U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

In cooperation with the U.S. Environmental Protection Agency

Geology, Hydrology, and Water Quality in the Vicinity of a Brownfield Redevelopment Site in East Moline, Illinois

By Robert T. Kay

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CONVERSION FACTORS, VERTICAL DATUM, AND ABBREVIATED WATER-QUALITY UNITS

Multiply	By	To obtain
	Length	
inch (in.)	2.54	centimeter
foot (ft)	0.3048	meter
mile (mi)	1.609	kilometer
	Area	
square foot (ft^2)	0.09290	square meter
	Volume	
cubic foot (ft^3)	0.02832	cubic meter
	Flow rate	
cubic foot per day (ft^3/d)	0.02832	cubic meter per day
gallon per minute (gal/min)	3.7685	liter per minute
	Hydraulic conductivity*	
foot per day (ft/d)	0.3048	meter per day
	Hydraulic gradient	
foot per foot (ft/ft)	0.3048	meter per meter
	Pressure	
pound per square inch (lb/in^2)	6.895	kilopascal

Temperature in degrees Celsius (°C) may be converted to degrees Fahrenheit (°F) as follows:

$$°F = (1.8 \times °C) + 32$$

Vertical datum: In this report, "sea level" refers to the National Geodetic Vertical Datum of 1929 (NGVD of 1929)—a geodetic datum derived from a general adjustment of the first-order level nets of both the United States and Canada, formerly called Sea Level Datum of 1929.

Altitude, as used in this report, refers to distance above or below sea level.

***Hydraulic conductivity:** Foot per day is the mathematicly reduced term of cubic foot per day times foot per square foot of aquifer cross-sectional area.

Abbreviated water-quality units used in this report: Chemical concentration is given in metric units. Chemical concentration is given in micrograms per liter (µg/L). Micrograms per liter is a unit expressing the concentration of chemical constituents in solution as weight (micrograms) of solute per unit volume (liter) of water. One thousand micrograms per liter is equivalent to 1 milligram per liter (mg/L).

Abbreviations:

µS/cm	microSiemens per centimeter	µg/L	micrograms per liter
mg/L	milligrams per liter	mv	millivolts

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Abstract

An investigation of the geology, hydrology, and water quality in the vicinity of a Brownfield redevelopment site in East Moline, Illinois, was designed to determine if metals and organic compounds detected in the fill deposits in this area posed a threat to the water resources. The hydrologic features of concern at the site are surface water at a pond and surrounding wetland, the Mississippi River, and an unnamed stream and ground water in the shallow aquifer. The shallow aquifer is composed of saturated fill, sand and gravel, and weathered bedrock.

The overall direction of surface- and ground-water flow in the study area is toward the Mississippi River. In the eastern part of the pond and wetland, ground water discharges to surface water. In the western part of the pond and wetland, surface water recharges to ground water. Every day during the period for which water-level data were available, between 4.7×10^{-4} and 1.4×10^{-1} cubic feet of water flowed across a 1 square foot area of aquifer.

Variations in values for oxidation-reduction potential and specific conductance may be affected by heterogeneity in the chemical composition of the fill and unconsolidated deposits and the bedrock units. Chemical and biological processes are altering the chemistry of the water in the pond relative to its ground-water source. Concentrations of iron and manganese in water samples appear to be affected by the local geochemical environment in the aquifer. The data do not indicate that contaminants in the fill material are having a substantial adverse affect on surface- or ground-water quality in the study area.

INTRODUCTION

Constituents present in waste fill materials in the vicinity of a Brownfield redevelopment site in East Moline, Illinois, have the potential to migrate into ground water and from ground water into surface water. Migration of contaminants in ground water to surface water has the potential to degrade surface-water quality to the point at which the viability of the pond and wetland habitat is compromised or a threat is posed to human health. To determine if ground-water contamination is present and to assess the potential for surface-water quality degradation resulting from inflow of contaminated ground water, the U.S. Geological Survey (USGS), in cooperation with the U.S. Environmental Protection Agency (USEPA), conducted an investigation of the geology, hydrology, and water quality in the vicinity of a pond and wetland that is being restored as part of the redevelopment of the Brownfield site. The Brownfield site (hereafter referred to as the site) is in the northern part of the city of East Moline, in Rock Island County (fig. 1). The site, as defined in this report, is bounded by 7th Street to the west, well MW5 to the north, well MW2 to the east, and well MW1 to the south (fig. 2). The area of concern for this investigation (hereafter referred to as the study area) extends from 12th Avenue to the south, 7th Street to the west, the Mississippi River to the north, and the John Deere manufacturing facility to the east (fig. 2). The site was a former wetland that has been partly filled. Sand, silt, and clay; foundry sand; and construction debris are the primary fill materials in the study area. Smaller amounts of industrial wastes also are present in the fill material.

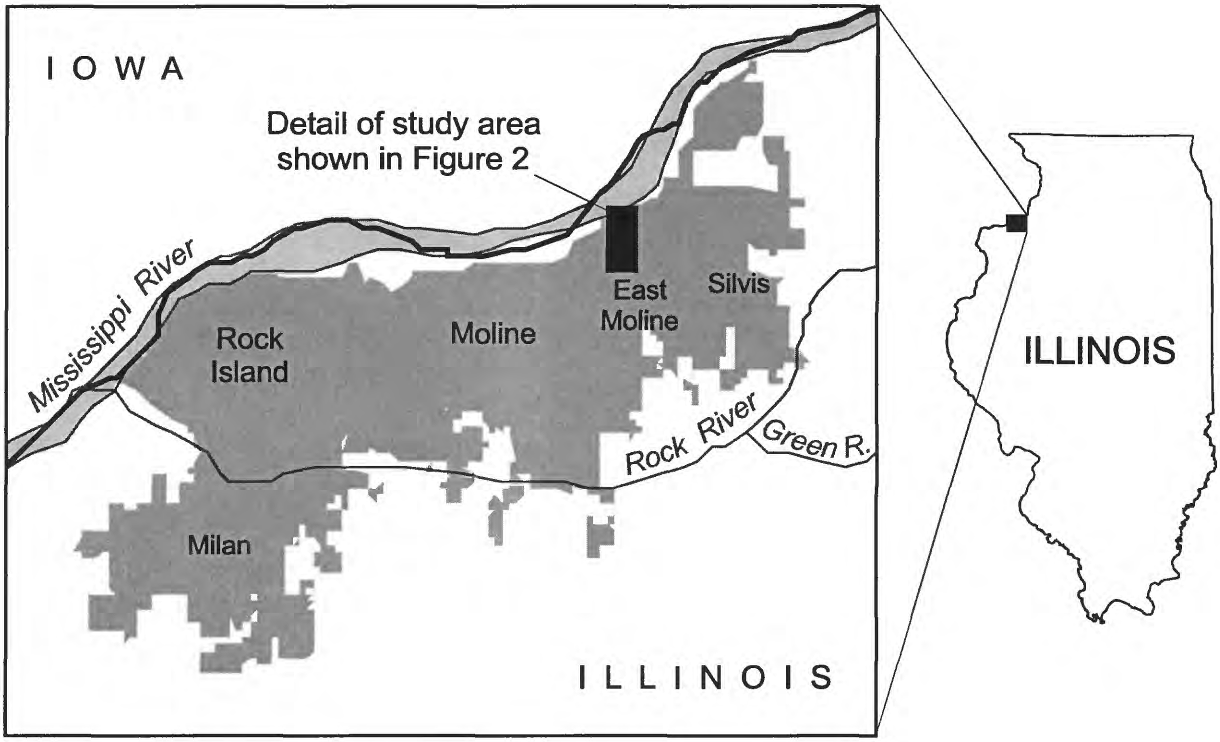

Figure 1. Location of East Moline and the study area within the State of Illinois.

These wastes have been found to contain elevated concentrations of metals, and volatile and semivolatile organic compounds (David Pluymers, BT2. Inc., written commun., 2000).

This investigation was designed to identify contaminants in surface water and ground water in the study area and determine the effect of hydraulic interaction between surface water and ground water on surface-water quality. The information obtained from this investigation can be used to determine the processes that affect the hydrology and water quality of the surface-water bodies in the study area and the most effective means of remediating any potential water-quality degradation.

Purpose and Scope

This report describes the results of a study of the geology, hydrology, and water quality in the vicinity of a pond and wetland in the study area. The results of two series of water-level measurements collected from nine wells and four surface-water gages are presented. In addition, this report presents the results of slug testing in the nine wells and water-quality sampling in five wells and the pond in the study area. The report identifies the directions of ground-water flow, characterizes the interaction between surface water and ground water, describes surface- and ground-water quality, and identifies the potential for surface-water quality degradation because of recharge from ground water.

Study Approach and Data Collection and Analysis

The investigation comprised three principal efforts: (1) collection of water-level data, (2) aquifer testing, and (3) water-quality sampling. Static water-level measurements were collected from five monitoring wells installed for this investigation (MW1–MW5), two monitoring wells installed for another investigation (P3, SMW3), two temporary well points (TWP1, TWP2) and three surface-water staff gages installed for this investigation (SW1, SW2, MISSMP1), and a surface-water staff gage (SW3) installed for another investigation (table 1, fig. 2). Static water-level measurements were collected on April 6, April 10, and May 22, 2000, and were used to identify the direction of surface-water and ground-water flow in the study area. Slug tests were done in each well monitored for this investigation to quantify the hydraulic properties of the aquifer and to help quantify the volume of flow

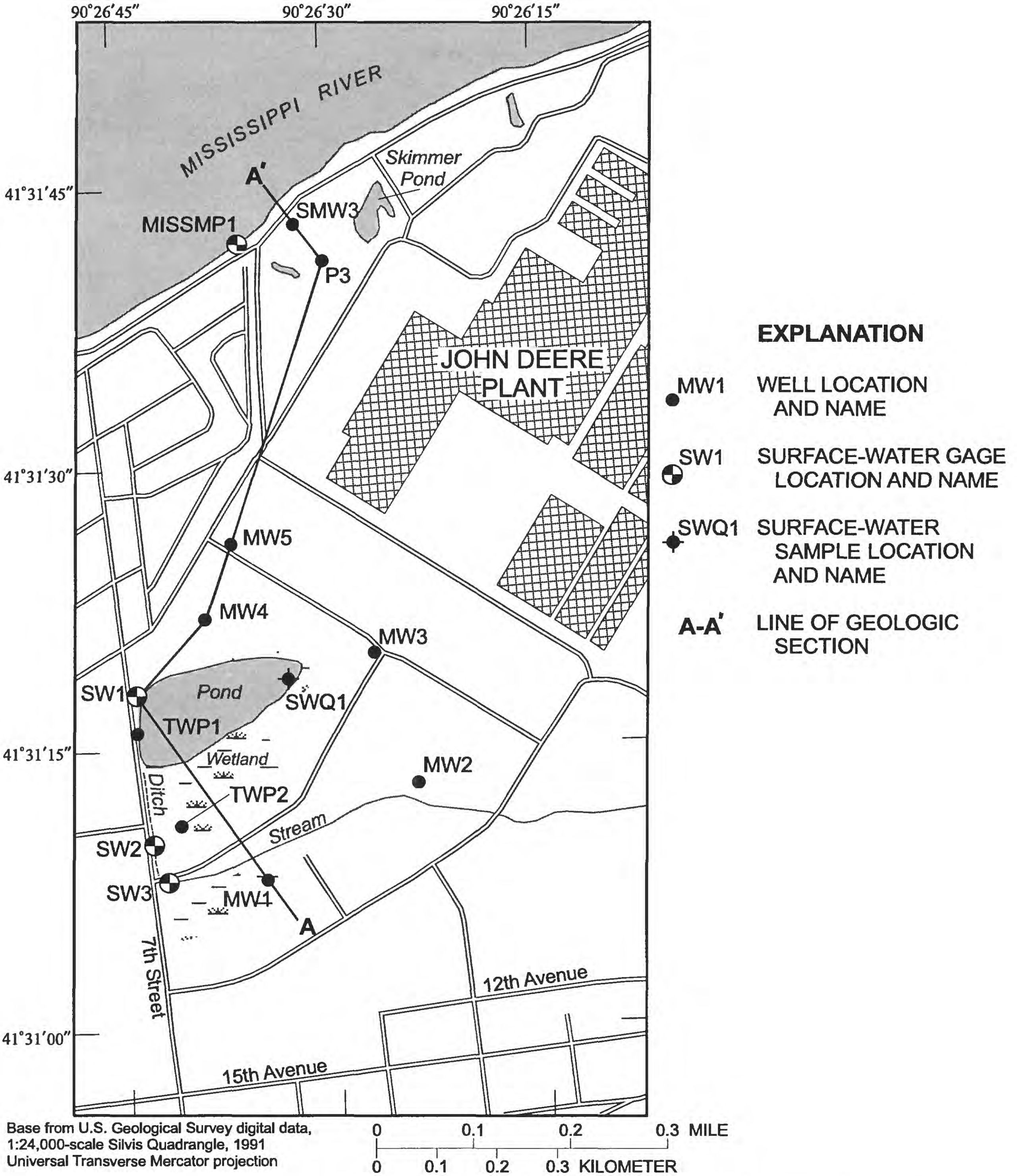

Figure 2. Location of the study area and line of geologic section A-A′ in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

Table 1. Well and surface-water gage information in the vicinity of a Brownfield redevelopment site, East Moline, Illinois

[np, deposits not present, >, greater than]

Well name	Latitude/longitude	Altitude, top of inner casing (feet above sea level)	Land-surface altitude (feet above sea level)	Depth of open interval (feet below land surface)	Lithology of bedrock at well	Thickness of fill deposits at well (feet)	Thickness of sand and gravel deposits at well (feet)	Thickness of silt and clay deposits at well (feet)	Bedrock penetrated (feet)
MW1	41°31′08″/90°26′35″	572.64	571	4.5-18.5	Limestone	4.5	8	np	6
MW2	41°31′13″/90°26′24″	572.17	570	5.0-16.5	Limestone	np	np	13.5	3
MW3	41°31′20″/90°26′27″	571.93	570	5.5-17.0	Shale	8	np	np	9
MW4	41°31′22″/90°26′39″	575.08	573	5.2-17.0	Limestone	7.5	2.5	2	5
MW5	41°31′26″/90°26′37″	574.94	573	5.0-17.0	Shale	np	12	np	5
P3	41°31′41″/90°26′30″	582.55	578	4.5-14	Bedrock not penetrated	10	np	4	0
SMW3	41°31′43″/90°26′32″	581.03	578	4.5-14.5	Limestone	9.5	np	np	5
TWP1	41°31′16″/90°26′44″	570.55	567	0.5-1.5	Bedrock not penetrated	np	np	>1.5	0
TWP2	41°31′11″/90°26′41″	569.87	567	0.5-1.5	Bedrock not penetrated	np	np	>1.5	0

Surface-water gage name	Latitude/longitude	Water body monitored	Altitude of reference point (feet above sea level)
SW1	41°31′18″/90°26′44″	Pond	567.96
SW2	41°31′10″/90°26′43″	Ditch	567.61
SW3	41°31′08″/90°26′42″	Stream	569.73
MISSMP1	41°31′42″/90°26′36″	Mississippi River	563.24

through the aquifer. Water-quality sampling was done in wells MW1–MW5 and at the north end of the pond to define surface- and ground-water quality, the spatial distribution of contaminants, and the potential for surface-water quality degradation because of recharge of contaminated ground water.

The monitoring wells were drilled using a hollow-stem auger. Wells TWP1 and TWP2 were drilled using a hand auger. All well screens were surrounded with a sand pack extending 0.5 to 1.0 ft above the top of the well screen. The sand pack for the monitoring wells was overlain by hydrated bentonite to about 1 ft below the land surface (to land surface for TWP1 and TWP2). Concrete was placed from the top of the bentonite to land surface in all monitoring wells.

Ground-water levels were measured with an electric water-level indicator, with increments of 0.01 ft. Ground-water levels were measured relative to the top of the 2-in. diameter polyvinyl chloride (PVC) riser casing in each well. Ground-water level altitudes were calculated by subtracting the depth to water from the surveyed altitude of the top of the PVC casing.

Surface-water levels were measured at gages SW1, SW2, and SW3 by reading the value of the water surface on the staff gages, which were incremented to 0.01 ft. The stage of the Mississippi River at gage MISSMP1 was determined by measuring the distance below a fixed point of known elevation at the river using a tape measure incremented to 0.01 ft. The river surface was choppy during the periods of measurement; the recorded stage represents an estimate of the actual stage, accurate to within about 0.50 ft.

Horizontal hydraulic conductivities were calculated from data collected during slug testing in wells MW1-MW5, SMW3, P3, TWP1 and TWP2 (fig. 2). For all wells except TWP1 and TWP2, slug tests involved insertion of a solid cylinder below the water level (head) and measurement of water-level decline (drawdown) with time using a calibrated 0–10 lb/in^2 pressure transducer connected to a datalogger (falling-head test), then removal of the cylinder and measurement of water-level rise with time (rising-head test). Because of the short height of the water column, slug tests for wells TWP1 and TWP2 involved pouring a volume of tap water into the wells and monitoring the decline in water level with the pressure transducer and datalogger. Multiple slug tests were done in each well, except well P3.

Slug-test data were analyzed on the basis of the technique developed by Bouwer and Rice (1976). This technique was developed for use in unconfined aquifers with wells that fully or partially penetrate the aquifer. The following conditions are assumed in the application of the Bouwer and Rice technique.

1. Drawdown of the water table in the vicinity of the well is negligible.
2. Flow above the water table can be ignored.
3. Head losses as the water enters the well are negligible.
4. The hydraulic unit tested is homogeneous and isotropic.

These conditions appear to have been met or approximated in most of the wells tested.

When analyzing the slug-test data on the basis of the Bouwer and Rice technique, the length of the well through which water enters the aquifer was assumed to equal the saturated length of the well screen, and the borehole diameter was assumed to equal the nominal outside diameter of the borehole. For those wells in which the water table intercepted the well screen, the radius of the well casing was calculated in accordance with the recommendations of Bouwer and Rice (1976). For those wells in which the water level was above the top of the screen, the radius of the casing was assumed to equal the nominal value of 1 in.

The aquifer thickness (D) is not well defined at the site and an estimation of the thickness is complicated by the presence of multiple saturated units (fill, silt and clay, sand and gravel, and bedrock) at all wells except TWP1 and TWP2. For all wells except TWP1 and TWP2, the saturated thickness of the aquifer is assumed to be 30 ft. This value represents an approximate maximum thickness from the water table to the base of the weathered part of the bedrock. The aquifer thickness at wells TWP1 and TWP2, which are open only to unconsolidated silt and clay deposits, is estimated to be 10 ft on the basis of the measured thickness of these deposits at nearby soil borings.

Although most slug tests had clearly defined trends in water level with time that were easily analyzed, data from some falling-head tests done in wells where the water table intercepted the well screen did not show a clearly defined trend. The rising-head tests in these wells typically did show clearly defined trends, indicating that the anomalous response can be attributed to drainage of water into the sand pack and the unsaturated materials above the water table. Data from the falling-head tests in the wells exhibiting anomalous responses were not analyzed and are not included in the report.

Water-quality data was collected on April 11–12, 2000, from wells MW1-MW5 using a positive-displacement Fultz pump with Teflon-lined tubing and placed approximately 1 ft above the bottom of the well. The wells were pumped at a rate of less than 1 gal/min to minimize the turbidity of the samples. Field parameters (temperature, pH, dissolved oxygen, oxidation-reduction potential, turbidity, and specific conductance) of the water from each well were measured during purging by use of a Hydrolab in-line flow through cell. A pumping rate of at least 0.5 gal/min could be sustained in all wells except MW3. Samples were collected after monitoring established that the field parameters had stabilized and turbidity values were less than 25 nephelometric turbidity units (NTU's). Samples were collected from well MW3 after it had been purged dry twice and water levels had returned to within 2 ft of hydrostatic. Pumps were decontaminated prior to purging each well.

A surface-water sample was collected from the eastern part of the pond next to fill deposits at location SWQ1 (fig. 2) by submerging the sample bottles just below the water surface so that the preservative stayed in the bottle. Field parameters also were collected from the pond. The sample from the pond was collected on April 11, 2000.

Samples were placed in pre-preserved bottles, immediately stored in iced coolers, and delivered to the lab for analysis within 30 hours of collection. Samples were analyzed for volatile organic compounds using USEPA method 8260B, for metals using USEPA methods SW6010B and SW7470, and for semivolatile organic compounds using USEPA methods SW8270B and SW8310. Pump blank, trip blank, matrix spike-matrix spike duplicate, and duplicate samples were collected for quality assurance and quality control. Review of the quality assurance and quality control data indicate the sampling results are acceptable.

Acknowledgments

The author thanks Terracon, Inc., particularly David Koch, for their assistance during the investigation. BT2, Inc., particularly David Pluymers, also are thanked for their assistance with the investigation.

GEOLOGY

The geologic description of the study area is based on lithologic logs from more than 90 monitoring wells, soil borings, and test pits (David Pluymers, written commun., 2000; David Koch, Terracon, Inc., written commun., 2000). Lithologic logs indicate that the surficial bedrock beneath the study area consists of weathered limestone and shale. The stratigraphy of the bedrock units is uncertain; however, the geologic map of Illinois (Willman and others, 1967) indicates the limestone is of Silurian age. Shale is present at the bedrock surface beneath most of the study area, with limestone at the bedrock surface in scattered locations (fig. 3). Lithologic logs indicate the limestone bedrock is less than 10 ft thick and overlies the shale. Plotting the bedrock lithology in cross section (fig. 4) indicates that the limestone and shale are laterally interspersed beneath the study area, and the altitude of the bedrock surface does not correlate with the bedrock lithology. The altitude of the top of the bedrock beneath the study area is about 569 ft at well SMW3 near the Mississippi River and decreases to less than 555 ft to the south and east (fig. 5).

Quaternary-aged silt and clay, and sand and gravel deposits (excluding fill material) unconformably overlie the bedrock beneath the study area. Sand and gravel deposits can be as much as 12 ft thick but are typically less than 5 ft thick where present in the study area (fig. 6). Sand and gravel deposits are present in much of the center of the study area and may intersect the northern part of the pond below the land surface (fig. 4). Silt and clay deposits have a maximum thickness of about 15 ft in the study area (fig. 7). These deposits are present in most of the study area for which data is available and appear to be the surficial geologic deposit beneath the pond and the wetland (fig. 4).

The Quaternary-aged deposits are overlain by fill materials, which are present in most of the study area where lithologic logs have been collected, except for small areas near well MW5 and in some of the wetland area south of the pond (fig. 8). Fill materials typically are less than 10 ft thick in the study area but are as much as 12 ft thick near the Mississippi River (fig. 4). Fill materials are composed of primarily natural material (sand, gravel, clay), foundry sand, and demolition debris. Lithologic logs also describe miscellaneous solid wastes, including scrap metal and railroad ties in the fill. Most of the pond shore and wetlands are in direct contact with fill materials.

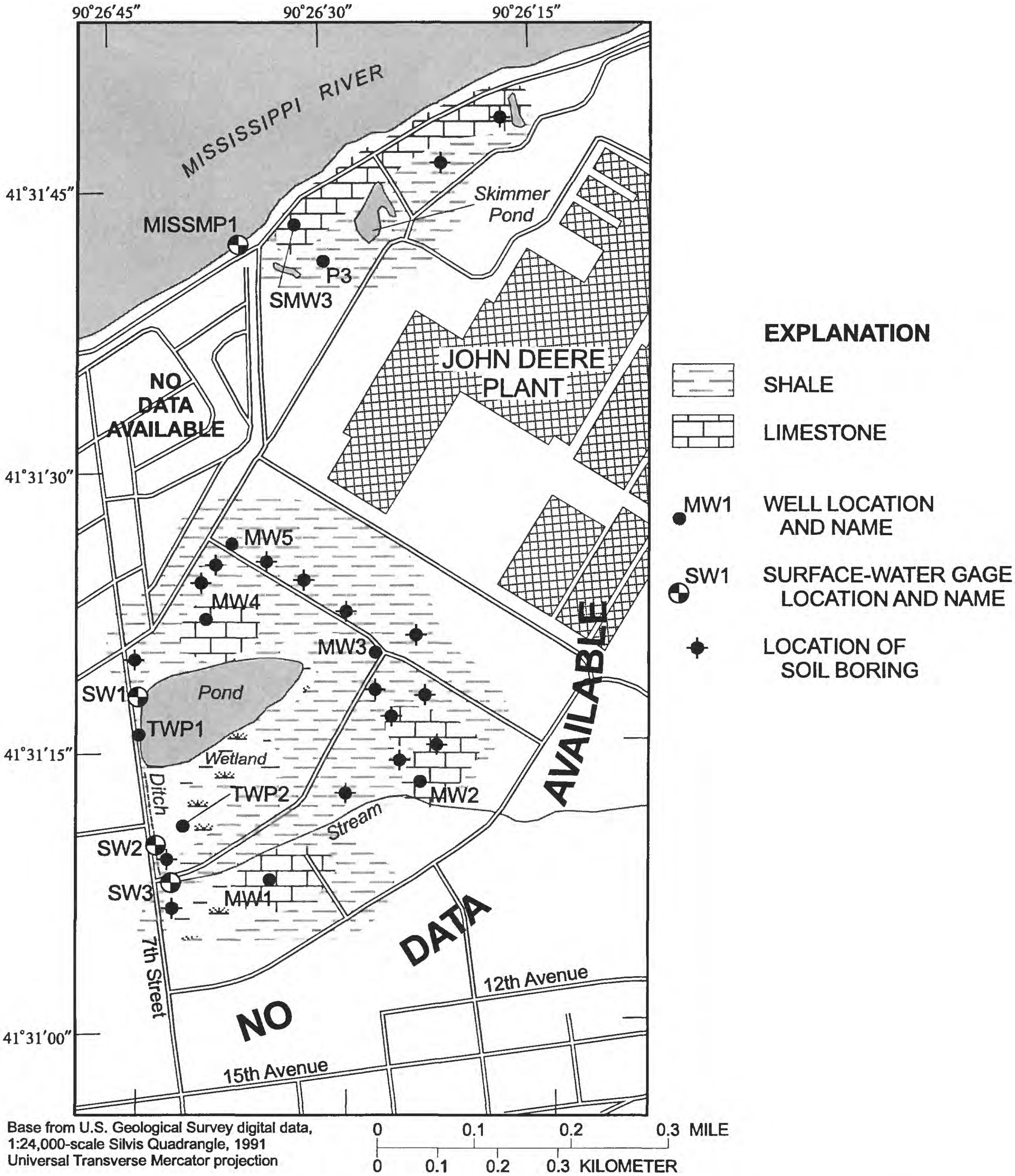

Figure 3. Lithology at the bedrock surface in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

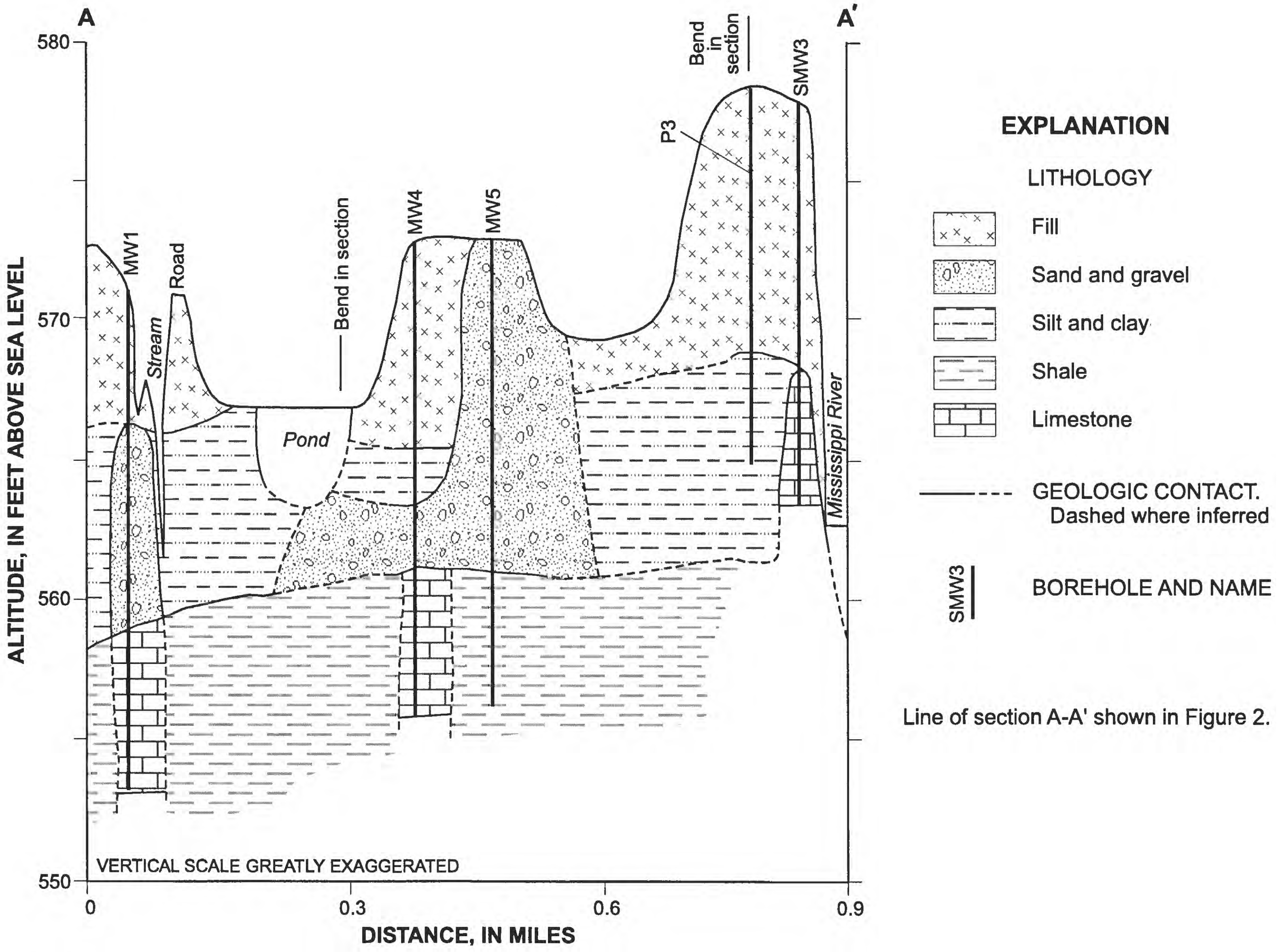

Figure 4. Line of geologic section A-A′ in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

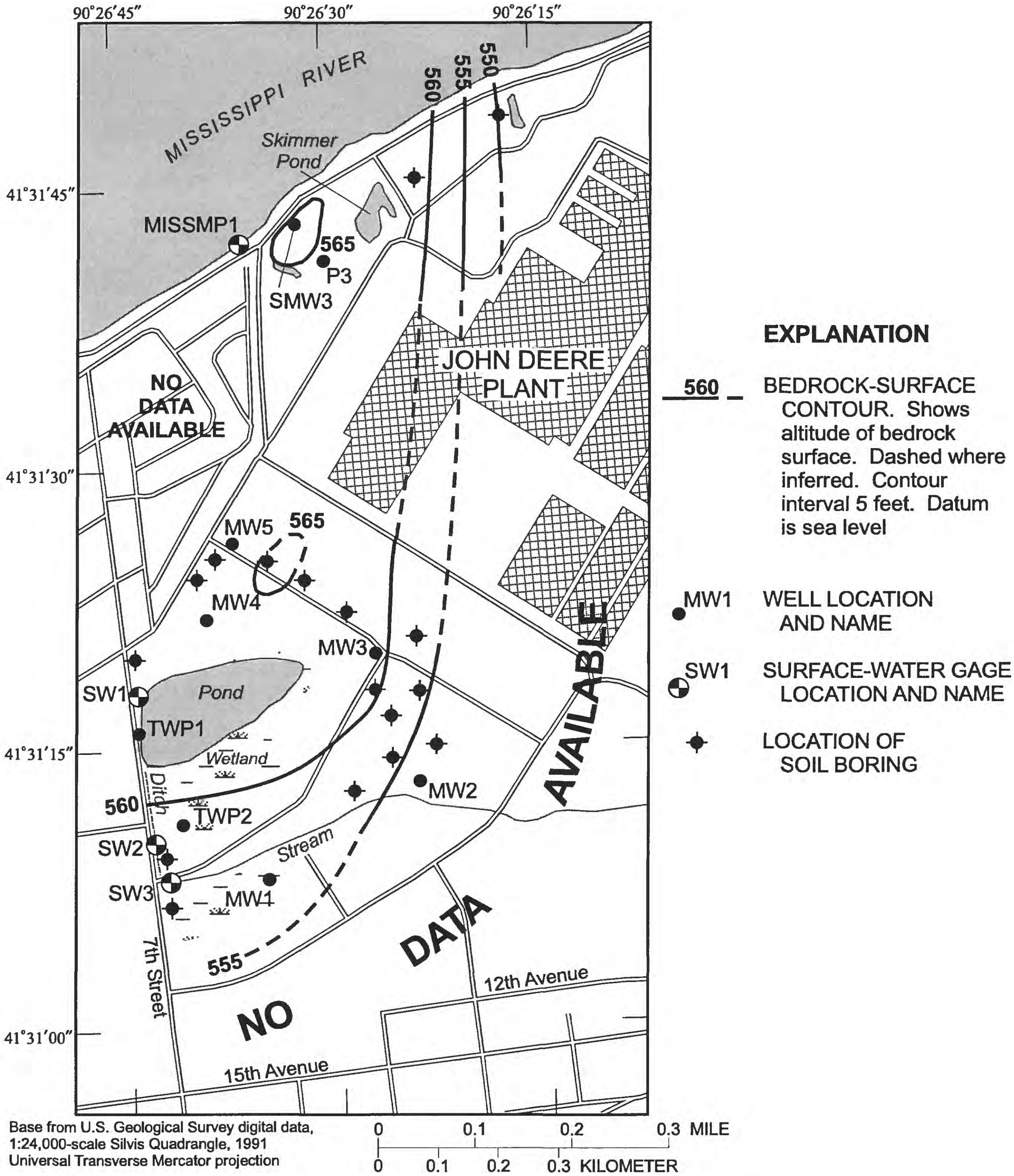

Figure 5. Bedrock-surface topography in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

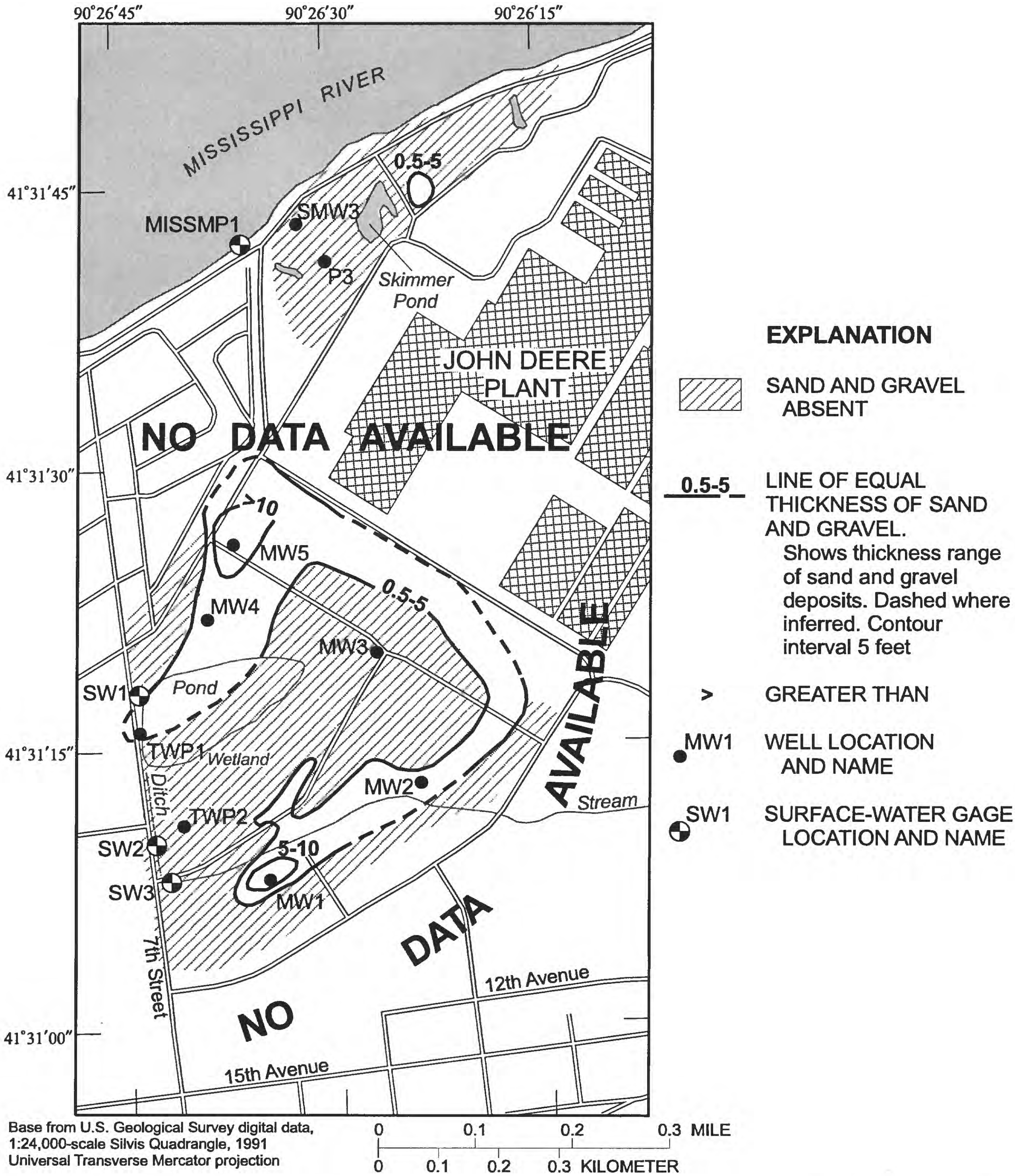

Figure 6. Thickness of sand and gravel deposits in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

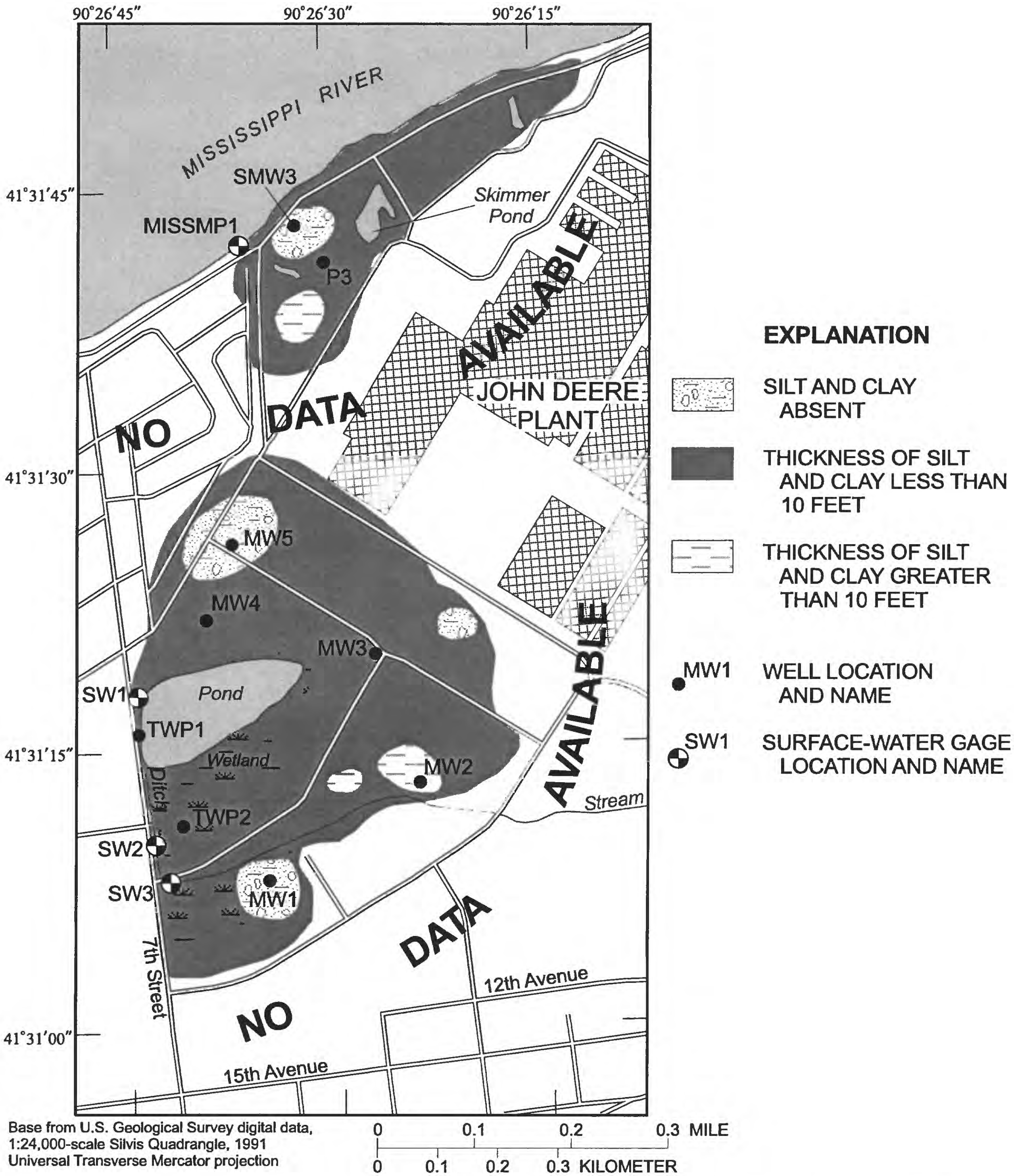

Figure 7. Thickness of silt and clay deposits in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

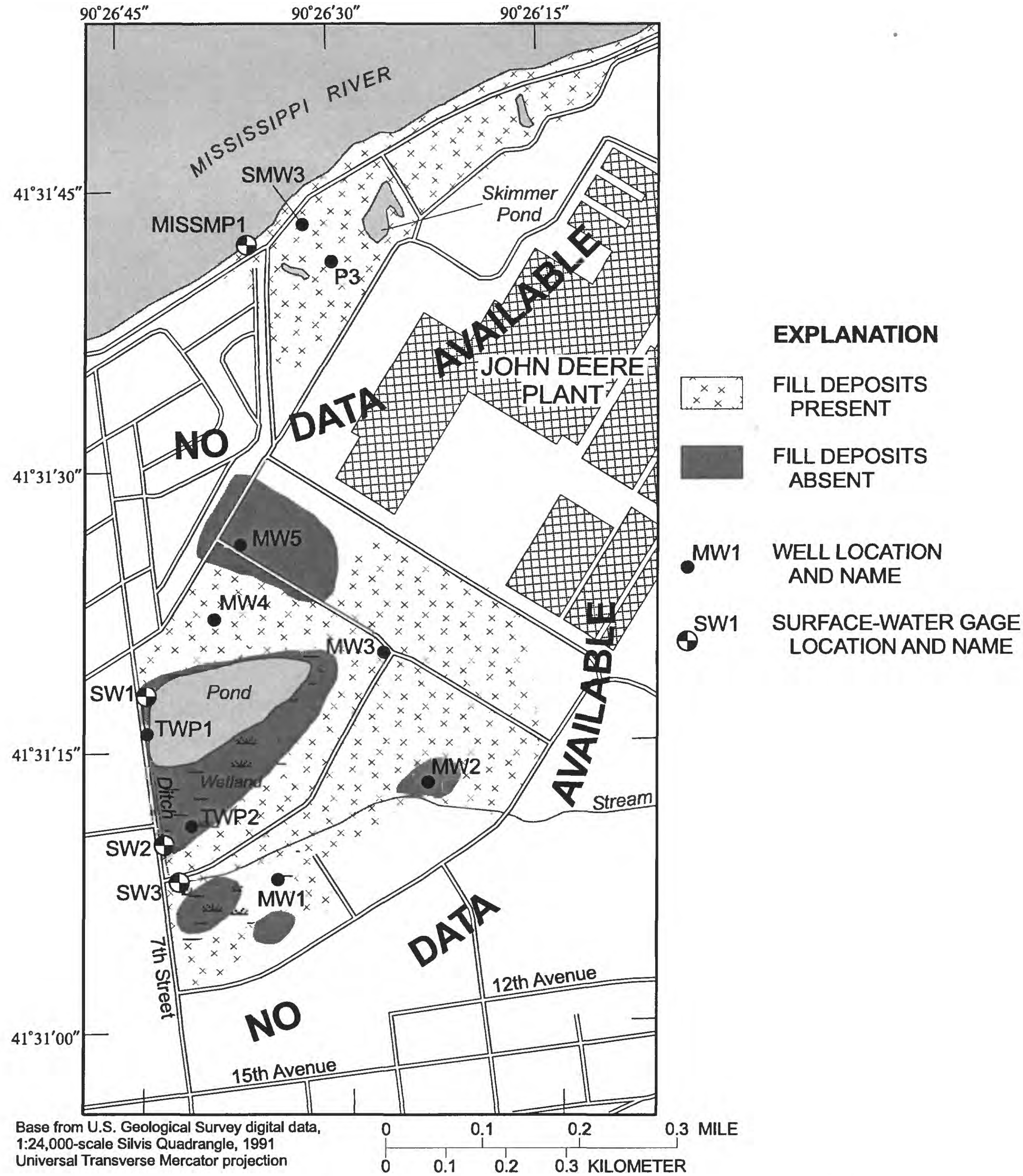

Figure 8. Location of fill deposits in the vicinity of a Brownfield redevelopment site, East Moline, Illinois.

HYDROLOGY

The hydrologic features of concern in the study area are surface water at the pond, the wetland, the Mississippi River, and the unnamed stream on the southern part of the study area (the stream) (fig. 2) and ground water in the shallow aquifer. The areal extent of the pond and surrounding wetland is affected by the amount of water added from precipitation and recharge from ground water and the amount of water removed by evaporation, surface-water flow through the ditch, and surface-water discharge to ground water. Barring an unusually high stage on the Mississippi River, the maximum extent of the wetland in the study area is affected by elevated surficial topographic features resulting from the presence of fill material associated with residential areas to the north, industrial areas to the east, 7th Street to the west, and the road between the stream and the wetland to the south. The shallow aquifer is composed of saturated fill, sand and gravel, silt and clay, and weathered bedrock present throughout the study area. Most of the monitoring wells are open to both the unconsolidated and bedrock deposits.

Analysis of water-level measurements collected on April 6, 10, and May 22, 2000 (table 2), shows similar directions of flow and indicate that ground water flows from areas of high water level in the eastern part of the study area toward the Mississippi River (figs. 9, 10). Water levels on April 6, 2000, are similar to those levels on April 10, 2000, and will not be discussed further in this report. The water-table configuration indicates that ground water discharges to surface water in the eastern part of the pond and wetland area. Surface water recharges ground water in the western part of the pond and wetland area. Ground water discharges to the Mississippi River in the northern part of the study area and to the stream in the southern part of the study area. Water levels were collected during periods when there was no substantial recent snowmelt or rainfall and are representative of conditions present during the year.

Approximately 20 ft west of gage SW3, the stream receives inflow from the pond and wetland from a ditch along 7th Street. The stream flows through a buried pipe from the confluence west beneath 7th Street out of the study area, eventually discharging to the Mississippi River. The ditch is the only pathway for surface-water flow from the pond and wetland out of the study area. A series of debris dams in the ditch, which in combination with small variations in surface topography in the interior part of the wetland area, affect the stage of the pond and the wetland, and,

Table 2. Water levels measured in the vicinity of a Brownfield redevelopment site, East Moline, Illinois, April-May, 2000

[na, not available]

Well name	Date of measurement	Water-level altitude (feet above sea level)	Date of measurement	Water-level altitude (feet above sea level)	Date of measurement	Water-level altitude (feet above sea level)
MW1	April 6, 2000	564.70	April 10, 2000	564.65	May 22, 2000	565.59
MW2	April 6, 2000	566.27	April 10, 2000	566.27	May 22, 2000	566.62
MW3	April 6, 2000	566.71	April 10, 2000	567.51	May 22, 2000	568.91
MW4	April 6, 2000	565.94	April 10, 2000	565.95	May 22, 2000	566.26
MW5	April 6, 2000	567.47	April 10, 2000	567.44	May 22, 2000	568.24
P3	April 6, 2000	569.55	April 10, 2000	569.42	May 22, 2000	570.07
SMW3	April 6, 2000	566.49	April 10, 2000	566.36	May 22, 2000	567.78
TWP1	April 6, 2000	na	April 10, 2000	565.94	May 22, 2000	566.24
TWP2	April 6, 2000	na	April 10, 2000	565.30	May 22, 2000	565.63
Surface-gage name	**Date of measurement**	**Water-level altitude (feet above sea level)**	**Date of measurement**	**Water-level altitude (feet above sea level)**	**Date of measurement**	**Water-level altitude (feet above sea level)**
SW1	April 6, 2000	565.99	April 10, 2000	566.00	May 22, 2000	566.28
SW2	April 6, 2000	565.14	April 10, 2000	565.26	May 22, 2000	565.20
SW3	April 6, 2000	561.95	April 10, 2000	561.96	May 22, 2000	562.52
MISSMP1	April 6, 2000	561.64	April 10, 2000	561.41	May 22, 2000	562.84

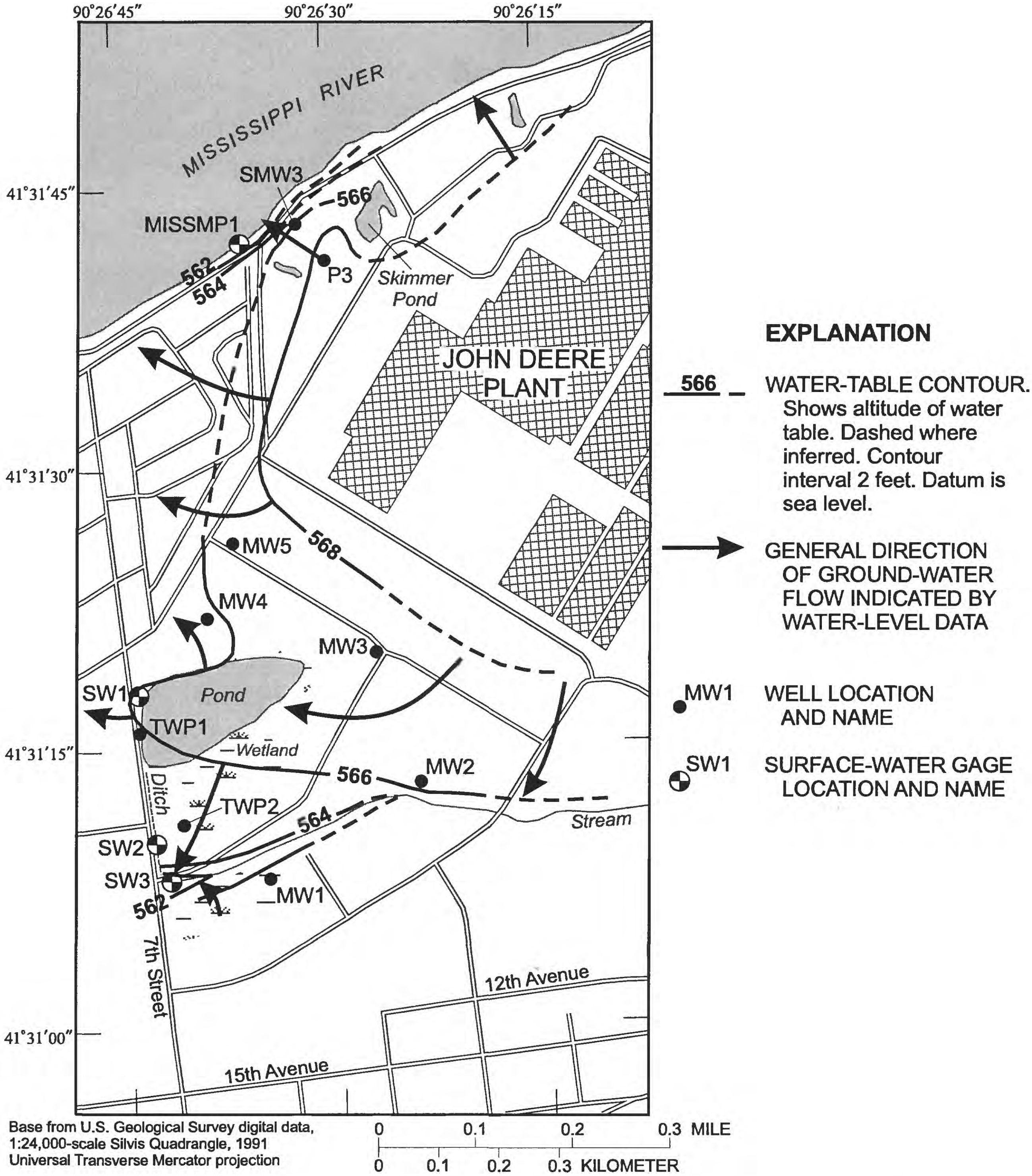

Figure 9. Water-table altitude in the vicinity of a Brownfield redevelopment site, East Moline, Illinois, April 10, 2000.

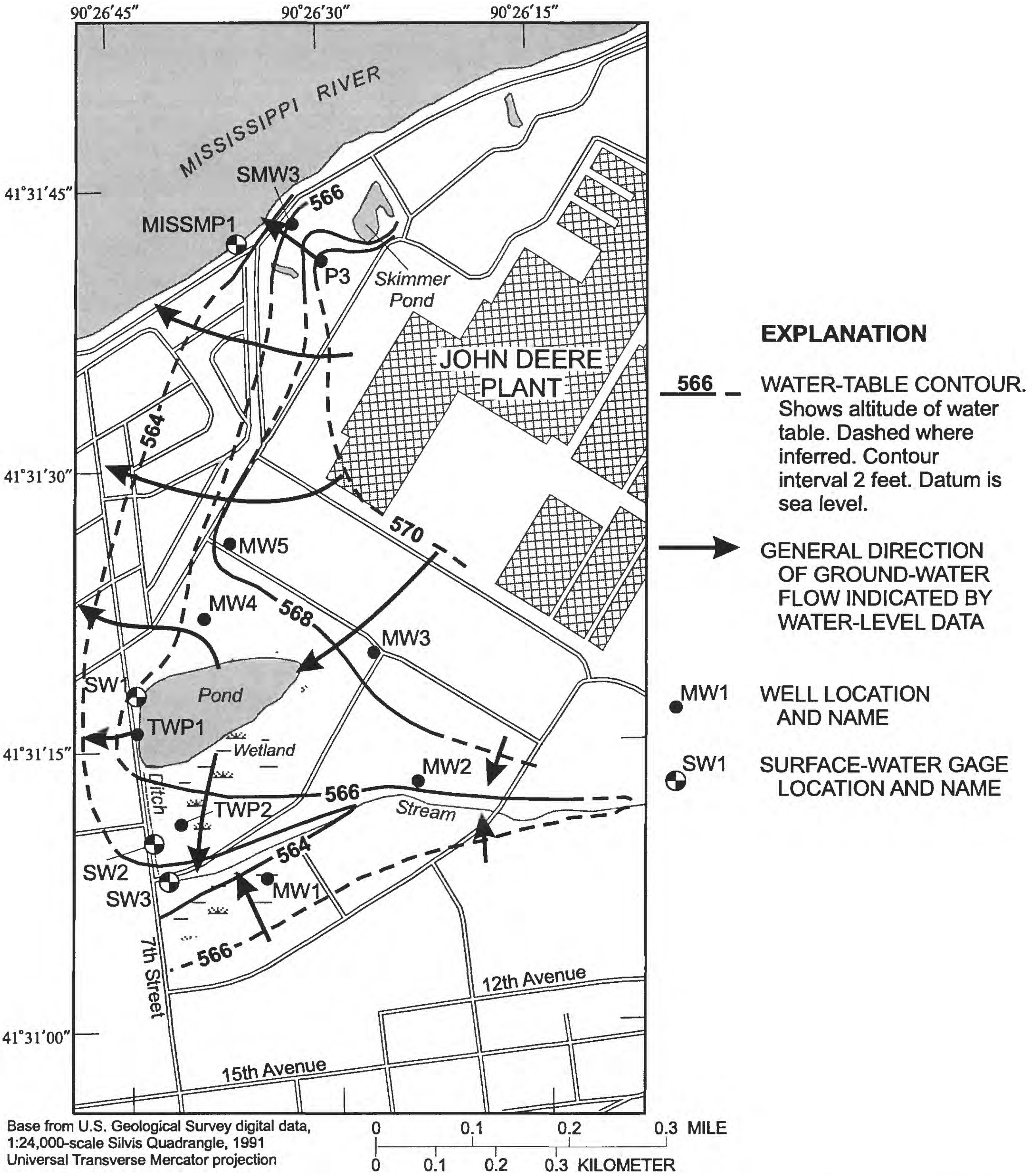

Figure 10. Water-table altitude in the vicinity of a Brownfield redevelopment site, East Moline, Illinois, May 22, 2000.

thereby, the areal extent of these water bodies. The largest fall in the elevation of the ditch is between gages SW2 and SW3. Water-level data also indicate a component of ground-water flow toward the ditch.

Calculated values for the mean horizontal hydraulic conductivity of the shallow aquifer at the wells ranged from 0.50 to 91.13 ft/d (table 3). The geometric mean hydraulic conductivity value for all slug tests done in the shallow aquifer within the study area is calculated to be 5.93 ft/d. Horizontal-hydraulic-conductivity values indicated no clear correlation with well location, sand thickness, or fill thickness at the well. Wells open to limestone bedrock (MW1, MW2, MW4, SMW3) had higher horizontal-hydraulic-conductivity values (range of geometric mean values is 3.2-90 ft/d; mean value 26 ft/d) than wells open to shale bedrock (MW3, MW5) (range is 0.52–1.4 ft/d; mean value 0.85 ft/d). Wells open only to the unconsolidated deposits (TWP1, TWP2, P3) tended to have intermediate values of horizontal hydraulic conductivity (range is 0.50–7.9 ft/d; mean value 2.9 ft/d). The size of the data set is too small to determine if these variations are statistically significant, or if the apparent trend is a function of the small (values from nine wells) data set.

Horizontal hydraulic gradients were calculated by dividing the change in the altitude of the water table (including surface-water levels) along two points parallel to the direction of flow by the horizontal distance between the two points. The horizontal hydraulic gradient was calculated along approximate lines of flow between well P3 and the Mississippi River, well MW3 and the pond, the pond and well MW4, well TWP2 and the stream, and well MW1 and the stream (figs. 9, 10). These flow lines represent the probable range of hydraulic gradients in the study area. The calculated horizontal hydraulic gradient along approximate lines of flow at the water table ranged from 2.0×10^{-4} to 2.1×10^{-2} ft/ft on April 10, 2000, and from 8.0×10^{-5} to 2.4×10^{-2} ft/ft on May 22, 2000 (figs. 9, 10, table 4). Gradients are highest at the flow lines between well MW1 and the stream and are similar to gradients between well P3 and the Mississippi River and well TWP2 and the stream. The lowest gradients were measured between the pond and well MW4.

Discharge (q) across a unit area of aquifer in a unit period of time is equal to

$$q = K\,A\,I, \tag{1}$$

where

K is the horizontal hydraulic conductivity, in feet per day;

I is the horizontal hydraulic gradient, in foot per foot; and

A is the cross-sectional area of the aquifer through which flow is moving, in square feet.

If K is equal to the geometric mean value for the aquifer (5.9 ft/d) and the values for I are those calculated along the line of section, between 4.7×10^{-4} and 1.4×10^{-1} ft^3 of water flowed across a 1 ft^2 area of aquifer every day during the period for which water-level data are available (table 4). Detailed assessment of the depth of the surface-water bodies in the study area and the length of shoreline receiving discharge

Table 3. Horizontal-hydraulic-conductivity values from slug tests done in wells in the vicinity of a Brownfield redevelopment site, East Moline, Illinois

[nt, test not done; nm, could not be analyzed, good curve match not available; --, not applicable]

Well name	Horizontal hydraulic conductivity (feet per day)				
	Test 1	Test 2	Test 3	Test 4	Mean value of tests in well
MW1	54	55	42	52	50
MW2	3.2	3.0	3.4	3.3	3.2
MW3	.16	1.7	nt	nt	.52
MW4	100	100	73	nm	90
MW5	1.6	1.2	1.5	1.3	1.4
P3	.50	nt	nt	nt	.50
SMW3	34	nm	34	nm	34
TWP1	7.9	11	5.7	nt	7.9
TWP2	6.1	6.7	nm	nt	6.4
Mean value of all tests	--	--	--	--	5.9

Table 4. Horizontal hydraulic gradients and discharge rates along selected lines of flow in the vicinity of a Brownfield redevelopment site, East Moline, Illinois, April–May 2000

Line of flow (see figures 9 and 10)	Water level at point 1 (feet above sea level)	Water level at point 2 (feet above sea level)	Length of flow line (feet)	Horizontal hydraulic gradient (foot per foot)	Horizontal hydraulic conductivity (feet per day)	Discharge across 1 square foot of aquifer (cubic foot per day)
			April 10, 2000			
P3-Mississippi River	569.42	561.41	400	0.020	5.93	.12
MW3-Pond	567.51	566.00	490	.0031	5.93	.018
Pond-MW4	566.00	565.95	250	.00020	5.93	.0012
TWP2-Stream	565.30	561.96	310	.011	5.93	.065
MW1-Stream	564.65	561.96	130	.021	5.93	.13
			May 22, 2000			
P3-Mississippi River	570.07	562.84	400	.018	5.93	.11
MW3-Pond	568.91	566.28	490	.0054	5.93	.032
Pond-MW4	566.28	566.26	250	.000080	5.93	.00047
TWP2-Steam	565.63	562.52	310	.010	5.93	.059
MW1-Stream	565.59	562.51	130	.024	5.93	.14

from ground water was beyond the scope of this investigation. The discharge value for the MW3-pond flow line, however, indicates that if the pond has a depth of about 3 ft and receives discharge from ground water over a length of about 1,000 ft, between 50 and 100 ft^3 of ground water would have discharged to the pond every day during the period of measurement (April 6, 10, and May 22, 2000). The well locations are not well suited for calculating the volume of water discharging from the pond into ground water. The lack of a large change in the water level of the pond during the period of measurement, however, indicates the volume of water discharging from the pond to ground water is similar to the volume of water flowing from ground water into the pond. Assuming a depth of about 20 ft for the Mississippi River, data from the P3-Mississippi River flow line indicate that between about 7,700 and 8,500 ft^3 of ground water discharged to the river every day during the period of measurement along the 3,600 ft of shoreline present in the study area.

WATER QUALITY

The measured temperature of the ground water during sampling ranged from 8.19 to 9.50°C. The temperature of the pond was within this range. Ground-water temperature in the southern part of the site was greater than 9.0°C, whereas ground-water temperature in the northern part of the site was less than 9.0°C (fig. 2) (table 5).

Specific conductance is a measure of the capability of a solution to conduct electricity and is often correlated with the total concentration of dissolved constituents. Specific-conductance values of the ground water ranged from 480 to 5,429 µS/cm and exceeded the specific conductance of the pond

Table 5. Water-quality data in the vicinity of a Brownfield redevelopment site, East Moline, Illinois, April 11–12, 2000

[<, less than; na, not applicable]

Sampling location	Temperature (degrees Celsius)	Specific conductance (microSiemens per centimeter)	pH (standard units)	Oxidation-reduction potential (millivolts)	Iron (milligrams per liter)	Barium (milligram per liter)	Manganese (milligrams per liter)	Nickel (milligrams per liter)	Zinc (milligram per liter)	Arsenic (milligram per liter)
MW1	9.50	5,429	6.64	35	6.96	0.139	2.91	<0.050	<0.040	0.012
MW2	9.39	1,651	6.87	49	3.78	.323	2.52	<.050	<.020	<.005
MW3	8.80	834	7.35	135	2.8	.147	2.08	2.08	<.020	<.005
MW4	8.19	1,413	6.85	131	5.97	.051	.541	<.050	.412	<.005
MW5	8.90	480	6.88	209	1.67	.049	.10	<.050	<.020	<.005
MW5 (duplicate)	na	na	na	na	2.72	.056	.123	<.050	<.020	<.005
SWQ1	9.25	475	7.41	145	.733	.037	.131	<.050	<.020	<.005

(475 µS/cm) (table 5). Specific-conductance values of ground water from wells MW3 and MW5, which are open to the shale bedrock, are less than 900 µS/cm. Specific-conductance values of ground water from wells MW1, MW2, and MW4, which are open to the limestone bedrock, exceed 1,400 µS/cm.

The pH is the negative log of the concentration of hydrogen ions in the water. A pH of about 7 represents neutral water. Low pH values indicate acidic water, and high pH values indicate alkaline water. pH values of ground-water samples were approximately neutral, ranging from 6.64–7.35 (table 5). The highest pH measured from the ground water was 0.06 less than the pH measured at the pond. pH values in ground water showed no clearly defined trends with respect to well location or lithology.

The oxidation-reduction potential (ORP) of water is a measure of electron activity and is an indicator of the relative tendency of a solution to accept or transfer electrons. The lower the ORP value, the more reducing, or electron accepting, the solution. ORP values in the ground water ranged from 35 to 209 mv (table 5). The ORP of the pond water was within this range, but exceeded ORP values in all but one well. ORP values of ground water decreased from 209 mv in the northern part of the site at well MW5 to 35 mv in the southern part of the site at well MW1.

The water from well MW1 had the highest temperature and specific conductance and lowest pH and ORP of any of the sampled wells; however, consistent trends in water quality were not detected in samples collected from the other wells. Trends in variations in ground-water quality with well location and lithology were observed for some field parameters. The lack of consistent identifiable trends with location or lithology, however, indicates the variation may only be a reflection of the small data set. Although the source of the variations in the values of the field parameters is uncertain, heterogeneity in the composition of the bedrock, unconsolidated, and fill materials clearly affects the chemical composition of the ground water in the study area.

The specific conductance of the pond water was lower than that of the ground water, whereas the pH of the pond water was higher than that of the ground water. In addition, the ORP of the water in the pond was higher than the typical value for ground water (table 5). These results indicate that chemical and biological processes are altering the chemistry of the water in the pond relative to its ground-water source.

Organic compounds were not detected in any of the samples collected for this investigation. Iron, barium, and manganese were detected in each sample collected for this investigation (table 5). Nickel was detected in the sample from well MW3. Arsenic and zinc were detected in the samples from wells MW1 and MW4, respectively (table 5). Nickel, in the sample from well MW3, was the only constituent detected above the USEPA Maximum Contaminant Level for drinking water (100 µg/L) (U.S. Environmental Protection Agency, 1996). Based on values from six samples, iron concentrations in water tended to increase with increased specific conductance and decrease with increasing pH and ORP. Manganese concentrations tended to decrease with increasing ORP but showed no clear relation to the other field parameters. These patterns indicate that the solubility of the metal compounds is affected by the local geochemical environment in the aquifer, which is likely to be affected by heterogeneities in the chemical composition of the fill and the unconsolidated and bedrock units. The data do not indicate that contaminants in the fill materials are degrading surface- or ground-water quality to the extent that a substantial threat to human health or the environment is presented.

SUMMARY AND CONCLUSIONS

The U.S. Geological Survey, in cooperation with the U.S. Environmental Protection Agency, characterized the geology, hydrology, and water quality in and around a wetland area at the East Moline Brownfield site in East Moline, Illinois. The goal of this investigation was to determine if metals and organic compounds were present in ground water and surface water and the effect of hydraulic interaction between surface water and ground water on surface-water quality.

The hydrologic features of concern in the study area are surface water at the pond, the wetland, the Mississippi River, and the unnamed stream on the southern part of the study area and ground water in the shallow aquifer. The shallow aquifer is permeable overall and composed of saturated fill and sand and gravel deposits and weathered bedrock.

The overall direction of flow is from high points in the eastern part of the study area toward the Mississippi River. Ground water discharges to surface water in the eastern part of the pond and wetland area. Surface water recharges to ground water in the western part of the pond and wetland area. Ground water also appears to discharge to the stream. Some surface water flows from the wetland and pond to the creek and out of the study area. Between 4.7×10^{-4} and 1.4×10^{-1} cubic feet of water flowed across a 1 square foot area of aquifer every day during the period for which water-level data are available (April 6, 10, and May 22, 2000).

Variations in water quality with location and lithology were observed for some field parameters (temperature, pH, oxidation-reduction potential, and specific conductance). These variations appear to reflect the effects of heterogeneity in the chemical composition of the fill, unconsolidated, and bedrock units, or if these are only apparent variations because of the small data set of nine samples.

Variations in the concentrations of the field parameters between surface water and ground water indicate that chemical and biological processes are altering the chemistry of the water in the pond relative to its ground-water source. Concentrations of iron and manganese in water samples showed some correlation with specific conductance, oxidation-reduction potential, or pH, indicating that the solubility of the metal compounds is affected by the local geochemical environment in the aquifer.

With the exception of nickel in one well, no metals were detected in water samples at concentrations above the U.S. Environmental Protection Agency Maximum Contaminant Level. Organic compounds were not detected in any water sample collected for this investigation. The data do not indicate that contaminants in the fill material are having a substantial adverse effect on surface- or ground-water quality in the study area.

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