GRAND DETOUR POTENTIAL WETLAND COMPENSATION SITE: HYDROGEOLOGIC CHARACTERIZATION REPORT

Grand Detour, Ogle County, Illinois
Section 13, T22N, R9E
(Federal Aid Project 742)

By

Steven E. Benton
Wetlands Geology Section
Transportation and Environment Center

Illinois Department of Natural Resources
ILLINOIS STATE GEOLOGICAL SURVEY
615 East Peabody Drive
Champaign, IL 61820-6964

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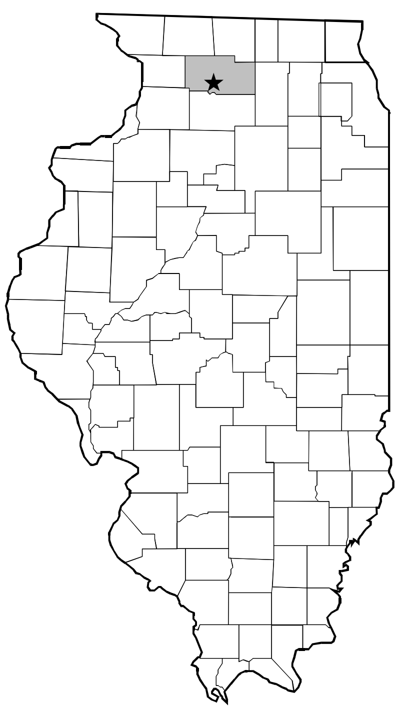

Abstract

Hydrogeologic data reveal that the conditions which would support wetlands do not occur at this site. Ground water is generally too deep, and inundation is too infrequent and of insufficient duration to satisfy the wetland hydrology criteria. In addition, the soil is non-hydric, underlying sediments are too coarse to maintain saturation, and there are no reversible hydrologic alterations.

The only alteration likely to result in jurisdictional wetland hydrology is excavation. Data collected in an adjacent IDOT-created wetland reveals that surface- and ground-water levels during the growing season satisfy the criteria for jurisdictional wetland hydrology. Using the IDOT-created wetland as a model, it was determined that excavating the site to the same elevation as the aquatic emergent portion of the wetland would increase the frequency and duration of flooding and bring the water table close enough to ground surface to support wetlands. Initial estimates suggest excavation in the range of 1.4 m (4.5 ft) to 2.0 m (6.4 ft) over the entire site will be required.

Table of Contents

Introduction . . . 1

Summary . . . 1

Recommendations . . . 1

Methods . . . 4

Geologic Characterization . . . 8
Regional Geology . . . 8
Site Geology . . . 8

Hydrologic Characterization . . . 8
Climate . . . 8
Regional Hydrology . . . 8
Site Hydrology . . . 11
Wetland Hydrology . . . 11

Wetland Model . . . 11

Conclusions and Recommendations . . . 15

Acknowledgments . . . 16

References . . . 17

Appendix A: Well Construction . . . 19

Appendix B: Depth to Ground Water . . . 20

Appendix C: Surface- and Ground-Water Elevations . . . 22

Appendix D: Geologic Logs . . . 25

Figures

1. Site map 2
2. Ground-water elevation at well 1M 5
3. Ground-water elevation at well 2M 6
4. Approximate excavation depths 7
5. Regional bedrock geology map 9
6. Monthly precipitation 10
7. Ground-water elevations 12
8. Surface-water elevations 13
9. Water-table on June 11, 2002 14

Tables

1. Number of flood events 3
2. Longest periods of flooding by the Rock River 3

Introduction

This report was prepared by the Illinois State Geological Survey (ISGS) in order to provide the Illinois Department of Transportation (IDOT) with information regarding the feasibility of wetland creation and/or restoration at the Grand Detour wetland compensation site. The site is located on the Rock River (Figure 1) near Grand Detour, IL in the SW¼, SW¼, Section 13, T22N, R9E in Ogle County, Illinois.

The purpose of this report is to provide IDOT with data regarding the hydrogeologic conditions of the study site and to make recommendations regarding wetland compensation. Therefore, for IDOT's convenience, a summary of the current hydrologic conditions and wetland design recommendations is presented first, followed by a discussion of the methods and supporting data. The supporting data include ground- and surface-water data and precipitation data collected from November 2000 to November 2002, and geologic data collected during the installation of monitoring wells.

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

Summary

The following indicates that the potential for wetland compensation at this site is low:

- The site is not mapped as wetland and there are no reversible hydrologic alterations, such as drainage ditches, levees, or drain tiles.

- Inundation and saturation on the site only occurred once during the monitoring period (June 2002), and then only for 4.2% of the growing season (8 days), which was not sufficient to satisfy the criteria for jurisdictional wetland hydrology.

- The only soil type mapped on the site is the Du Page silt loam (U.S. Soil Conservation Service 1980), which is not a state (U.S. Department of Agriculture 1991) or county (U.S. Department of Agriculture 1995) listed hydric soil. In addition, the permeability of the Du Page silt loam ranges from 0.36 m/d (1.20 ft/d) to 1.22 m/d (4.00 ft/d) (U.S. Soil Conservation Service 1980), which indicates a limited capacity to retard drainage.

- Geologic samples (Appendix D) collected during the installation of the monitoring wells reveal that the sediments may have even less capacity to retard drainage than is indicated by the soil mapped on the site. The permeability of sandy loam and sandy clay loam ranges from 1.22 m/d (4.00 ft/d) to 3.66 m/d (12.00 ft/d), while the permeability of loamy sand ranges from 3.66 m/d (12.00 ft/d) to 12.20 m/d (40.00 ft/d) (U.S. Department of Agriculture 2002).

Recommendations

The data collected at this site indicate that it is currently not a wetland, and that it likely was not a wetland in the past. Therefore, wetland conditions will have to be created, and the only alteration likely to result in wetland hydrology is excavation. River-stage and ground-water data reveal that excavating the site would increase the frequency and duration of flooding, and intercept the water table. Using the adjacent IDOT-created wetland (Figure 1) as a model, we recommend, for the following reason, that the proposed site be lowered to the same elevation (197.90 m) as the IDOT aquatic emergent wetland.

- Assuming there is no change in the direction and rate of ground-water flow, then excavating the proposed site to the elevation of the aquatic emergent wetland would increase the duration of saturation. Figures 2 and 3 show that, if ground-surface elevation at wells 1M and 2M had been

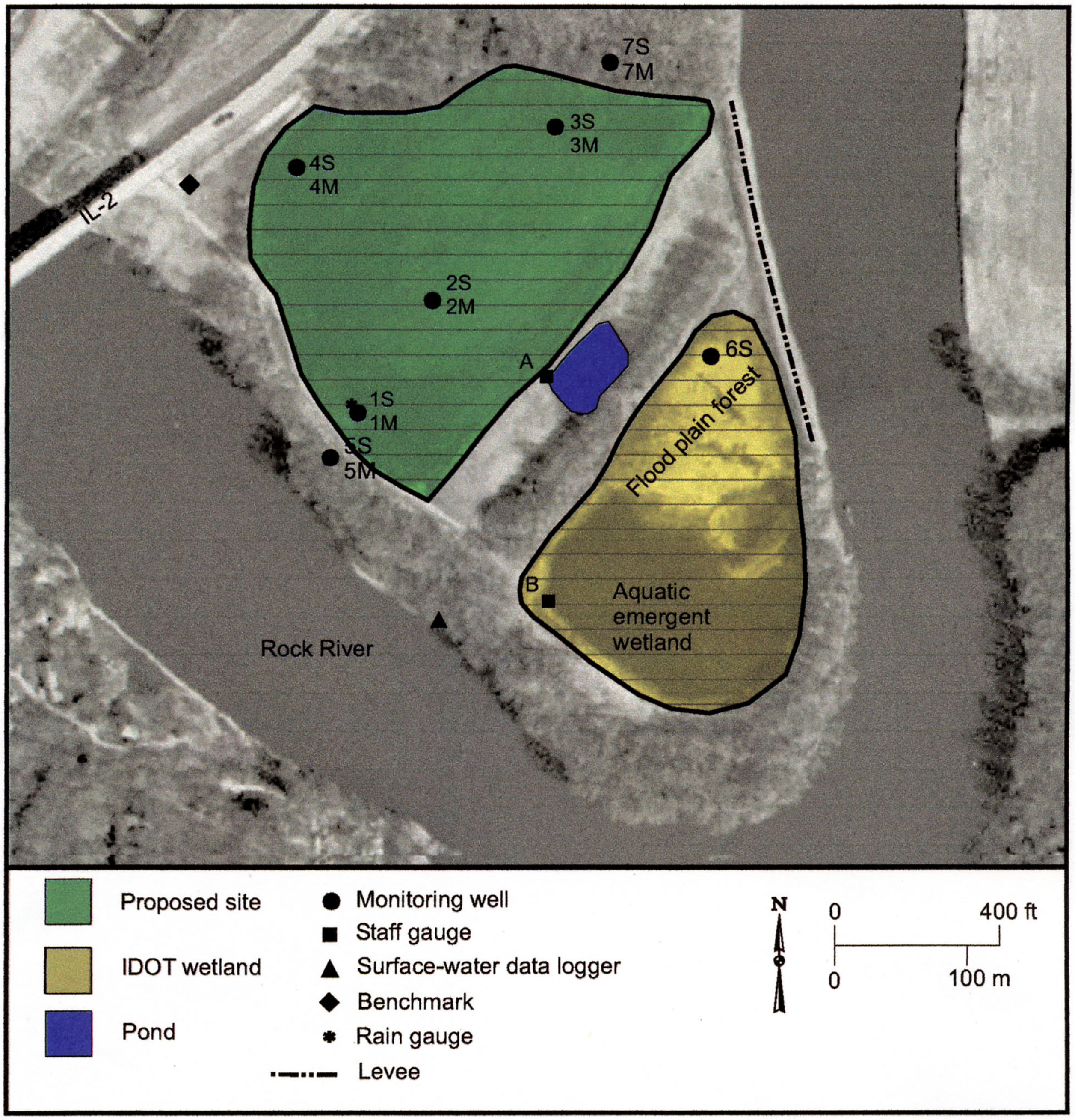

Figure 1: Site map (Aerial photography from the Illinois Digital Orthophoto Quadrangle, Grand Detour SE)

at 197.90 m, then saturation may have occurred for a duration sufficient to satisfy the wetland hydrology criteria in both 2001 and 2002.

- Lowering ground surface elevation would also increase the frequency and duration of flooding. Rock River stage data recorded at Dixon, IL (1993-2000) and at the site (2001 and 2002), reveal that the IDOT-created wetland floods much more often than the proposed site (Table 1). Analysis of the stage data reveals that the duration of flooding in the IDOT-created wetland is also much greater than on the proposed site. Table 2 shows that the duration of flooding in the IDOT aquatic emergent wetland was sufficient to conclusively satisfy the wetland hydrology criteria (duration ≥ 24 days) in 7 out of 10 years. In the IDOT flood plain forest, the duration of flooding was sufficient to conclusively satisfy the criteria in only two years, but may have satisfied the criteria (duration > 9 days to < 24 days) in three additional years (1996, 1998, and 1999), for a total of 5 out of 10 years. On the proposed site, the duration of flooding may have satisfied the criteria only in 2000, and only in the lower portions of the site.

Site Locations	Elevation of site locations (m)	Number of times since 1992 that elevation has been exceeded, that is, inundation has occurred, during the growing season
IDOT aquatic emergent wetland (Gauge B)	197.90	33
IDOT flood plain forest (Well 6S)	198.48	27
Lowest measured ground elevation on the proposed site at well cluster 1	199.26	6
Highest measured ground elevation on the proposed site at well cluster 2	199.85	4

Table 1: Number of flood events

Year	IDOT Aquatic emergent wetland	IDOT Flood plain forest	Well cluster 1	Well cluster 2
	Longest periods of flooding (days) (at least 24 consecutive days needed to satisfy the wetland hydrology criteria)			
1993	57	25	0	0
1994	0	0	0	0
1995	8	2	0	0
1996	47	12	3	1
1997	6	1	0	0
1998	45	19	0	0
1999	26	11	0	0
2000	90	79	16	9
2001	47	1	0	0
2002	28	7	3	<3

Table 2: Longest periods of flooding by the Rock River

- The excavation depths required to support wetland on the proposed site range from 1.4 m to 2.0 m (Figure 4) and are the difference between ground-surface elevations measured at the well locations (Appendix A) and the ground-surface elevation of the IDOT aquatic emergent wetland. The areas shown on Figure 4 are approximations only. It is recommended that the excavation not be bowl-shaped, instead the topography should be varied in order to produce a variety of habitats. In addition to excavation, it is also recommended that the levee along the Rock River be extended along the north side of the proposed site. The material excavated from the site could be used to build the levee. The levee will prevent the flow of flood water across the site, reducing the risk of scour and making it easier to establish a hydrophytic plant community.

Methods

A total of 13 monitoring wells were installed for this study (Figure 1). Eight wells (1S, 1M, 2S, 2M, 3S, 3M, 4S and 4M) in four well clusters were installed on the proposed site, four wells (5S, 5M, 7S, and 7M) in two well clusters were installed in areas adjacent to the proposed site, and one well (6S) was installed in IDOT flood plain forest. Details of well construction are in Appendix A. The purpose of the on-site wells was to determine ground-water flow directions and the extent of wetland hydrology. The purpose of the off-site wells was to determine if wetland hydrology occurs in areas adjacent to the site that are lower in elevation. Water levels in the wells were measured on a monthly basis from July to March and biweekly in April, May, and June. Depth-to-water and surface- and ground-water elevation data are in Appendix B and Appendix C, respectively.

Two staff gauges were also installed (Figure 1). Gauge A was installed in a pond adjacent to the site and Gauge B was installed in the IDOT aquatic emergent wetland. The purpose of the gauges was to determine the extent and duration of inundation, and if there is a relationship between surface- and ground-water fluctuations. Water depths at the gauges were measured monthly from July to March and biweekly in April, May, and June.

In addition to the monitoring wells and staff gauges, two electronic data loggers were installed: one in the Rock River (Figure 1), and the other in well 2M. The data loggers were used to determine if there is a relationship between river stage and the water level in well 2M. In addition, the data logger in the Rock River was used to determine if there is a relationship between river stage at the site and at Dixon, IL. The data logger in the Rock River was installed in March 2001 and programmed to record stage at hourly intervals. The data logger in well 2M was installed in April 2002 and programmed to record the water level hourly.

A tipping-bucket rain gauge equipped with an electronic data logger was installed near well cluster 1 in May 2001. Precipitation data were collected from May 2001 to November 2001 and from April 2002 to November 2002. These data were used to determine the duration and intensity of individual rainfall events. Precipitation data were also obtained from the Midwestern Regional Climate Center (MRCC) at the Illinois State Water Survey (ISWS). These data were recorded at the climate station in Dixon, Illinois (Station# 112348), and were used to determine long-term (monthly, seasonal, and annual) precipitation trends.

Temperature data were obtained from the National Water and Climate Center (NWCC) of the Natural Resources Conservation Service (NRCS) and were used to determine the average length of the growing season at the site. The data were recorded at Dixon, IL and covered the period from 1961 to 1990. The data show that the average length of the growing season is 188 days, starting on April 15 and ending on October 20. In order to conclusively satisfy the criteria for jurisdictional wetland hydrology, saturation or inundation must occur for at least 12.5% of the growing season (Environmental Laboratory 1987). At the Grand Detour site, this is about 24 days.

The elevations of the stage gauges, dataloggers, and monitoring wells were measured relative to a benchmark established by IDOT using a Sokkia B-1 automatic level and a fiberglass extending rod. The elevation of the benchmark was determined relative to the National Geodetic Vertical Datum (NGVD) of 1929.

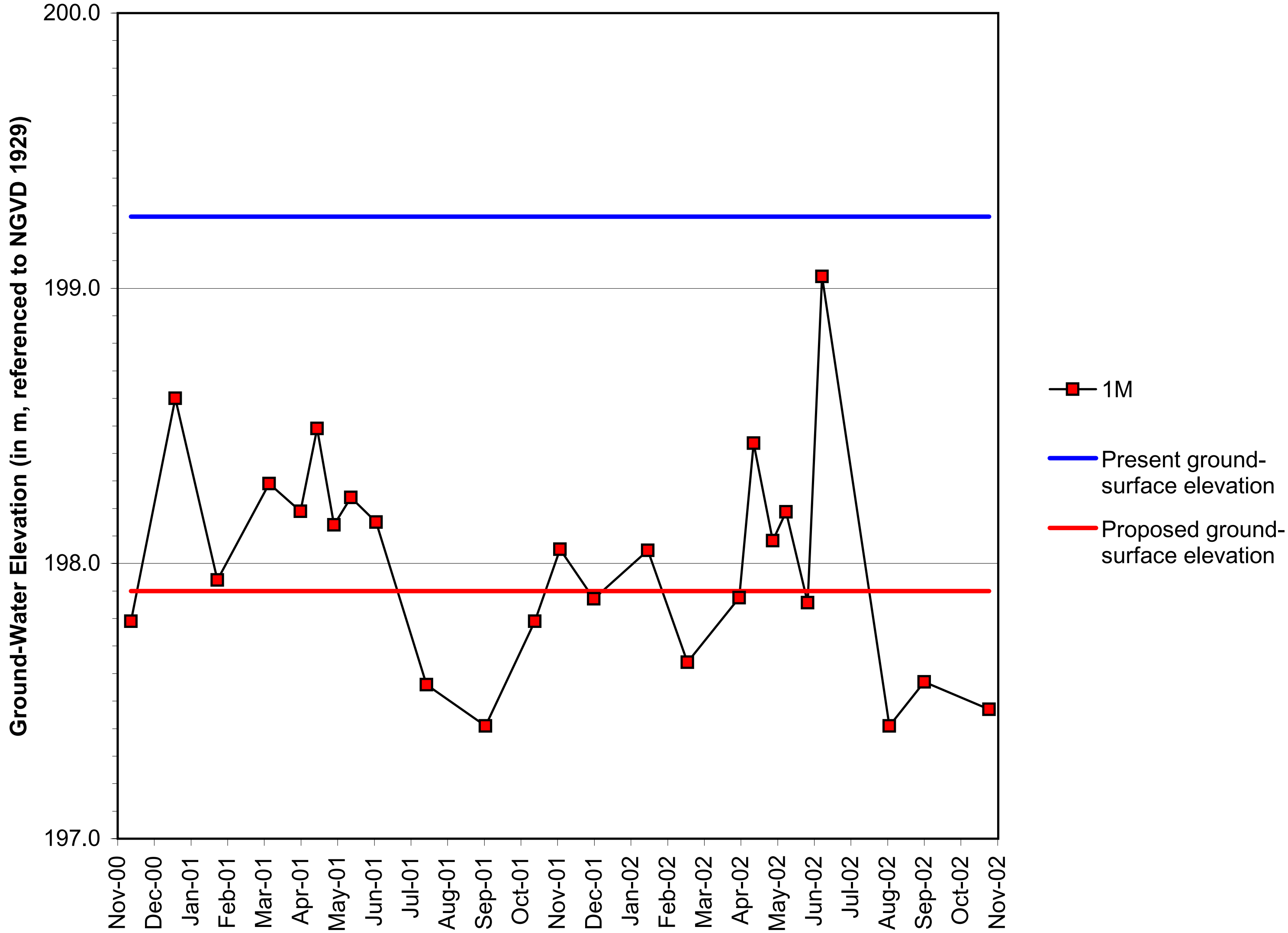

Figure 2: Ground-Water Elevation at Well 1M

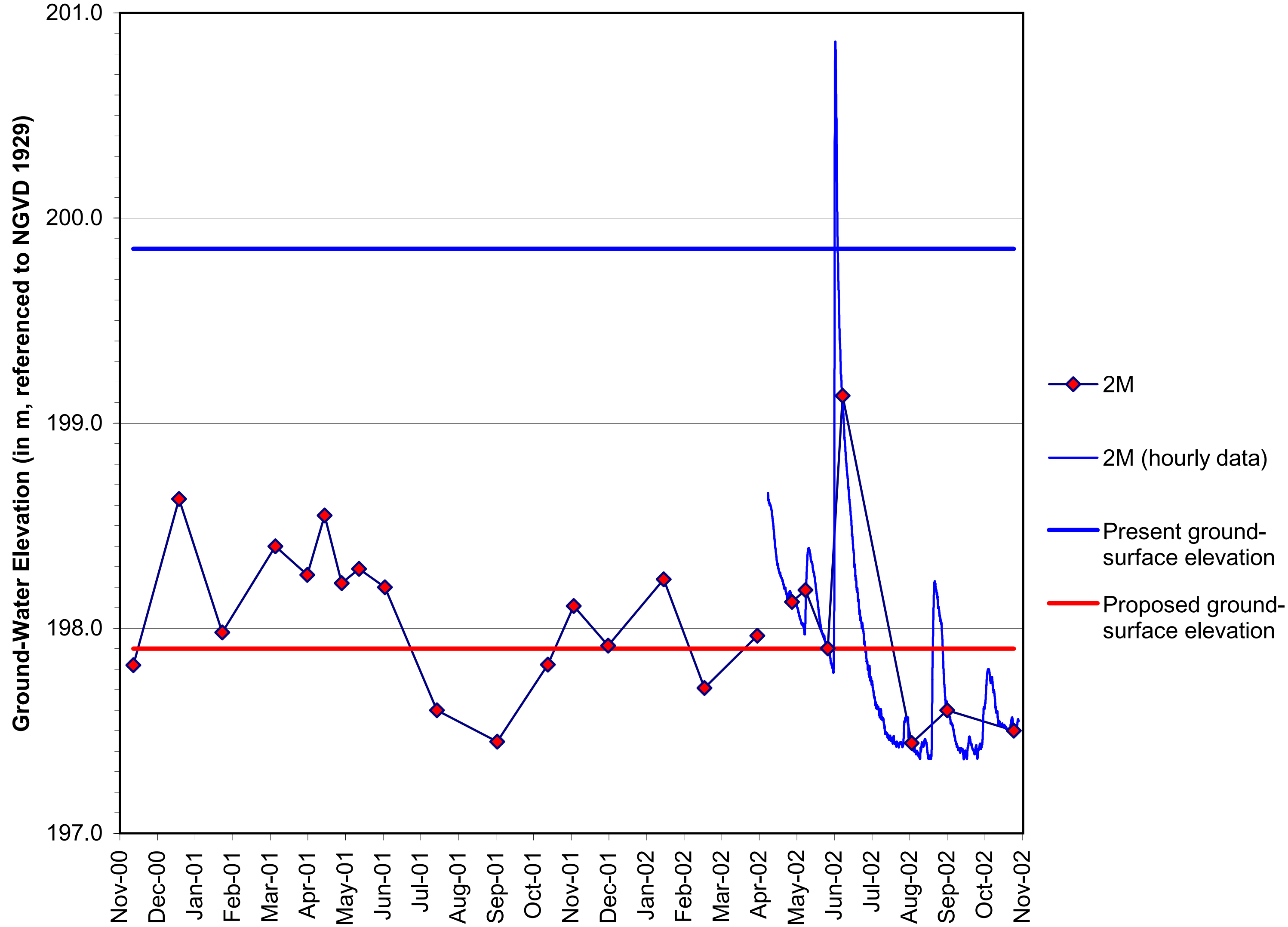

Figure 3: Ground-water elevation at well 2M

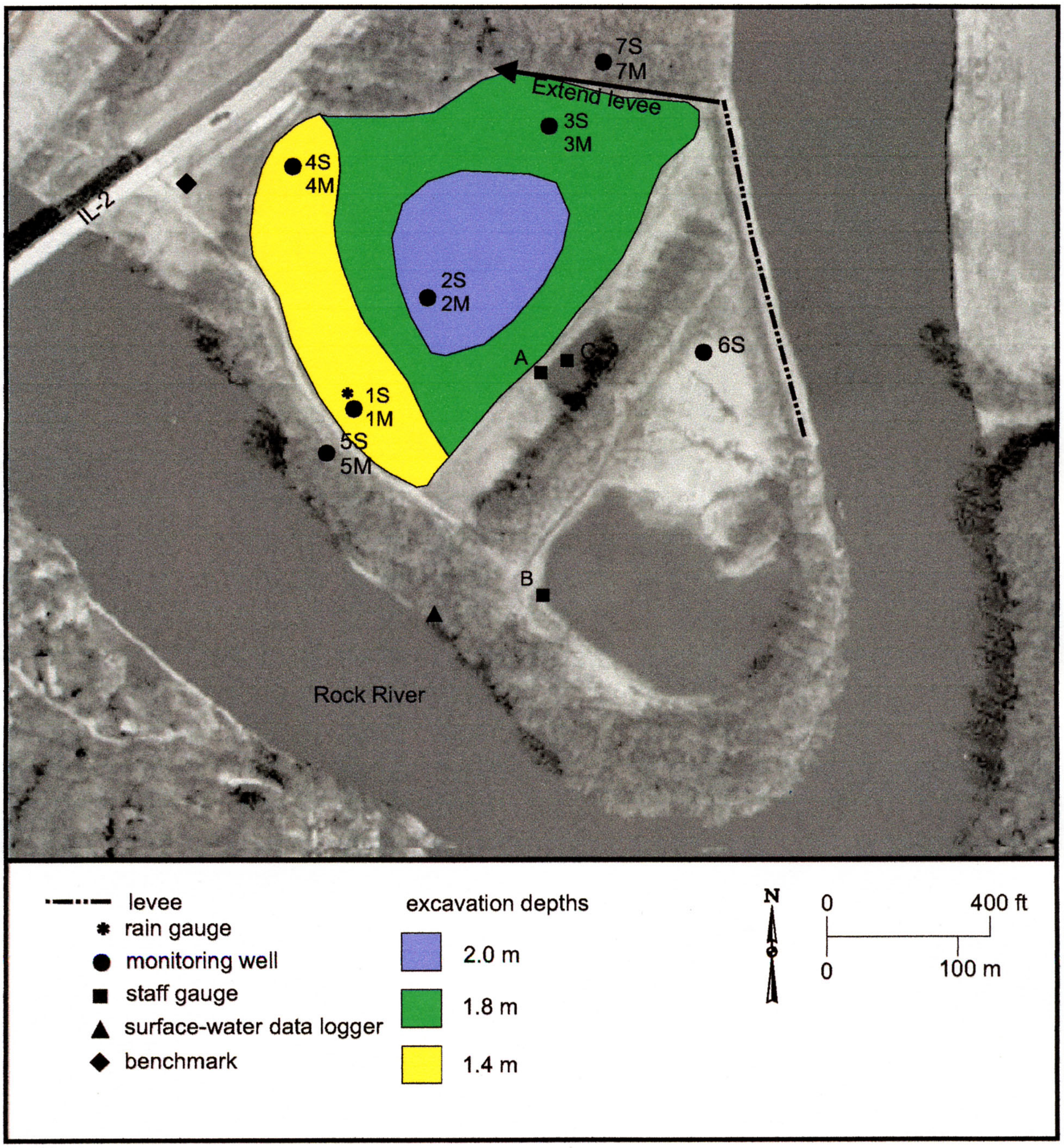

Figure 4: Approximate excavation depths

In addition, the geographic locations of the staff gauges, monitoring wells, and dataloggers were determined using a Trimble Pro XR/XRS GPS receiver and TSC Asset Surveyor. The locations were differentially corrected using the Trimble Pathfinder software.

Geologic Characterization

Regional Geology
The bedrock underlying the region is sandstone of the Ordovician Ancell Group (Willman and Templeton 1963 and Willman, et. al. 1975). The St. Peter Formation and the Glenwood Formation of the Ancell Group are both present in the vicinity of the study site (Figure 5). The Glenwood Formation is found below the glacial deposits (Bevan 1926) and probably underlies the site. Outcrops of the Glenwood Formation and the St. Peter Formation are visible in the river bluff south of the study site and in road cuts along IL-2 (Elder 1935).

The glacial deposits in the region are generally < 12 m thick (Piskin and Bergstrom 1975, Berg and Kempton 1988). Under the study site, the sediments consist of < 6 m of Cahokia Formation alluvium over < 6 m of Henry Formation sand and gravel (Berg and Kempton 1988, Hansel and Johnson 1996).

Site Geology
The character of the sediments at the site was noted during the installation of the monitoring wells (Appendix D). It was generally found that the sediments are coarse-grained, being predominantly composed of loamy sand, sandy loam, and sandy clay loam up to 2.3 m (7.8 ft) thick over fine to medium sand and sand and gravel to a depth of at least 2.7 m (8.9 ft).

In the IDOT created wetland (Figure 1), the sediments are somewhat different. A boring near well 6S revealed about 0.38 m of clayey silt over 0.22 m of clayey sand, over 0.15 m of sandy clay. The clayey silt is probably the “hydric top soil” spread over the mitigation site (IDOT 1993). The clayey sand and sandy clay are probably “riverwash” deposits mapped by the U.S. Soil Conservation Service (1980). This conclusion is supported by the presence of snail shells and shell fragments found throughout the clayey sand and sandy clay.

The only soil type mapped on the study site is the Du Page Silt Loam (U.S. Soil Conservation Service 1980). This is a well-drained soil that forms in alluvium on flood plains. The permeability throughout the soil column is 0.36 m/d (1.20 ft/d) to 1.22 m/d (4.00 ft/d), and the water-table is generally > 1.8 m (5.9 ft) below ground surface. In addition, the soil is rarely flooded, and it is rated as poor for wetland vegetation and wildlife.

Hydrologic Characterization

Climate
Total precipitation during the monitoring period was 199.09 cm (78.38 in), which was 110% of average. The wettest month was June 2002 (195% of average) and the driest month was December 2001 (53% of average). Figure 6 shows that monthly precipitation, as recorded at Dixon, IL, was above average in 13 months and below average in 11 months. The longest period of above average precipitation was April 2002 to June 2002, which was 128% of average, while the longest period of below average precipitation was November 2001 to January 2002, which was 67% of average. The largest rainfall event during the monitoring period was on June 3 and June 4, 2002, when 15.54 cm (6.12 in) of precipitation was recorded by the on-site rain gauge.

Regional Hydrology
The study site is within the 100-year flood plain of the Rock River (Federal Emergency Management Agency 1988). Base-flood elevations at the site range from 201.8 m (661.9 ft) to 202.1 m (662.9 ft). The highest ground-surface elevation measured at the site was 199.85 m (655.51 ft) (well cluster 2).

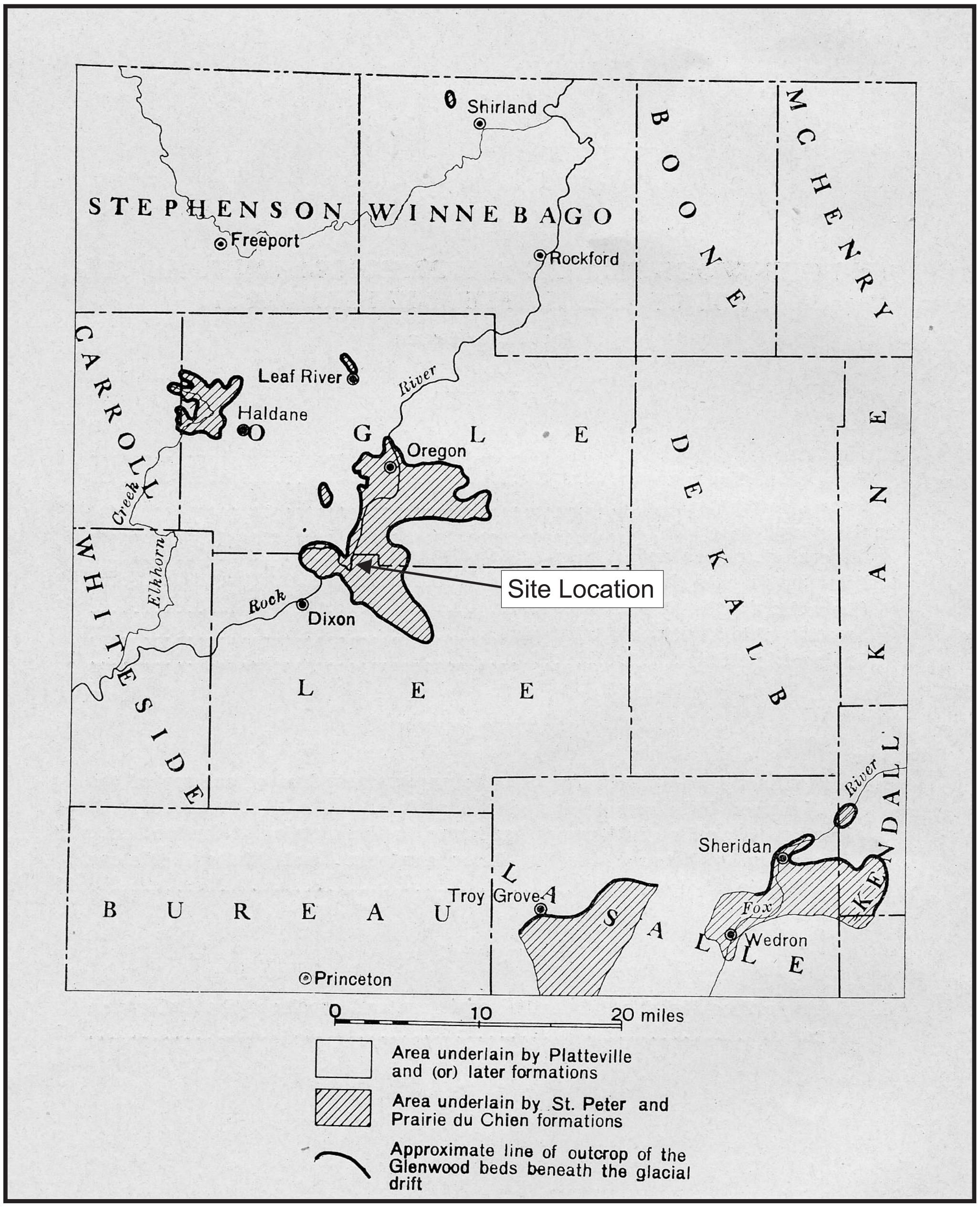

Figure 5: Regional bedrock geology map (Source: Bevan 1926)

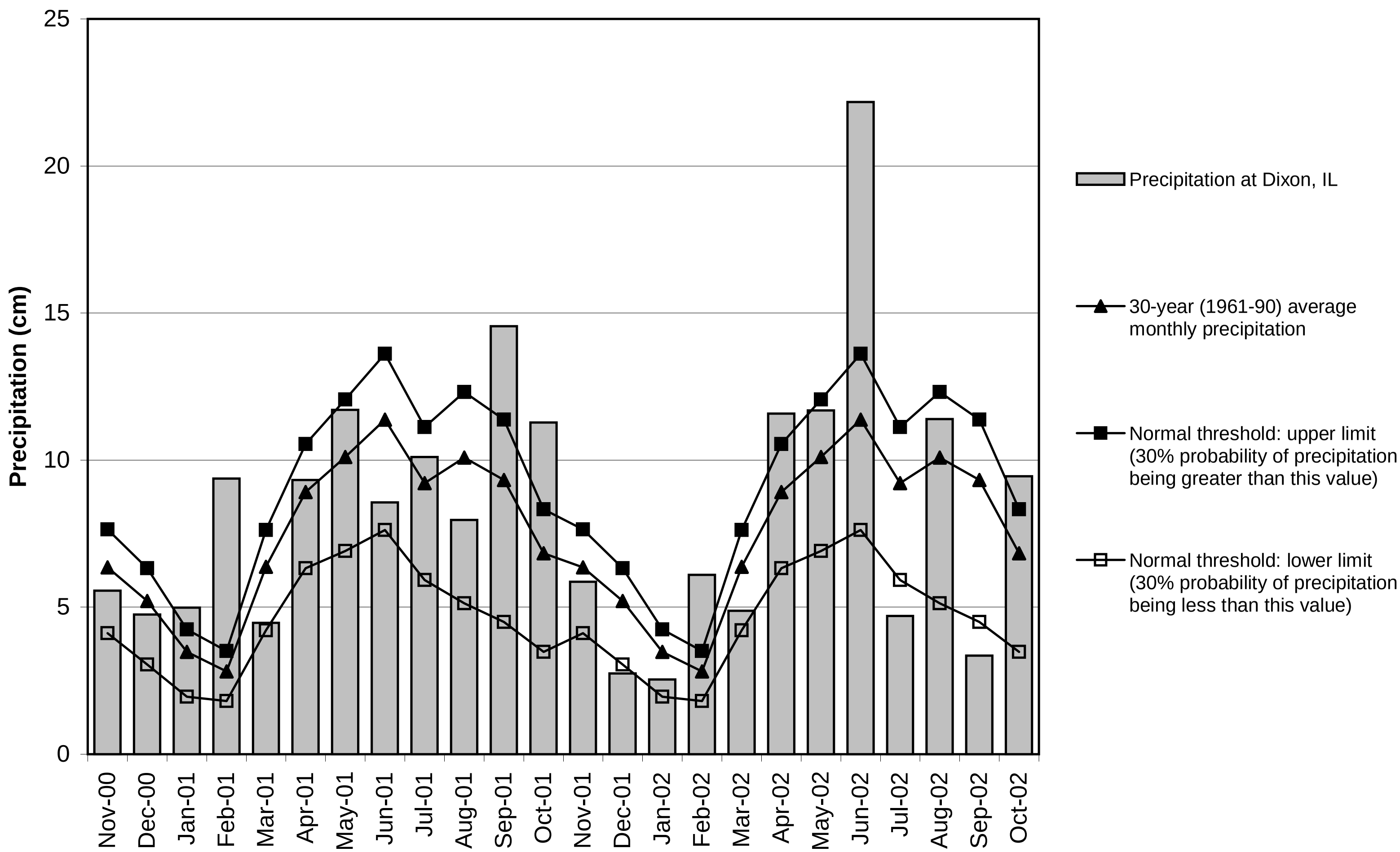

Figure 6: Monthly precipitation

Therefore, during a 100-yr flood event, the minimum depth of inundation over the entire site would range from 2.0 m (6.6 ft) to 2.3 m (7.6 ft).

The nearest gauging station is on the Rock River, about 17.0 km (10.4 mi) downstream of the site in the stilling pool of the Commonwealth Edison hydroelectric plant in Dixon, IL. This gauge is maintained and operated by the Illinois Department of Natural Resources (IDNR). Stage is recorded in 15-minute intervals (Tom Maloney, IDNR personal communication).

The Office of Water Resources Planning Division at the IDNR provided stage data going back to May 1993 (Tom Maloney, pers. comm.). The elevation of the datum is 195.19 m (640.22 ft) above mean sea level and flood stage is 3.66 m (12.00 ft). Analysis of the stage data reveals that the Rock River has exceeded flood stage at Dixon three times since 1992.

Site Hydrology
Figures 7 and 8 are graphs of ground-water and surface-water elevations, respectively. The figures show that surface- and ground-water tend to be highest in the winter and spring. Figure 9 shows that, on June 11, 2002, ground water flowed toward the Rock River from the northern portion of the proposed site. Analysis of the surface- and ground-water data (Appendix C) shows that this is generally the case throughout the monitoring period. This suggests that the northern portion of the site is a recharge area, and that the Rock River at this location is a gaining stream.

Wetland Hydrology
Depth-to-ground-water (Appendix B) and Rock River data (Figure 8) reveal that, during the monitoring period, saturation (depth-to-ground-water < 30 cm) and inundation occurred on the proposed site only in June 2002. This was the result of a flood event caused by 15.54 cm (6.12 in.) of precipitation on June 3 and June 4. The total period of saturation and inundation was about 8 days or 4.2% of the growing season, which was not long enough to satisfy the criteria for jurisdictional wetland hydrology.

Rock River data also indicate that inundation occurred in 1996 and 2000. However, the periods of inundation were not long enough to conclusively satisfy the wetland hydrology criteria (period of inundation/saturation ≥ 12.5% of the growing season). In 1996, the period of inundation lasted 1 to 3 days (Table 2), which was < 2% of the growing season, while in 2000, the period of inundation lasted 9 to 16 days (Table 2), which was < 5.0% to 8.5% of the growing season.

In areas adjacent to the site (well clusters 5 and 7), the duration of saturation and inundation during the monitoring period was generally about the same as on the site. Only in the IDOT-created wetlands did inundation and/or saturation occur for periods long enough to satisfy the criteria for jurisdictional wetland hydrology. Rock River data (Figure 8) reveal that the IDOT aquatic emergent wetland was flooded for at least 47 consecutive days in 2001 and 28 consecutive days in 2002 (Table 2). In the IDOT flood plain forest, the period of saturation in 2002 was at least 57 consecutive days (Table 2). Rock River stage data also reveals that, in the period 1993 to 2000 (Table 2), inundation due to flooding occurred for periods long enough to conclusively satisfy the jurisdictional criteria five times in the IDOT aquatic emergent wetland and twice in the IDOT flood plain forest.

Wetland Model

The occurrence of jurisdictional wetland hydrology in the IDOT-created wetland makes it possible to use it as a model for creating wetland on the proposed site. The goal is to recreate on the site the conditions that support wetland hydrology in the adjacent IDOT-created wetland.

The differences which appear to result in inundation and saturation in the IDOT-created wetlands are geology and elevation. The geologic logs (Appendix D) show that the sediments in the IDOT flood plain forest (Well 6S) are finer grained than the sediments underlying the site. The permeability of these

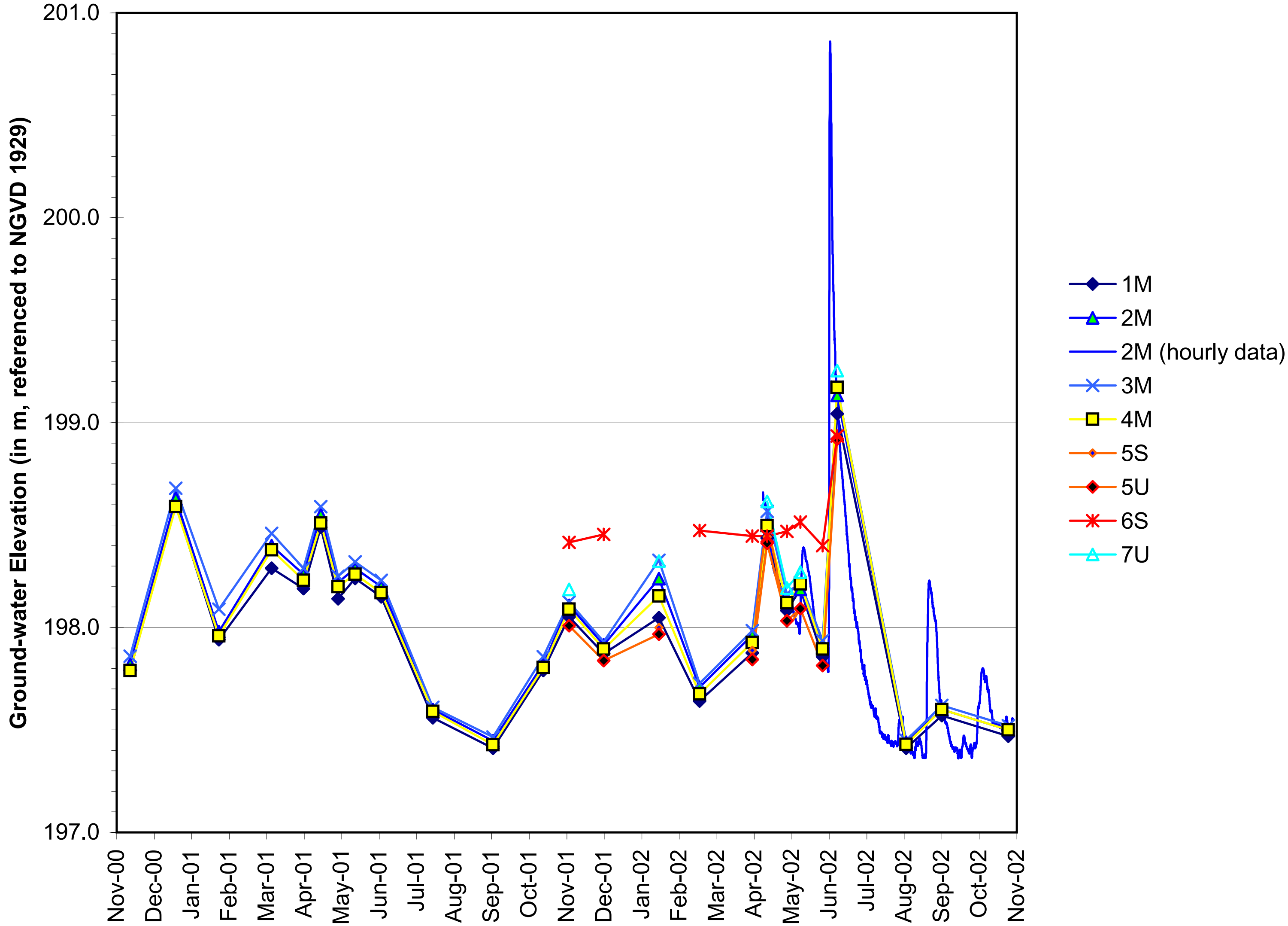

Figure 7: Ground-water elevations

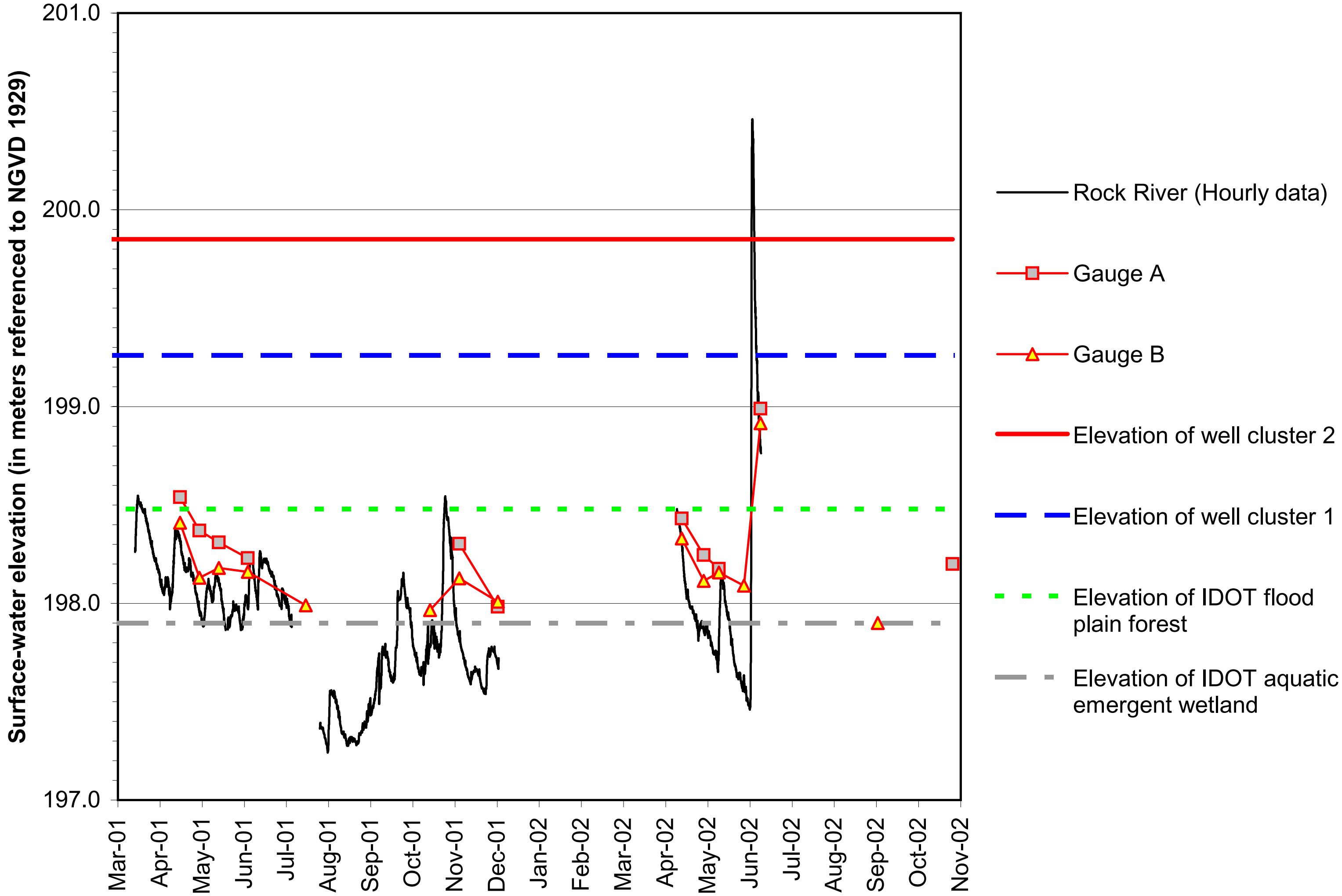

Figure 8: Surface-water elevations

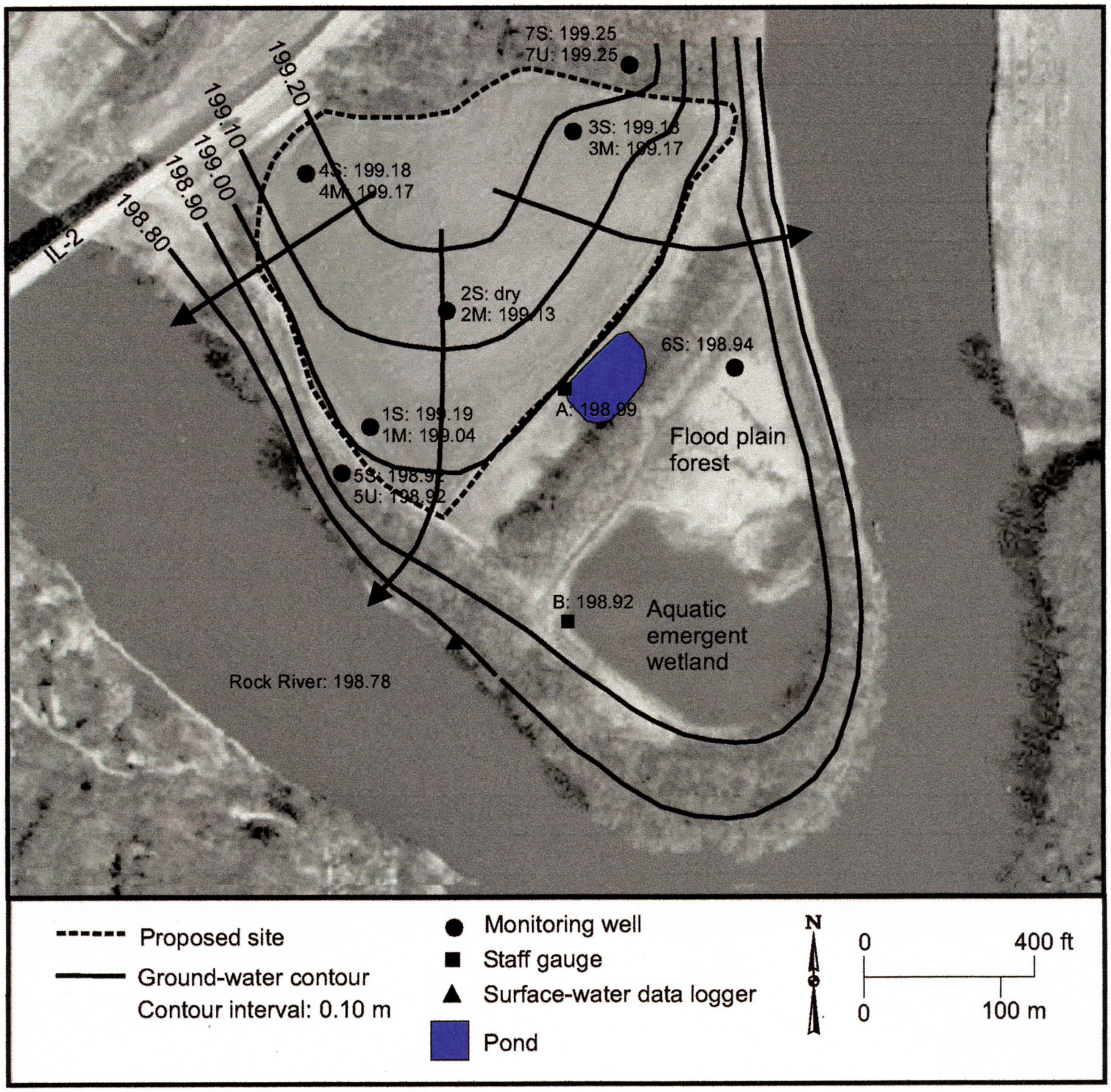

Figure 9: Water-table on June 11, 2002

sediments may be $\leq$ 1.22 m/d (4.00 ft/d), while the permeability of the sediments underlying the site could be 10 times greater than in the IDOT flood plain forest.

In terms of elevation, the IDOT flood plain forest is 0.78 m to 1.37 m lower than the proposed site, while the IDOT aquatic emergent wetland is 1.36 m to 1.95 m lower than the proposed site. As a result, the frequency and duration of flooding in the IDOT-created wetlands is much greater than on the proposed site (Table 1 and Table 2).

Comparing the frequency and duration of flooding in the IDOT-created wetlands reveals that, while the frequency of flooding is about the same (Table 1), the duration of flooding in the aquatic emergent wetland is greater than in the flood plain forest (Table 2). As a result, the aquatic emergent wetland has conclusively satisfied the criteria for jurisdictional wetland hydrology in 7 out of 10 years, while the flood plain forest has conclusively satisfied the jurisdictional criteria in only 2 out of 10 years, and may have satisfied the criteria in 3 additional years. Therefore, lowering the proposed site to the same elevation as the IDOT aquatic emergent wetland (197.90 m) would not only increase the probability of flooding, but also the likelihood of satisfying the criteria for jurisdictional wetland hydrology.

Besides allowing flooding from the Rock River, lowering the elevation of the proposed site to the elevation of the nearby IDOT aquatic emergent wetland may also increase the duration of saturation to within 30 cm of ground surface. Figures 2 and 3 suggest that, if the site had been at the same elevation as the IDOT aquatic emergent wetland, then the water table would likely have been close enough to ground surface to cause saturation for a sufficient duration to support wetlands.

The drawbacks to this plan are the risks of creating a deep-water habitat and opening the site to scouring and/or deposition during flood events. The first drawback can be addressed by not excavating below an elevation of 197.90 m. The second drawback can be addressed by extending the levee on the north side of the IDOT wetland (Figure 4) westward along the north side of the proposed site. Material excavated from the site could be used to construct the levee. The levee would prevent the flow of water across the site and reduce the chance of scouring.

One unknown factor in this plan is the effect of excavation on ground water. Excavating the site to the water-table could increase evapotranspiration. This would cause the water-table to move downward, resulting in a situation similar to what was observed during the monitoring period, rather than in saturation to ground surface.

Excavation could also affect ground-water flow, possibly increasing the rate of flow both into, and out of, the excavation, or even causing the direction of flow to change. One possibility is that the direction of ground-water flow between the site and the IDOT-created wetlands could reverse, resulting in the drainage of the existing IDOT-created wetlands.

Conclusions and Recommendations

The results of this investigation reveal the following about the proposed mitigation site.

- The site does not presently satisfy wetland hydrology criteria. The sediments underlying the site are too coarse, ground-water levels are too deep, it is flooded only rarely, and the duration of flooding is not long enough to satisfy the criteria for jurisdictional wetland hydrology.
- The only hydrologic alteration likely to produce wetland hydrology on the site is excavation. The anticipated excavation depths range from 1.4 m to 2.0 m. Analysis of surface- and ground-water data indicate that lowering the site to the same elevation as the IDOT aquatic emergent wetland would result in jurisdictional wetland hydrology from flooding and saturation. However, steps would have to be taken to protect the site from scouring and to prevent the creation of a

deep-water habitat.

Acknowledgments

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Appendix A: Well Construction

Well#	Date Installed	Well Diameter (cm)	Hole Depth (cm)	Well Length (cm)	Screen Length (cm)	Screened Interval (cm)	Sand Pack (cm)	Seal (cm)	Ground Surface Elevation (m)	Screen Elevation (m)
1S	8/1/00	2.54	73.0	184.6	27.9	41.0-68.9	73.0-35.0	35.0-2.0	199.256	198.567-198.846
1M	10/30/00	2.54	207.1	305.0	146.5	52.1-198.6	207.1-45.0	45.0-5.0	199.256	197.270-198.735
2U	8/1/00	2.54	74.0	187.7	31.2	37.2-68.4	74.0-33.0	33.0-2.0	199.846	199.162-199.474
2M	10/30/00	2.54	277.0	381.0	146.5	122.0-268.5	277.0-100.0	100.0-70.0	199.846	197.161-198.626
3S	8/1/00	2.54	76.0	187.0	30.4	40.3-70.7	76.0-33.0	33.0-2.0	199.684	198.977-199.281
3M	10/30/00	2.54	258.0	365.0	146.5	103.0-249.5	258.0-88.0	88.0-64.0	199.684	197.189-198.654
4S	8/1/00	2.54	73.0	191.2	30.2	39.2-69.4	73.0-32.0	32.0-2.0	199.337	198.643-198.945
4M	10/30/00	2.54	219.0	305.0	146.5	64.0-210.5	219.0-50.0	50.0-5.0	199.337	197.232-198.697
5S	10/30/01	2.54	78.0	190.5	28.0	45.5-73.5	78.0-31.0	31.0-2.0	198.572	197.837-198.117
5U	10/30/01	2.54	107.0	190.0	27.5	75.0-102.5	107.0-53.0	53.0-2.0	198.572	197.547-197.822
6S	10/30/01	2.54	75.0	189.5	27.5	43.0-70.5	75.0-36.0	36.0-2.0	198.482	197.777-198.052
7S	10/30/01	2.54	76.0	190.0	27.5	44.0-71.5	76.0-28.0	28.0-2.0	199.054	198.339-198.614
7U	10/30/01	2.54	100.0	190.0	27.3	68.2-95.5	100.0-50.0	50.0-2.0	199.054	198.099-198.372

Appendix B: Depth to Ground Water (in meters)

Date	Depth to Water (in m referenced to ground surface)													
	8/7/00	9/9/00	10/16/00	11/13/00	12/20/00	1/24/01	3/8/01	4/3/01	4/17/01	5/1/01	5/15/01	6/5/01	7/17/01	9/4/01
1S	dry	dry	dry	dry	0.62	dry	dry	dry	0.55	dry	dry	0.70	dry	dry
1M	**	**	**	1.46	0.65	1.31	0.96	1.07	0.77	1.12	1.02	1.11	1.70	1.85
2S	dry	dry	dry	dry	dry	dry	frozen	dry	dry	dry	dry	dry	dry	dry
2M	**	**	**	2.01	1.20	1.85	1.43	1.59	1.30	1.64	1.56	1.66	2.26	2.41
3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
3M	**	**	**	1.83	1.01	1.68	1.23	1.38	1.09	1.43	1.35	1.45	2.07	2.21
4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
4M	**	**	**	1.53	0.74	1.36	0.95	1.10	0.82	1.14	1.07	1.16	1.75	1.90
5S	**	**	**	**	**	**	**	**	**	**	**	**	**	**
5U	**	**	**	**	**	**	**	**	**	**	**	**	**	**
6S	**	**	**	**	**	**	**	**	**	**	**	**	**	**
7S	**	**	**	**	**	**	**	**	**	**	**	**	**	**
7U	**	**	**	**	**	**	**	**	**	**	**	**	**	**

** indicates well is not yet installed
– indicates water above land surface
shading indicates depth to water is ≤ 0.304 m

Appendix B: *continued*

Depth to Water (in m referenced to ground surface)														
Date	10/15/01	11/5/01	12/3/01	1/17/02	2/19/02	4/3/02	4/15/02	5/1/02	5/12/02	5/30/02	6/11/02	8/6/02	9/4/02	10/28/02
1S	0.63	dry	dry	dry	dry	dry	dry	dry	0.51	dry	0.07	dry	dry	dry
1M	1.47	1.21	1.39	1.21	1.62	1.38	0.82	1.17	1.07	1.40	0.21	1.84	1.69	1.78
2S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
2M	2.04	1.75	1.94	1.62	2.15	1.90	global	1.76	1.66	1.94	0.71	2.41	2.25	2.35
3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	0.50	dry	dry	dry
3M	1.82	1.55	1.74	1.35	1.95	1.69	1.11	1.52	1.46	1.75	0.51	2.23	2.07	2.16
4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	0.16	dry	dry	dry
4M	1.53	1.24	1.44	1.18	1.66	1.41	0.83	1.22	1.12	1.44	0.16	1.90	1.74	1.84
5S	**	0.56	dry	0.57	dry	0.68	0.12	0.54	0.48	dry	-0.34	dry	dry	dry
5U	**	0.54	0.71	0.58	dry	0.70	0.13	0.54	0.48	0.76	-0.35	dry	dry	dry
6S	**	0.05	0.01	frozen	-0.01	0.02	0.02	0.01	-0.03	0.08	-0.45	dry	dry	dry
7S	**	dry	dry	dry	dry	dry	0.44	dry	dry	dry	-0.20	dry	dry	dry
7U	**	0.90	dry	0.76	dry	dry	0.47	0.86	0.78	dry	-0.20	dry	dry	dry

** indicates well is not yet installed
– indicates water above land surface
shading indicates depth to water is ≤ 0.304 m

Appendix C: Surface- and Ground-Water Elevations

Surface- and Ground-Water Elevation (in m referenced to ground surface)													
Date	8/7/00	9/9/00	10/16/00	11/13/00	12/20/00	1/24/01	3/8/01	4/3/01	4/17/01	5/1/01	5/15/01	6/5/01	7/17/01
1S	dry	dry	dry	dry	198.62	dry	dry	dry	198.71	dry	dry	198.56	dry
1M	**	**	**	197.79	198.60	197.94	198.29	198.19	198.49	198.14	198.24	198.15	197.56
2S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
2M	**	**	**	197.82	198.63	197.98	198.40	198.26	198.55	198.22	198.29	198.20	197.60
3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
3M	**	**	**	197.86	198.68	198.09	198.46	198.29	198.59	198.25	198.32	198.23	197.61
4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
4M	**	**	**	197.79	198.59	197.96	198.38	198.23	198.51	198.20	198.26	198.17	197.59
5S	**	**	**	**	**	**	**	**	**	**	**	**	**
5U	**	**	**	**	**	**	**	**	**	**	**	**	**
6S	**	**	**	**	**	**	**	**	**	**	**	**	**
7S	**	**	**	**	**	**	**	**	**	**	**	**	**
7U	**	**	**	**	**	**	**	**	**	**	**	**	**
Gauge A	198.05	dry	dry	dry	frozen	frozen	flooded	flooded	198.54	198.37	198.31	198.23	dry
Gauge B	198.26	dry	dry	dry	frozen	frozen	bent	bent	198.41	198.13	198.18	198.16	197.99

** indicates well is not yet installed
wbg indicates water is below bottom of gauge

Appendix C: *continued*

Surface- and Ground-Water Elevation (in m referenced to ground surface)													
Date	9/4/01	10/15/01	11/5/01	12/3/01	1/17/02	2/19/02	4/3/02	4/15/02	5/1/02	5/12/02	5/30/02	6/11/02	8/6/02
1S	dry	dry	dry	dry	dry	dry	dry	dry	dry	198.75	dry	199.19	dry
1M	197.41	197.79	198.05	197.87	198.05	197.64	197.88	198.44	198.08	198.19	197.86	199.04	197.41
2S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry
2M	197.45	197.82	198.11	197.92	198.24	197.71	197.96	global	198.13	198.19	197.90	199.13	197.44
3S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	199.18	dry
3M	197.47	197.86	198.13	197.93	198.33	197.73	197.99	198.57	198.16	198.22	197.94	199.17	197.45
4S	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	dry	199.18	dry
4M	197.43	197.81	198.09	197.90	198.15	197.68	197.93	198.50	198.12	198.21	197.90	199.17	197.43
5S	**	**	198.00	dry	198.00	dry	197.89	198.44	198.03	198.09	dry	198.92	dry
5U	**	**	198.01	197.84	197.97	dry	197.84	198.41	198.03	198.09	197.82	198.92	dry
6S	**	**	198.42	198.45	frozen	198.47	198.45	198.45	198.47	198.52	198.40	198.94	dry
7S	**	**	dry	dry	dry	dry	dry	198.62	dry	dry	dry	199.25	dry
7U	**	**	198.19	dry	198.33	dry	dry	198.62	198.19	198.27	dry	199.25	dry
Gauge A	wbg	wbg	198.30	197.98	frozen	wbg	wbg	198.43	198.25	198.18	wbg	198.99	wbg
Gauge B	wbg	197.97	198.13	198.01	wbg	wbg	missing	198.33	198.11	198.16	198.09	198.92	wbg

** indicates well is not yet installed
wbg indicates water is below bottom of gauge

Appendix C: *continued*

Surface- and Ground-Water Elevation (in m referenced to ground surface)		
Date	9/4/02	10/28/02
1S	dry	dry
1M	197.57	197.74
2S	dry	dry
2M	197.50	197.70
3S	dry	dry
3M	197.52	197.77
4S	dry	dry
4M	197.50	197.67
5S	dry	dry
5U	dry	dry
6S	dry	dry
7S	dry	dry
7U	dry	dry
Gauge A	wbg	198.20
Gauge B	197.90	wbg

** indicates well is not yet installed
wbg indicates water is below bottom of gauge

Appendix D: Geologic Logs

Well 1M

0-0.55 m	Dark brown (10YR3/3) loamy SAND grading to grayish brown (10YR5/2) sandy LOAM.
0.55-1.55 m	Grayish brown (10YR5/2) sandy LOAM.
1.55-2.07 m	Brown, fine to medium SAND with shell fragments.

Well 2M

0-0.55 m	Dark brown (10YR3/3) loamy SAND grading to grayish brown (10YR5/2) sandy LOAM.
0.55-1.55 m	Grayish brown (10YR5/2) sandy LOAM.
1.55-2.77 m	Brown, fine to medium SAND with shell fragments.

Well 3M

0-1.50 m	Dark brown (10YR3/3) to grayish brown (10YR5/2) sandy clay LOAM.
1.50-2.30 m	Sandy clay LOAM.
2.30-2.58 m	Sand and Gravel.

Well 6S

0-0.06 m	Clayey SILT.
0.06-0.60 m	Dark brown, gravelly, clayey SAND with shell fragments.
0.60-1.00 m	Sandy CLAY with shell fragments.