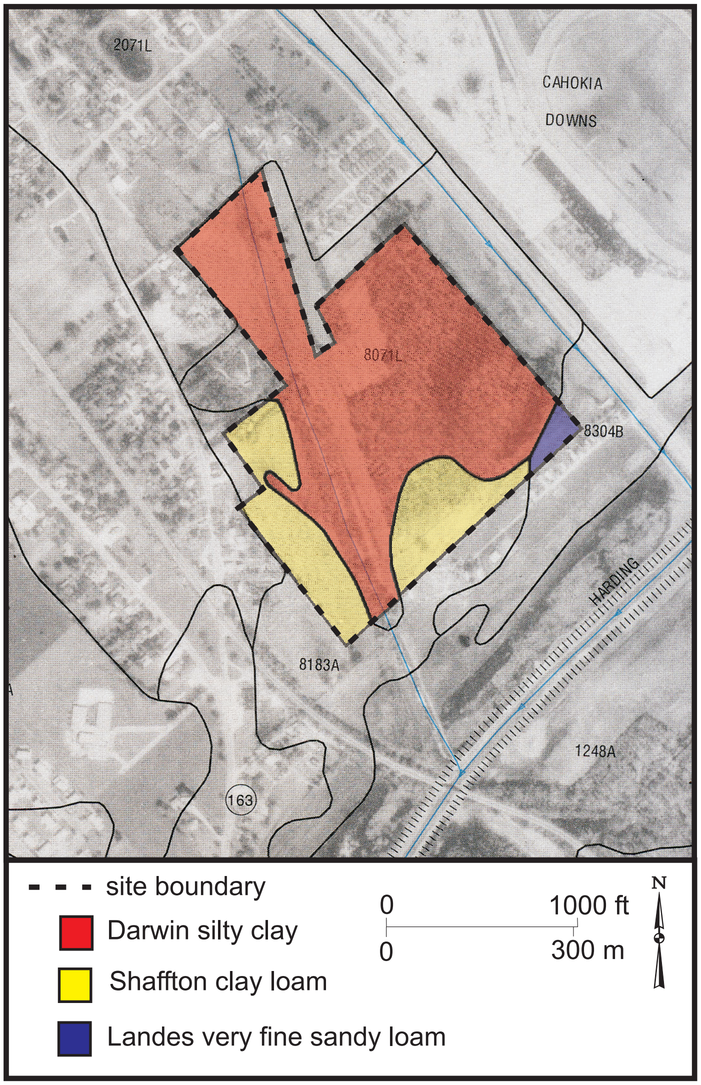

Figure 3: On-site soils (USDA 2000)

Wetland Restoration/Creation

Wetland can be restored/created in two areas of the site (figure 4): in the NWI-mapped wetland southwest of Westerheide Drive and in the farmed area highlighted in green. Topographic transects (figure 5, appendix D) and figure 1 reveal that the NWI-mapped wetland is in a closed depression, while the area highlighted in green is in a swale. To restore/create wetland in these areas, we recommend the following:

- Remove the berms along the primary drainage ditch (Figure 2), fill the ditch, build a new berm across the southeastern end of the valley (Figure 4), and incorporate a spillway or culvert in the new berm. This will retain precipitation and runoff on the site and inundate the swale. On-site observations indicate that, along the northwestern boundary of the site, runoff enters the site from the adjacent parcel at an elevation of 123.47 m (405.10 ft) (figure 4), flows down the secondary ditch, and discharges into the primary ditch (figure 2). This runoff must be accommodated, therefore, a spillway or culvert will have to be incorporated in the new berm in order to limit the surface-water elevation in the wetland to no more than about 123.4 m (404.9 ft), which will inundate about 6.0 acres (2.4 ha) (figure 4) of the site.

- If additional wetland acreage is required, then it is recommended that it be created by excavation. Because surface-water elevation has to be limited to no more than about 123.4 m, and jurisdictional wetland hydrology only occurs were land-surface is inundated, the farm fields will have to be lowered to an elevation lower than 123.4 m (404.9 ft). Lowering land-surface to an elevation of 123.2 m (404.2 ft) would result in a depth of inundation of about 0.2 m (0.6 ft), which would likely be sufficient to support wetland.

- In addition, filling the ditch (figure 2) along the southeast side of the NWI-mapped wetland will likely restore wetland in this portion of the site. On-site observations reveal that jurisdictional wetland hydrology, which covered approximately 8.5 acres (3.4 ha) (figure 2) of the mapped wetland in 2003, generally occurred where the wetland was inundated. Therefore, filling the drainage ditch would trap more water in the mapped wetland, thereby increasing the area of inundation and the area of jurisdictional wetland hydrology.

- If this option is selected, it is recommended that, before filling the ditch, a topographic survey of the NWI-mapped wetland be conducted in order to determine how much wetland acreage will likely be restored.

These alterations could result in the restoration/creation of at least 8.1 ha (20 ac) to as much as 12.1 ha (30 ac) of wetland. However, there are certain drawbacks.

- Filling the drainage ditch along the southeast side of the NWI-mapped wetland could impact the residences (highlighted in red) along the southeast boundary of the site (figure 4). On-site observations reveal that the field between the wetland and the residences is partially flooded in the spring and after large storm events. Options for reducing the risk of impacting the residences include: building a berm and/or digging a drainage ditch between the residences and the wetland.

- The amount of excavation will depend on the acreage required, which may generate large volumes of sediment. For example, the farm field between IL-163 and the primary ditch has an area of about 10.0 acres (4.0 ha). Lowering the land-surface elevation to 123.2 m (404.2 ft) means removing roughly 1600 m^3 (56,500 ft^3) of sediment. While some of the sediment could be used to create new berms and fill ditches, it is likely that off-site disposal will be needed.

- These options also increase the risk of impacting the residences (highlighted in red) along IL-

163 (figure 4). Building a berm along the western boundary of the site (figure 4) would help protect the residences from flooding, but altering the hydrology of the farm fields could affect the water-table, resulting in flooded basements or crawlspaces, if present. Further investigation may be required.

Methods

A total of 31 monitoring wells at fourteen locations were installed on the site (Figure 6). Details of well construction can be found in Appendix A. The shallow (S) wells were designed to monitor near-surface water levels and were used to determine where saturation occurs in the soil zone. The upper (U) wells were used to determine ground-water elevation at depths > 1.4 m (4.6 ft) and to track ground-water fluctuations when ground water was lower than the screened portion of the S-wells.

Depth to water in the wells was measured monthly during the monitoring period, except in Spring 2003, when water levels were measured on April 1st and April 15th, then weekly from April 30th to June 10th (appendix B). Ground-water elevations (appendix C) were calculated by subtracting the depth to water measured from the top of the well casing from the elevation of the top of the well casing.

A pressure transducer, equipped with a data logger, was installed in well RDS1 in Spring 2002. The transducer measured the height of the water column in the well, and the data logger was programmed to record the height in 3-hour intervals. The height of the water column was converted to ground-water elevation by adding the height to the elevation of the transducer. The purpose was to determine if a measurement interval shorter than the monthly and biweekly intervals could detect the presence/absence of wetland hydrology in an area of the site that did not appear to have wetland hydrology in 2001.

In addition to the monitoring wells, surface-water elevation in the main drainage ditch was monitored with a staff gauge (A) and an electronic data logger (Figure 6). Surface-water depth at the gauge was measured on the same schedule as water levels in the monitoring wells. Surface-water depth at the data logger was recorded in 1-hour intervals. Water depth was converted to elevation by subtracting the water depth from the elevation of the staff gauge and logger. The purpose of the gauge and data logger was to monitor fluctuations of the surface-water level in main drainage ditch.

On-site precipitation data were collected with a tipping-bucket rain gauge equipped with a data logger. The on-site data were supplemented with precipitation data recorded at the Southern Illinois University Research Center in Belleville, IL (Station# 110510), which is about 14.5 miles east-southeast of the site. These data were obtained from the National Water and Climate Center (NWCC 2003) of the Natural Resources Conservation Service (NRCS) and from the Midwestern Climate Center (MCC 2003) at the Illinois State Water Survey (ISWS). The precipitation data were used to determine the effect of monthly, seasonal, and annual precipitation trends on surface- and ground-water levels and wetland hydrology.

Temperature data for Belleville, IL were also obtained from the NWCC. These data were used to determine the length of the growing season for the region. The growing season (Environmental Laboratory 1987) is the period between the last occurrence of 28^{o}F temperatures in the spring and the first occurrence in the fall. According to the data, the median length (5 out of 10 years) of the growing season for the region was 201 days, with the median starting date on April 3 and the median ending date on October 21 (NWCC 2003).

The elevations of the staff gauges, water-level meters, and monitoring wells were measured relative to a benchmark established on site by the ISGS, and measured relative to the North American Vertical Datum of 1988. A Sokkia B-1 automatic level and a fiberglass extending rod were used to measure elevations on the site.

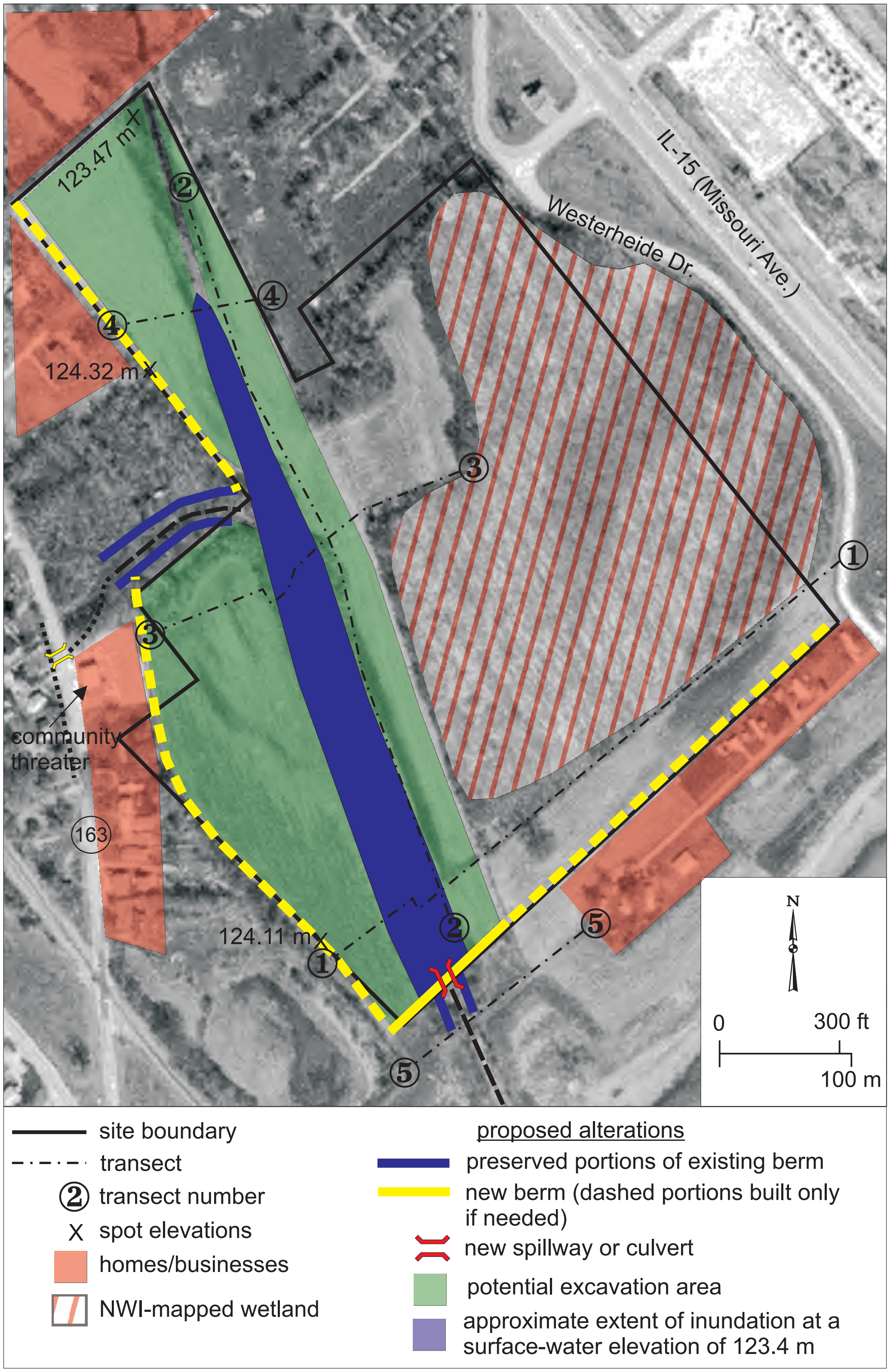

Figure 4: Proposed alterations

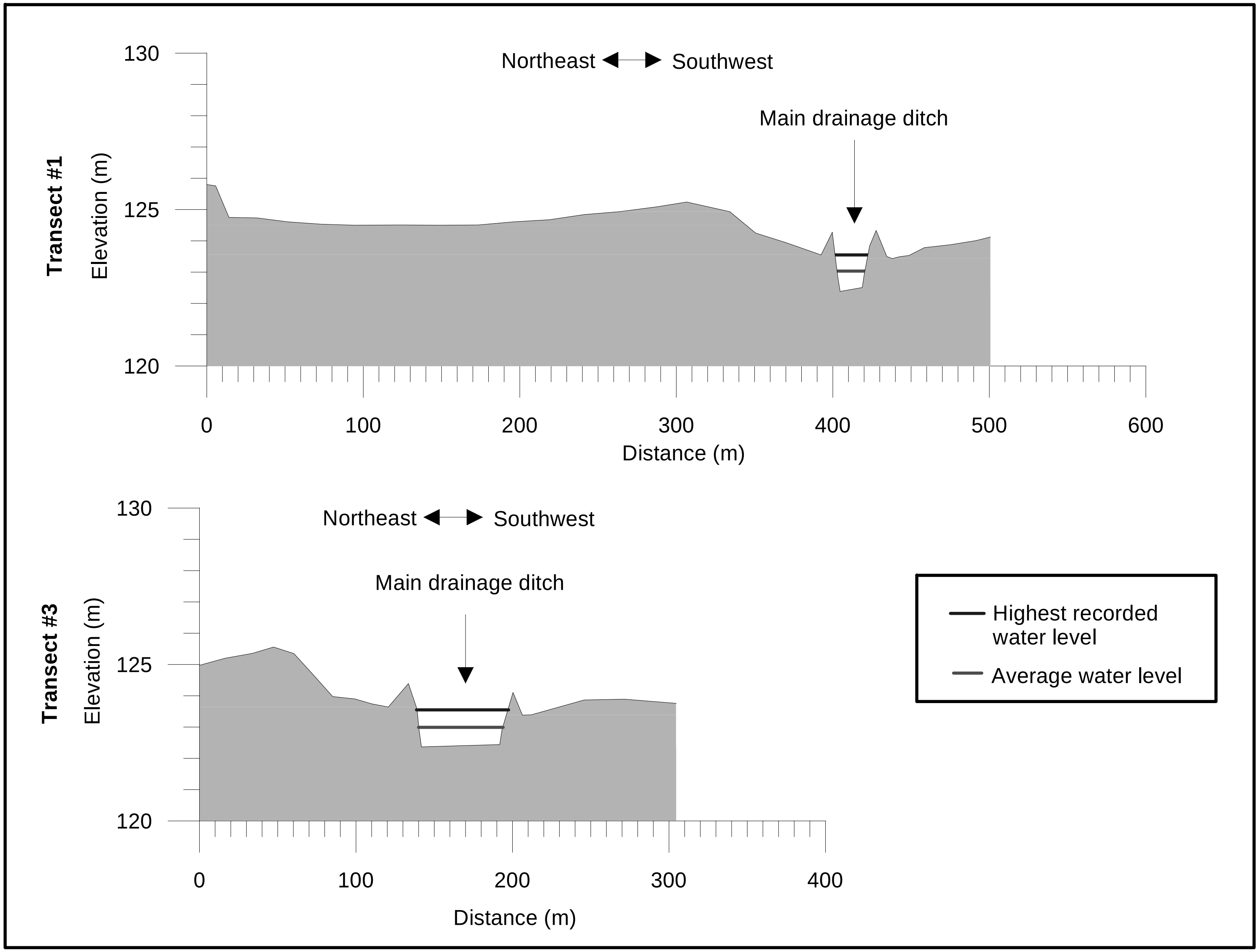

Figure 5: Topographic transects 1 and 3

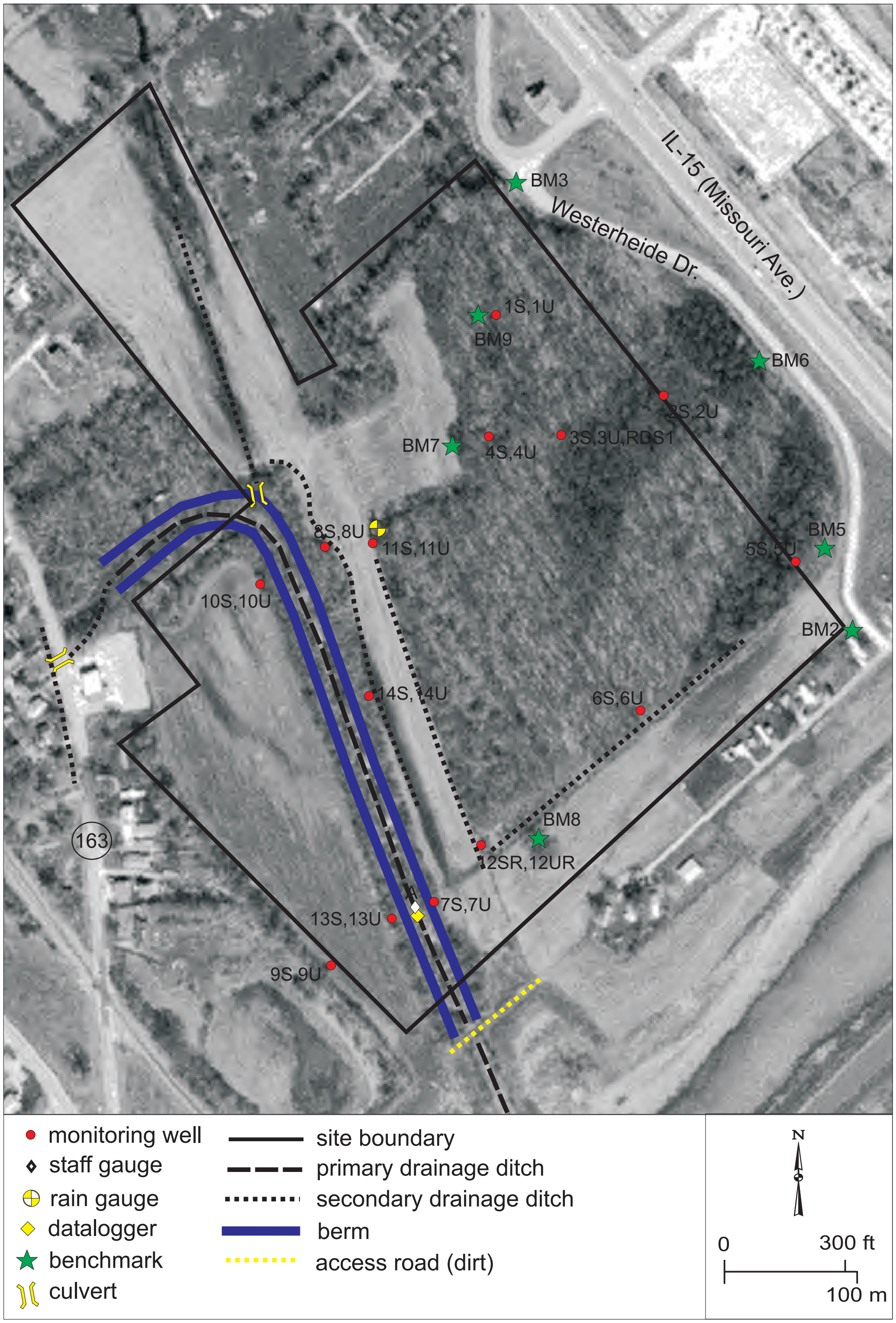

Figure 6: Monitoring network

Site Characterization

Setting

The study site is in the American Bottoms of the Mississippi River. Historic maps (Fenneman 1909, USGS 1931) show that the site was once part of Pittsburg Lake. Remnants of this lake, which was drained by Harding Ditch, are still visible in Holton State Park (figure 1). On subsequent maps (USGS 1931, USGS 1935, USGS 1954), the site is mapped as part of a complex of wetlands extending to the northwest. It is likely that the primary drainage ditch, which appears on the 1931 map, and the secondary drainage ditches (Figure 2), were dug in order to drain these wetlands.

Topographic transects of the site (appendix D, figure 5, see figure 4 for transect locations) and figure 1 show a shallow depression in the northeastern portion of the site which generally corresponds to the NWI-mapped wetland southwest of Westerheide Drive (figure 2), and a deeper, somewhat steep-sided swale in the southwestern portion of the site, which corresponds to the farm fields.

Geology

The geology of the site was characterized by examining published sources of geological data and collecting samples (appendix E) from soil borings using a hand auger. Samples were collected from six (1, 2, 3, 4, 5, and 6) soil borings in the NWI-mapped wetland (figure 6), and from six soil borings (7, 11, 12, 12SR, 13, and 14) in the swale (figure 6). Soil boring depths ranged from about 1 m to about 2 m. The samples collected from the soil borings were examined in the field for color, texture, and structure.

In general, the sediments underlying the study site consist of unconsolidated sediments of the Cahokia Formation overlying the Henry Formation (Berg and Kempton 1987, Hansel and Johnson 1996, Lineback 1979). The Cahokia is a silty alluvial formation recently deposited in flood plains (Willman and Frye 1970). The Henry is a glacial outwash formation (Willman and Frye 1970) consisting of stratified sand and gravel deposited along the fronts of moraines and in river valleys (Hansel and Johnson 1996).

The on-site samples reveal that the sediments in the swale are predominantly silty clay grading into sandy silt or fine to very fine sand at depths ranging from 1.0 m to 1.5 m. In the valley, the texture of the sediments is more varied. Though still predominantly silt and clay, there are also intervals of sand, silty sand, and sandy clay.

Soils

Three soil types are mapped on the site (Figure 3): the Darwin silty clay, the Landes very fine sandy loam, and the Shaffton clay loam (USDA 2000). The Darwin soil, which covers about 70% of the site, is on the state (USDA 1991) and county (USDA 1995) lists of hydric soils in Illinois, while the Landes and Shaffton soils are non-hydric.

Soil colors and the occurrence of redoximorphic features (appendix E) reveals that the sediments in the portion of the site mapped as Darwin silty clay are mostly hydric. In the NWI-mapped wetland, the soil in the upper 30 cm of boreholes 1, 2, 3, 4, 5, and 6 is black or very dark gray and has a matrix chroma of 1, which satisfies the definition of a hydric soil (Environmental Laboratories 1987). In the swale, the soil in the upper 30 cm of boreholes 7, 11, 13, and 14 had a matrix chroma of 2 with faint to distinct redoximorphic features, which also satisfies the definition of a hydric soil (Environmental Laboratories 1987). However, in boreholes 12, and 12SR the soil may be non-hydric. In boreholes 12 and 12SR, there are either no redoximorphic features in the upper 30 cm, or they only appear near the lower limit for a hydric soil.

Hydrology

Total precipitation recorded at Belleville, IL during the monitoring period was 114.53 cm (45.09 in), which was 98% of average for the period. The data recorded at Belleville (figure 7) show that precipitation was slightly to well above average from July 2002 to October 2002, May 2003 to June 2003, and in August 2003, and slightly to well below average from November 2002 to April 2003, and in July 2003. The wettest period was from May 2003 to June 2003 which accounted for about 30% of the total precipitation which fell during the period. The driest period was from November 2002 to January 2003 which accounted for only about 5% of the precipitation which fell during the period

Comparing the precipitation data at Belleville with the data recorded by the on-site range gauge reveals some differences in the amounts of precipitation recorded (figure 7). In April and May 2003, the amounts recorded by the on-site rain gauge were significantly greater than the amounts recorded at Belleville, while in June and August 2003 the amounts recorded by the on-site rain gauge were significantly less than that recorded at Belleville. These differences probably arise from areal variations in rainfall.

Comparing precipitation data recorded by the on-site rain gauge with data recorded at a nearby ISGS study site (Tiernan) reveals that the amounts of precipitation recorded at the ISGS sites are similar (figure 7). This similarity is probably due to the proximity of the sites; the Tiernan site is about 5 miles west-northwest of the Centreville site, which is 14.5 miles west-northwest of the research station in Belleville. Therefore, where precipitation data for the Centreville site are missing, the data recorded at the Tiernan site are used as an analog for precipitation at the Centreville site.

Figures 8 and 9 are hydrographs showing ground-water elevations for the S-wells and U-wells, respectively. Included on both figures is surface-water elevation in the primary drainage ditch. The figures show that the highest ground-water elevations were recorded in May 2003. This was probably the result of above-average precipitation at the site in both April and May (figure 7). Precipitation in April 2003 was 107% of average, while in May 2003 it was 159% of average.

Precipitation at the site was probably also above average in June 2003. However, ground-water levels show, except for a brief recovery on June 27, and overall decline starting about the end of May. By August, many of the wells were dry (appendix C). In combination with below-average precipitation at the site in both July and August, this decline was probably the result of the effect of evapotranspiration, which in Illinois tends to be at its highest in the summers (Neely and Heister 1987).

The combination of evapotranspiration and below-average precipitation probably also accounts for the low ground-water levels at the site in the summer and fall of 2002. While the data recorded at Belleville shows that precipitation was above average from July 2002 to October 2002 (figure 7), the data recorded at Tiernan shows that precipitation was above average only in October, and was well below average in both July and September.

Figures 10 and 11 are water-table maps showing ground-water flow on May 13, 2003. The maps show that ground-water flow in both the S-wells (figure 10) and U-wells (figure 11) is toward the primary drainage ditch. Plots of ground-water elevations on other dates (not shown) reveal that this is the general pattern of ground-water flow throughout the year.

The National Wetlands Inventory (NWI-1988) indicates about 52% of the site is wetland. This includes the forested depression southwest of Westerheide Drive, along the primary drainage ditch, and in the farm field north of the primary drainage ditch (figure 2). On the other hand, the Illinois Natural History Survey (INHS) has stated that the entire site is wetland (Robinson 2002).

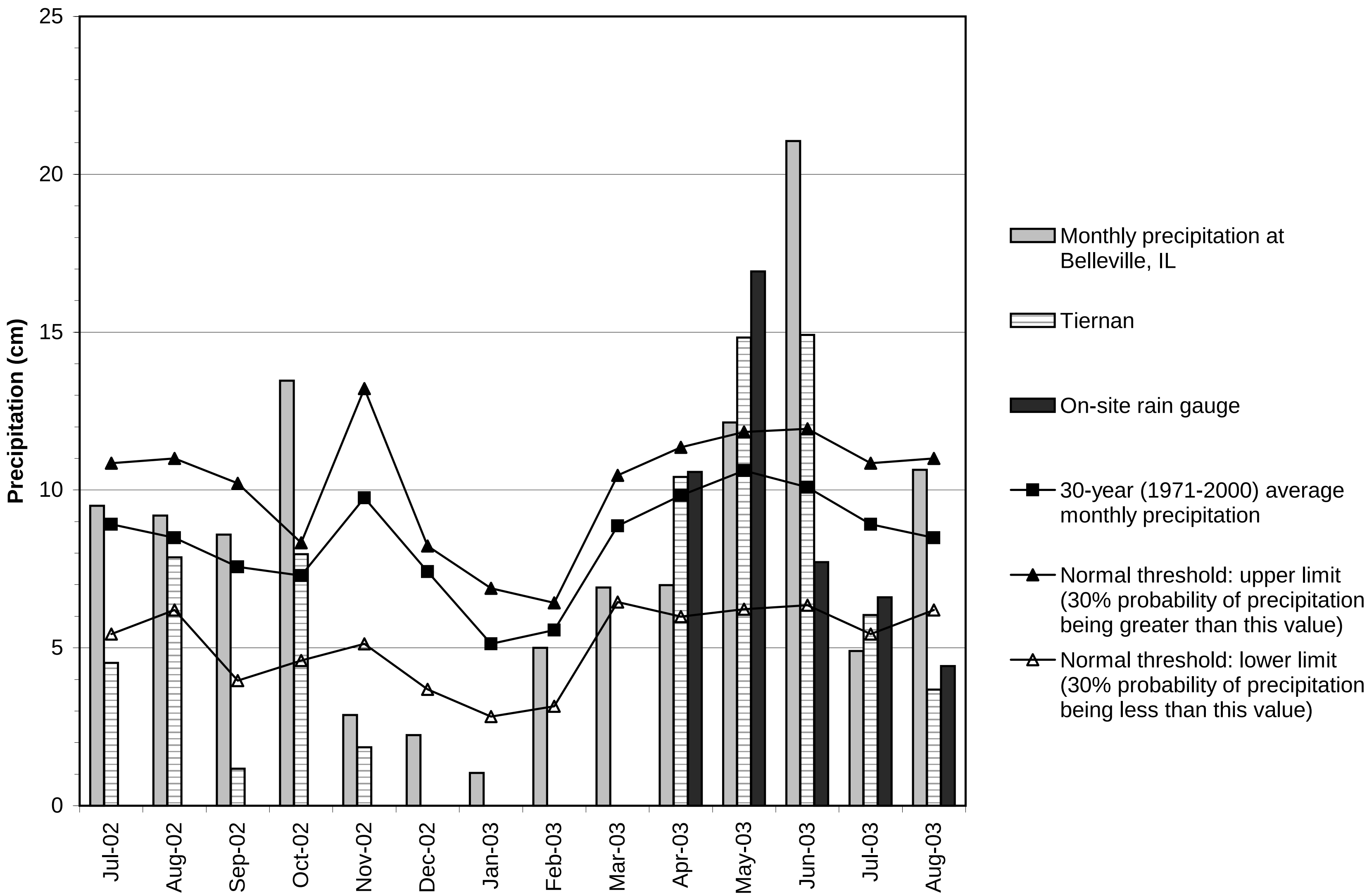

Figure 7: Monthly precipitation

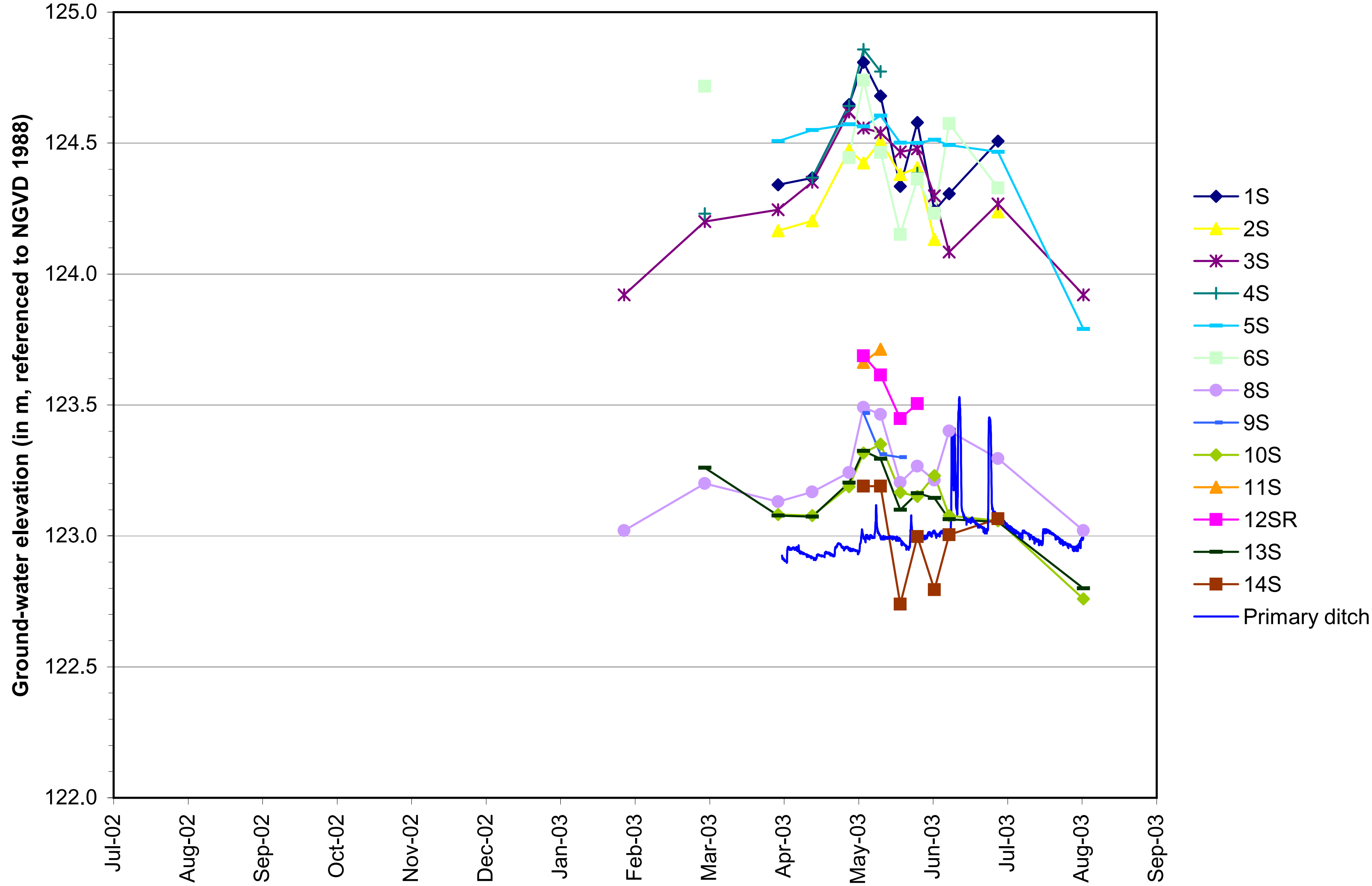

Figure 8: Ground-water elevation in the S-wells

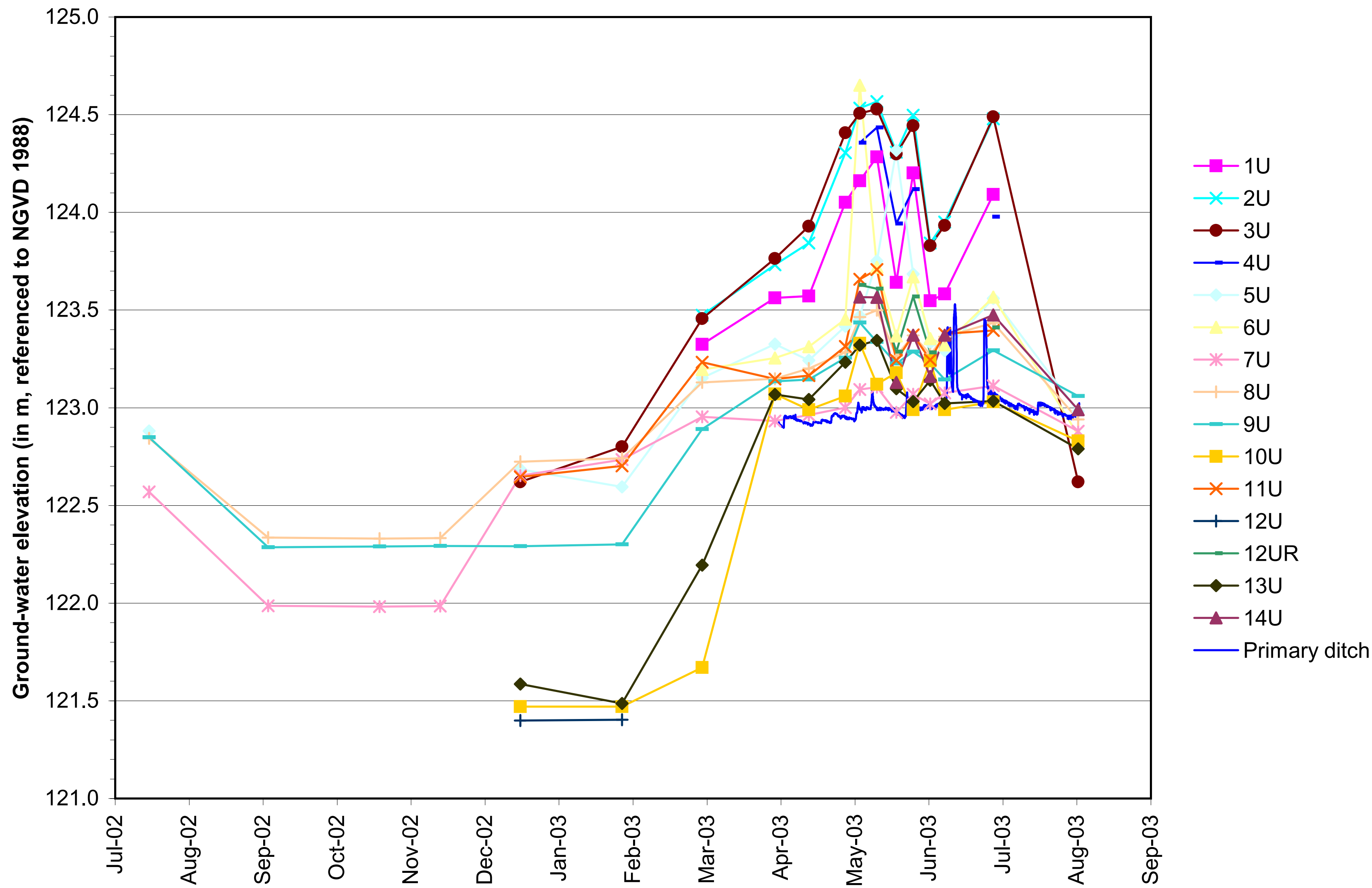

Figure 9: Ground-water elevation in the U-wells

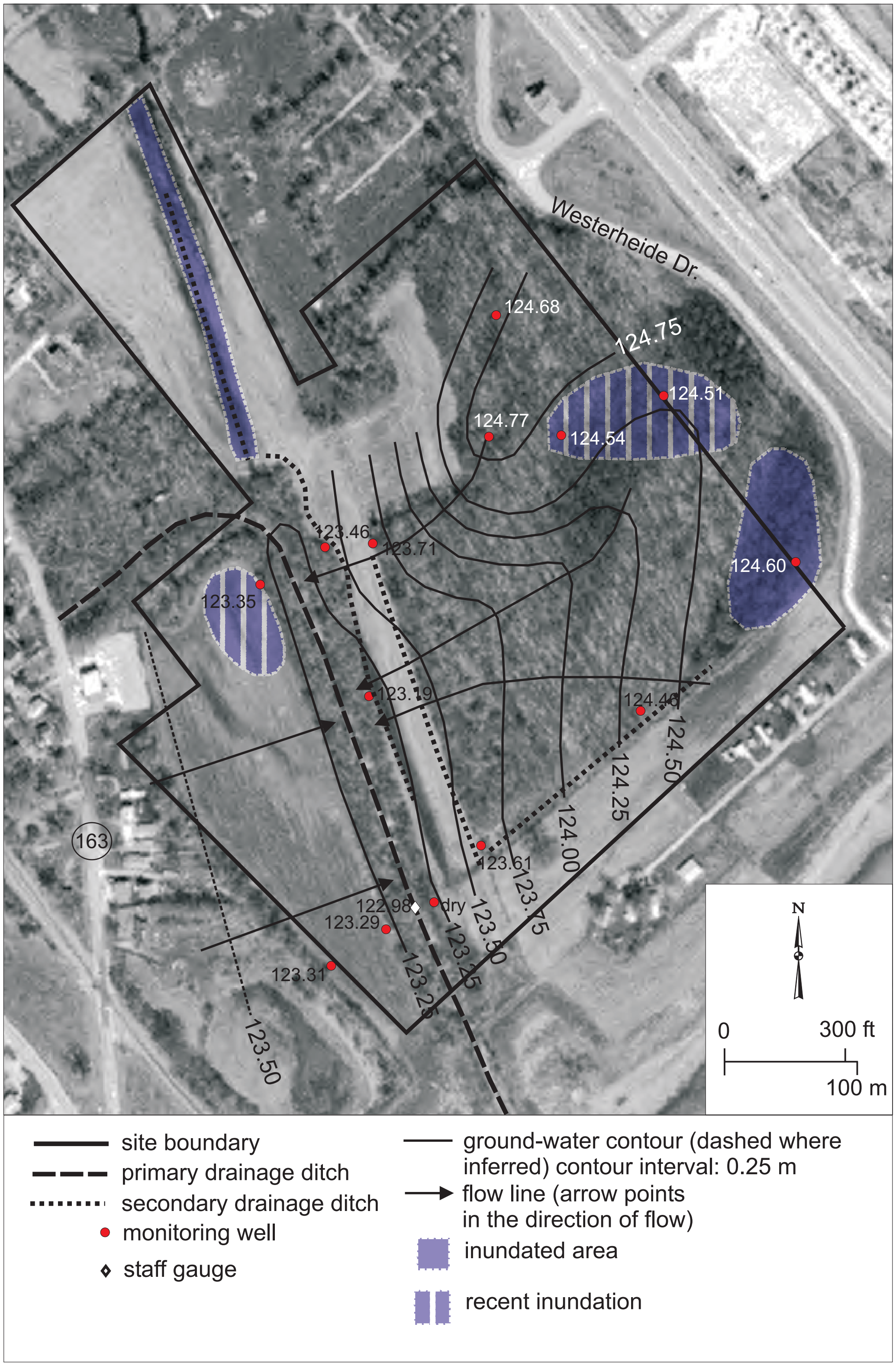

Figure 10: Ground-water elevations in S-wells on May 13, 2003

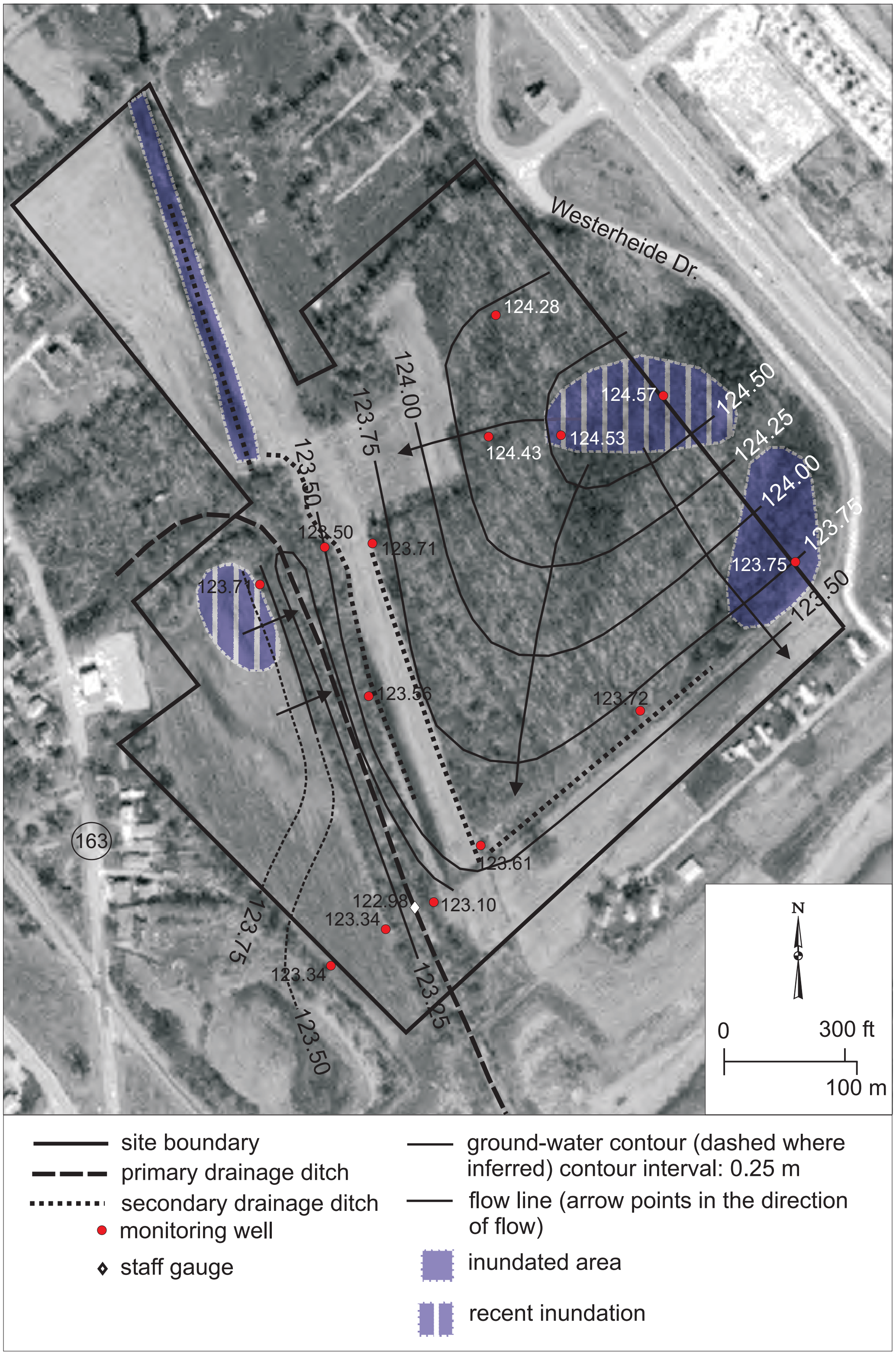

Figure 11: Ground-water elevation in the U-wells on May 13, 2003

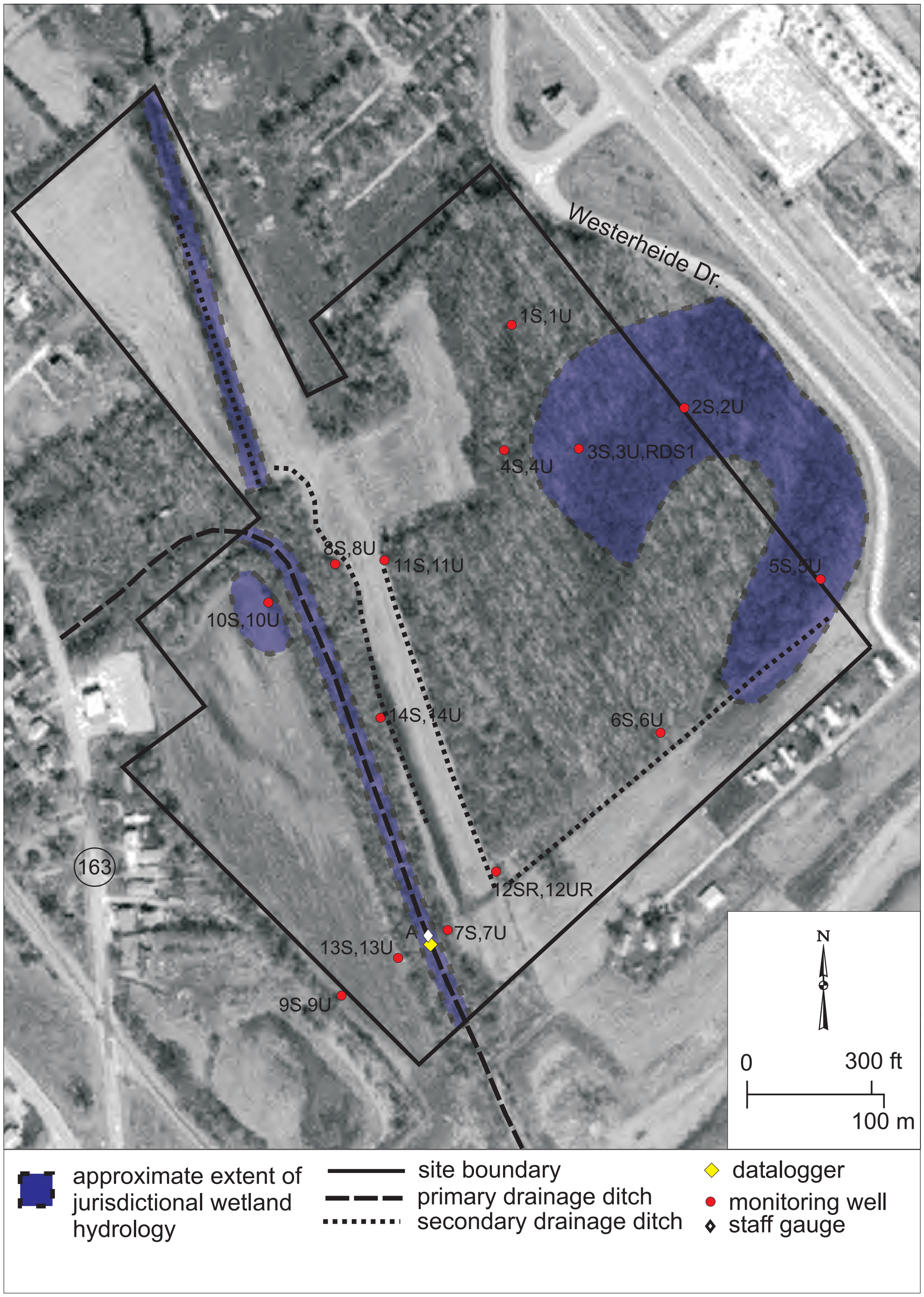

Figure 12: Extent of jurisdictional wetland hydrology in 2003

Figure 12 shows where jurisdictional wetland hydrology occurred on the site in 2003. Depth-to-water data (appendix B) reveals that wells 2S, 3S, 5S, and 10S had saturation (depth-to-water $\leq$ 0.30 m) for greater than 12.5% of the growing season, which satisfies the criteria for jurisdictional wetland hydrology (Environmental Laboratory 1987), while wells 1S and 4S had saturation for 6.9% (14 days) of the growing season which may have satisfied the criteria. On-site observations also revealed that jurisdictional wetland hydrology generally occurred on those areas of the site that were inundated.

The occurrence of inundation on the site is probably due to the hydraulic properties of the soils (table 1). The Darwin soil especially, which is mapped (figure 3) in those areas of the site in which inundation occurred (figure 10), has the capacity to retard infiltration. At a permeability of 0.01 in/hr (0.02 cm/hr), it would take nearly two months for surface water to infiltrate 12 in (30 cm), while at a permeability of 0.06 in/hr (0.15 cm/hr), it would still take more than a week to infiltrate 12 in (30 cm).

Soil Type	Hydric	Permeability (in/hr)	Flooding	Water Table
Darwin silty clay	yes	0-62 in: 0.01-0.06 62-80 in: 0.06-0.20	Occasional, long duration, Jan-Jun	Depth: 0.0-1.0 ft Type: apparent Period: Nov-May
Landes very fine sandy loam	no	0-39 in: 2.0-6.0 39-80 in: 6.0-20.0	Occasional, brief duration, Jan-Jun	Depth: > 6.0 ft Type: not listed Period: not listed
Shaffton clay loam	no	0-24 in: 0.60-2.00 24-66 in: 6.00-20.00	Occasional, brief duration, Jan-Jun	Depth: 1.0-2.0 ft Type: apparent Period: Dec-Apr

Table 1: Hydraulic properties of on-site soil types (USDA 2000).

The permeability of the Shaffton and Landes soils are much higher, and thus surface water would infiltrate more quickly. For example, in the Shaffton soil, where the permeability ranges 0.60 in/hr (1.52 cm/hr) to 2.00 in/hr (5.08 cm/hr), it would take less than 1 day for surface-water to infiltrate 12 inches. This probably accounts for the fact that the areas of the site mapped as Shaffton soil and Landes soil were not inundated in either 2002 or 2003.

Conclusions

The results of this study reveal that most of the site was probably wetland in that past. However, though hydric soil is still present under most of the site, only a small area (~18%) satisfies the criteria for jurisdictional wetland hydrology. Therefore, most of the site would probably not satisfy the three-parameter definition of a wetland (Environmental Laboratories 1987).

Options for creating/restoring wetland at this site include the following:

- Remove the berms along the primary drainage ditch (Figure 2), fill the ditch, build a new berm across the southeastern end of the valley (Figure 4), and incorporate a spillway or culvert in the new berm. This will retain precipitation and runoff on the site and inundate the swale. On-site observations indicate that, along the northwestern boundary of the site, runoff enters the site from the adjacent parcel at an elevation of 123.47 m (figure 4), flows through the farm field via a ditch, and discharges into the primary ditch (figure 2). This runoff must be accommodated, therefore, a spillway or culvert will have to be incorporated in the new berm in order to limit the surface-water elevation in the wetland to no more than about 123.4 m, which will inundate about 6.0 acres (2.4 ha) (figure 4) of the site.

- If additional wetland acreage is required, then it is recommended that it be created by excavation. Because surface-water elevation has to be limited to no more than about 123.4 m, and jurisdictional wetland hydrology only occurs were land-surface is inundated, the farm fields will have to be lowered to an elevation lower than 123.4 m. Lowering land-surface to an elevation of 123.2 m would result in a depth of inundation of about 0.2 m, which would likely be sufficient to support wetlands.

- In addition, filling the ditch (figure 2) along the southeast side of the NWI-mapped wetland will likely restore wetland in this portion of the site. On-site observations reveal that jurisdictional wetland hydrology, which covered approximately 8.5 acres (3.4 ha) (figure 2) of the mapped wetland in 2003, generally occurred where the wetland was inundated. Therefore, filling the drainage ditch would trap more water in the mapped wetland, thereby increasing the area of inundation and the area of jurisdictional wetland hydrology.

- If this option is selected, it is recommended that, before filling the ditch, a topographic survey of the NWI-mapped wetland be conducted in order to determine how much wetland acreage will likely be restored.

The drawback to this plan is the risk of impacting nearby residences. Therefore, steps will have to be taken, such as building berms along the margins of the site and limiting the surface-water elevation in the wetlands, to minimize the risk of off-site impacts.

Acknowledgments

Funding for this study was provided by the Illinois Department of Transportation (IDOT) under contract# IDOT SW WIP FY04. Paula Sabatini, ISGS and Katy Werner assisted with the installation of the monitoring network, and Marshall Lake, ISGS and Bonnie Robinson, ISGS, collected the surface- and ground-water data.

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Appendix A: Well Construction

Well #	Date Installed	Hole Depth (cm)	Well Length (cm)	Screened Length (cm)	Screened Interval[1] (cm)	Sand Pack (cm)	Seal[2] (cm)	Ground Elevation[3] (m)	Screen Elevation (m)
1S	6/18/2002	75.0	189.9	30.0	71.0-41.0	75.0-30.0	30.0-0.0	124.773	124.063-124.363
1U	6/18/2002	195.0	300.3	29.0	190.6-161.6	195.0-152.0	152.0-98.0	124.760	122.854-123.144
2S	6/20/2002	76.0	190.5	30.0	71.3-41.3	76.0-30.0	30.0-2.0	124.615	123.902-124.202
2U	6/20/2002	201.0	343.6	32.7	196.5-163.8	201.0-148.0	148.0-86.0	124.615	122.650-122.977
3S	6/20/2002	76.0	195.5	32.2	71.6-39.4	76.0-30.0	30.0-2.0	124.613	123.897-124.219
3U	6/20/2002	203.0	343.2	31.2	198.2-167.0	203.0-150.0	150.0-97.5	124.613	122.631-122.943
RDS1	7/15/2002	50.0	125.0	10.4	45.2-34.7	50.0-25.0	none	124.613	124.161-124.266
4S	6/20/2002	77.0	186.8	24.7	71.4-46.7	77.0-31.0	31.0-7.0	124.855	124.141-124.388
4U	4/30/2003	110.0	194.5	34.8	106.8-72.0	110.0-59.0	59.0-3.0	124.897	123.829-124.177
5S	7/15/2002	76.0	189.9	30.3	71.8-41.5	76.0-29.5	29.5-0.0	124.479	123.761-124.064
5U	7/15/2002	205.0	345.8	31.8	201.8-170.0	205.0-147.0	147.0-5.0	124.479	122.461-122.779
6S	7/15/2002	77.0	192.9	31.7	72.6-40.9	77.0-30.0	30.0-5.0	124.877	124.151-124.468
6U	7/15/2002	201.0	341.2	31.1	196.6-165.5	201.0-135.0	135.0-20.0	124.877	122.911-123.222
7S	7/16/2002	76.0	195.4	30.0	71.6-41.6	76.0-26.0	26.0-0.0	123.905	123.189-123.489
7U	7/16/2002	201.0	341.2	30.2	196.4-166.2	201.0-140.0	140.0-0.0	123.905	121.941-122.243

1. Depth below ground surface.
2. Bentonite seal (Where the seal does not extend to ground surface, the annulus was filled with auger cuttings).
3. Referenced to NGVD 1988.

Appendix A: continued

Well #	Date Installed	Hole Depth (cm)	Well Length (cm)	Screened Length (cm)	Screened Interval[1] (cm)	Sand Pack (cm)	Seal[2] (cm)	Ground Elevation[3] (m)	Screen Elevation (m)
8S	7/16/2002	73.0	194.6	31.8	68.8-37.0	73.0-28.0	28.0-5.0	123.740	123.052-123.370
8U	7/16/2002	200.0	343.4	31.1	195.8-164.7	200.0-150.0	150.0-50.0	123.740	121.782-122.093
9S	7/16/2002	77.0	186.7	28.6	73.5-44.9	77.0-30.0	30.0-0.0	124.085	123.350-123.636
9U	7/16/2002	177.4	297.9	31.9	174.2-142.3	177.4-115.0	115.0-5.0	124.085	122.343-122.662
10S	7/16/2002	79.0	187.8	24.2	72.3-48.1	79.0-33.0	33.0-0.0	123.365	122.642-122.884
10U	11/19/2002	154.0	271.8	35.5	150.0-114.5	154.0-107.0	107.0-0.0	123.333	121.833-122.188
11S	11/19/2002	74.0	190.0	30.0	70.8-40.8	74.0-30.0	30.0-0.0	124.079	123.371-123.671
11U	11/19/2002	152.0	251.1	29.7	148.8-119.1	152.0-95.0	95.0-0.0	124.053	122.565-122.862
12S	11/19/2002	75.0	184.6	27.1	71.8-44.7	75.0-25.0	25.0-0.0	124.116	123.398-123.669
12U	11/19/2002	152.0	193.8	36.4	148.8-112.4	152.0-100.0	100.0-0.0	124.121	122.633-122.997
12SR	4/30/2003	75.0	186.7	32.0	70.7-38.7	75.0-28.0	28.0-0.0	124.178	123.471-123.791
12UR	4/30/2003	102.0	188.6	28.7	98.5-69.8	102.0-56.0	56.0-3.0	124.178	123.193-123.480
13S	11/19/2002	75.0	191.9	30.5	71.8-41.3	75.0-30.0	30.0-0.0	123.516	122.798-123.103
13U	11/19/2002	156.0	265.8	31.8	152.8-121.0	156.0-95.0	95.0-0.0	123.522	121.994-122.312
14S	4/30/2003	78.0	185.6	31.1	73.7-42.6	78.0-30.0	30.0-0.0	123.483	122.746-123.057
14U	4/30/2003	96.0	185.8	31.7	91.7-60.0	96.0-40.0	40.0-0.0	123.483	122.566-122.883

1. Depth below ground surface.
2. Bentonite seal (Where the seal does not extend to ground surface, the annulus was filled with auger cuttings).
3. Referenced to NGVD 1988.

Appendix B: Depth-to-water

Depth to ground water (in meters, referenced to ground surface)					
Date	7/17/02	9/4/02	10/20/02	11/14/02	12/17/02
1S	dry	dry	dry	dry	dry
1U	dry	dry	dry	dry	dry
2S	dry	dry	dry	dry	dry
2U	dry	dry	dry	dry	dry
3S	dry	dry	dry	dry	dry
3U	dry	dry	dry	dry	dry
4S	dry	dry	dry	dry	dry
4U	**	**	**	**	**
5S	dry	dry	dry	dry	dry
5U	1.60	dry	dry	dry	1.79
6S	dry	dry	dry	dry	dry
6U	dry	dry	dry	dry	dry
7S	dry	dry	dry	dry	dry
7U	1.34	1.92	1.92	1.92	1.25
8S	dry	dry	dry	dry	dry
8U	0.90	1.40	1.41	1.41	1.02

** indicates that well is not yet installed

Appendix B: continued

Depth to ground water (in meters, referenced to ground surface)					
Date	7/17/02	9/4/02	10/20/02	11/14/02	12/17/02
9S	dry	dry	dry	dry	dry
9U	1.24	1.80	1.79	1.79	1.79
10S	dry	dry	dry	dry	dry
10U	**	**	**	**	1.86
11S	**	**	**	**	damaged
11U	**	**	**	**	1.41
12S	**	**	**	**	dry
12SR	**	**	**	**	**
12U	**	**	**	**	2.72
12UR	**	**	**	**	**
13S	**	**	**	**	dry
13U	**	**	**	**	1.94
14S	**	**	**	**	**
14U	**	**	**	**	**

** indicates that well is not yet installed

Appendix B: continued

	Depth to ground water (in meters, referenced to ground surface)											
Date	1/28/03	3/2/03	4/1/03	4/15/03	4/30/03	5/6/03	5/13/03	5/21/03	5/28/03	6/4/03	6/10/03	6/30/03	8/4/03
1S	dry	dry	0.43	0.40	0.12	-0.04	0.09	0.43	0.19	0.53	0.46	0.26	dry
1U	dry	1.43	1.20	1.20	0.72	0.61	0.48	1.13	0.57	1.22	1.19	0.68	dry
2S	dry	dry	0.45	0.46	0.19	0.24	0.15	0.28	0.25	0.53	dry	0.42	dry
2U	dry	1.14	0.88	0.82	0.35	0.13	0.09	0.35	0.16	0.82	0.71	0.18	dry
3S	dry	0.41	0.37	0.31	0.04	0.10	0.12	0.19	0.18	0.36	0.58	0.39	dry
3U	1.81	1.16	0.85	0.73	0.25	0.15	0.13	0.36	0.21	0.83	0.73	0.17	dry
4S	dry	0.62	dry	0.53	0.25	0.04	0.12	dry	0.51	dry	dry	dry	dry
4U	**	**	**	**	**	0.54	0.46	0.95	0.78	dry	dry	0.92	dry
5S	dry	frozen	-0.03	-0.03	-0.05	-0.04	-0.08	0.02	0.02	0.01	0.03	0.06	0.73
5U	1.88	1.33	1.15	1.28	1.10	1.05	0.77	0.20	0.84	1.19	1.23	0.96	1.55
6S	dry	0.16	dry	dry	0.50	0.21	0.48	0.80	0.58	0.72	0.37	0.62	dry
6U	dry	1.68	1.62	1.63	1.49	0.30	1.23	1.58	1.28	1.59	1.62	1.38	2.09
7S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
7U	1.17	0.95	0.97	0.95	0.91	0.82	0.80	0.93	0.84	0.89	0.83	0.80	1.03
8S	dry	0.54	0.61	0.61	0.54	0.29	0.31	0.57	0.51	0.56	0.38	0.48	dry
8U	1.00	0.61	0.59	0.58	0.49	0.31	0.28	0.51	0.41	0.50	0.41	0.34	0.84

** indicates that well is not yet installed
shaded indicates depth to water is ≤ 0.30 m

Appendix B: continued

Depth to ground water (in meters, referenced to ground surface)													
Date	1/28/03	3/2/03	4/1/03	4/15/03	4/30/03	5/6/03	5/13/03	5/21/03	5/28/03	6/4/03	6/10/03	6/30/03	8/4/03
9S	dry	dry	dry	dry	dry	0.64	0.80	0.81	dry	dry	dry	dry	dry
9U	1.78	1.19	0.95	0.97	0.85	0.67	0.77	0.88	0.82	0.88	0.97	0.82	1.06
10S	dry	dry	0.28	0.29	0.18	0.05	0.02	0.20	0.22	0.14	0.29	0.31	0.60
10U	1.86	1.66	0.26	0.38	0.30	0.04	0.24	0.18	0.37	0.13	0.37	0.33	0.53
11S	dry	dry	dry	dry	dry	0.36	0.31	dry	dry	dry	dry	dry	dry
11U	1.35	0.82	0.91	0.86	0.71	0.37	0.32	0.78	0.65	0.78	0.65	0.63	dry
12S	dry	destroyed											
12SR	**	**	**	**	**	0.49	0.56	0.73	0.67	dry	dry	dry	dry
12U		destroyed											
12UR	**	**	**	**	**	0.55	0.57	0.89	0.61	0.89	dry	0.77	dry
13S	dry	0.26	0.44	0.47	0.34	0.22	0.25	0.45	0.38	0.40	0.48	0.49	0.75
13U	2.04	1.33	0.45	0.51	0.31	0.23	0.20	0.45	0.52	0.41	0.53	0.51	0.76
14S	**	**	**	**	**	0.29	0.29	0.74	0.49	0.69	0.48	0.42	dry
14U	**	**	**	**	**	-0.08	-0.08	0.35	0.11	0.32	0.11	0.01	0.50

** indicates that well is not yet installed
shaded indicates depth to water is $\leq$ 0.30 m

Appendix C: Ground-water Elevations and Surface-water Elevations

Surface- and ground-water elevation (in meters, referenced to ground surface)					
Date	7/17/02	9/4/02	10/20/02	11/14/02	12/17/02
1S	dry	dry	dry	dry	dry
1U	dry	dry	dry	dry	dry
2S	dry	dry	dry	dry	dry
2U	dry	dry	dry	dry	dry
3S	dry	dry	dry	dry	dry
3U	dry	dry	dry	dry	dry
4S	dry	dry	dry	dry	dry
4U	**	**	**	**	**
5S	dry	dry	dry	dry	dry
5U	122.88	dry	dry	dry	122.68
6S	dry	dry	dry	dry	dry
6U	dry	dry	dry	dry	dry
7S	dry	dry	dry	dry	dry
7U	122.57	121.99	121.98	121.98	122.65
8S	dry	dry	dry	dry	dry
8U	122.84	122.33	122.33	122.33	122.72

** indicates that well is not yet installed

Appendix C: continued

Surface- and ground-water elevation (in meters, referenced to ground surface)					
Date	7/17/02	9/4/02	10/20/02	11/14/02	12/17/02
9S	dry	dry	dry	dry	dry
9U	122.85	122.29	122.29	122.29	122.29
10S	dry	dry	dry	dry	dry
10U	**	**	**	**	121.47
11S	**	**	**	**	damaged
11U	**	**	**	**	122.65
12S	**	**	**	**	dry
12SR	**	**	**	**	**
12U	**	**	**	**	121.40
12UR	**	**	**	**	**
13S	**	**	**	**	dry
13U	**	**	**	**	121.59
14S	**	**	**	**	**
14U	**	**	**	**	**
Gauge A	122.67	dry	dry	dry	dry

** indicates that well is not yet installed

Appendix C: continued

Surface- and ground-water elevation (in meters, referenced to ground surface)													
Date	1/28/03	3/2/03	4/1/03	4/15/03	4/30/03	5/6/03	5/13/03	5/21/03	5/28/03	6/4/03	6/10/03	6/30/03	8/4/03
1S	dry	dry	124.34	124.37	124.65	124.81	124.68	124.33	124.58	124.24	124.31	124.51	dry
1U	dry	123.32	123.56	123.57	124.05	124.16	124.28	123.64	124.20	123.55	123.58	124.09	dry
2S	dry	dry	124.16	124.20	124.47	124.42	124.51	124.38	124.41	124.13	dry	124.24	dry
2U	dry	123.47	123.73	123.84	124.30	124.53	124.57	124.31	124.50	123.84	123.95	124.48	dry
3S	dry	124.20	124.24	124.35	124.62	124.56	124.54	124.47	124.48	124.30	124.08	124.69	dry
3U	122.80	123.46	123.76	123.93	124.41	124.51	124.53	124.30	124.44	123.83	123.93	124.49	dry
4S	dry	124.23	dry	124.37	124.64	124.86	124.77	dry	124.38	dry	dry	dry	dry
4U		**	**	**	**	124.36	124.43	123.94	124.12	dry	dry	123.98	dry
5S	dry	frozen	124.51	124.55	124.57	124.56	124.60	124.50	124.50	124.51	124.49	124.47	123.79
5U	122.59	123.15	123.33	123.24	123.42	123.47	123.75	124.32	123.68	123.33	123.29	123.56	122.98
6S	dry	124.72	dry	dry	124.44	124.74	124.46	124.15	124.36	124.23	124.57	124.33	dry
6U	dry	123.19	123.25	123.31	123.45	124.65	123.72	123.37	123.67	123.35	123.32	123.57	122.86
7S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
7U	122.73	122.95	122.93	122.96	123.00	123.09	123.10	122.98	123.07	123.02	123.08	123.11	122.88
8S	dry	123.20	123.13	123.17	123.24	123.49	123.46	123.20	123.27	123.21	123.40	123.29	dry
8U	122.74	123.13	123.15	123.20	123.28	123.46	123.50	123.26	123.37	123.27	123.36	123.43	122.94

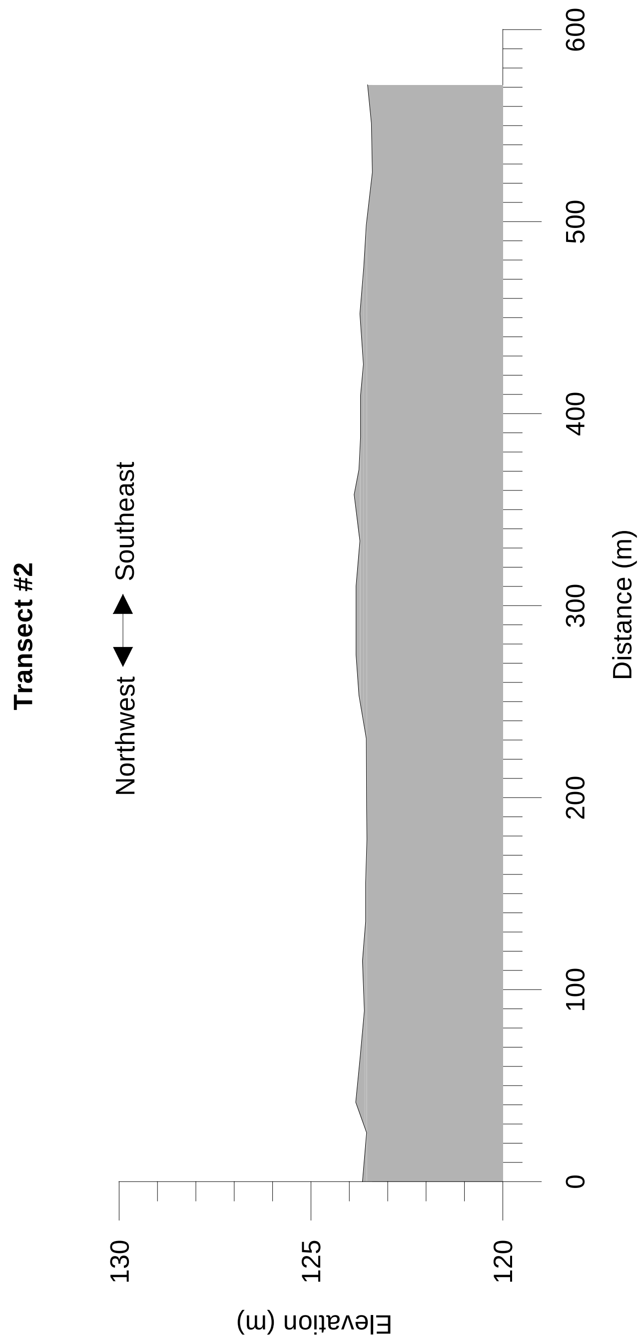
** indicates that well is not yet installed

Appendix C: continued

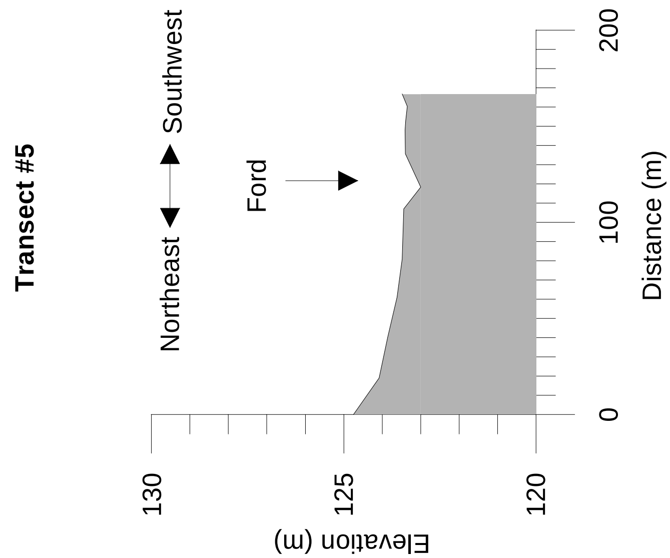
Surface- and ground-water elevation (in meters, referenced to ground surface)													
Date	1/28/03	3/2/03	4/1/03	4/15/03	4/30/03	5/6/03	5/13/03	5/21/03	5/28/03	6/4/03	6/10/03	6/30/03	8/4/03
9S	dry	dry	dry	dry	dry	123.47	123.31	123.30	dry	dry	dry	dry	dry
9U	122.30	122.89	123.13	123.14	123.26	123.44	123.34	123.23	123.29	123.23	123.14	123.29	123.06
10S	dry	dry	123.08	123.08	123.19	123.32	123.35	123.17	123.15	123.23	123.08	123.06	122.76
10U	121.47	121.67	123.07	122.99	123.06	123.33	123.12	123.18	122.99	123.24	122.99	123.03	122.83
11S	dry	dry	dry	dry	dry	123.66	123.71	dry	dry	dry	dry	dry	dry
11U	122.70	123.23	123.15	123.16	123.31	123.66	123.71	123.24	123.37	123.24	123.38	123.40	dry
12S	dry	destroyed											
12SR	**	**	**	**	**	123.69	123.61	123.45	123.50	dry	dry	dry	dry
12U	121.40	destroyed											
12UR	**	**	**	**	**	123.63	123.61	123.29	123.57	123.28	dry	123.41	dry
13S	dry	123.26	123.08	123.07	123.20	123.32	123.29	123.10	123.16	123.14	123.06	123.05	122.80
13U	121.49	122.19	123.07	123.04	123.23	123.32	123.34	123.10	123.03	123.14	123.02	123.03	122.79
14S	**	**	**	**	**	123.19	123.19	122.74	123.00	122.79	123.00	123.07	dry
14U	**	**	**	**	**	123.57	123.56	123.13	123.37	123.16	123.37	123.47	122.99
Gauge A	dry	122.76	122.87	122.91	122.94	122.99	122.98	122.98	123.03	123.02	123.09	123.06	122.93

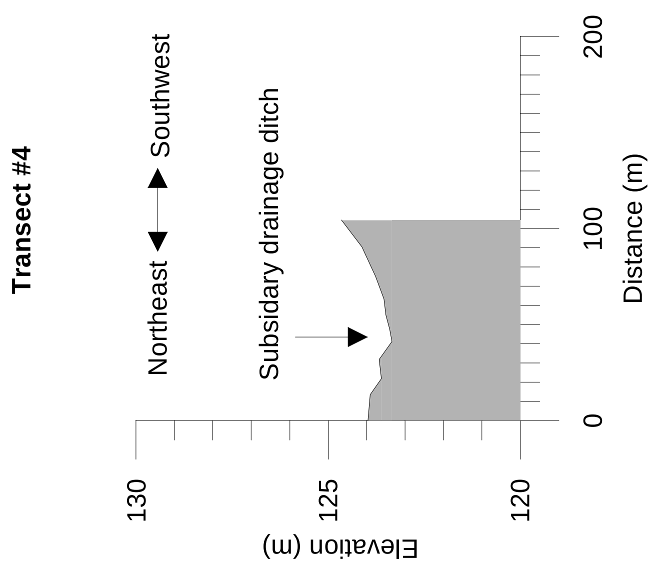
** indicates that well is not yet installed

Appendix D: Topographic Transects



Appendix D: continued





Appendix E: Geologic Logs

Borehole: **1**
Location: **SW SW, Section 33, T2N, R9W, Centreville Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-30	Black, 10YR2/1, silty CLAY
30-115	Dark gray, 10YR4/1, silty CLAY, with dark yellowish brown, 10YR4/6, redox concentrations and black Mn nodules.
115-160	Grayish brown, 2.5Y5/2, silty CLAY and CLAY
160-195	Dark grayish brown, 2.5Y4/2, sandy SILT, with dark yellowish brown, 10YR4/6 redox concentrations, black Mn nodules, weakly calcareous.

Borehole: **2**
Location: **SW SE, Section 33, T2N, R9W, Centreville, Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-15	Black, 10YR2/1, silty CLAY
15-30	transition to
30-100	Dark grayish brown, 2.5Y4/2, silty CLAY, with many, coarse, yellowish brown, 10YR5/8, redox concentrations.
100-130	Dark grayish brown, 2.5Y4/2, sandy CLAY and silty CLAY, with many, medium, redox concentrations.
130-160	Dark grayish brown, 2.5Y4/2, very moist to wet, sandy SILT, with common, medium, redox concentrations
160-203	Dark grayish brown, 2.5Y4/2, saturated, sandy SILT.

Borehole: **3**
Location: **SW SE, Section 33, T2N, R9W, Centreville Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-15	Black, 2.5Y2.5/1, silty CLAY, with few, fine, strong brown, 7/5YR4/6, redox concentrations.
15-30	Dark gray, 2.5Y4/1, silty CLAY, with few, fine, dark yellowish brown, 10YR3/6, redox concentrations.
30-100	Dark gray, 2.5Y4/1, silty CLAY, with many, coarse, dark yellowish brown, 10YR3/6, redox concentrations.
100-155	Dark gray, 2.5Y4/1, silty CLAY, with common, coarse, dark yellowish brown, 10YR3/6, redox concentrations.
155-203	Dark grayish brown, 10YR4/2, to dark gray, 2.5Y4/1, sandy SILT, with common, medium, dark olive brown, 2.5Y3/3, redox concentrations.

Borehole: **4**
Location: **NE NW, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-29	Very dark gray, 10YR3/1, silty CLAY, root zone, no redox features.
29-100	Dark grayish brown, 10YR4/2, silty CLAY, with many, medium, dark yellowish brown, 10YR4/6, redox concentrations.
100-110	Dark grayish brown, 10YR4/2, sandy, clayey, SILT, few, coarse, redox concentrations.

Appendix E: continued

Borehole:	**5**
Location:	**SW SE, Section 33, T2N, R9W, Centreville Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-10	O-horizon, humus, dense root mat over very dark brown, 10YR2/2, silty CLAY.
10-50	Very dark gray, 10YR3/1, silty CLAY, with many medium, strong brown, 7.5YR4/6, redox concentrations starting at 23 cm.
50-110	Dusky red, 2.5YR4/2, silty, sandy, CLAY, with many, medium to coarse, dark yellowish brown, 10YR4/6, redox concentrations.
110-190	Dusky red, 2.5YR4/2, silty, sandy, CLAY, with common, very coarse, yellowish brown, 10YR5/8, redox concentrations, and black Mn nodules.
190-205	Dusky red, 2.5YR4/2, sandy SILT.

Borehole	**6**
Location:	**SW SE, Section 33, T2N, R9W, Centreville Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-40	Black, 10YR2/1, silty, sandy, CLAY.
40-100	Dark grayish brown, 10YR4/2, silty, sandy, CLAY, with few to many, dark yellowish brown, 10YR4/4, redox concentrations, roots.
100-140	Grayish brown, 10YR5/2, silty CLAY, with few, dark yellowish brown, 10YR4/4, redox concentrations, and black, Mn nodules.
140-170	Sandy CLAY, wet at about 150 cm.
170-200	Brown, fine to very fine SAND.

Borehole	**7**
Location:	**NW NE, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-8	Very dark gray, 10YR3/1, silty SAND.
8-65	Light yellowish brown, 2.5Y6/3, SAND with lenses of dark gray, 2.5Y4/1, CLAY and common, coarse, strong brown, 7.5YR5/8, redox concentrations in clay lenses and along contacts between clay and sand.
65-100	Dark gray, 2.5Y4/1, sandy SILT, with common, fine, redox concentrations.
100-200	Greenish gray, 5/5GY, and grayish brown, 2.5Y5/2, sandy SILT, with many, coarse, strong brown, 7.5YR4/6, redox concentrations and many old root channels. Saturated at 180 cm.

Borehole:	**11**
Location:	**NE NW, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-50	Very dark grayish brown, 10YR3/2, silty CLAY, with few, dark yellowish brown, 10YR4/6, redox concentrations.
50-60	Dark grayish brown, 10YR4/2, very fine SAND, with dark yellowish brown, 10YR4/6, redox concentrations.
60-152	Brown, 10YR4/3, silty SAND to very fine to fine SAND.

Appendix E: continued

Borehole: **12**
Location: **NW NE, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-30	Very dark grayish brown, 10YR3/2, silty SAND
30-70	Brown, 10YR5/3, sandy SILT, with many, distinct, dark yellowish brown, 10YR4/6, redox concentrations.
70-152	Brown, 7.5YR5/3, sandy SILT, with few, distinct, dark yellowish brown, 10YR4/6, redox concentrations.

Borehole: **12R**
Location: **NW NE, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-27	Very dark grayish brown, 10YR3/2, sandy CLAY, no redox features.
27-32	Grayish brown, 2.5Y5/2, sandy SILT, with few, fine, distinct, yellowish brown, 10YR5/6, redox concentrations.
32-45	Brown, 10YR4/4, silty SAND, with dark yellowish brown, 10YR4/6, redox concentrations and gray, 10YR5/1, redox depletions.
45-62	Brown, 10YR5/3, silty CLAY, with many, fine to coarse, strong brown, 7.5YR4/6, redox concentrations, and gray, 10YR5/1, redox depletions.
62-67	transition to
67-102	Brown, 10YR4/3, calcareous, sandy SILT, with few, fine, dark yellowish brown, 10YR3/6, redox concentrations, and few, medium, dark grayish brown, 10YR4/2, redox depletions, and hard, light gray to white calcareous nodules along root traces.

Borehole: **13**
Location: **SE NW, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-100	Very dark grayish brown, 10YR3/2, grading to very dark gray, 10YR3/1, silty CLAY, with few, distinct, brown, 10YR4/3, redox concentrations.
100-156	Dark yellowish brown, 10YR4/4, sandy SILT.

Borehole: **14**
Location: **NE NW, Section 4, T1N, R9W, Stookey Twp., St. Clair Co., IL.**

Depth (cm)	**Description**
0-42	Very dark gray, 10YR3/1, silty CLAY, with few, fine, faint, very dark grayish brown, 10YR3/2, redox concentrations and few, black, Mn nodules.
42-55	Very dark gray, 10YR3/1, CLAY, with few, fine, faint, very dark grayish brown, 10YR3/1, redox concentrations.
55-96	Grayish brown, 10YR5/2, silty CLAY, with many, fine, distinct, yellowish brown, 10YR5/6, redox concentrations, and gray oxidation halos along root channels.