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Basal Sand and Gravel Thickness of the Middle Illinois River Valley

Bureau, LaSalle, Marshall, Peoria, Putnam, and Woodford Counties, Illinois

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2015

Introduction

The thickness of the basal sand and gravel is depicted for the middle Illinois River region from east of the big bend of the river near Hennepin to south of Chillicothe. This deposit resides directly above the bedrock surface and is a composite of several episodes of glacial, interglacial, and postglacial deposition. Its youngest components reside at land surface, where they compose terraces, and on the floodplain along the modern Illinois River and its major tributaries. Its older components are buried by diamicton, silt and clay, other thinner sand and gravel units, and paleosols, and occur (1) east of the Illinois River valley beneath uplands and above the Middle Illinois Bedrock Valley, and (2) above three buried bedrock valleys: Princeton Bedrock Valley, Ticona Bedrock Valley, and Wyoming Bedrock Valley (Fig. 1).

The basal sand and gravel constitutes a major drinking water resource for the region. This map was produced to provide insight into its thickness variabilities, and together with an aquifer sensitivity map (Berg et al. 2015), provides water resource managers and economic development agencies with basic information to evaluate water resource potential and ensure water protection.

This map covers more than 500 square miles (1,295 square kilometers), including nine 1:24,000-scale U.S. Geological Survey 7.5-minute quadrangles—Putnam, Florid, McNabb, Lacon, Henry, Varna, Rome, Chillicothe, and Washburn—and the southern half of three quadrangles—Princeton South, DePue, and Spring Valley. Detailed mapping in this region was an outgrowth of geologic investigations for a proposed highway improvement project, funded by the Illinois Department of Transportation, along Illinois Route 29 on the west side of the Illinois River north of Chillicothe (Berg et al. 2002). This map is complemented by surficial geology (McKay and Berg 2010), bedrock topography (Berg et al. 2009), and basal sand and gravel elevation (Berg et al. 2012) maps of the same region along the middle Illinois River valley (MIV).

Methodology

The thickness of the basal sand and gravel was determined by subtracting the bedrock topography (Berg et al. 2009) from the top elevation of the deposit (Berg et al. 2012). For the younger sand and gravel composing terraces and in the floodplain of the modern Illinois River and its tributaries, the top elevation is land surface. For the older deposits, where the basal sand and gravel is buried by younger deposits, the top elevation was determined by evaluating logs of borings and by seismic profiling. A total of 621 logs of water wells, engineering borings, coal test borings, 21 Illinois State Geological Survey (ISGS) exploratory borings, and many field-described outcrops were used to determine the elevation of this basal sand and gravel. These data are on file in the ISGS Geologic Records Unit. In the northeastern portion of the map, seismic reflection profiles, recorded along 5.15 miles of roads (8.3 kilometers), were used to determine the elevation of the basal sand and gravel within the Ticona Bedrock Valley (Murphey 2005). Logs of nearby water wells were used as a basis for estimating seismic velocities of glaciofluvial deposits, which allowed direct comparison of seismic (acoustic) reflection travel time to material composition. This provided a means to interpret the elevation of the basal sand and gravel.

To interpret borehole and seismic information, numerous cross sections were constructed to best visualize the continuity of the basal sand and gravel between logs throughout the MIV region. The elevation of the buried part of the surface was hand contoured to conform to borehole data. Because the basal sand and gravel unit occurs at the land surface and along the lower part of valley walls in the MIV, land-surface elevation contours from the USGS 7.5-minute topographic Digital Line Graph (DLG) data set were merged with the interpreted, hand-drawn surface elevation contours representing the buried parts of the basal sand and gravel surface. The basal sand and gravel surface elevation contours and the bedrock surface elevation surface contours were converted from vector line format to raster format (Esri grid) with the Topo To Raster surface interpolation geoprocessing tool in the Esri ArcGIS Toolbox (versions 9.x–10.x), both with 30-meter (98.4-feet) ground resolution cell size, conforming to the same geographic extent, and containing cell values in feet. The raster cell values of the bedrock raster file were subtracted from the cell values of the basal sand and gravel raster file to derive the thickness values of the basal sand and gravel unit. To improve the visual appearance of the raster representation of the thickness map, cell values were averaged using the Focal Statistics geoprocessing tool. Finally, the raster file was converted to a vector format feature class of isopachous lines with an isopach interval of 10 feet (3.1 meters) using the Contour geoprocessing tool.

Geologic History

The basal sand and gravel is a thick, continuous unit. However, this deposit is the result of multiple glacial advances and retreats across the region and their associated glaciofluvial and modern fluvial events. It reflects a complex erosional and depositional history of the ancient Mississippi River (AMR), the ancestral Illinois River (following AMR diversion about 24,800 years ago), and now the modern Illinois River (following the approximate time of the last meltwater discharge of ancestral Lake Michigan about 13,000 years ago). Following is a brief geological history of the region, as well as a discussion of the variable nature of the basal sand and gravel using five ISGS test borings as examples.

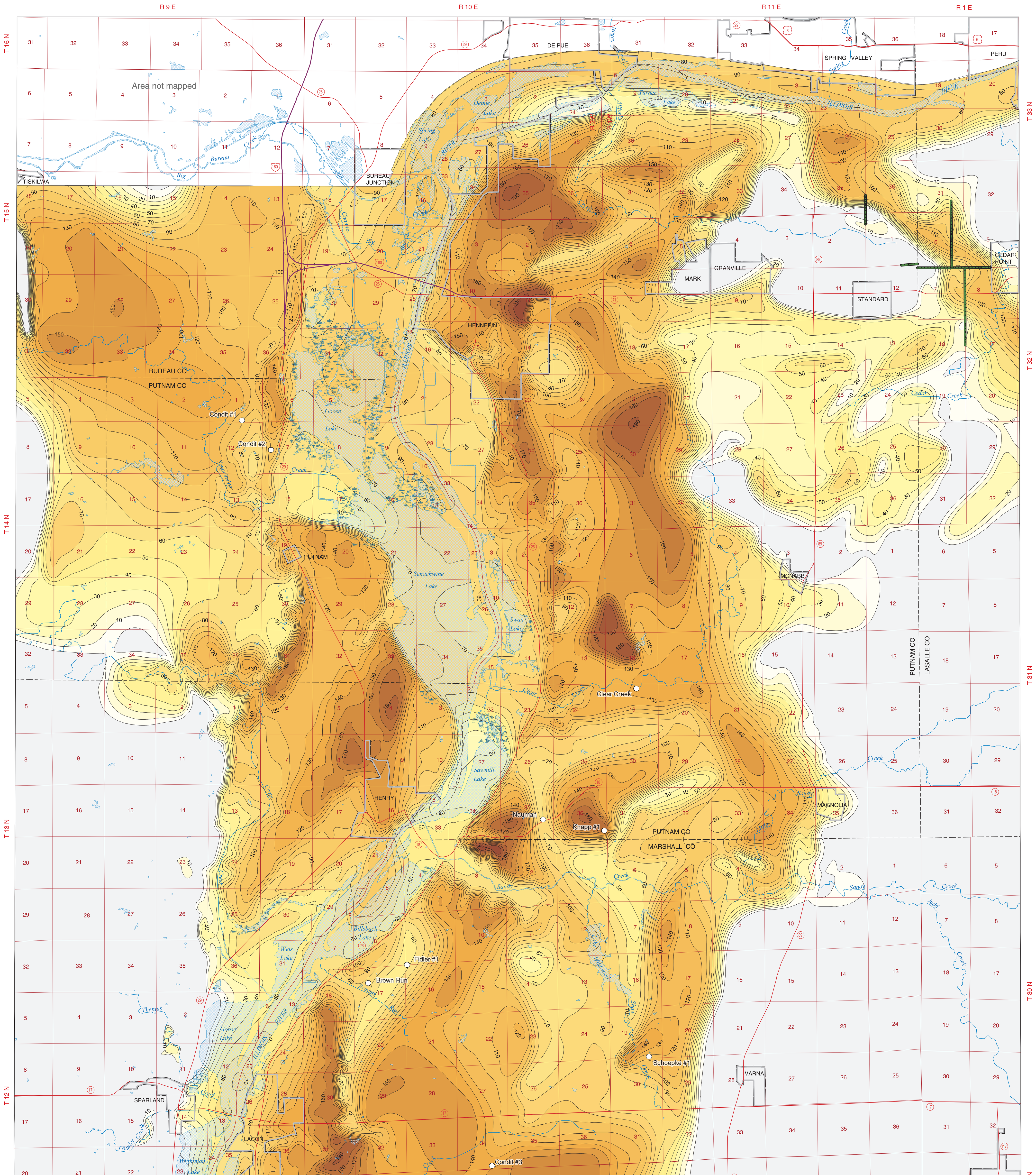
The approximate age of the basal sand and gravel, including the sand composing the younger terraces, was determined for 41 samples by using optically stimulated luminescence (OSL) of fluvial quartz sand. All samples were obtained from cores of ISGS test borings and from outcrops. Twenty nine of these samples at 13 sites are reported in McKay and Berg (2008) and on the basal sand and gravel elevation map (Berg et al. 2012). The remaining 12 ages recently have been obtained from three additional sites—nine new ages from two ISGS test borings and three ages from two outcrops (Table 1).

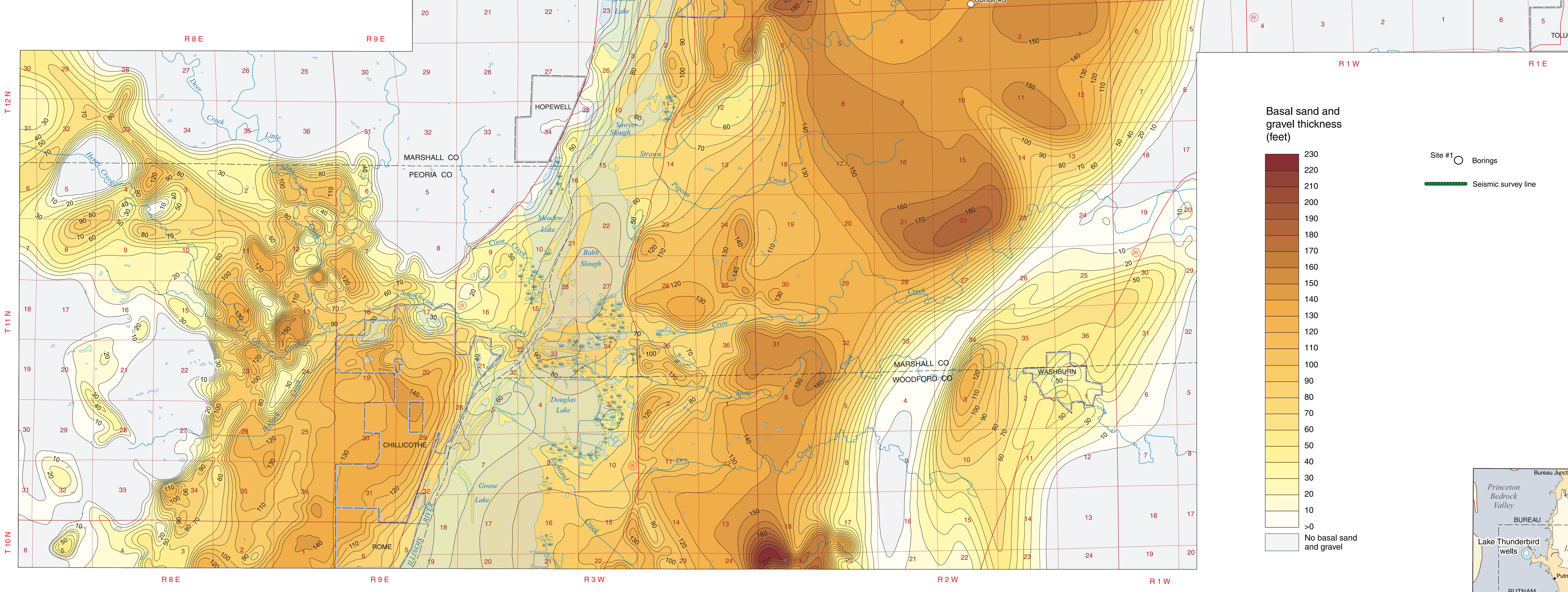
Table 1 Optically stimulated luminescence (OSL) ages for the middle Illinois River valley basal sand and gravel

Site	Laboratory ID/ sample number	Elevation (ft)	OSL age (yr)
Brown Run	ISGS 128/X-1042-1	530	84,290 ± 8,160
Clear Creek	ISGS 126/CC 2011-1	508	90,700 ± 9,330
	ISGS 127/CC 2011-2	515	109,098 ± 10,770
Fidler #1	ISGS 117/Fidler 155	505	31,940 ± 2,460
	ISGS 118/Fidler 191	466	41,180 ± 3,780
	ISGS 119/Fidler 234	426	42,470 ± 4,180
	ISGS 120/Fidler 277	383	39,260 ± 3,310
Condit #3	ISGS 121/Condit #3 178	492	108,080 ± 9,940
	ISGS 122/Condit #3 189	481	149,290 ± 13,910
	ISGS 123/Condit #3 225	445	120,820 ± 12,080
	ISGS 124/Condit #3 245	425	110,720 ± 9,580
	ISGS 125/Condit #3 271	399	115,470 ± 12,270

The ages (McKay et al. 2008; Berg et al. 2012) reveal that the buried portion of the basal sand and gravel was deposited by multiple glacial and interglacial events beginning in the early Illinois Episode at approximately 193,000 years ago. Deposition (the uniformity of which is unknown) persisted through the Illinois Episode, which ended approximately 125,000 years ago. There is clear evidence of sand and gravel deposition during the Sangamon Interglacial Episode. The two new ages (Table 1) from the Clear Creek site [about 3 miles (4.8 kilometers) north of Henry on the east side of the river; T 31 N, R 1 W, Sec. 19] both verified an earlier age reported by Berg et al. (2012) of 96,070 ± 6,060. In addition, an OSL age from beneath till near Brown Run (about halfway between Henry and Lacon on the east side of the river; T 30 N, R 2 W, Sec. 17) yielded a Sangamon age of 84,290 ± 8,160, and sand from the Condit #3 boring (T 30 N, R 2 W, Sec. 34), discussed below, also yielded a Sangamon age (Table 1). The Sangamon Interglacial Episode lasted from about 125,000 to 75,000 years ago.

During the Illinois Episode, and perhaps during the early Wisconsin Episode, the AMR reoccupied various portions of the bedrock valley after each glacial retreat until the river was blocked and diverted by a glacier to its present Mississippi River course around 24,770 ± 250 calibrated years before present. This radiocarbon age was from a sample at the top of lake sediment from a core (Nauman site) on the east side of the river (McKay et al. 2008). About 12 miles (19.3 kilometers) to the northwest of this site, four OSL determinations of the buried basal sand and gravel from an ISGS test drilling site (Condit #1) reveal ages with a mean weighted average of 24,800 ± 1,100 calibrated years before present, which is consistent with the calibrated radiocarbon age of AMR diversion from the Nauman site east of the river.





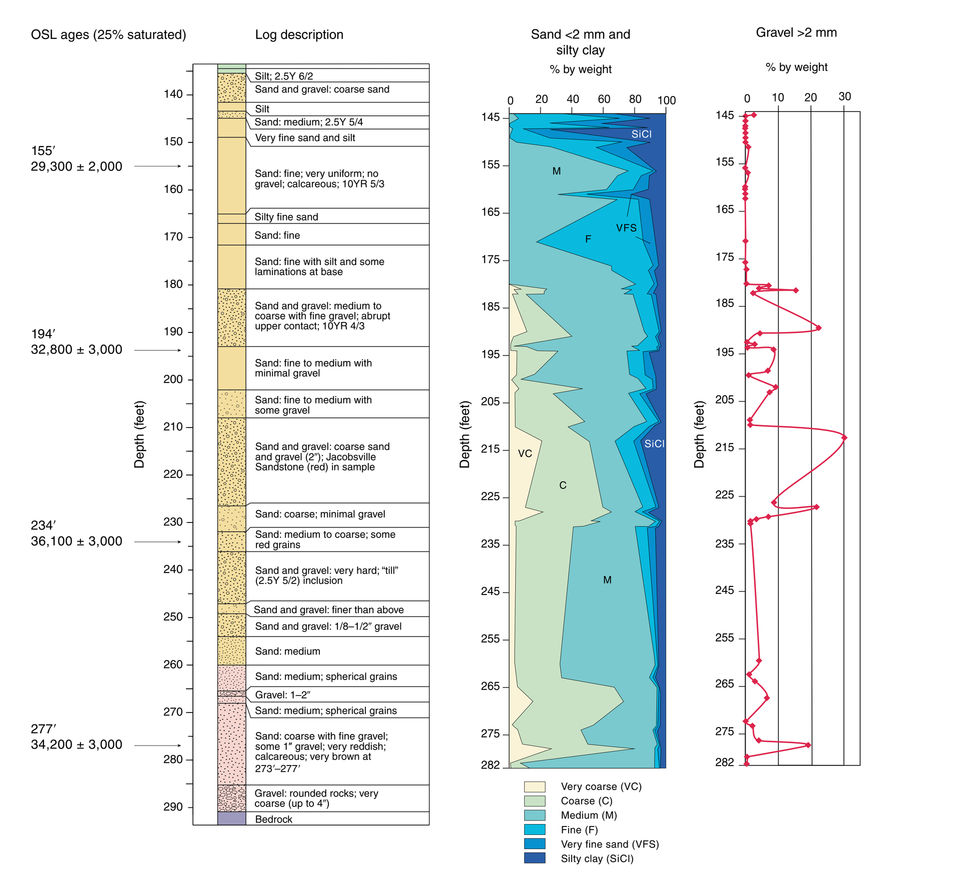


Figure 2 Boring log of the basal sand and gravel interval of the ISGS Fidler #1 boring and optically stimulated luminescence (OSL) ages.

During the final glacial retreat, thick sand and gravel was deposited on modern terraces about 19,000 years ago (Berg et al. 2012). Since then, sand and gravel, as well as silt and clay, have been and are still being deposited on the modern Illinois River floodplain and its tributaries.

Thickness and Character of the Basal Sand and Gravel

Logs from five ISGS exploratory boreholes, drilled in the study region, serve as examples of the generalized glacial stratigraphy and thickness variability of the basal sand and gravel. Ages of the deposits reported below are from Berg et al. (2012) or Table 1 of this map sheet.

Condit #1 Located over the Princeton Bedrock Valley, west of the Illinois River and in the northwestern portion of the map, 90 feet (27.4 meters) of basal sand and gravel is buried beneath 145 feet (44.2 meters) of primarily Wisconsin Episode diamictons. With a mean weighted average age of 24,800 ± 1,100 years old, the lower 40 feet (12.2 meters) is medium to coarse sand and gravel, whereas the upper 50 feet (15.2 meters) is primarily medium to coarse sand.

Fidler #1 About 12 miles (19.2 kilometers) southeast of Condit #1 and east of the river is 155 feet (47.2 meters) of basal sand and gravel that is buried beneath 135 feet (41.1 meters) of Wisconsin Episode deposits that are mainly diamicton. Four new OSL ages at depths of 155, 194, 234, and 277 feet (47.2, 59.1, 17.3, and 84.4 meters; Fig. 2) suggest deposition prior to the Wisconsin Episode glacial maximum. The upper 45 feet (13.7 meters) is fine and very fine sand, the middle 52 feet (15.8 meters) is medium to coarse sand with considerable gravel, and the lower 58 feet (15.7 meters) is primarily medium to coarse sand with minimal gravel. Figure 2 shows the Fidler #1 log description and OSL ages.

Condit #3 About 4 miles (6.4 kilometers) south of Fidler #1 is 130 feet (39.6 meters) of basal sand and gravel underlying 145 feet (44.2 meters) of Illinois Episode and Wisconsin Episode deposits that are mainly diamictons. There are five new OSL ages at depths of 178, 189, 225, 245, and 271 feet (54.3, 57.6, 68.6, 74.7, and 82.6 meters; Table 1). Except for the 149,290 age, the other four ages suggest deposition during the early Sangamon Interglacial, similar to the Clear Creek, Brown Run, and other sites (Berg et al. 2012) to the north. The upper 67 feet (20.4 meters) is primarily sand with considerable gravel, whereas the lower 63 feet (19.2 meters) is mainly medium sand with minimal gravel.

Knapp #1 Located about 4 miles (6.4 kilometers) east of Henry is 163 feet (49.7 meters) of basal sand and gravel buried by 120 feet (36.6 meters) of Wisconsin Episode diamictons and silts. The Sangamon Geosol has formed into the lowermost silt and the upper part of the basal sand and gravel. With three viable OSL ages ranging from 112,800 ± 8,000 to 127,200 ± 10,700 (Berg et al. 2012), deposition occurred in the very latest Illinois Episode/early Sangamon Interglacial. The upper 138 feet (42 meters) is very fine to medium sand, whereas the lower 25 feet (7.6 meters) is mainly gravel and coarse sand.

Schoepke #1 Located about 7 miles (11.3 kilometers) east of Lacon and about 1 mile (1.6 kilometers) west of the bedrock valley wall is 100 feet (30.5 meters) of basal sand and gravel buried by 188 feet (57.3 meters) of sediment composed of 37 feet (11.3 meters) of Wisconsin Episode diamictons, 25 feet (7.6 meters) of silt, the Sangamon Geosol developed into 106 feet (32.3 meters) of Illinois Episode diamicton, and 20 feet (6.1 meters) of silt. With three OSL ages ranging from 142,700 ± 15,500 to 171,100 ± 14,700 (Berg et al. 2012), deposition occurred in the early/middle Illinois Episode. The upper 42 feet (12.8 meters) is very fine sand with silt, whereas the lower 58 feet (17.7 meters) is primarily coarse sand with gravel.

Prominent Map Features

1. Thick, buried basal sand and gravel overlies the Princeton, Ticona, and Wyoming Bedrock Valleys (Fig. 1). The deposit is particularly wide [~4 miles (6.4 meters)] overlying the Princeton Bedrock Valley. This is the region where sediment-laden outwash settled into a lake that formed in front of the glacier that blocked the AMR. When a breach formed to the west, creating the present course of the Mississippi River, the lake drained, leaving the relatively flat upper surface (Berg et al. 2012) of the basal sand and gravel.

2. The thickest basal sand and gravel occurs throughout the main MIV channel. Where it is buried by younger sediments, its thickest portions occur where the surface of the basal sand and gravel is relatively flat (Berg et al. 2012). Where exposed at land surface, its thickest portions occur as an expansive terrace surrounding Henry, as well as a terrace surrounding Lacon and a terrace north and south of Hennepin.

3. Thin basal sand and gravel occurs beneath sinuous channel-like features on the east side of the river in the middle portion of the map. The largest feature trends southeast and then south, and most likely reflects the main channel of the AMR during the Sangamon Episode and the early Wisconsin Episode.

4. The thinnest basal sand and gravel occurs primarily in two areas—along the course of the modern Illinois River where the river has eroded much of the deposit, and along the flanks of the bedrock valley.

Map Use

This thickness map of the basal sand and gravel provides water resource managers, developers, and water-well drillers with insights into areas where the greatest potential exists for finding adequate groundwater supplies in the glacial deposits of the MIV. It is an important component for evaluating the water-yielding potential of the region and developing a groundwater flow model. Water-use data (Fig. 1, Table 2) provide some insights into availability and yield. However, the relatively low population and overall use are not indicative of the region's full water resource potential.

Figure 3 shows the thickness of fine-grained deposits above the basal sand and gravel. Depths to the top of the unit vary because of thicknesses of overlying diamictons and other sediments, being particularly thicker where moraines cross the region. Paleochannels incised into the top of the basal sand and gravel also increase the thickness of overlying deposits. The range in depth of 120–188 feet (36.6–57.3 meters) to the top of the buried basal sand and gravel, as described for the five ISGS boreholes above, is typical for the region.

The thickness map in combination with information on the depth to the top of the basal sand and gravel are key components for evaluating the aquifer sensitivity for the region (Berg et al. 2015). The deeper the aquifer from land surface, the greater is the natural protection from overlying finer grained deposits, and the lesser is the likelihood of potential groundwater contamination from surface or near-surface land-use activity.

Water Use

On the basis of available subsurface data, the basal sand and gravel consists of a single hydrostratigraphic unit. However, because this unit has been deposited at different times under various glacial and interglacial regimes with varying energies and directional components spanning almost the last 200,000 years, its heterogeneity is considerable, both vertically and laterally. Therefore, considerably more subsurface data would be required to better understand its complexities. The intent of this map is not to show detailed heterogeneity, but rather to provide an overview of thickness variabilities.

The basal sand and gravel is a viable aquifer in the MIV. According to water-use data (Table 2) provided by the Illinois State Water Survey (ISWS), eight communities with 20 municipal supply wells draw their supplies from the basal sand and gravel (Fig. 1). However, only Washburn and Lake Wildwood withdraw groundwater from the buried and older basal sand and gravel. The wells at Lake Wildwood are the deepest at 270 and 275 feet (82.3 and 83.8 meters), withdrawing groundwater from the Illinois Episode deposits. Henry, Lacon, Sparland, Chillicothe, and Hennepin use the younger, unconfined deposits that now make up terraces along the Illinois River for their groundwater source, whereas Lake Thunderbird uses unconfined deposits along Senachwine Creek, a tributary to the Illinois River. Sparland has the shallowest wells at 33 and 34 feet (10.1 and 10.4 meters). Groundwater pumpage data from 2011–2012 (Table 2) show that Chillicothe and Lacon were the largest users, with both the Lacon #4 well and the Chillicothe #8 well pumping more than 100 million gallons per year. Total withdrawal from the eight municipalities was about 840 million gallons per year, or about 2.3 million gallons per day.

The basal sand and gravel is also the water resource for 869 private residential and 156 other wells (e.g., irrigation, noncommunity, industrial or commercial, parks, schools, etc.) in the MIV (personal communication with Tim Bryant, ISWS, August 5, 2013). They are finished at an average depth of about 90 feet (27.4 meters) for the unconfined basal sand and gravel within the floodplain and terraces along the Illinois River and about 180 feet (54.9 meters) for the buried and older basal sand and gravel. For private residential wells, 302 wells are finished in the unconfined basal sand and gravel, and 567 wells are finished in the buried basal sand and gravel. Assuming water usage of 80 gallons/day/person (Pat Mills, U.S. Geological Survey-Urbana, personal communication, August 5, 2013; Kenny et al. 2009) and an average household size of 2.46 persons (average for the five counties of the study region: Marshall, Putnam, Bureau, Peoria, and Woodford; U.S. Census Bureau 2012), about 200 gallons/day and 72,000 gallons/year are used for each household with a private residential well, with a total residential usage of 62,568,000 gallons/year. Withdrawal information for other wells is confidential, not widely available, or both and is therefore not reported here.

Acknowledgments

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Table 2 Municipal wells, well depth, and 2011–2012 pumpage in gallons per year from the basal sand and gravel in the study area

Well name and number	Depth (ft)	Pumpage
Henry 3	62	37,488,000
Henry 4	74	38,127,000
Henry 5	135	73,392,000
Lacon 2	50	9,986,400
Lacon 3	50	61,603,200
Lacon 4	60	100,519,800
Sparland 2	33	18,823,000
Sparland 3	34	17,587,000
Utilities Inc., Lake Wildwood Utilities Corp. 1	270	7,127,000
Utilities Inc., Lake Wildwood Utilities Corp. 3	275	10,422,000
Chilicothe 2	124	82,348,000
Chilicothe 3	123	80,362,000
Chilicothe 6	106	25,051,000
Chilicothe 7	100	70,678,000
Chilicothe 8	122	105,821,000
Lake Thunderbird Subd. 1	103	19,895,834
Lake Thunderbird Subd. 2	85	943,166
Hennepin PWD 3	100	43,364,000
Washburn 1	137	18,050,000
Washburn 2	137	18,050,000
Gallons pumped/year		839,638,400
Gallons pumped/day		2,299,000

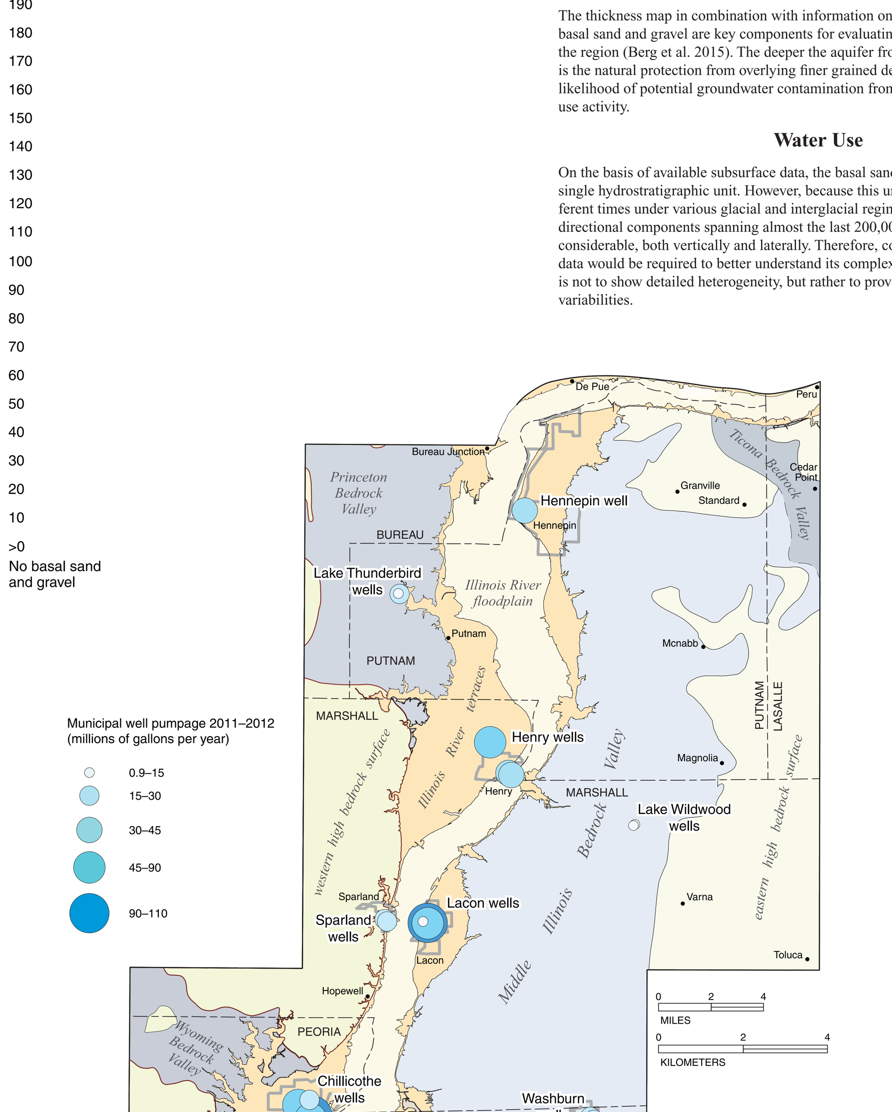

Figure 1 Municipal water supply wells pumping from basal sand and gravel in the Middle Illinois Bedrock Valley (data courtesy of the Illinois Water Inventory Program at the Illinois State Water Survey). Major geologic provinces are also shown.

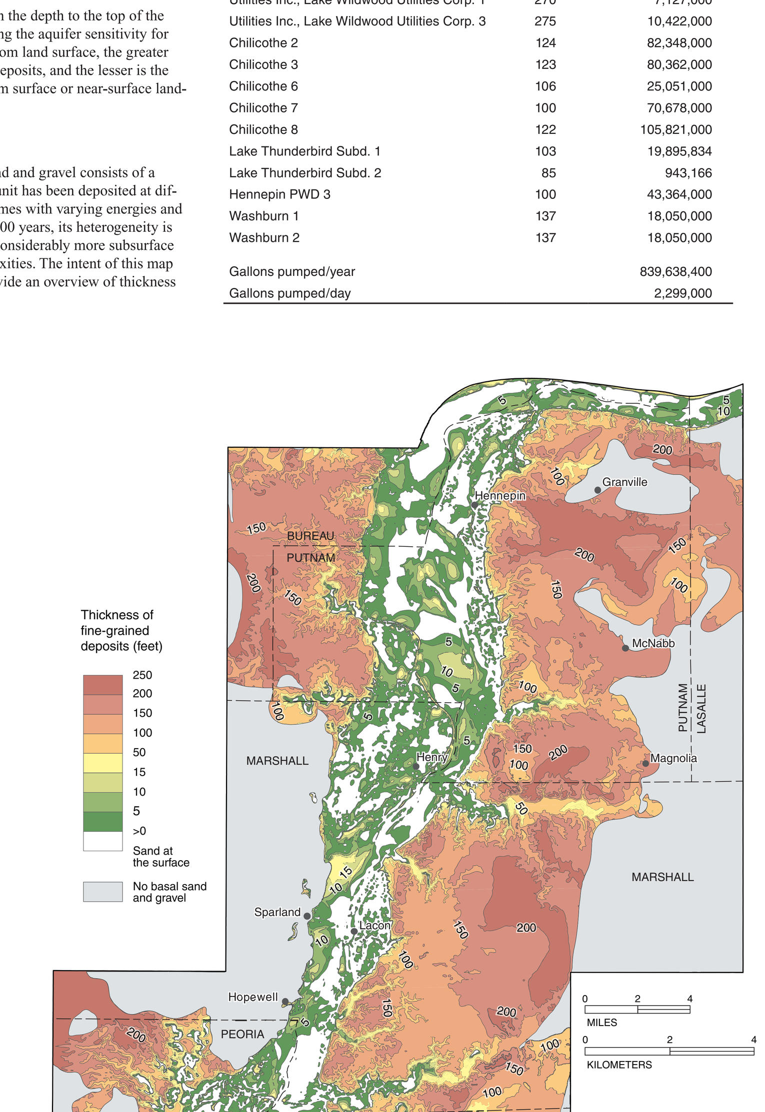

Figure 3 Thickness of fine-grained deposits overlying the basal sand and gravel in the Middle Illinois Bedrock Valley.

Base map compiled by Illinois State Geological Survey from digital and paper data provided by the United States Geological Survey.

North American Datum of 1983 (NAD 83)
Projection: Transverse Mercator

SCALE 1:62,500

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Geology based on fieldwork by E. Donald McKay III and Richard C. Berg, 2001–2011.

Digital cartography by Barbara J. Stiff, Brittany M. Walbright, Deette M. Lund, and Jennifer E. Carrell, Illinois State Geological Survey.

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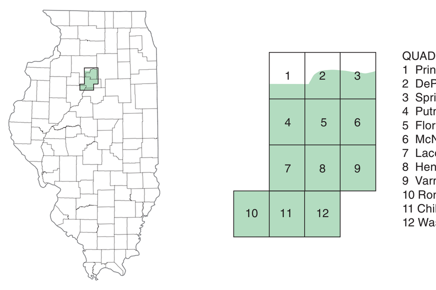

QUADRANGLES
1 Princeton South
2 DePue
3 Spring Valley
4 Putnam
5 Florid
6 McNabb
7 Lacon
8 Henry
9 Varna
10 Rome
11 Chillicothe
12 Washburn

APPROXIMATE MEAN DECLINATION, 2015

Municipal boundary line
County line
Swampy lowland areas
Rivers and water bodies
Interstate route
U.S. route
State route